Evidence Brief

LEEPS
Learning together to advance
Evidence and Equity in Policymaking

Enabling sustainable and gender-inclusive energy systems with AI: Lessons from emerging evidence

By Jim Oduor, University of Nairobi's Institute of Climate Change and Adaptation (ICCA); Patricia Mbogo, Alliance of Civil Society Organisations for Clean Energy Access (ACCESS) Coalition; and Fianyo Governor, National Council for Curriculum and Assessment (NaCCA), Ghana.

Key Messages

- Artificial Intelligence (AI) optimises decentralised renewable systems. Studies confirm that AI improves grid efficiency, storage, and forecasting in off-grid solar and wind systems, reducing energy costs and improving reliability.
- Equity and gender considerations are often overlooked. Most AI applications in energy lack frameworks to ensure gender inclusion or address power asymmetries.
- AI supports inclusive energy planning. Multi-criteria decision-making tools using AI can incorporate equity and sustainability indicators in national energy strategies.
- Data and infrastructure gaps limit AI's potential. Weak data systems, limited digital infrastructure, and low AI literacy in low- and middle-income countries (LMICs) hinder effective deployment and scalability.
- Successful pilot programmes show promise. World Bank-supported AI-integrated microgrids have improved access and affordability in select humanitarian and off-grid communities in LMIC settings, indicating replicability with proper safeguards.

Executive Summary

AI holds transformative potential to accelerate access to clean, reliable, and equitable energy systems in low- and middle-income countries (LMICs). In regions like sub-Saharan Africa, where centralised grids remain limited, AI-driven solutions such as predictive maintenance, smart metering, and energy demand forecasting are enabling decentralised renewable energy systems to thrive. These innovations can enhance affordability, reliability, and efficiency, especially for underserved and off-grid populations.

However, unless carefully designed and governed, AI applications risk reproducing existing social and gender inequalities. Evidence shows that most AI models are not gender-responsive and often lack contextual sensitivity to the lived realities of women and marginalised groups. While some global and national frameworks acknowledge these equity gaps, implementation remains weak, and cross-sector alignment is limited.

To ensure that AI accelerates and does not undermine sustainable and inclusive energy transitions, governments and development actors must invest in gender-responsive design, strengthen local technical capacity, and embed ethical governance in AI-enabled energy programmes.

AFIDEP
African Institute for Development Policy

ARIN
AFRICA RESEARCH & IMPACT NETWORK

Background

The world is rapidly shifting to cleaner energy to fight climate change and ensure everyone has access to electricity [1,2]. Artificial Intelligence(AI), defined broadly as computational systems capable of performing tasks typically requiring human intelligence, is emerging as a transformative force in this transition [3,4]. AI technologies are increasingly being used to optimise renewable energy integration, enhance grid reliability, forecast energy demand, and support data-driven energy planning (5). Importantly, AI holds particular promise for low- and middle-income countries (LMICs), where innovation can leapfrog traditional infrastructure constraints to deliver decentralised, efficient, and climate-resilient energy solutions [2].

Across Africa, several pilot initiatives demonstrate AI's potential in managing solar microgrids, improving energy forecasting in rural areas, and reducing energy losses through predictive maintenance tools [6,7]. These innovations align with broader Sustainable Development Goals (SDGs), particularly SDG 7 (affordable and clean energy), SDG 5 (gender equality), and SDG 13 (climate action). However, these benefits remain unequally distributed, with significant digital, infrastructural, and capacity divides between regions and populations [8,9]. Women, rural communities, and marginalised groups are frequently excluded from both the design and benefits of AI-enabled energy systems. For example, the African Technology Policy Studies (ATPS) network and partner organisations emphasise how digital literacy, technology access, and structural inequalities disproportionately limit women's participation in AI technologies, risking their continued exclusion unless inclusive design and training programs are embedded from the start [10].

The landscape of AI deployment in Africa also presents unique challenges. These include limited access to high-quality data, infrastructure gaps, inadequate regulatory frameworks, and concerns about algorithmic bias and digital colonialism [11]. Without careful governance and inclusive innovation strategies, AI could exacerbate existing inequalities rather than close them. Additionally, concerns about the dominance of non-African actors in AI research and deployment risk sidelining local knowledge systems, priorities, and needs.

Despite this awareness, policymakers still face a knowledge gap about how to achieve this. The literature remains fragmented across technical, social, and governance domains, necessitating a structured synthesis of available evidence to inform how AI can be used not only to improve energy access and sustainability but also to promote gender and geographical equity. This evidence brief addresses this gap by synthesising existing evidence on the use of AI to improve equitable energy access and sustainability and identifying policy-relevant recommendations for LMIC settings.

Methodology

This brief is based on a rapid evidence synthesis of peer-reviewed articles, institutional reports, and policy reviews (2016 - 2024). The studies selected focus on the applications of AI in renewable energy, energy equity, and inclusive innovation, especially in African or LMIC contexts. Search platforms included PubMed, Google Scholar, and World Bank databases. The following terms were used to conduct a general search, "artificial intelligence and energy systems," "AI and renewable energy transitions," "gender equity and energy transitions," "women and access to renewable energy," "AI and gender in LMICs," "inclusive innovation in Africa," "AI governance and marginalized communities," and "local capacity building and AI energy solutions."

The synthesis prioritised peer-reviewed journal articles, institutional reports, and national policy documents that addressed AI applications in energy systems, with a particular focus on gender inclusion, local capacity, and ethical governance. Sources were included if they provided evidence or policy-relevant insights applicable to LMIC contexts.

Data extraction was performed using a standardised tool to capture key study characteristics, intervention details, main findings, and their relevance to sustainable and gender inclusive energy using AI. Findings were then analysed thematically and synthesised narratively to generate practical recommendations aligned with Kenya's policy priorities and programmatic needs.

Key Findings

Emerging evidence highlights the transformative potential of AI in accelerating the clean energy transition while simultaneously advancing gender and social equity goals in low- and middle-income countries (LMICs). However, realising this potential requires deliberate design and governance to mitigate the risk of reinforcing existing inequalities.

First, gender and social equity must be systematically embedded in AI-enabled energy interventions. Gender-blind energy policies can inadvertently entrench exclusion, especially when intersectional factors, such as income, geography, and ethnicity, affect access to energy services [18] Johnson et al, notes that AI and energy transitions that ignore gender risks aggravate exclusion and energy poverty [18]. While AI could contribute positively to 134 out of 169 SDGs targets, it may also deepen inequalities if not explicitly governed with equity in mind [5]. In addition, AI must proactively address bias and fairness to prevent harm, particularly in essential service sectors like energy [19].

AI-enabled solutions are impactful in fragile, off-grid, or peri-urban areas, where conventional energy infrastructure is lacking.

The literature stresses the importance of robust ethical governance and accountability mechanisms for AI in energy transitions. Without these safeguards, AI risks amplifying disparities in access, affordability, and benefit distribution. Studies have argued that ethical AI governance must go beyond technical performance to include normative values like justice, transparency, and inclusivity [5, 19].

Evidence suggests that the integration of AI into decision-support tools has shown promise in improving the alignment of national and sub-national energy policies with sustainability goals. For instance, Siksnelyte-Butkiene et al. (2020) demonstrate that combining AI with multi-criteria decision-making (MCDM) frameworks enhances the ability of policymakers to evaluate trade-offs between environmental, social, and economic objectives [20]. This is particularly relevant for LMICs seeking to balance development needs with climate goals.

AI-enabled solutions are especially impactful in fragile, off-grid, or peri-urban areas, where conventional energy infrastructure is lacking. The World Bank documents pilot cases where AI-supported solar microgrids improved access and affordability in humanitarian contexts, suggesting the scalability of such models for energy-insecure communities [21].

Finally, there is strong consensus on the need for cross-sectoral collaboration to support inclusive AI and energy systems. Sustainable results are more likely when energy planning involves stakeholders from gender, technology, environmental, and policy sectors working together to ensure that solutions reflect local needs and priorities [18,21].

These findings point to the critical importance of centering equity, ethical design, and inclusive governance in AI-driven energy transitions, especially in regions with historically low energy access and high social vulnerability.

Table 1. Studies and interviews included in the review, insights and recommendations

Study ID	Key findings
Johnson et al., 2020	Energy policies and transitions that ignore gender and intersectionality risk reinforcing systemic exclusion and energy poverty.
Vinuesa et al., 2020	AI can positively impact 134 of 169 SDG targets, but risks harming progress on SDG 5 (Gender Equality) and SDG 10 (reduced inequalities) if ethical use is not prioritised.
Siksnelyte-Butkiene et al., 2020	Multi-criteria decision-making (MCDM) methods help align renewable energy transitions with sustainability priorities; integration with AI tools is emerging.
Floridi et al., 2018	Ethical challenges in AI use include fairness, transparency, and accountability- particularly when deployed in critical systems like energy.
World Bank, 2021	AI applications (e.g., smart meters, predictive maintenance) are improving reliability and affordability in off-grid and fragile contexts.

Recommendations

- National governments and Energy Ministries should embed gender and social equity in AI and energy policy frameworks by mandating gender-responsive design, requiring data collection, and ensuring inclusive participation of women and marginalised groups in AI-enabled energy programmes.
- Regional and national regulatory authorities should establish ethical AI governance and accountability mechanisms to safeguard against algorithmic bias, ensure transparency in data use, and align AI deployment with human rights and sustainability principles.
- Policymakers and planning commissions should integrate AI with decision-support tools for sustainable energy planning, using multi-criteria decision-making frameworks that balance economic, environmental, and social trade-offs in national and sub-national energy strategies.
- Development partners, multilateral agencies (The World Bank, The African Development Bank (AfDB), and humanitarian actors should scale up AI pilots in off-grid, fragile, or underserved communities by investing in infrastructure, supporting local innovation ecosystems, and ensuring scalability through inclusive financing mechanisms.
- Research institutions, civil society, and cross-sectoral networks should promote collaboration in AI for energy development, fostering partnerships between gender experts, technologists, policymakers, and community organisations to ensure locally relevant, inclusive, and context-sensitive AI solutions.

Acknowledgement

The authors acknowledge the contributions of Dr Violet Murunga, Belinda Korir and Derick Ngaira of the African Institute for Development Policy (AFIDEP), Lilian Mayieka of the Kenya Medical Research Institute (KEMRI), and Lavender Ochieng' of the Africa Research and Impact Network (ARIN) who reviewed and refined the content of this policy brief. The development of this policy brief was made possible under the Africa Evidence and Equity in Policymaking Alliance (AEEPA) – LEEPS Project, funded by the International Development Research Centre (IDRC), the William & Flora Hewlett Foundation, and Robert Bosch Stiftung GmbH.

References

1. IEA [Internet]. 2021 [cited 2025 July 26]. World Energy Outlook 2021 – Analysis. Available from: https://www.iea.org/reports/world-energy-outlook-2021

2. Khan MS, Umer H, Faruqe F. Artificial intelligence for low income countries. Humanit Soc Sci Commun. 2024 Oct 25;11(1):1422.

3. IEA [Internet]. [cited 2025 July 28]. Executive summary – Energy and AI – Analysis. Available from: https://www.iea.org/reports/energy-and-ai/executive-summary

4. IEA [Internet]. 2017 [cited 2025 July 25]. Digitalization and Energy – Analysis. Available from: https://www.iea.org/reports/digitalisation-and-energy

5. Vinuesa R, Azizpour H, Leite I, Balaam M, Dignum V, Domisch S, et al. The role of artificial intelligence in achieving the Sustainable Development Goals. Nat Commun. 2020 Jan 13;11(1):233.

6. Paul J. AI-powered micro solar power grid systems for isolated communities. 2025 Jan 1;

7. Using Predictive Analytics to Promote Off-grid Solar Connectivity in Kenya [Internet]. [cited 2025 July 26]. Available from: https://www.atlasai.co/insights/case-study-using-predictive-analytics-to-promote-off-grid-solar-connectivity-in-kenya?utm_source=chatgpt.com

8. Mbatha B. Digital divide: a phenomenon of unequal adoption of technology by SMMEs in the agribusiness sector in South Africa. Commun J Commun Stud Afr. 2024 Dec;43(2):64–75.

9. Jieutsa L, Gbaguidi I, Nadifi W, Koseki S. Deployment of digital technologies in African cities: emerging issues and policy recommendations for local governments. Data Policy. 2024 Jan;6:e21.

10. atps. Strengthening the Capacity of Women and Marginalized Communities in Africa's Agriculture and Food Systems to Harness the Potentials of Artificial Intelligence Technology [Internet]. African Technology Policy Studies Network. 2023 [cited 2025 July 26]. Available from: https://atpsnet.org/strengthening-the-capacity-of-women/

11. Ade-Ibijola A, Okonkwo C. Artificial Intelligence in Africa: Emerging Challenges. In: Eke DO, Wakunuma K, Akintoye S, editors. Responsible AI in Africa: Challenges and Opportunities [Internet]. Cham: Springer International Publishing; 2023 [cited 2025 July 26]. p. 101–17. Available from: https://doi.org/10.1007/978-3-031-08215-3_5

12. National Energy Policy 2018. 2018 [cited 2025 July 26]; Available from: http://repository.kippra.or.ke/handle/123456789/1947

13. Gender-Policy-in-Energy.pdf [Internet]. [cited 2025 July 26]. Available from: https://www.energy.go.ke/sites/default/files/KAWI/Other%20Downloads/Gender-Policy-in-Energy.pdf

14. Digital Economy Blueprint: Powering Kenya's Transformation [Internet]. [cited 2025 July 26]. Available from: https://repository.kippra.or.ke/items/7611aa16-73e8-44ca-8c16-e894066a9802

15. Kenya National AI Strategy [Internet]. [cited 2025 July 26]. Available from: https://www.data4sdgs.org/resources/kenya-national-ai-strategy

16. NATIONAL POLICY ON GENDER AND DEVELOPMENT.

17. National Information, Communications and Technology (ICT) Policy 2019. 2019 [cited 2025 July 26]; Available from: http://repository.kippra.or.ke/handle/123456789/1728

18. Johnson O, Han JYC, Mortensen S, Aung MT, Boyland M, Resurrección BP. Assessing the gender and social equity dimensions of energy transitions. 2020 Apr 2 [cited 2025 July 26]; Available from: https://www.sei.org/publications/assessing-the-gender-and-social-equity-dimensions-of-energy-transitions/

19. Floridi L, Cowls J, Beltrametti M, Chatila R, Chazerand P, Dignum V, et al. AI4People—An Ethical Framework for a Good AI Society: Opportunities, Risks, Principles, and Recommendations. Minds Mach. 2018 Dec 1;28(4):689–707.

20. Siksnelyte-Butkiene I, Zavadskas EK, Streimikiene D. Multi-Criteria Decision-Making (MCDM) for the Assessment of Renewable Energy Technologies in a Household: A Review. Energies. 2020 Jan;13(5):1164.

21. World Bank [Internet]. [cited 2025 July 26]. Solar Mini Grids Could Sustainably Power 380 million People in Africa by 2030 – if Action is Taken Now. Available from: https://www.worldbank.org/en/news/press-release/2023/02/26/solar-mini-grids-could-sustainably-power-380-million-people-in-afe-africa-by-2030-if-action-is-taken-now.

LEEPS
Learning together to advance
Evidence and Equity in Policymaking

Alliance for Evidence and Equity
in Policymnaking in Africa

AFIDEP
African Institute for
Development Policy

ARIN
AFRICA RESEARCH & IMPACT NETWORK