International Scholars Journals

African Journal of Gender and Women Studies ISSN: 2736-1578, Vol. 11 (11), pp. 001-005, November, 2026. Available online at www.internationalscholarsjournals.org © International Scholars Journals

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Research Article

Women in Renewable Energy Engineering: Gendered Barriers and Mentorship Ecosystems

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Received: 4 October 2026; Revised: 2 November 2026; Accepted: 6 November 2026; Published: 16 November 2026.

ABSTRACT

The global transition toward clean energy infrastructure promises millions of new technical and engineering jobs over the coming decades, yet women remain severely underrepresented in grid engineering, wind turbine installation, and energy systems design (IRENA, 2025; IEA, 2023). Masculine workplace cultures, lack of female field mentors, inadequate personal protective equipment (PPE) tailored to female bodies, and unsafe remote field site conditions deter female engineering graduates from remaining in the sector. This paper examines the structural and cultural factors shaping female engineers' retention in renewable energy firms across Nigeria, South Korea, and Sweden. Grounded in gendered organization theory and feminist science studies, the study draws on career-trajectory interviews with 48 female energy engineers (16 per country). We argue that achieving a just energy transition requires gender-audited field safety standards, structured technical sponsorship, and equitable leadership pipelines. Mentorship alone is insufficient; without sponsorship, fitted PPE, safe field conditions, and transparent promotion criteria, mentoring becomes advice to endure an unchanged workplace rather than a pathway to change it.

Keywords: Renewable energy engineering; women in engineering; gendered organization theory; just energy transition; workplace culture; mentorship; Nigeria; South Korea; Sweden.

1. Introduction

The energy transition is often narrated as a technological and investment story: gigawatts added, costs falling, grids modernised. It is also a workforce story. The International Energy Agency (IEA) estimates that clean energy employment has grown rapidly and will continue to expand as solar, wind, storage, grids, and energy efficiency scale (IEA, 2023). The International Renewable Energy Agency (IRENA) finds that women hold only 32% of full-time jobs in renewable energy, the same share as in 2019 despite sector growth, and only 28% of science, technology, engineering and mathematics (STEM) roles and 19% of senior leadership positions (IRENA, 2025). In other words, the sector that claims to build the future is reproducing the gender inequalities of the past. This is not only a fairness problem. Research on innovation and safety shows that diverse teams improve problem-solving, risk assessment, and design for varied users, while homogenous teams are more likely to miss hazards that affect people unlike themselves (Nielsen et al., 2017; Harding, 2015).

This article focuses on retention, not only recruitment. Many firms can recruit female graduates; fewer keep them through the critical early-career years when field experience, certifications, and visibility determine who becomes a senior engineer. In Nigeria, women engineers describe navigating unreliable field logistics, long travel, and expectations that they prove toughness in male crews. In South Korea, women engineers describe long-hours cultures, hierarchical decision-making, and a sharp motherhood penalty in a context of very low fertility and intense work-family conflict. In Sweden, often held up as a gender-equality model, women engineers still describe persistent horizontal segregation, subtle exclusion from informal networks, and the paradox that generous parental leave can coexist with gendered engineering cultures (Stoet & Geary, 2018; Charles & Grusky, 2004). Comparing three very different national contexts makes it possible to distinguish what is universal about gendered engineering organisations from what is shaped by national policy, labour markets, and culture.

We ask three questions. First, what structural and cultural factors shape whether female renewable energy engineers stay, move sideways, or leave? Second, how do field safety, PPE, and remote site conditions function as gendered barriers rather than neutral technical inconveniences? Third, what kinds of mentorship

ecosystems actually change retention and progression, and how do they differ from mentorship that merely helps women cope? Drawing on 48 career-trajectory interviews, we argue for a shift from pipeline thinking to ecosystem thinking: retention is produced by interlocking practices around safety, sponsorship, scheduling, and promotion, not by individual resilience.

2. Theoretical Framework: Gendered Organisations and Feminist Science Studies

Joan Acker's theory of gendered organisations remains the most powerful account of why formally gender-neutral workplaces produce gendered outcomes (Acker, 1990; Acker, 2006). Acker argues that organisations are not gender-neutral containers into which women are added; gender is built into the division of labour, symbols and culture, patterns of interaction, and individual identities and subjectivities. The 'ideal worker' is imagined as someone unencumbered by care, always available for overtime and remote deployment, physically able to endure harsh conditions, and socially comfortable in male homosocial networks. In renewable energy engineering, that ideal maps neatly onto the field engineer who can travel at short notice, climb a turbine, work nights during commissioning, and bond with a crew in remote accommodation. Women who cannot or will not conform to that ideal are not simply different; they are read as less committed, less reliable, or less technically serious.

Feminist science studies adds a second lens: knowledge and artefacts are not neutral (Harding, 2015; Wajcman, 2010). PPE designed for an average male body, a turbine nacelle with no provision for privacy, a control room roster that assumes no caring responsibilities, and a promotion rubric that rewards uninterrupted field tenure are not accidents; they encode assumptions about who the engineer is. When women must alter oversized harnesses, gloves, or coveralls, they are not experiencing a minor inconvenience. Research by the Society of Women Engineers and construction safety bodies finds that 89% of tradeswomen have difficulty obtaining properly fitting PPE, and 77% report that ill-fitting PPE created safety hazards, including fall, chemical-exposure, and entanglement risks (Society of Women Engineers, 2023; CPWR, 2023). In this sense, PPE is a feminist issue: a badly fitting harness can literally make a woman unsafe.

Figure 1 summarises the framework. Four gendered processes - division of labour, symbols and culture, interactions, and identity/structure - mediate retention through national context. A just energy transition, in this framing, is not only about who gets clean electricity, but about who gets to build, maintain, and govern the systems that deliver it (Jenkins et al., 2016; Sovacool et al., 2023).

Figure 1. Gendered organisation lens: *how everyday practices reproduce inequality.*

Source: *Authors' synthesis based on Acker (1990, 2006) and feminist science studies.*

3. Literature Review

3.1 Women in renewable energy: global patterns

IRENA's second edition of Renewable Energy: A Gender Perspective (2025), based on organisations and individuals from 119 countries, is the most comprehensive assessment to date. It reports women hold 32% of full-time renewable energy jobs, 45% of administrative roles, 36% of non-STEM technical roles, 28% of STEM roles, 22% of medium-skilled installation roles, and only 19% of senior management and board roles (IRENA, 2025). The pattern is a familiar funnel: women are present at entry, thinner in technical field roles, and scarcest at the top. The IEA similarly notes that energy remains one of the least gender-diverse sectors, with women underrepresented in leadership and technical occupations across fossil and clean energy (IEA, 2023). In engineering more broadly, women earn about 20% of undergraduate engineering degrees in many countries but hold only about 13-16% of engineering workforce roles, with attrition concentrated in the first decade (National Academies, 2020; Society of Women Engineers, 2023).

3.2 Masculine workplace cultures and the leaky pipeline

The 'leaky pipeline' metaphor suggests women drip out for individual reasons. Feminist research reframes leakage as push: women are pushed by hostile cultures, biased evaluation, lack of sponsorship, and work-family conflict (Cech & Blair-Loy, 2014; Williams et al., 2016). In male-dominated STEM, women report restricted access to informal networks, biased competence evaluations, and exclusion from high-visibility assignments. A UK study by Atkins found 57% of women leave engineering by age 45 compared with 17% of men, citing lack of role models and mentoring, macho culture, and inflexible working (Atkins, 2023). In Nigeria, studies of women in engineering and construction describe patriarchal norms, sexual harassment, and expectations that women prove themselves repeatedly, alongside strong peer networks and faith-based resilience strategies (Adeyemi et al., 2022; Okafor et al., 2023). In South Korea, research on women in STEM points to hierarchical chaebol and public-sector cultures, long hours, and the career penalty of marriage and motherhood, despite high female educational attainment (Kim & Park, 2022; OECD, 2023). In Sweden, despite high gender-equality rankings, engineering remains horizontally segregated, and women report subtle exclusion and the burden of being the 'only' woman on a team (Charles & Grusky, 2004; Faulkner, 2009).

3.3 Mentorship versus sponsorship

Mentorship is widely prescribed, but evidence distinguishes mentorship from sponsorship. Mentorship provides advice, encouragement, and coaching. Sponsorship involves a senior person actively advocating for a junior person in promotion, assignment, and pay decisions, including in rooms the junior person is not in (Ibarra et al., 2010; Hewlett, 2013). Women are often over-mentored and under-sponsored: they receive advice but not advocacy. The distinction matters in field engineering, where who gets a turbine commissioning lead, a grid substation project, or an overseas training slot determines technical capital. Structured sponsorship, with named sponsors, transparent criteria, and accountability, has stronger effects on progression than informal mentoring alone (National Academies, 2020). Peer mentoring also matters: women-only and mixed peer networks provide belonging, tactics for navigating field sites, and collective voice to raise safety issues without being labelled as complaining.

3.4 PPE, field safety, and the body at work

Field safety is rarely treated as a gender issue, yet it is central. PPE designed for male bodies, lack of sex-separated sanitation and sleeping accommodation on remote sites, and absence of harassment reporting mechanisms make fieldwork disproportionately costly for women. Canadian and UK surveys find that a majority of women report PPE that does not fit, with 58% wearing the wrong size, 28% not wearing all required PPE due to fit, and 38% using workarounds (CCOHS, 2023; GMB, 2023). Offshore energy surveys find 68% of women without

correctly fitting coveralls (Energy Voice, 2023). In wind and solar, ill-fitting harnesses and gloves increase fall and entanglement risk. Gender-audited safety standards would require fit-testing across body sizes, provision of women's PPE in all sizes, private sanitation, safe transport, and a zero-tolerance harassment protocol with independent reporting. These are not accommodations; they are basic safety.

4. Methods

This study used qualitative career-trajectory interviews with 48 female energy engineers: 16 in Nigeria, 16 in South Korea, and 16 in Sweden. Participants worked in grid engineering, wind, solar, storage, and energy systems design, in firms ranging from utilities and EPC contractors to start-ups and public agencies. They ranged from 2 to 18 years of experience, with 28 in early career (under 7 years), 14 in mid-career, and 6 in senior roles. Purposive sampling sought diversity in sub-sector, firm size, and caregiving status. Interviews lasted 60-90 minutes, were conducted in English, Korean, or Swedish by female researchers, transcribed, translated where needed, and thematically analysed using framework analysis informed by Acker's gendered organisation theory (Gale et al., 2013). Ethical approvals were obtained in all three countries; pseudonyms are used. Limitations include purposive sampling, reliance on self-report, and the cross-sectional nature of interviews, which cannot track long-term retention causally. Findings are interpreted alongside IRENA and IEA workforce data rather than as population estimates.

Table 1. Sample and country contexts.:

Country	Participants	Sub-sectors represented	National context note
Nigeria	16	Grid, solar mini-grids, EPC	Rapid solar growth, infrastructure gaps, patriarchal norms
South Korea	16	Grid, wind, storage, systems design	High STEM education, long-hours culture, motherhood penalty
Sweden	16	Wind, grid, systems, sustainability	Strong equality policy, persistent segregation

Source: *Fieldwork records, 2024-2025.*

5. Findings

5.1 Masculine cultures and the ideal field worker

Across all three countries, women described a shared ideal: the engineer who is always available, endures hardship without complaint, and bonds through after-hours socialising. In Nigeria, a grid engineer said, 'If you say you cannot travel at night, they say you are not serious.' In South Korea, a wind engineer described hoesik (team dinners) and late-night commissioning as informal promotion gates: missing them meant missing information. In Sweden, a systems engineer described being the only woman in design reviews where her suggestions were ignored until repeated by a male colleague, a pattern documented as 'hepeating' in feminist workplace research (Faulkner, 2009). The culture was not always overtly hostile; it was often exhausting. Women spent energy managing perceptions, proving competence repeatedly, and deciding when to speak up about safety without being labelled difficult.

5.2 PPE and field site safety as retention issues

PPE was a concrete, daily reminder of not being designed for. Nigerian participants described oversized coveralls, boots, and harnesses borrowed from male colleagues, and gloves too large to safely handle tools. Korean participants described a lack of women's sizes in company PPE catalogues and embarrassment at requesting them. Swedish participants, despite stronger regulation, still described harnesses and fall-arrest systems fitted to male torsos. Remote sites amplified risk: shared dormitories, no locked toilets, poor lighting on paths to turbines, and no safe transport after night shifts. One Nigerian solar engineer said she stopped accepting remote deployments after a night when she had no safe place to sleep. One Korean engineer described avoiding overnight site work after harassment by a subcontractor, with no clear reporting channel. Safety, in these accounts, was not abstract; it was whether a woman could do fieldwork without risking her body or dignity.

5.3 Lack of female field mentors and the sponsorship gap

Most participants had mentors, but few had sponsors. Early-career women described senior men who gave technical advice but did not advocate for them. Women who had a female field mentor described a decisive difference: someone who had navigated the same sites, knew how to request fitted PPE without apology, and could model how to lead a crew. Yet female field mentors were scarce because women had left. This is the mentorship trap: the absence of senior women makes it harder to retain junior women, which keeps senior women scarce. Participants who stayed often credited a single sponsor: a manager who assigned them a commissioning lead, nominated them for certification, or defended their promotion. One Swedish participant said, 'My sponsor said my name in a room I was not in. That changed everything.' That line captures the sponsorship distinction (Hewlett, 2013; Ibarra et al., 2010).

Table 2. Comparative barrier synthesis from 48 interviews.:

Barrier domain	Nigeria	South Korea	Sweden	Retention consequence
Culture / ideal worker	Night travel, toughness test	Long hours, hoesik, hierarchy	Subtle exclusion, hepeating	Exhaustion, exit
PPE / safety	Oversized PPE, no safe lodging	No women's sizes, harassment risk	Harness fit, remote site safety	Avoiding field roles
Mentorship	Few senior women, informal mentoring	Mentoring without sponsorship	Peer networks but few sponsors	Stalled progression
Leadership pipeline	Opaque promotion, family duties	Motherhood penalty, career break	Parental leave + segregation	Leaving at mid-career

Source: *Authors' thematic analysis.*

5.4 What kept women in: mentorship ecosystems

Women who stayed described ecosystems, not single mentors. Figure 2 maps this ecosystem: peer mentoring for belonging, technical mentoring for field skills and certifications, sponsorship for advocacy, and a leadership pipeline with transparent criteria. The most effective ecosystems had four features. First, structured matching with a named technical mentor for the first two years, not ad hoc advice. Second, sponsor accountability: sponsors were expected to nominate mentees for visible assignments and to report on progression. Third, peer cohorts: groups of 4-6 women across firms who met regularly, shared tactics, and raised collective safety concerns. Fourth, organisational changes: fitted

PPE stocked as standard, gender-audited site checklists, and promotion criteria that counted field leadership, safety improvements, and mentoring, not only uninterrupted tenure. Where these existed, women described fieldwork as challenging but doable; where they did not, they described fieldwork as a test of endurance.

Figure 2. Mentorship ecosystem: *from advice to sponsorship to leadership.*

Source: *Authors' synthesis of interview data.*

Table 3. Mentorship ecosystem elements.:

Ecosystem element	What it does	Example in practice
Peer mentoring	Belonging, tactics, collective voice	Cross-firm cohort, monthly check-ins
Technical mentoring	Field skills, certifications	Named mentor, 2-year structured plan
Sponsorship	Advocacy in promotion rooms	Sponsor nominates for lead roles
Leadership pipeline	Transparent progression	Published criteria, pay-equity audit

Source: *Authors' synthesis.*

6. Discussion

The comparison shows both convergence and divergence. Convergence: in all three countries, gendered organisations, ill-fitting PPE, and sponsorship gaps push women out, even where national gender-equality contexts differ sharply. Divergence: the form differs. In Nigeria, material infrastructure and safety logistics dominate; in South Korea, long-hours culture and motherhood penalty dominate; in Sweden, subtle exclusion and segregation persist despite strong policy. This suggests that a just energy transition cannot rely on a single global template. It needs gender-audited standards that are locally adapted: in Nigeria, safe transport and lodging and reliable PPE supply chains; in South Korea, reform of working hours, parental leave uptake by men, and transparent promotion; in Sweden, accountability for informal exclusion and for who gets high-visibility field leads.

The findings also challenge the idea that mentoring alone will fix retention. Mentoring without sponsorship, PPE, and safety reform is, in the words of one participant, 'advice to survive a broken system.' Sponsorship must be structured, not left to chemistry. Firms should publish promotion criteria, track who gets field leads and certifications by gender, audit pay, and hold sponsors accountable. Safety audits should be gendered: fit-testing, sanitation, lighting, transport, and harassment reporting should be checked before a site is declared ready, not after a woman reports harm. These are not costs to be minimised; they are investments in a workforce the transition urgently needs.

Policy implications follow for governments, regulators, and funders. Procurement and licensing for renewable projects should require gender-audited safety standards, fitted PPE, and anti-harassment protocols. Climate finance should include gender indicators for workforce retention, not only for beneficiary numbers. Engineering accreditation should require field safety and inclusive leadership training. And firms should report, by gender, field assignment, certification, promotion, and pay, so that progress can be verified rather than asserted.

7. Conclusion

Women in renewable energy engineering are not leaving because they lack talent or interest. They are leaving because organisations built around a male ideal worker, equipped with PPE that does not fit them, and governed by sponsorship that rarely reaches them, make fieldwork disproportionately costly. A just energy transition requires changing those organisations: gender-audited field safety, fitted PPE as standard, safe remote sites, structured technical sponsorship, and equitable leadership pipelines. Mentorship ecosystems that combine peer belonging, technical mentoring, and sponsorship can retain women, but only when organisations change alongside them. If the sector that builds the future cannot keep the women who build it, its claim to justice will remain incomplete.

Acknowledgements

We thank the 48 engineers who shared their career stories, and the firms and professional networks in Nigeria, South Korea, and Sweden that facilitated recruitment. Institutional support was provided by the authors' universities.

Conflict of Interest

The authors declare no conflict of interest.

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