

GENDER INEQUALITY IN STEM AND RENEWABLE ENERGY EDUCATION IN UGANDA: MAKERSPACES AS PATHWAYS TO GENDER-RESPONSIVE LEARNING

RODNA NEJEDNAKOST U STEM I OBRAZOVANJU O OBNOVLJIVOJ ENERGIJI U UGANDI: MAKERSKI PROSTORI KAO PUTEVI KA RODNO ODGOVORNOM UČENJU

Rafat AL AFIF^{1*}, Nikoleta NIKISIANLI¹, Aidah NAMAGAMBE^{1,2}, Hillary KASEDE², Christoph PFEIFER¹

¹ Institute of Chemical and Energy Engineering, University of Natural Resources and Life Sciences, Muthgasse 107, 1190 Vienna, Austria

² Department of Mechanical Engineering, College of Engineering, Design, Art and Technology, Makerere University, P.O. Box 7062, Kampala, Uganda

Correspondence: rafat.alafif@boku.ac.at

ABSTRACT

This study examines ongoing gender inequality in Uganda's STEM and renewable energy education pipeline, set against the backdrop of severe energy poverty and gendered burdens. It highlights the societal and innovation costs of women's underrepresentation and explores makerspaces as inclusive, practical environments. The research aims to place girls' and women's STEM pathways within Uganda's energy transition and evaluate makerspaces as a catalyst for gender-responsive learning and skills development. Using a sequential explanatory mixed-methods approach, the study incorporates: (i) a focused review; (ii) empirical fieldwork at universities and the Makerere University makerspace; and (iii) three iterative Training-of-Trainers cycles, involving surveys, interviews, focus groups, observations, and artefact reviews, alongside quantitative and qualitative analyses of inclusion and pedagogy. Results reveal deeply rooted structural barriers—such as unpaid care, labour-market discrimination, and competitive cultures—that restrict women's participation. Well-designed makerspace training enhanced technical skills, confidence, and perceived relevance; female participation increased across training rounds, although the risk of male dominance remains without targeted measures. The study recommends coordinated, multi-level actions: adopting gender-responsive pedagogy, increasing female representation and mentorship in STEM faculties, and integrating makerspaces into supportive policies and curricula to promote scalable, gender-inclusive, hands-on learning for renewable energy careers.

Keywords: gender inequality, renewable energy education, makerspaces, trainers' cycles

REZIME

Ova studija ispituje kontinuiranu rodnu nejednakost u obrazovanju u oblastima STEM i obnovljivih izvora energije u Ugandi, u kontekstu ozbiljnog energetskeg siromaštva i rodni opterećenja. Ona ističe društvene i inovativne troškove nedovoljne zastupljenosti žena i istražuje „makerske prostore“ kao inkluzivna, praktična okruženja. Cilj istraživanja je da postavi STEM puteve devojčica i žena u okviru energetske tranzicije Ugande i proceni „makerske prostore“ kao katalizator za rodno odgovorno učenje i razvoj veština. Koristeći sekvencijalni objašnjavajući pristup mešovitim metoda, studija uključuje: (i) fokusirani pregled; (ii) empirijski terenski rad na univerzitetima i „makerskom prostoru“ Univerziteta Makerere; i (iii) tri iterativna ciklusa obuke trenera, koji uključuju ankete, intervjue, fokus grupe, posmatranja i preglede artefakata, uz kvantitativne i kvalitativne analize inkluzije i pedagogije. Rezultati otkrivaju duboko ukorenjene strukturne barijere – kao što su neplaćena briga, diskriminacija na tržištu rada i konkurentna kultura – koje ograničavaju učešće žena. Dobro osmišljena obuka u „makerskom prostoru“ poboljšala je tehničke veštine, samopouzdanje i percipiranu relevantnost; učešće žena se povećalo tokom rundi obuke, iako rizik od muške dominacije ostaje bez ciljanih mera. Studija preporučuje koordinisane akcije na više nivoa: usvajanje rodno odgovorne pedagogije, povećanje zastupljenosti žena i mentorstva na STEM fakultetima i integrisanje „makerskih prostora“ u politike podrške i nastavne planove i programe kako bi se promovisalo skalabilno, rodno inkluzivno, praktično učenje za karijere u oblasti obnovljive energije.

Cljučne reči: rodna nejednakost, obrazovanje o obnovljivoj energiji, „makerski prostori“, ciklusi trenera

INTRODUCTION

The imperative to achieve gender equity in education and sustainable development is especially acute in contexts where energy poverty and entrenched social norms intersect. Despite notable global and national progress in educational access, many girls and young women continue to encounter socio-economic and cultural barriers that constrain their ability to complete and benefit from quality education of their choice (Bangura and Mambo, 2023). Emerging research highlights the transformative potential of collaborative learning environments in mitigating these challenges. Maker Spaces, in particular, have shown promise, with studies shown that women in makerspaces engage deeply

with learning and creative exploration, develop confidence and resilience (Tomko, et. al. 2020). Early educational experiences are of utmost importance, as they have been shown to positively influence students' later choices in mathematics and science courses as well as their career ambitions (Kermani and Aldemir, 2015). In primary education, science and mathematics are part of the core curriculum worldwide, and both girls and boys are generally expected to receive equal exposure to these subjects. However, the amount of instructional time dedicated to them varies significantly across countries and regions. Moreover, in many settings, gender stereotypes are already reinforced at this stage. Research shows that teachers often underestimate girls'

abilities in mathematics compared to boys, even when their performance is similar.

The gender gap in STEM participation becomes more pronounced in lower secondary education, when students begin to specialise and choose subjects to pursue further. During this period, girls tend to lose interest in STEM subjects at a higher rate than boys. Data from various countries also show that by Grade 12, boys are more likely than girls to enrol in advanced mathematics and physics courses. This results in only about 30% of female students globally choosing to pursue STEM-related fields in higher education (www.alikecreative.com).

Uganda's energy sector vividly illustrates the nexus between gender inequality and sustainable development. The transition to renewable energy sources for green energy production represents a promising pathway to address the growing scarcity of conventional energy resources while ensuring the generation of clean, sustainable power (Afif and Pfeifer, 2022; Haddad, et al, 2024; Afif, et al, 2023a; Afif et al, 2020; Afif et al, 2023b; Ayed, et al, 2023; Afif et al, 2024; Pavkov et al, 2022; Radojčin et al, 2022; www.iea.org; Tereka et al, 2025). However, despite Uganda's substantial endowment of renewable energy resources, including hydropower, solar, geothermal, and biomass, the effective exploitation of these resources remains constrained. In particular, investment in the sector and the meaningful participation of women within it continue to be limited. The government has nonetheless demonstrated commitment to expanding generation capacity and improving access in alignment with Sustainable Development Goal 7 (Affordable and Clean Energy) and Vision 2040. Despite these initiatives, energy poverty persists as a critical challenge. According to IEA. En (www.iea.org), only about 30% of Ugandans had access to electricity by 2022, with rural electrification remaining particularly limited, reaching only 1 in 7 residents. Moreover, 95% of households continue to rely predominantly on firewood and charcoal for cooking, a dependence that raises profound social, environmental, and health concerns (Tereka et al, 2025).

The gendered dimensions of this energy deficit are especially pronounced. Women and girls bear the primary responsibility for household energy provision, often walking 4-10 km to collect firewood and biomass, a task that not only consumes considerable time but also exposes them to heightened security risks, including sexual and gender-based violence (www.unwomen.org). Heavy reliance on traditional biomass fuels also contributes to severe indoor air pollution, substantially increasing the prevalence of acute respiratory infections and related morbidity and mortality (Mpagi and Kooijman, 2020). These conditions undermine public health, reduce life expectancy, and constrain women's opportunities for education and income generation, thereby reinforcing cycles of economic dependence and gender inequality. Expanding access to modern, cleaner cooking technologies offers a transformative pathway, improving health outcomes, reducing gender-based vulnerabilities, and enhancing the overall safety and well-being of women and their families.

Despite their disproportionate burden, women remain structurally marginalised within Uganda's renewable energy sector. The limited participation of women in the energy workforce, including the sustainable energy sector, is closely linked to their persistent underrepresentation in STEM education. Deeply ingrained discriminatory social norms, coupled with exclusionary and non-inclusive learning environments, continue to constrain the engagement of girls and young women in science,

technology, engineering, and mathematics disciplines (*UN Women*). The underrepresentation of women in energy education, research, and technical fields diminishes diversity in the design of renewable energy solutions and risks the development of technologies that inadequately address women's needs (Menerscheid and Kotecha, 2024). Rectifying this imbalance is critical, not only for gender justice but also to enhance the effectiveness of Uganda's energy transition. Greater inclusion of women through equitable access to renewable energy education and training can foster their roles as innovators, entrepreneurs, and decision-makers, thereby advancing both gender equality and sustainable development (Kooijman et al, 2023).

This study seeks to address these gaps by situating girls' and women's STEM trajectories within Uganda's broader energy access and transition agenda and by examining the role of Maker Spaces as a practical lever for gender-responsive learning and skills development. It contributes novel, policy-aligned insights by: (a) synthesizing evidence on where and why attrition of girls in STEM intensifies from primary through lower secondary stages; (b) analyzing how social norms, safety, sanitation, and school-based gender violence intersect with instructional exposure and teacher expectations to shape STEM engagement; (c) mapping these educational dynamics to the needs of Uganda's renewable energy sector, where women suffer from underrepresentation.

BACKGROUND

Gendered Attrition Across Uganda's STEM Pipeline

Persistent gender asymmetries characterise Uganda's STEM pipeline: only one in four students admitted to science education programs is female, and women constitute less than one-third of science researchers, reflecting entrenched cultural norms and admissions practices that favour men (*UNESCO*). These gaps constrain progression into advanced technical careers and attenuate the visibility of female role models within universities (Lasekan et al, 2024).

Energy Access Deficits and Gendered Household Burdens

Energy poverty intensifies educational and occupational constraints for women. As of 2022, approximately 30% of Ugandans had electricity access (about one in seven in rural areas), and roughly 95% of households relied on firewood and charcoal for cooking—conditions that impose substantial time and safety burdens on women and girls and elevate exposure to indoor air pollution and related morbidity (Tereka et al, 2025).

From Education to Workforce: Implications for the Sustainable Energy Sector Underrepresentation in STEM education translates into limited participation of women in the sustainable energy workforce, narrowing the diversity of perspectives informing technology design and risking solutions that insufficiently address women's needs (*UN Women*).

Structural Determinants of Women's STEM Participation Evidence highlights structural barriers across education and early careers—including disproportionate unpaid care responsibilities, labour-market discrimination, and competitive campus and makerspace cultures that erode belonging when not deliberately moderated—which dampen persistence in male-dominated technical trajectories (Sulla et al, 2025).

Maker Centred, Practice-Oriented Learning: Opportunities and Risks

Intentionally inclusive makerspaces foster collaborative, practice-oriented learning that strengthens technical self-efficacy, supports identity development, and helps close the gap between knowledge acquisition and application for girls and women (Sulla et al, 2025). However, without explicit governance safeguards, makerspaces can reproduce exclusionary norms (e.g., “benevolent sexism”), necessitating structured inclusion measures from the outset (Lasekan et al, 2024).

Policy Commitments and the Implementation Gap in Gender-Responsive Pedagogy National and institutional agendas increasingly endorse hands-on, maker-centered approaches and gender-responsive pedagogy, yet implementation often remains symbolic in daily practice, limiting inclusive teaching essential for participation (Ministry of Education and Sports). Embedding makerspaces within accredited curricula and assessment, with dedicated resources and gender-responsive monitoring, is pivotal to translating policy intent into scalable practice (Tizikara et al, 2019).

System-Level Indicators and Alignment with Renewable Energy Labor-Market Pathways Uganda’s low ranking on the Gender Inequality Index and only marginal gains in female tertiary enrolment—alongside persistent imbalances across institutions and disciplines—underscore the need to link educational reforms with labor-market pathways in the renewable energy sector (WitU W in TU). Positioning gender-responsive, hands-on training at this nexus is central to advancing both equity and the effectiveness of the energy transition (www.genderinitiativeug.org).

METHODOLOGY

Research design: This study employs a sequential explanatory mixed-methods approach to examine women’s STEM pathways within Uganda’s energy transition context. An integrated framework connects gendered barriers in education and training to labour market demands in the renewable energy sector. The methodology merges evidence synthesis, empirical investigation, and intervention-based learning through Maker Spaces.

Study components and context: The research comprises three elements:

(i) a targeted review of literature, policy documents, and datasets to identify patterns and drivers of female attrition in STEM; (ii) empirical fieldwork conducted in universities and Maker Spaces, including the Makerere University makerspace; (iii) three iterative Training-of-Trainers (ToT) cycles implemented as embedded case studies to evaluate Maker Spaces as gender-responsive environments for renewable energy skills development.

Participants: Participants were purposively selected from higher education and the energy ecosystem, including university lecturers, laboratory technologists, program coordinators, and stakeholders from the renewable energy sector. This enabled analysis of institutional practices, gender norms, and structural constraints influencing women’s participation in STEM and energy-related fields.

Data collection: Quantitative surveys assessed STEM self-efficacy, pedagogical confidence, and perceptions of gender inclusion within learning environments. Qualitative data (interviews, focus groups, and observations) explored how social norms, institutional conditions, and gender-related barriers shape engagement. ToT cycles generated pre/post data on gender-

responsive pedagogy and implementation capacity, complemented by artefact reviews of renewable energy-related projects (e.g., solar and clean energy applications).

Data analysis: Quantitative data were analysed using descriptive and inferential statistics, while qualitative data were examined thematically. Findings were triangulated to map the relationship between STEM training pathways and the skills demands and gender gaps within Uganda’s renewable energy sector.

Stakeholder engagement and ethics: Engagement with universities, sector actors, and relevant institutions supported policy alignment and validation of findings. Ethical procedures included institutional approval, informed consent, anonymisation, and safeguarding protocols.

RESULTS AND DISCUSSION

Structural barriers: unpaid care, labour market discrimination, competitive cultures

The reference review showed pronounced time-use asymmetries that constrain women’s educational continuity: women and girls (15+) devote 14.6% of their time to unpaid care and domestic work versus 6.7% for men, heightening interruptions in schooling and training (Global Education Monitoring Report) labour-force data further indicated that 42% of women work as unpaid family workers compared to 16% of men, alongside restricted sectoral access and gender-differentiated pay—conditions that dampen incentives to pursue male-dominated technical trajectories [29]. Evidence also demonstrated that competitive campus cultures and unmoderated makerspaces can marginalise women; absent deliberate design and management, such spaces tend to become male-dominated, reinscribing bias and eroding belonging and persistence (Derera et al, 2020).

Makerspaces as catalysts for gender-inclusive, hands-on learning

The review indicated that intentionally inclusive makerspaces mitigate these barriers by fostering collaborative, practice-oriented learning that strengthens technical self-efficacy and supports identity formation for girls and women (UNESCO Women). This aligns with evidence that girls often outperform in knowledge acquisition but lag in application; maker-centered pedagogy—iterative making, testing, and real-world problem-solving—directly targets this application gap while cautioning that, without safeguards, “Boys with Toys” dynamics can exclude women (Sulla et al, 2025).

Interventions within the PHRE project at Makerere University

Project evidence showed that three makerspace-based Training-of-Trainers cycles at Makerere University deliberately prioritised female MSc participation to build competencies and pathways into teaching and research roles, with female participation rising across rounds (UNESCO Women). Complementary institutional measures were articulated to consolidate gains: review of the university gender policy; student and faculty participation quotas; increased inclusion of women-authored scholarship; a pilot “Societal and Gender Aspects in Energy” lecture; and mobilisation of female lecturers and external stakeholders as role models and mentors (Sulla et al, 2025).

Institutional frameworks supporting gender equality in energy education

Policy analysis revealed an enabling yet uneven landscape. Uganda’s Energy Gender and Equity Compact allocates resources for gender issues in the energy sector, and national STI and girls’ education strategies provide scaffolding; however, these frameworks frequently remain symbolic in daily practice and underemphasize gender-responsive pedagogy essential for inclusion (www.unwomen.org; UN Women, UNIDO). Internationally aligned agendas (e.g., SDG4 implementation) underscore strengthening STEM through hands-on, maker-centred approaches, positioning makerspaces as practical vehicles for equitable skills development in higher education (Zakoth et al, 2024; Getachew, 2025).

Gender participation at Makerere University: staff and student distributions

Staffing and enrolment data showed persistent asymmetries (Tables 1–3): women comprise 23.6% of secondary science teachers and 30% of lecturers in public universities, constraining the visibility of role models and mentorship pipelines. Within the School of Engineering, the Master of Science in Renewable Energy has the highest female participation among programs, indicating greater traction for women in this domain and reinforcing the strategic placement of makerspace interventions in renewable energy education.

Table 1. Teaching staff at Engineering department of Makerere University, as of May 2025

Group	Department/course	Male	Female	Total
Teaching staff	Department of Mechanical Engineering	15	2	17
	Civil and Environmental Engineering	31	4	35
	Electrical and Computer Engineering	22	11	33
Technicians	Department of Mechanical Engineering	8	0	8
Full Professors	Department of Mechanical Engineering	1	0	1
	Electrical and Computer Engineering	0	0	0
	Civil and Environmental Engineering	1	0	1

Table 2 shows the sex ratio at Master student level in three study programmes, being: Master of Science in Renewable Energy (MRET), Master of Science in Mechanical Engineering (MSME) and Master of Science in Technology Innovation and Industrial Development (MTIID). While the share of female students amounts to only 6% at MSME and 10% at the MTIID, it is remarkably higher with the Master programme in Renewable Energy (MRET) amounting to 31%.

Table 2: Masters students in 3 study programmes at Makerere University in year 1 of 2024-2025

Program	Male	Female	Total
MRET	41	18	59
MSME	33	2	35
MTIID	26	3	29

Table 3 presents Bachelor student numbers in Mechanical (MECH), Agricultural (BAGE), Water and Irrigation (WIE), and Bioprocessing Engineering (BPE). Female participation is higher at the Bachelor level (31–42%) and remains similar in year 2 (31–43%). Variations in later years—especially in MECH (16% in year 3, 34% in year 4)—are due to administrative course arrangements: students from BAGE, WIE, and BPE share courses with Mechanical Engineering in the first two years, then move to their home department for years 3 and 4.

Trends in female participation across training rounds

Program monitoring showed an upward trend in women’s engagement: female participation increased from 1 participant in the first makerspace training to 5 in the second, with a further increase in the third round. Post-training feedback indicated enhanced technical competence, confidence, and perceived applicability of renewable energy technologies across academic and professional contexts, suggesting that gender-responsive makerspace design leads to meaningful shifts in engagement and professional identity.

Table 3: Bachelor students in four study programmes at Makerere University

Year of Program study	Male	Female	Total	
Year 1 MECH	68	31	99	
	BAGE	27	16	43
	WIE	21	15	36
	BPE	21	15	36
Year 2 MECH	63	28	91	
	BAGE	15	11	26
	WIE	14	9	23
	BPE	13	10	23
Year 3 MECH	32	6	38	
	BAGE	0	0	0
	WIE	0	0	0
	BPE	0	0	0
Year 4 MECH	71	37	108	
	BAGE	0	0	0
	WIE	0	0	0
	BPE	0	0	0

Recommendations

Mainstream gender-responsive pedagogy in STEM programs

Institutionalise gender-responsive pedagogy (GRP) through compulsory staff development, Training-of-Trainers (ToT) cascades, and teaching assessment rubrics that evaluate inclusive practices, collaborative problem-solving, and practical skills. Focus on maker-centred, inquiry-based activities that enhance technological self-efficacy and science identity for girls and women, with clear attention to social and structural barriers influencing participation.

Embed GRP in course design and assessment by integrating iterative making, real-world applications, and reflective practices that address the documented gap between knowledge acquisition and application for girls in STEM.

Expand female representation and mentorship among STEM educators

Establish recruitment, promotion, and retention targets for women in STEM faculties and laboratories, supported by targeted fellowships and leadership development. Evidence shows that increasing female educators enhances girls' engagement, confidence, and persistence in STEM.

Formalise mentorship frameworks—cross-rank mentoring groups, peer networks, and links between industry and academia—and make the visibility of role models evident through teaching, seminars, and supervision; at Makerere, suggested quotas and structured participation of female lecturers provide a promising model for expansion.

Strengthen curricula and remove bias in learning materials

Conduct systematic audits of STEM syllabi and instructional media to identify and eliminate gender bias; diversify canon by increasing women-authored scholarship and case studies. Curricula should foreground authentic inquiry, societal relevance, and hands-on experimentation to engage diverse learners while aligning theory with practice.

Introduce dedicated content on gender, society, and energy systems (e.g., a pilot lecture on “Societal and Gender Aspects in Energy”) to normalize gender analysis as a technical competence within renewable energy programs.

Create safe, collaborative learning environments in makerspaces

Establish governance frameworks—codes of conduct, anti-harassment protocols, moderated tool access, and transparent reporting—to pre-empt “Boys with Toys” dynamics and “benevolent sexism” that displace women from technical tasks.

Redesign participation logics toward cooperative builds, rotating roles, structured peer support, and inclusive scheduling and space allocation; these measures counter competitive cultures that marginalise women and translate the collaborative ethos of makerspaces into sustained, equitable engagement.

Embed makerspaces within supportive policies and curricula for scaling

Align makerspace development with national and institutional policy frameworks that earmark resources for gender equity in the energy sector (e.g., the Energy Gender and Equity Compact) and leverage scholarships targeted at girls and women to widen access.

Integrate makerspaces into accredited curricula and program standards as assessed practical components, with dedicated budgets, staffing, and gender-responsive monitoring and

evaluation indicators; Uganda's PHRE-linked makerspaces illustrate how policy-aligned, hands-on ecosystems can build confidence and competence for women in renewable energy fields.

CONCLUSION

Gender inequality across Uganda's STEM and renewable energy education pipeline remains systemic, driven by socio-cultural norms, structural constraints, and limited access to supportive learning, with clear costs for women's participation and for the inclusiveness of energy solutions. These dynamics are reinforced by gendered time burdens in unpaid care and by exclusionary educational cultures that heighten attrition from secondary through tertiary levels and into technical careers. Evidence indicates that intentionally designed makerspaces can strengthen technical competence, confidence, and applied problem-solving for women, but without deliberate governance, they risk reproducing male-dominated norms. Within this landscape, the PHRE initiative at Makerere University demonstrated promising momentum: female participation rose across makerspace training sessions, and participants reported skill transfer to teaching, research, and applied renewable energy projects. Durable impact will require coordinated reforms to mainstream gender-responsive pedagogy, expand female representation and mentorship among STEM educators, and embed makerspaces within accredited curricula and policy frameworks.

ACKNOWLEDGMENTS: The article is published in the framework of the project “Promotion of Hybrid Renewable Energy Systems Towards Electricity Access in Uganda” (PHRE), funded by APPEAR. APPEAR is a programme of the Austrian Development Cooperation

REFERENCES

- Bangura PS, Mambo AW. *Barriers to Female Education and its Impact on Slow Socio-Economic Development of the Family: A Case of Africa International University. Research Journal of Education, Teaching and Curriculum Studies [Internet]. 2023 Aug 7;1(1):23–36. Available from: <https://utafitionline.com/index.php/rjetcs/article/view/280>*
- Tomko M, Newstetter W, Alemán MW, Nagel RL, Linsey J. *Academic makerspaces as a “design journey”: developing a learning model for how women students tap into their “toolbox of design.” AI EDAM [Internet]. 2020 Aug 1 [cited 2025 Dec 10];34(3):363–73. Available from: <https://www.cambridge.org/core/journals/ai-edam/article/abs/academic-makerspaces-as-a-design-journey-developing-a-learning-model-for-how-women-students-tap-into-their-toolbox-of-design/C8F3B0C45F82C83FE1E450260F037B69>*
- Kermani H, Aldemir J. *Preparing children for success: integrating science, math, and technology in early childhood classroom. Early Child Dev Care [Internet]. 2015 Sep 2;185(9):1504–27. Available from: <http://www.tandfonline.com/doi/full/10.1080/03004430.2015.1007371>*
- UNESCO. *Cracking the code: girls' and women's education in science, technology, engineering and mathematics (STEM) [Internet]. 2017. Available from: www.alikecreative.com*
- Afif R Al, Pfeifer C. *Biochemical methane potential of three-phase olive mill solid waste: Influence of temperature and supplemental enzymes. Carbon Resources Conversion. 2022 Sep;5(3):248–54.*

- Haddad A, Jaber H, Khaled M, Al Afif R, Ramadan M. An investigation on coupling fuel cell, wind turbine and PV as green to green system. *Int J Hydrogen Energy*. 2024 Jan;52:923–32.
- Al Afif R, Ayed Y, Maaitah ON. Feasibility and optimal sizing analysis of hybrid renewable energy systems: A case study of Al-Karak, Jordan. *Renew Energy*. 2023 Mar;204:229–49.
- Al Afif R, Anayah SS, Pfeifer C. Batch pyrolysis of cotton stalks for evaluation of biochar energy potential. *Renew Energy*. 2020 Mar;147:2250–8.
- Al Afif R, Tondl G, Pfeifer C. Experimental and simulation study of hydrochar production from cotton stalks. *Energy*. 2023 Aug;276:127573.
- Ayed Y, Al Afif R, Fortes P, Pfeifer C. Optimal design and techno-economic analysis of hybrid renewable energy systems: A case study of Thala city, Tunisia. *Energy Sources, Part B: Economics, Planning, and Policy*. 2024 Dec 31;19(1).
- Al Afif R, Kapidžić M, Pfeifer C. Evaluation of biochar and hydrochar energy potential derived from olive mills waste: The case of Montenegro. *Energy*. 2024 Mar;290:130234.
- Pavkov I, Radojčin M, Stamenković Z, Bikić S, Tomić M, Bukurov M, Despotović B. Hydrothermal Carbonization of Agriculture Biomass: Characterization of Hydrochar for Energy Production. *Solid Fuel Chemistry*. 2022 June 19; 56(3).
- Radojčin M, Bikić S, Pavkov I, Bukurov M, Despotović B, Stamenković Z, Oluški, N. Experimental investigation on thermophysical properties of iobiofluids. *Advances in Mechanical Engineering, Advanced Practices in Aerospace and Energy Engineering*. 2022 Jan 19;14(1)
- IEA IEA. *Energy Policy Review Uganda 2023* [Internet]. 2023. Available from: www.iea.org
- Tereka S, Pétursson JG, Byakagaba P, Ingólfssdóttir AH. Gender and socio-economic determinants of rural household adoption of clean energy practices in Uganda: Implications for energy transition pathways. *Energy for Sustainable Development* [Internet]. 2025 Oct 1 [cited 2025 Sep 15];88:101780. Available from: <https://www.sciencedirect.com/science/article/pii/S0973082625001309>
- Equal Opportunities Commission (EOC), UN Women. *Gender and Equity Compact for the Energy and Mineral Development Sector 2016/2017 – 2019/2020*. [Internet]. Kampala; Uganda; 2017. Available from: www.unwomen.org
- Mpigi J, Kooijman A. *Gender and energy country briefs-UGANDA*. 2020.
- UN Women, UNIDO. *Gender Equality and the Sustainable Energy Transition*. New York and Vienna; 2023.
- [19] Remerscheid C, Kotecha S. *Empowering Women in Clean Energy: Advancing and Retaining an Equitable Workforce* [Internet]. 2024. Available from: www.shortlist.net
- Kooijman A, Clancy J, Cloke J. *Extending energy access assessment: The added value of taking a gender perspective*. *Energy Res Soc Sci* [Internet]. 2023 Feb 1 [cited 2025 Sep 15];96:102923. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S2214629622004261>
- Orlando, Beatriz M, Janik VL, Vaidya P, Angelou N, Zumbyte I, et al. *Getting to Gender Equality in Energy Infrastructure: Lessons from Electricity Generation, Transmission, and Distribution Projects*. Energy Sector Management Assistance Program (ESMAP) Technical Report 012/18. [Internet]. Washington, DC; 2018. Available from: www.esmap.org.
- Lasekan OA, Godoy Pena MT, Odebode AJ, Mabica AP, Mabasso RA, Mogbadunade O. *Fostering Sustainable Female Participation in STEM Through Ecological Systems Theory: A Comparative Study in Three African Countries*. Sustainability [Internet]. 2024 Nov 2;16(21):9560. Available from: <https://www.mdpi.com/2071-1050/16/21/9560>
- Sulla F, Agueli B, Lavanga A, Logrieco MGM, Fantinelli S, Esposito C. *Analysis of the Development of Gender Stereotypes and Sexist Attitudes Within a Group of Italian High School Students and Teachers: A Grounded Theory Investigation*. Behavioral Sciences [Internet]. 2025 Feb 18 [cited 2025 Sep 10];15(2):230. Available from: <https://www.mdpi.com/2076-328X/15/2/230>
- Ministry of Education and Sports. *Gender in Education Sector Policy*. 2016.
- Tizikara C, Nakayiwa-Mayega F, Otto F. *Investing in women as drivers of growth: A gender-based assessment of the Science, Technology and Innovation ecosystem in Uganda*. African Journal of Rural Development. 2019;4(2):261–81.
- WitU W in TU. *Annual Report 2022*. 2022;
- Home - Gender Tech Initiative Uganda [Internet]. [cited 2025 Dec 10]. Available from: <https://www.genderinitiativeug.org/>
- Global Education Monitoring Report – Gender Report: Deepening the debate on those still left behind. UNESCO; 2022.
- Kasirye I. *Addressing Gender Gaps in the Ugandan Labour Market*. 2011 [cited 2025 Sep 10]; Available from: <https://ageconsearch.umn.edu/record/150532>
- Derera E, Croce F, Phiri M, O'Neill C. *Entrepreneurship and women's economic empowerment in Zimbabwe: Research themes and future research perspectives*. The Journal for Transdisciplinary Research in Southern Africa [Internet]. 2020 Dec 9;16(1). Available from: <http://www.td-sa.net/index.php/td/article/view/787>
- Zakoth D, Mauroner O, Emes J. *The role of makerspaces in innovation processes: an exploratory study*. R&D Management [Internet]. 2024 Mar 3;54(2):398–428. Available from: <https://onlinelibrary.wiley.com/doi/10.1111/radm.12594>
- Getachew A. *Maker Spaces: The Catalysts of Innovation and Creativity by Complementing Practice-Oriented Teaching Learning in Ethiopian Universities of Applied Sciences*. Lecture Notes in Networks and Systems [Internet]. 2025 [cited 2025 Sep 10];1280 LNNS:595–605. Available from: https://link.springer.com/chapter/10.1007/978-3-031-83523-0_56

Received: 2. 4. 2026.

Accepted: 13. 4. 2026.