SUSTAINABLE ENERGY FOR ALL

REPORT

The Gender-Energy Nexus in the AI Era: Challenges and Opportunities

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Abbreviations

AI	Artificial Intelligence
ICCPT	Integrated Clean Cooking Planning Tool
ICT	Information and Communications Technology
IEA	International Energy Agency
IEAP	Integrated Energy Access Plan
ILO	International Labour Organization
LMIC	Low- and Middle-Income Country
OECD	Organisation for Economic Cooperation and Development
R&D	Research & Development
SDG	Sustainable Development Goal
SEforALL	Sustainable Energy for All
SME	Small and Medium-Sized Enterprise
STEM	Science, Technology, Engineering and Mathematics
UN	United Nations

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Executive Summary

The intersection of gender, energy and Artificial Intelligence (AI) presents both challenges and opportunities for achieving gender equality and sustainable development. AI can be a critical enabler in accomplishing 134 of the 169 targets under the framework of the Sustainable Development Goals (SDGs), with over 600 AI-enabled use cases identified.[1] However, the impact of AI at the intersection of SDG7 (Affordable and Clean Energy) and SDG5 (Gender Equality) requires significant attention.

While AI shows positive potential for supporting SDG7 by ensuring universal access to affordable, reliable, sustainable and modern energy for all, SDG5 has the lowest number of AI-enabled use cases, with only 10 out of approximately 600 cases identified.[2] This disparity is concerning considering that lack of energy access disproportionately affects women and girls.[3] UN Women has reported that if current trends continue, by 2030, an estimated 341 million women and girls will still lack electricity, with 85 percent of them in Sub-Saharan Africa.[4]

1 McKinsey & Company: AI for social good: Improving lives and protecting the planet

2 Take, for instance SDG3 (good health and well-being) which has 165 use cases identified and 128 use cases with at least one deployment in 2023. For more information, see McKinsey & Company: AI for social good: Improving lives and protecting the planet

3 United Nations: Policy briefs in support of the High-Level Political Forum 2022: Addressing energy's interlinkages with other SDGs

4 UN Women: What we do

KEY CHALLENGES:

- **Energy access gap:** Currently, 685 million people worldwide lack access to electricity, with Sub-Saharan Africa most affected. Additionally, 2.1 billion people lack access to clean cooking technologies.[5] The lack of modern energy access disproportionately affects women and girls, impacting their health, education, economic opportunities and ability to leverage AI applications.
- **Gender data deficit:** The lack of sex-disaggregated data in the energy sector results in AI applications that fail to adequately address the specific needs and experiences of women.
- **Digital gender divide:** Women are disproportionately affected by limited access to digital technologies, the internet and electricity required for online connectivity. Men are 21 percent more likely to be online than women, with the gap widening to 52 percent in least developed countries.[6]
- **Workforce gender imbalance:** Women are underrepresented in the energy and AI sectors, especially in technical and leadership roles, and overrepresented in care work and the informal economy.
- **AI development bias:** The lack of diversity in AI development teams leads to technologies that reflect and perpetuate gender biases.
- **Gender and energy investment gaps:** Between 2018 and 2023, total AI grant funding for SDG7 reached only USD 0.03 billion, while SDG5 received just USD 0.04 billion. This imbalance is also seen in private sector investment, with USD 49 billion invested in AI towards SDG7 goals, compared to a negligible USD 0.62 billion for SDG5.[7]

  These funding gaps limit the potential for AI to address gender-specific needs in the energy sector, risking the exclusion of women from technological advancements and hindering progress towards both SDG7 and SDG5.
- **Diversion of energy from communities:** AI data centres located in low-resource areas can exacerbate existing inequalities, as these communities often lack the political and economic power to advocate for their energy and water needs. This perpetuates energy poverty and marginalization, disproportionately affecting women who manage household energy needs and are more vulnerable to energy scarcity.

There are policy opportunities that can ensure an equitable and gender just energy transition supported and facilitated by AI. These include: expanding the representation of women in STEM roles within the energy and AI-related sectors; creating diverse and gender-balanced AI development teams; increasing women's participation in energy policy and decision-making; establishing environmental regulations and ethical frameworks for the use of AI in energy; ensuring AI and energy solutions are developed and implemented through a gender-responsive lens; and applying a gender lens to investment in the energy and technology sectors.

By implementing these recommendations and ensuring that women's perspectives are integral to the development and application of AI in the energy sector, we can work towards a more inclusive, sustainable and gender-equitable future. The path forward requires collaborative efforts from policymakers, industry leaders and stakeholders to prioritize gender equality in the rapidly evolving landscape of energy and AI technologies.

5 The World Bank: Tracking SDG 7: The energy progress report

6 UNDP: Bridging the gender digital divide: A way out of crisis

7 McKinsey & Company: AI for social good: Improving lives and protecting the planet

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KEY RECOMMENDATIONS:

- **Ensure women's involvement** as decision-makers in the drafting and adopting of policies/legislation and regulatory frameworks guiding AI development and implementation.
- **Adopt environmental standards** regulating AI development and operation with the input of women and diverse communities.
- **Ensure transparency and accountability** in deploying AI applications for energy.
- **Increase women's access to digital literacy training** opportunities at all ages and levels.
- **Expand opportunities**, such as the Sustainable Energy for All (SEforALL) STEM Traineeship programme, and pathways for women to enter and advance in STEM positions within the energy sector.
- **Provide retraining and upskilling opportunities** targeted at increasing women's representation in STEM technical positions, including in the energy and AI workforces, to promote women's participation in capacity-building activities around energy access planning and data management.
- **Commit to targeted job recruitment and implementing retention strategies**, including networking opportunities and mentorship, to encourage women's employment, retention and advancement in STEM technical jobs.
- **Address gender bias in AI systems** by integrating more women into the STEM workforce and ensuring ongoing monitoring and human oversight of AI applications.
- **Collect and analyze sex- and age-disaggregated data** to ensure inputs/outcomes of AI do not reflect biases and that the needs and experiences of women, including young women, are addressed through energy policies, projects and programmes.

- **Map energy access** to identify communities where it is lacking, focusing on areas where a lack of energy access disproportionately affects women and youth.
- **Scale up women-led energy solutions** through increased financing and collaborations/partnerships.

Introduction

The climate crisis, energy transition and increasing digitization through the adoption of Artificial Intelligence (AI) have significant implications for gender equality and climate management.[8]

The ability of AI applications to process large quantities of data and inform decision-making is transforming global social, economic and political dynamics. AI applications are contributing to the fight against climate change by predicting weather, tracking sea levels, mapping deforestation and improving access to clean energy. Additionally, AI fosters gender equality by supporting women-led businesses and unlocking access to information, financing and marketing. Importantly, women continue to play a central role in the innovation and development of AI applications.[9]

However, growing concerns regarding the environmental impact of AI, such as carbon emissions and energy and water consumption, and its effect on gender equality, including job displacement and the perpetuation of gender biases, must be addressed.10 The interplay between AI and energy systems further complicates this landscape. As the energy sector undergoes a transition towards more sustainable and digital solutions, AI is playing an increasingly important role in optimizing energy production, distribution and consumption. However, the gender gap in the energy sector may exacerbate the unequal impact of AI on a sustainable and just energy transition. This report explores the critical intersections of these issues, emphasizing how AI applications can advance a sustainable, equitable and just energy transition.

Research by Vinuesa et al. finds that AI can be a critical enabler in accomplishing 134 of the 169 targets under the Sustainable Development Goals (SDGs) framework, as established by the United Nations (UN) in the 2030 Agenda.. As of 2023, approximately 600 AI-enabled use cases have the potential to support the SDGs, with AI having particularly high potential to support SDG3 (Good Health and Well-Being), SDG4 (Quality Education), SDG7 (Affordable and Clean Energy), SDG11 (Sustainable Cities and Communities) and SDG13 (Climate Action). AI applications in drug screening, vaccine design, supply chain problem-solving in rural areas and early warning systems for natural disasters can contribute significantly to the achievement of the SDGs.11

Research further points to the positive benefits of AI to SDG7 – universal access to affordable, reliable, sustainable and modern energy for all.[12] It is evidenced that AI has a positive impact on targets 7.1, 7.2, 7.3, 7.a and 7.b through its ability to contribute to energy access through increasing data on supply and demand, enhancing energy efficiency through the employment and usage of smart grids, supporting education and capacity-building in the energy sector, tracking energy poverty, and fostering international collaboration.[13]

AI applications are being used to project the electricity demand and load profiles of rural households for sizing mini-grids and other off-grid systems. For example, using household survey data, climate data and satellite imagery to apply machine-learning algorithms for determining occupant behaviour patterns and appliance ownership, AI has contributed to the computation of hourly load profiles for rural households. This data-driven approach can estimate load profiles with high accuracy without extensive on-site data collection, which is valuable for designing appropriately sized and cost-effective mini-grid electrification solutions.[14]

AI is poised to support the uptick of smart grids and the vast amount of data they produce.[15] By enabling smart grids that match electrical demand to times when renewable energy is abundant, AI can help optimize the use of variable renewable sources like solar and wind power. As the electricity grid becomes more decentralized with distributed sources like rooftop solar, AI can help manage the complexity of the grid by accurately forecasting supply and demand, offering optimization strategies that will be crucial for the transition to renewable energy.[16]

Further, AI can be used for bridging the existing data gaps that limit energy planning efforts. For instance, using satellite imagery and other publicly available sources to geographically identify patterns allowing the classification of building footprints into different typologies (residential,

8 Gooddard, V. et al.: Gender equality and the environnent in digital economies

9 Montgomery, C.: The “hidden figures” of AI: Women shaping a new era of ethical innovation

10 OECD: The effects of AI on the working lives of women; Masterson, V.: 9 ways AI is helping tackle climate change

11 McKinsey & Company: AI for social good: Improving lives and protecting the planet

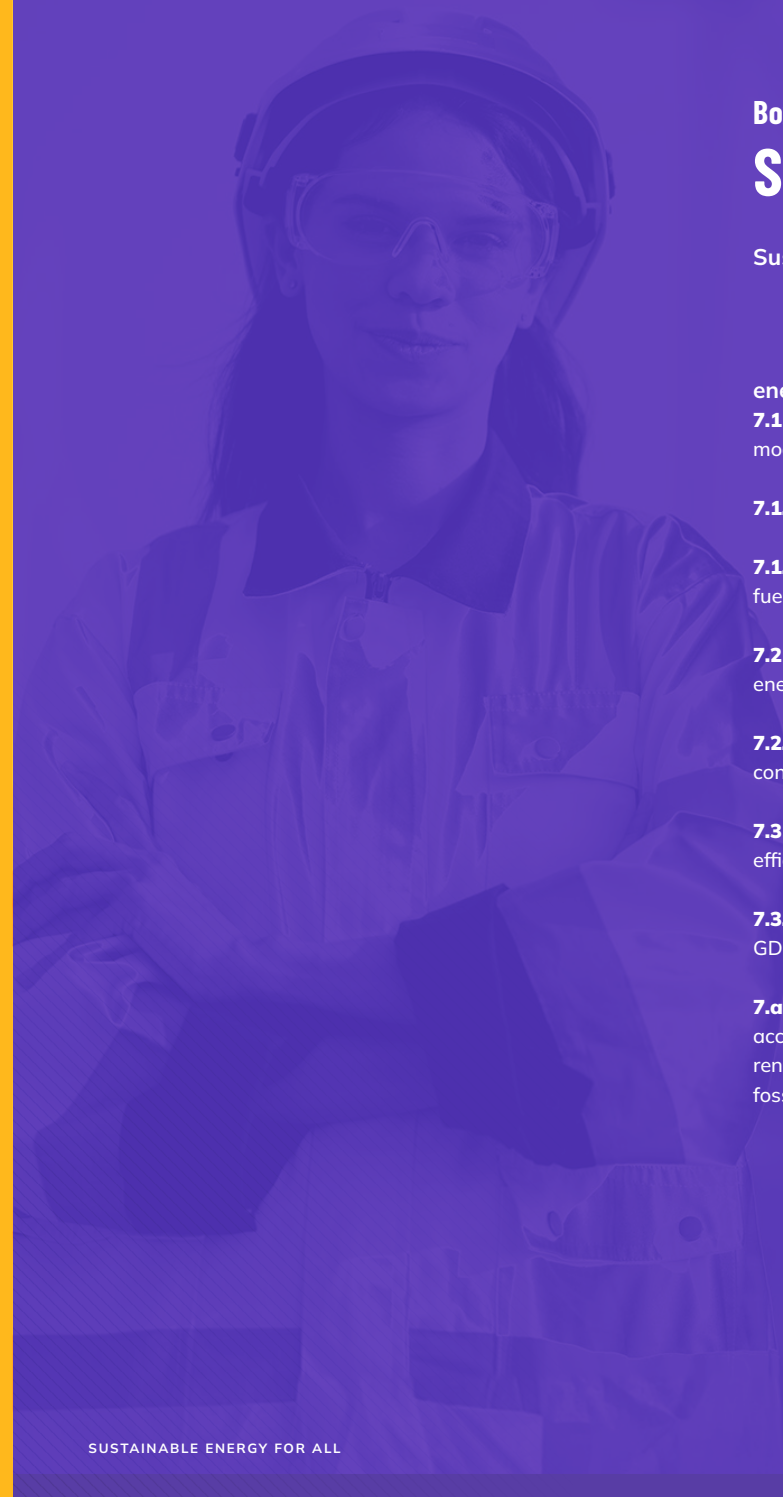
12 Vinuesa, R., et al: The role of artificial intelligence in achieving the Sustainable Development Goals

13 Vinuesa, R., et al: The role of artificial intelligence in achieving the Sustainable Development Goals

14 Dominiguez, C.: Estimating the electricity demand of rural households to improve energy access planning in developing countries

15 See Rosie, V., Miller, J. & Oh, S.: Why AI and energy are the new power couple

16 See Vinuesa, R., et al: The role of artificial intelligence in achieving the Sustainable Development Goals



Box 1.

Sustainable Development Goal 7

Sustainable Development Goal 7 (SDG7) aims to ensure access to affordable, reliable, sustainable and modern energy for all by 2030.

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services

7.1.1 Proportion of population with access to electricity

7.1.2 Proportion of population with primary reliance on clean fuels and technology

7.2 By 2030, increase substantially the share of renewable energy in the global energy mix

7.2.1 Renewable energy share in the total final energy consumption

7.3 By 2030, double the global rate of improvement in energy efficiency

7.3.1 Energy intensity measured in terms of primary energy and GDP

7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology

7.a.1 International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems

7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support

7.b.1 Installed renewable energy-generating capacity in developing and developed countries (in watts per capita)

Source: United Nations: Goal 7

public facilities, industrial, etc.), has helped policymakers understand urbanization patterns and better target energy access, sustainable cooling, energy efficiency and other infrastructure interventions.[17]

The global market for AI applications in the energy sector could be worth up to USD 13 billion, serving over 50 different uses across the energy system.[18] While more research is needed, trends suggest that developed economies with strong technology sectors and investment into AI applications, such as China, the United States and countries across the European Union, have the highest potential for AI adoption in the energy sector.[19] In contrast, countries with underdeveloped or aging energy infrastructure may face challenges integrating AI solutions due to their incompatibility with existing systems.[20] Notably, the potential for AI adoption in the energy sector can vary significantly across countries, depending on factors such as government policies, research & development (R&D) investment, the availability of skilled labour and the overall technological readiness of the domestic energy industry.

Despite the rapid integration of AI into the energy sector, significant risks remain. Vinuesa et al.'s analysis highlights that AI may be detrimental to as many as 59 SDG targets, including those under SDG7.1 and 7.2. AI data centres are energy intensive, produce a high carbon footprint and require a large amount of water for operating and cooling machinery, which poses risks to exacerbating climate change and directing resources away from communities. Moreover, AI applications identifying technically recoverable oil and gas resources may reduce global fossil fuel prices and the competitiveness of renewable energy sources.[21] Early action is crucial to mitigate these risks.

The effects of AI integration into the energy sector may also be significant regarding the impact on women and a gender-responsive energy transition. To understand this, it is important to understand the interlinkages between SDG7 and SDG5 (Gender Equality). Lack of energy access disproportionately affects women and girls.[22] UN Women has reported that if current trends continue, by 2030, an estimated 341 million women and girls will still lack electricity, 85 percent of them in Sub-Saharan Africa.[23]

Gender roles and responsibilities result in different energy needs and capacities to access energy services and appliances.[24] Women in developing countries, for instance, bear the primary responsibility for household cooking and fuel collection, leading to higher exposure to harmful emissions and related health consequences, time poverty and increased risk of gender-based violence.[25] The lack of access to modern energy cooking services has substantial health, economic and social consequences. If we fail to meet the clean cooking target of SDG7.1.2, the cost of inaction would total USD 800 billion annually.[26]

Furthermore, women's limited access to electricity restricts their educational and economic opportunities, increasing their likelihood of working in the informal sector or taking on lower-paid roles, and exacerbating the gender wage gap in the energy sector. Sociocultural norms and legislation further impact women's ability to own or inherit land, and their freedom of movement.[27] Compounded, these challenges decrease women's ability to control energy resources and capital, making energy poverty a significant issue for them. Securing energy access, employment, leadership and entrepreneurship opportunities for women within the energy sector is essential for the achievement of SDG7 and SDG5.

Although critical to advancing gender equality and the energy transition, only 10 of the approximately 600 AI-enabled use cases have been identified as supporting SDG5, with just eight having at least one deployment in 2023. SDG5 represents the lowest number of AI-enabled use cases.[28] This highlights the urgent need to address the gender data gap, talent limitations, funding restrictions and lack of political and institutional will to support solutions that advance SDG5.

This report explores the intersections between SDG7, SDG5 and the increasing adoption of AI applications. Women are uniquely affected by the rise in AI technologies in the energy sector, facing challenges related to energy access, the digital gender gap and underrepresentation in workforces and decision-making spaces. Early action by organizations, governments and the private sector is needed to avoid perpetuating energy access and representation disparities and to ensure the adoption of AI technologies and the energy transition benefit all.

17 Sustainable Energy for All: Harnessing machine learning to improve energy access plans

18 Allsup, M. & Weinstein, L.: Seven ways utilities are exploring AI for the grid

19 World Economic Forum: How venture capital is investing in AI in the top five global economies — and shaping the AI ecosystem

20 Brookings: AI in the Global South: Opportunities and challenges towards more inclusive governance; OECD: Artificial intelligence, developing-country science and bilateral co-operation

21 Vinuesa, R., et al: The role of artificial intelligence in achieving the Sustainable Development Goals

22 United Nations: Policy briefs in support of the High-Level Political Forum 2022: Addressing energy's interlinkages with other SDGs

23 UN Women: What we do

24 Cecelski, E. & Oparaocha, S.: The lack of gender targets for clean energy is harming women and girls

25 Clean Cooking Alliance: Women & clean cooking

26 Energy Sector Management Assistance Program (ESMAP): The state of access to modern energy cooking services

27 ENERGIA: Energy access; International Energy Agency: Understanding gaps in the energy sector

28 Take, for instance SDG3 (good health and well-being) that has 165 use cases identified and 128 use cases with at least one deployment in 2023. For more information, see McKinsey & Company: AI for social good: Improving lives and protecting the planet

Box 2.

Sustainable Development Goal 5

Sustainable Development Goal 5 (SDG5) aims to achieve gender equality and empower all women and girls by 2030.

5.1 End all forms of discrimination against all women and girls everywhere

5.1.1 Whether or not legal frameworks are in place to promote, enforce and monitor equality and non-discrimination on the basis of sex

5.2 Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation

5.2.1 Proportion of ever-partnered women and girls aged 15 years and older subjected to physical, sexual or psychological violence by a current or former intimate partner in the previous 12 months, by form of violence and by age

5.2.2 Proportion of women and girls aged 15 years and older subjected to sexual violence by persons other than an intimate partner in the previous 12 months, by age and place of occurrence

5.3 Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation

5.3.1 Proportion of women aged 20-24 years who were married or in a union before age 15 and before age 18

5.3.2 Proportion of girls and women aged 15-49 years who have undergone female genital mutilation/cutting, by age

5.4 Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate

5.4.1 Proportion of time spent on unpaid domestic and care work, by sex, age and location

5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life

5.5.1 Proportion of seats held by women in (a) national parliaments and (b) local governments

5.5.2 Proportion of women in managerial positions

5.6 Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences

5.6.1 Proportion of women aged 15-49 years who make their own informed decisions regarding sexual relations, contraceptive use and reproductive health care

5.6.2 Number of countries with laws and regulations that guarantee full and equal access to women and men aged 15 years and older to sexual and reproductive health care, information and education

5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws

5.a.1 (a) Proportion of total agricultural population with ownership or secure rights over agricultural land, by sex; and (b) share of women among owners or rights-bearers of agricultural land, by type of tenure

5.a.2 Proportion of countries where the legal framework (including customary law) guarantees women's equal rights to land ownership and/or control

5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women

5.b.1 Proportion of individuals who own a mobile telephone, by sex

5.c Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels

5.c.1 Proportion of countries with systems to track and make public allocations for gender equality and women's empowerment

Source: United Nations: Goal 5

Challenges

ENERGY ACCESS GAPS

Access to energy is essential for creating employment, driving economic growth, improving living standards and alleviating poverty. Energy access provides electricity for homes, businesses and community spaces, enabling the operation of computers, transportation and medical equipment. However, 685 million people still lack access to electricity, the majority of them in Sub-Saharan Africa.[1] Additionally, approximately 2.1 billion people worldwide lack access to clean cooking technologies, continuing to rely on polluting open fires or inefficient stovesfuels.[2]

Climate change and energy poverty disproportionally impact women and girls.[3] In households without access to clean cooking technologies and electricity, women and children face significant hardships to their socioeconomic status and health. Women are underrepresented in energy decision-making, as well as in the design and delivery of energy solutions. Women represent only 32 percent of the renewable energy workforce and hold only 11 percent of ministerial positions responsible for energy, natural resources and mining across 190 countries.[4]

The lack of modern energy access impacts women and girls in multiple areas, including health, education and economic opportunities. Yet, the UN and other organizations have reported that female-headed households are less likely to be included in national electrification strategies due to their disadvantaged economic status.[5] The result is that energy programmes, policies and projects tend to neglect the ways in which energy access and poverty differently affect men, women, boys and girls.

Women and girls benefit significantly from increased access to energy services. Gender equality and energy access are interconnected, offering multiple development gains such as poverty reduction, food security, access to health services, education and jobs, reduced inequality and climate protection. With increased access to energy, both for electrification and clean cooking, women benefit from having to work fewer hours, having more time for themselves and improved health outcomes. Increased access to energy services also allows women and girls to participate in educational activities, employment and entrepreneurship opportunities in their communities and in politics.[6] The implementation of energy policies that benefit women as energy consumers, energy producers and household energy managers, is an essential step in establishing and increasing gender equity in the energy sector.

Furthermore, energy access is crucial for utilizing AI applications, which can drive significant socioeconomic advancements. Poor infrastructure and network quality affect entire communities and disproportionately affect women living in remote areas, limiting their ability to benefit from AI in education, employment and other sectors.[7]

This exclusion prevents women from contributing to AI learning and developing solutions that benefit their communities.

1 The World Bank: Tracking SDG 7: The energy progress report

2 The World Bank: Tracking SDG 7: The energy progress report

3 For more information see Cecelski, E. & Oparaocha, S.: The lack of gender targets for clean energy is harming women and girls & United Nations: Women in the shadow of climate change

4 IRENA: Renewable Energy: A gender perspective; Note it was not possible for UN Women to discern women's share in energy ministries alone. UN Women: Gender Equality in the Sustainable Energy Transition

5 Dominguez, C.: Accelerating the energy transition in developing countries: Inclusion of women in clean energy strategies

6 Climate Investment Funds: Gender and renewable energy: Entry points for women's livelihoods and employment; United Nations: Accelerating SDG7: Policy brief 4

7 OECD: Bridging the digital gender divide

GENDER DATA DEFICIT

The gender data gap, characterized by a lack of information about women's lives, is particularly concerning in the energy sector, where the lack of sex-disaggregated data is a major obstacle to achieving a gender-transformative energy transition.[8] Sex-disaggregated data are crucial for understanding gender differences and inequalities in the energy sector. Despite this need, SDG7 is one of six SDGs that have no gender-specific indicators.[9]

Historically, the male-dominated energy sector has adopted a gender-blind approach to data collection and analysis. Without sex-disaggregated data, it is difficult to identify and address the gaps and disparities between women and men in the energy sector, which can impact various economic and social outcomes. This lack of data perpetuates a 'male-oriented' policymaking approach, resulting in gender-neutral policies and programmes that may exacerbate existing inequalities.[10] Achieving a just and equitable energy transition is significantly hindered without high-quality sex-disaggregated data to inform decision-making.[11]

At the root of the gender data gap in the energy sector, and consequently gender-biased AI applications, is the absence of gender-sensitive policies, regulations and law enforcement. To address this issue, women must be empowered and assigned to leadership positions and high-level decision-making roles. By influencing policies, regulations and laws to be gender-sensitive, they can ensure the collection and use of sex-disaggregated data in AI applications. Mainstreaming gender into national statistical strategies and prioritizing it in data collection are essential steps to bridge the gender data gap.[12]

At the intersection of energy, gender and AI, the exclusion of women from the benefits of AI becomes evident. Inaccurate or unrepresentative data can lead AI applications to produce suboptimal solutions, reflecting the 'bias in, bias out' nature of these technologies.[13] Research finds that "data created, processed, and interpreted within unequal power structures can reproduce the same exclusions and discriminations present in society."[14] A study analyzing 133 AI systems used across various industries from 1988 to 2021 revealed that 44 percent displayed gender bias, while 26 percent displayed both gender and racial biases.[15] The gender data gap, reflected and reinforced by AI applications, produces outputs that perpetuate inequalities. Data not disaggregated by gender conceal "important differences between people of different gender identities," obscuring potential over- or underrepresentation.[16] This issue is particularly concerning for women in lower- and middle-income countries (LMICs), which suffer from a larger gender data gap than more wealthy nations.[17]

The challenge then becomes: without accurate sex-disaggregated data, what data are AI technicians inputting into AI technologies, and what outputs are we receiving? Without sex-disaggregated data in the energy sector, the input data used to train AI systems may contain inherent biases, continuing to reflect the male-dominated history of the industry, which works to amplify and perpetuate biases in outputs and decision-making. This may lead to AI applications that provide a lower quality of service or unfair allocation of resources for women,

8 SEforALL: Improving energy data to enhance gender equality

9 Cecelski, E. & Oparaocha, S.: The lack of gender targets for clean energy is harming women and girls

10 Feenstra, M.: Gender just energy policy engendering the energy transition in Europe

11 For more information see SEforALL: Improving energy data to enhance gender equality

12 UN Women: Making women and girls visible: Gender data gaps and why they matter

13 Wajcman, J. & Young, E.: Feminism confronts AI: The gender relations of digitalisation

14 Wajcman, J. & Young, E.: Feminism confronts AI: The gender relations of digitalisation

15 UNIDAR: Does military AI have gender? Understanding bias and promoting ethical approaches in military applications of AI

16 Smith, G. & Rustagi, I.: When good algorithms go sexist: Why and how to advance AI gender equity

17 See Wajcman, J. & Young, E.: Feminism confronts AI: The gender relations of digitalisation; McKinsey & Company: AI for social good: Improving lives and protecting the planet

creating a cycle where gender biases in AI contribute to gender-neutral policies and programmes, further entrenching existing inequalities.

Women's underrepresentation across the energy sector – whether as professionals, decision-makers or in terms of data concerning them – results in their exclusion from AI's potential to address gender-specific needs and patterns. Addressing this issue requires thoughtful design and implementation of AI applications to ensure they meet the diverse needs of all individuals.

DIGITAL GENDER DIVIDE

The digital gender divide, marked by significant disparities in digital technology access, use and ownership between men and women, is a critical issue globally. Men are 21 percent more likely to be online than women, a gap that widens to 52 percent in least developed countries.[18] In 2024, women in low- and middle-income countries were approximately 13 percent less likely to own a smartphone than men.[19] As of March 2023, Sub-Saharan Africa had one of the widest gender gaps in mobile internet use, with over 190 million women not using mobile internet services, reflecting a 37 percent gender gap.[20] The Mobile Gender Gap Report (2024) by GSMA found that women, particularly those in rural areas with low literacy levels, low incomes or disabilities, were less likely than men to have equal use of these services even when access was available.[21]

The digital gender divide is driven by several factors, including the gender gap in energy access, affordability issues and sociocultural disparities. Lack of energy access is a crucial contributor to the digital gender divide, and the gender disparity within the energy access gap is particularly concerning.[22] Women, often the primary energy managers

18 UNDP: Bridging the gender digital divide: A way out of crisis

19 GSMA: The mobile gender gap report 2024

20 Kwakwa, V.: Accelerating gender equality: Let's make digital technology work for all

21 GSMA: The mobile gender gap report 2024

22 See International Energy Agency: Energy and gender

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in households and key actors in deploying clean energy solutions in rural communities, are significantly impacted by these disparities.[23] Electrification interventions that fail to include a gender perspective further widen the digital gender gap.[24]

Women also face financial barriers, often earning 30–50 percent less than men and having less access to financial and credit services that support investing in entrepreneurial activities, which could provide them with increased social and economic empowerment.[25] This financial exclusion widens the digital gender divide, as women lack the means to afford devices, services and electricity – key enablers of technology and online connectivity.

Additionally, women's financial dependence and limited ability to make household-level decisions on spending, including energy spending, is a prohibitive factor to their online connectivity. Women and men differ in the priorities they place on spending. For instance, studies find that increases in female shares of income, which have been correlated to increased female power in the household, have led to a greater investment in education, housing, family-targeted durable goods and nutrition for children.[26] However, women continue to have less financial power than men and experience limited access to decision-making power over household spending, particularly across Sub-Saharan Africa.

There are a number of factors that contribute to this including sociocultural norms, discriminatory legislation, higher rates of women's unemployment and gender segregation into lower paying jobs, women's overrepresentation in the informal economy, women's lack of access to, control over, and ownership of land and other productive assets, the gender wage gap, restrictions to accessing financing for women entrepreneurs, and a disproportionate share of unpaid care and domestic work.[27]

Notably, most people who are aware of the existence of mobile internet believe it is equally important for both men and women to use it. However, among those who disagree, more people think it is more important for men to use mobile internet. For instance, in Pakistan, 42 percent of men and 28 percent of women who are aware of the existence of mobile internet believe it is more important for men. Only 1 percent of male respondents and 4 percent of female respondents felt it is more important for women. In Nigeria, 21 percent of men and 6 percent of women who are aware of mobile internet also believe it is more important for men.[28] The spending priorities of families, especially those in which males control household spending, may be reflected by such beliefs that technology and connectivity are of greater importance for men, particularly in countries where husbands, fathers or other senior family members dictate when and how women use the internet.

Sociocultural norms and biases also stand in the way of women's digital participation. In many countries, internet connectivity is perceived as a threat to the traditional social order.[29] In response, some countries have instituted legal barriers to women's access to online services, including decrees declaring internet use "immoral" for women and legislation that prevents unwed women from owning smartphones.[30] Further, while online violence is not exclusive to women and girls, it does impact the way they are able to participate in the digital ecosystem. In 2021, the Institute of Development Studies found that between 16 and 58 percent of women have experienced technology-facilitated gender-based violence.[31]

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23 ENERGIA: Energy access

24 Dominguez, C.: Accelerating the energy transition in developing countries: Inclusion of women in clean energy strategies

25 Malmström, M. et al.: Research: How to close the gender gap in startup financing; Dominguez, C.: Accelerating the energy transition in developing countries: Inclusion of women in clean energy strategies

26 Ashraf, N. et al.: Female empowerment: Impact of a commitment savings product in the Philippines

27 For more information: UN Women: Facts and figures: Economic empowerment; UNDP: Equal participation of women in green decisions is the key to the successful development of the country's economy

28 GSMA: The mobile gender gap report 2024

29 USAID: The gender digital divide primer

30 For more information, see UNICEF: What we know about the gender digital divide for girls: A literature review; UN Women: The gender digital divide must be bridged to ensure we leave no one behind; USAID: The gender digital divide primer

31 It is notable that violence directed towards men is not gender based. Insititute of Development Studies: Global evidence on the prevalence and impact of Online Gender-based Violence (OGBV)

The gender gaps in digital and energy access inhibit women and girls from utilizing and benefitting from AI solutions and platforms. The benefits to AI, such as applying for jobs, networking, developing solutions for their locales, and establishing small or medium enterprises (SMEs), are less accessible to women who lack digital connectivity. Over 90 percent of jobs worldwide now have a digital component, making connectivity and access to data crucial job requirements.[32] However, women are disproportionately unable to implement, utilize or manage AI or other technological systems.[33]

The digital literacy divide, marked by differences in access to digital tools and knowledge, further exacerbates these challenges.[34] Women and girls who lack access to technology do not gain the skills and knowledge essential to enter the science, technology, engineering and mathematics (STEM) workforce and influence the creation of AI, which has impacts that will be discussed in the following sections.[35] This lack of representation perpetuates gender data gaps in AI, reinforcing a cycle of exclusion.

The gender gap in AI creates a self-perpetuating cycle. Since women are less connected via digital technologies than men, they have fewer entry points into tech, leading to their underrepresentation in these sectors. This underrepresentation means women have limited access to the technology used to gather important data for AI applications, which in turn perpetuates gender data gaps. Ensuring access to electricity, the availability of technology and the knowledge to use this technology is essential to closing the digital divide and allowing women to fully benefit from AI and the energy transition.[36]

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32 UNICEF: What we know about the gender digital divide for girls: A literature review

33 OECD: The effects of AI on the working lives of women

34 IEEE: What is the digital divide?

35 UN Women: Power on: How we can supercharge an equitable digital future

36 World Economic Forum: Why we must act now to close the gender gap in AI

WORKFORCE GENDER IMBALANCE

While AI has the potential to create new jobs,[37] the loss of existing jobs is a long-recognized challenge posed by the increasing adoption of AI technologies; Goldman Sachs estimates that AI could replace 300 million jobs globally.[38] The impact of AI on the workforce affects women and men differently, according to the type of employment (formal or informal) and gender-based employment segregation, which is the "unequal distribution of female and male workers across and within jobs."[39]

The formal sector consists of legally registered firms that pay taxes and are monitored by government oversight, while the informal sector includes firms that are not registered, including small, household-run businesses.[40] Informal labour, prevalent in emerging markets and developing countries, poses obstacles to sustainable development and gender equality. Informal workers often face poverty due to a lack of social protection, wage gaps and levels of education that are lower than those of workers in the formal sector.[41] Women are disproportionately represented in the informal economy; in 2019, 92 percent of informal jobs in developing countries were held by women, compared to 87 percent by men.[42] In Sub-Saharan Africa, 74 percent of women in non-agricultural jobs are in informal employment.[43] Women in the informal economy typically occupy the most precarious and low-paying jobs.[44]

Gender-based employment segregation also extends to specific sectors. Women are overrepresented in low-productivity service sector roles, including retail, health, social work and education.[45] In contrast, women remain persistently underrepresented in STEM fields. According to the International Labour Organization (ILO), men occupy 72 percent of occupations in information technology, science and engineering across 121 countries.[46]

Women's lack of access to STEM roles has significantly impacted the technology and energy sectors. The International Energy Agency (IEA) reports that the gender gap in the energy sector is twice as large as in the non-energy sector, with significantly fewer women working in the energy sector than men, particularly in STEM and technical non-STEM positions.[47] Women comprise only 22 percent of the traditional energy sector workforce and are listed in less than 11 percent of energy patent applications (compared to the share of women inventors in international patent applications broadly at 16.5 percent in 2021).[48]

The energy sector faces multiple barriers that hinder women's full participation and advancement, perpetuating this gender disparity. These obstacles are deeply rooted in societal, cultural and institutional structures, ranging from limited awareness of career opportunities to educational disparities in STEM fields. The industry's male-dominated culture, coupled with biased hiring practices, further exacerbate this challenge. Technical skill requirements and physically demanding work environments, often perceived as unsuitable for women due to societal stereotypes, add another layer of complexity. Further, legal discrimination persists in several countries, including Belize, Cameroon,

37 World Economic Forum: Jobs of tomorrow: Large Language Models and jobs

38 Hatzius, J., et al: The potentially large effects of Artificial Intelligence on economic growth (Briggs/Kodnani)

39 Carranza, E., et al: Gender-based employment segregation: Understanding causes and policy interventions

40 World Economic Forum: Why developing countries should create more formal jobs

41 International Monetary Fund: What is the informal economy?

42 World Bank: Female labour force participation; WIEGO: Women and men in the informal economy: A statistical brief

43 UN Women: Women in informal economy

44 International Monetary Fund: What is the informal economy?

45 Carranza, E., et al: Gender-based employment segregation: Understanding causes and policy interventions

46 International Labour Organization: These jobs are dominated by women

47 International Energy Agency: Energy and gender

48 GWNET: Facts and figures; Cecelski, E. & Oparaocha, S.: The lack of gender targets for clean energy is harming women and girls; World Intellectual Property Organization: International Women's Day 2022 ; World Intellectual Property Organization: International Women's Day 2022

the Democratic Republic of Congo, Kiribati, Malaysia, Nigeria, St Vincent and the Grenadines and Swaziland, which maintain laws that explicitly restrict women's participation in the energy sector, such as prohibiting them from working night shifts in electricity generation. A lack of support for work-life balance disproportionately affects women, further compounding these issues.[49]

While these challenges are not exclusive to the energy industry, they interact in ways that further increase the gender gap.[50] For instance, the scarcity of technically trained women can be traced back to limited enrolment of girls and women in STEM education, which is influenced by pervasive social and cultural norms that shape women's roles and opportunities within their communities.

This trend extends to renewable energy, where women represent only 32 percent of the renewable workforce globally.[51] Women tend to gravitate towards administrative and non-STEM technical jobs, and only a small number occupy higher-paying STEM technical and managerial roles.[52] Women in the renewable energy sector face a range of barriers to entry and progression, including gender bias, limited access to education and finance, gender stereotypes, legal discrimination, gender-based violence and lack of support for work-life balance.[53]

Women's underrepresentation in technical STEM roles in the renewable energy sector is significant for the future of the energy transition, as women's involvement brings benefits towards achieving SDG7. Evidence demonstrates that female employees and leaders are more willing than their male peers to act on climate and are more effective when doing so. Companies with a gender-diverse workforce reduce CO2 emissions by 5 percent more than those with only men in management. Further, women with the credentials to work in STEM tend to have the skills needed to be more inclined towards action-oriented and solution-driven responses to climate change.[54] Notably, women's representation in leadership and decision-making roles must complement technical expertise to advance progress towards SDG7 and SDG5.

Similar trends are seen in the AI sector, where the workforce is heavily male dominated. A 2019 Organisation for Economic Cooperation and Development (OECD) report found that women represent only 29 percent of science R&D positions globally,[55] and only 12 percent of AI positions requiring over 10 years experience are held by women.[56] Across 160 companies in 21 African countries, only 29 percent of the AI workforce was comprised of women in 2021.[57] This lack of gender diversity contributes to AI technologies often reflecting the perspectives and biases of their predominantly male developers.

Employment segregation by gender is linked to educational sorting, gender gaps in access to assets and capital, sociocultural norms and biases, intra-household allocation of time, safety and mobility constraints, a lack of female role models and networks, gender biases in recruitment, selection, hiring, evaluation and promotion, and workplace culture.[58] The digital literacy gap is particularly significant as well. Women's underrepresentation across these industries has implications for both the energy sector and the development and implementation of AI applications.

The segregation of women into informal employment impacts their ability to benefit from AI technologies and contribute to the energy

49 For more information, see Remerscheid, C. & Kotecha, S.: Empowering women in clean energy: Advancing and retaining an equitable workforce; UN Women: Gender analysis in technical areas: Energy infrastructure; International Finance Corporation: Women's participation in the renewable energy workforce in Sub-Saharan Africa: Identifying barriers and opportunities for women as leaders and employees

50 International Energy Agency: Innovative solutions require a diverse and equitable energy sector; Global Energy Alliance for People and Planet: Gender empowerment in the renewable energy sector

51 IRENA: Renewable energy: A gender perspective

52 IRENA: Renewable energy and jobs: Annual review 2023

53 See UN Women: Gender analysis in technical areas: Energy infrastructure

54 World Bank: Green jobs for women can combat the climate crisis and boost equality

55 OECD: The effects of AI on the working lives of women

56 Gomez-Herrera, E. & Koeszegi: A gender perspective on Artificial Intelligence and jobs: The vicious cycle of digital inequality

57 Mitchel, O.: AI labour gender gap

58 Carranza, E., et al: Gender-based employment segregation: Understanding causes and policy interventions

sector. While women's economic contribution lies predominantly in the informal sector and in unpaid domestic work reliant on energy access, new energy technologies and policies have prioritized investments in large projects associated with men's formal work over improving energy solutions for women's informal enterprises and domestic responsibilities. Yet, women must access adequate energy supplies to operate SMEs and home industries.[59]

For instance, women dominate the informal food sector, which is highly dependent on energy sources. However, new energy technologies and investments have focused more on large infrastructure projects associated with men's work rather than improving energy access for women's informal enterprises and domestic activities. Women running small businesses and home industries require access to diverse energy sources to power different activities like operating enterprises, preserving foods and preparing traditional meals. However, energy policies have paid only minimal attention to technologies that could improve productivity and reduce unpaid domestic work burdens for women in the informal sector.[60]

Across Africa, women-led businesses often have less access to finance- and energy-related services than those headed by men, particularly as women are more likely to work in the informal sector.[61] The lack of energy access and adequate energy supplies impacts women's ability to utilize and benefit from energy-reliant AI technologies, affecting their income-generating potential and wider economic development.

Further, informal-sector workers are often excluded from the design of data collection tools or data collection processes. This lack of consultation contributes to the exclusion of women's perspectives and knowledge within AI development teams.[62]

In the formal sector, the potential for AI to create new jobs raises concerns about disproportionately negative effects on women's employment. Research indicates that jobs traditionally held by women, such as administrative and legal positions, face high risks of being replaced by AI.[63] This is exemplified by the 31–41 percent decline in jobs such as bank tellers, data entry clerks and executive secretaries. In contrast, technical fields where women are underrepresented including AI and machine learning, data analysis and network engineering have high potential for job growth through AI augmentation.[64] Research by the ILO indicates that over double the share of women's employment may be disrupted by AI automation compared to men's, owing to women's disproportionate representation in clerical roles across high- and middle-income countries.[65] The automation of such roles will exacerbate gender inequalities in the workforce unless proactive measures are taken.

AI's application in the energy sector, particularly through robotics and automation, may disproportionately impact women's employment.[66] Women often occupy roles susceptible to automation in the energy sector, such as monitoring, inspections and repetitive operations.[67] As AI replaces energy jobs traditionally associated with 'women's work,' many women may face limited pathways to entering the energy workforce. Without intentional steps to ensure equal distribution of AI benefits, the shift toward increased automation may compound the barriers women face in accessing education, finance and leadership roles in the energy sector.

59 Cecelski, E.: The role of women in sustainable energy development

60 de Groot, J. et al.: Fuelling women's empowerment? An exploration of the linkages between gender, entrepreneurship and access to energy in the informal food sector

61 OECD: 8. Women and SDG 7 – Affordable and clean energy: Ensure access to affordable, reliable, sustainable and modern energy for all

62 Partnership on AI: Our approach

63 See Gonzales, M.: AI more likely to replace jobs held by women. Here's why; International Labour Organization: These occupations are dominated by women

64 World Economic Forum: Jobs of tomorrow: Large Language Models and jobs

65 International Labour Organization: Generative AI likely to augment rather than destroy jobs

66 Allsup, M. & Weinstein, L.: Seven ways utilities are exploring AI for the grid

67 While monitoring, inspection, and repetitive operations roles are often held by women, there are notable differences across industries. Women's employment in these roles for large physical assets like oil and gas facilities, power plants and the power grid tends to be lower. These positions are often more physically demanding, higher paying and technically complex, leading to a disproportionate representation of men in the energy sector. In contrast, roles traditionally filled by women tend to be less physically intensive and lower paying.

AI DEVELOPMENT GENDER BIAS

A significant challenge in the development and deployment of AI applications is the persistence of gender bias. This bias can infiltrate AI systems at every stage, from the selection and collection of data to the subjective decisions made during data handling and processing. [68] If the training data used to build AI models contain inherent biases, these biases will be reflected in the algorithm's outputs or decision-making. This issue is compounded by the fact that many of these subjective choices are made by men in the Global North, reflecting a tendency to favour perspectives and power imbalances biased towards men.[69]

The absence of women in AI development teams results in technologies that reflect and perpetuate gender biases. For instance, personal digital assistants like Siri or Alexa, which are often assigned feminized traits or features such as names or voices, reinforce longstanding gender stereotypes by performing tasks traditionally associated with women's labour.[70] Research has shown that gender bias in AI systems can lead to unfair allocation of resources, information and opportunities for women. AI systems used in hiring and recruitment often deprioritize women's applications due to biased training data.[71] A recent study found that around 61.5 percent of AI systems exhibiting gender bias allocated resources in ways that disadvantaged women, including hiring software and ad targeting systems that overlooked women's job applications and profiles in favour of those of men.[72]

These gender biases within AI systems are linked to several factors, including the underrepresentation of women in data science and AI fields, the digital gender divide (where

68 Manasi, A., et al: Addressing gender bias to achieve ethical AI

69 See Browne, J., et al: Feminist AI: Critical perspectives on algorithms, data, and intelligent machines; OECD: The effects of AI on the working lives of women

70 See Costa, P.: Conversing with personal digital assistants: on gender and artificial intelligence; Manasi, A., et al: Addressing gender bias to achieve ethical AI; Sutko, D.: Theorizing femininity in artificial intelligence: a framework for undoing technology's gender troubles; UNESCO: I'd blush if I could: closing gender divides in digital skills through education

71 See Gomez-Herrera, E. & Koeszegi: A gender perspective on Artificial Intelligence and jobs: The vicious cycle of digital inequality; Australian Human Rights Commission: Using artificial intelligence to make decisions: Addressing the problem of algorithmic bias

72 Smith, G. & Rustagi, I.: When good algorithms go sexist: Why and how to advance AI gender equity

women are less likely than men to own smartphones that generate important data for training datasets), the lack of data disaggregated by sex or gender, and existing biases and stereotypes in the training data and among people who work with these systems.[73] These examples illustrate how AI currently perpetuates existing gender stereotypes and inequalities.

The energy sector is not exempt from the challenge of gender bias in AI technologies. While further research is needed on the specific gender biases of AI in the energy sector, existing research suggests that women's underrepresentation in the STEM, energy and science R&D fields reflects broader trends of gender bias and power imbalances in AI systems.[74] The lack of women's representation in the energy sector means the industry misses out on the potential leverage AI could provide to address gender-specific needs and patterns of activity if designed and implemented thoughtfully.

For instance, AI systems could integrate data from a gender perspective to adjust energy grid operations in ways that are more responsive to women's needs, such as improved lighting for safety and transportation.[75] To ensure AI applications are responsive to women's roles as energy consumers, producers, managers and users, it is crucial to have representation from women in their development so that gender biases and discrimination are addressed. Women bring unique perspectives and problem-solving skills valuable in creating AI applications that serve diverse populations. Excluding women risks perpetuating systems that fail to benefit the entire population, particularly those disproportionately affected by a lack of energy access and energy poverty.

GENDER & ENERGY INVESTMENT GAPS

The parallel challenges discussed in the preceding sections pose significant obstacles for AI applications to achieve progress towards SDG7 and SDG5. Limited funding, inadequate gender mainstreaming in AI development and the diversion of energy resources by AI technologies hinder progress towards these critical goals.

Despite the potential of AI to promote sustainable energy access and gender equality, funding in these areas remains insufficient. Between 2018 and 2023, total AI grant funding for SDG7 reached only USD 0.03 billion, while SDG5 received just USD 0.04 billion. This funding is well below investments made towards other SDGs, such as SDG3 (Good Health and Well-Being), which reached USD 0.33 billion, and SDG4 (Quality Education), which reached USD 0.13 billion. Alarmingly, only 10 percent of AI grant funding from US-majority foundations was directed towards organizations in LMICs, where the need and potential impact are often greatest.[76]

This disparity is also seen in private sector investment. While substantial capital – USD 49 billion – has been invested in AI towards SDG7 goals, primarily energy efficiency through autonomous vehicles, investment targeting gender equality is negligible at USD 0.62 billion, the lowest of all SDGs.[77] This underfunding restricts the integration of AI in achieving equitable energy transitions and gender equality, limiting innovation and progress in these critical areas. There is an urgent need to realign private and public resources strategically to support AI-enabled solutions that advance gender equity and sustainable energy access.

Women's economic opportunities and access to financial resources are also limited across sectors. AI companies founded by women raise significantly less capital than those founded by men, receiving on average six times less funding.[78] Achieving parity in capital investment is crucial for leveraging AI to support SDG7 and SDG5.

73 Smith, G. & Rustagi, I.: When good algorithms go sexist: Why and how to advance AI gender equity

74 UN Women: Artificial intelligence and gender equality

75 Zhu, T., et al: More than privacy: Applying differential privacy in key areas of Artificial Intelligence https://arxiv.org/pdf/2008.01916.pdf

76 McKinsey & Company: AI for social good: Improving lives and protecting the planet

77 McKinsey & Company: AI for social good: Improving lives and protecting the planet

78 2X & Sagana: Project Catalyst: Tracking gender lens investment activity in private markets

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DIVERSION OF ENERGY FROM COMMUNITIES

The growing demand for energy-intensive AI-powered data centres presents additional challenges. These centres require large amounts of electricity and water to operate, often straining local infrastructure and resources. The energy required to train a single large language model is estimated to produce around 300,000 kg of carbon dioxide emissions, a significant environmental cost.[79] By 2030, the total electricity demand for information and communications technologies (ICTs) could reach 20 percent of global demand, compared to the current 1 percent.[80] AI data centres also use substantial amounts of water for cooling, with up to 9 litres evaporating for every kilowatt-hour of energy used.[81] This can significantly impact already scarce water resources, especially in regions facing climate change challenges. The increased energy demand by AI data centres can directly impact energy availability for surrounding communities, potentially leaving households without reliable access to energy.[82] This issue is particularly concerning in low-resource areas where access to electricity and water is already limited.

For example, in 2023, there were 10 data centres in Lagos, Nigeria, each using a significant amount of water for cooling and electricity generation. In Nigeria, only 36 percent of the urban population and 21 percent of the rural population had access to safe drinking water in 2022.[83] Additionally, while the urban population has 100

79 Dhar, P.: The carbon impact of artificial intelligence

80 Vinuesa, R., et al: The role of artificial intelligence in achieving the Sustainable Development Goals

81 Gordon, C.: AI is accelerating the loss of our scarcest natural resource: Water

82 Tecere, A.: AI and energy consumption challenge data centers to innovate amid growing demand

83 World Bank: Indicator

percent electricity access, only 21 percent of the rural population had electricity access in 2021, according to the World Bank.[84] As demand for data centre services rises with the growth of AI, the energy and water usage of these facilities may have a significant impact on the water availability for the local population.[85]

Housing these data centres in low-resource areas can exacerbate existing inequalities, as the communities may lack the political and economic power to advocate for their energy and water needs, perpetuating a cycle of energy poverty and marginalization. Women, who often manage household energy needs and are more vulnerable to the consequences of energy scarcity, may be disproportionately affected. This will become far more problematic if data centres are in rural areas where electricity and water access are much lower than in urban areas.

These challenges are compounded by a lack of gender-responsive policies in the energy and AI sectors. The absence of gender mainstreaming and gender analysis in policies, programmes and projects means that the specific needs and challenges faced by women, men, boys and girls are often overlooked. In the energy sector, this gap means that women's distinct needs, experiences and knowledge are inadequately represented in energy planning and policymaking processes, potentially leading to energy policies that exacerbate existing inequalities. Currently, most national energy policy frameworks remain gender blind.[86]

Incorporating women's input in AI development is crucial for creating technologies that address the unique challenges faced by women and girls in their communities. Women can provide valuable insights into how AI systems can be designed to avoid perpetuating existing inequalities and biases. For example, women's participation in AI development can help identify and mitigate potential biases in training data, ensuring more equitable outcomes.

To address these challenges, sustainable solutions are needed to ensure that the growth of AI does not come at the expense of energy and water access for local communities, particularly those in low-resource areas. This may involve investing in renewable energy sources, implementing energy-efficient technologies and prioritizing the needs of local communities in the development and deployment of AI systems.

84 Energy Sector Management Assistance Program (ESMAP): SDG 7.1.1 Access to electricity

85 Taha, A. & Olufemi, A.: Data centers' straining water resources as AI swells

86 UN Women: Gender equality in the sustainable energy transition

Opportunities & Responsibilities

Stakeholders investing in the energy and AI sectors must take proactive measures to harness AI applications for advancing both energy access and gender equality. This includes ensuring women are actively involved in the workforce and decision-making. Additionally, financial resources play a crucial role in integrating energy and gender considerations across all stages of policy, programme, project planning, implementation and monitoring. By prioritizing these steps, we can effectively leverage AI technologies to achieve more inclusive and sustainable outcomes.

DIVERSIFYING AI DEVELOPMENT TEAMS

It is imperative that AI development teams embody diversity and representation and include individuals from varied backgrounds and perspectives. Gender-diverse teams enrich workplace environments by offering diverse viewpoints to address complex issues, enhancing decision-making processes, and driving innovation and overall company performance. McKinsey's 2020 Diversity Wins report underscores the financial benefits of diverse organizations, showing that they are 25 percent more likely to outperform financially than non-diverse ones.[1] Moreover, research spanning from 2000 to 2019 reveals that gender-balanced scientific teams of six or more researchers are significantly more likely to produce novel and highly cited papers compared to same-gender teams of similar size. Specifically, teams with equal gender representation demonstrate the strongest benefits in terms of novelty and impact.[2] These findings underscore the critical role of gender balance in fostering innovative and impactful research, particularly in fields where women's underrepresentation can perpetuate biases and stereotypes influencing policymaking and programme planning.

1 Santos, M. et al.: How to be an inclusive leader for gender-diverse teams

2 KelloggInsight: Gender-balanced teams do better work

In the realm of AI development, a diverse team plays a pivotal role in ensuring unbiased training data and swiftly identifying and correcting emerging biases through continuous monitoring and human oversight. Diverse teams are better able to recognize and address biases before they become integrated into the machine learning models. By integrating diverse viewpoints, experiences and expertise, these teams curate training data to carefully remove inherent biases and ensure the AI system reflects and serves the entire target population.[3] They scrutinize data, algorithms and outputs from varied perspectives, implement ongoing monitoring, and employ oversight mechanisms to audit AI operations for biases. Such practices are instrumental in developing inclusive and equitable AI solutions that meet the diverse needs and challenges of user groups.[4]

Conversely, homogenous teams are susceptible to shared blind spots and may overlook critical factors, perpetuating societal biases and creating AI systems that discriminate against or inadequately serve marginalized communities. Achieving genuine diversity necessitates intentional recruitment efforts across gender, race, ethnicity, socioeconomic status, abilities and other dimensions, while fostering an inclusive culture that values diverse perspectives. By prioritizing diversity in AI development teams, organizations can cultivate ethical, unbiased and equitable AI technologies that contribute positively to societal advancement.

ACCELERATING WOMEN'S REPRESENTATION IN STEM

Addressing the challenges outlined requires a concerted effort to increase women's representation as both workers and decision-makers, particularly in the clean energy and technology sectors, which are pivotal to sustainable development. The projected growth of 14 million new jobs in the clean energy sector by 2030 necessitates a diverse and inclusive workforce, with a significant emphasis on elevating women into technical and leadership roles.[5] This effort not only addresses existing disparities but also presents numerous opportunities to bolster women's participation in STEM fields, particularly in energy-related domains.

A critical opportunity lies in reshaping school and university curricula to nurture young girls' interest in STEM careers, especially in the energy, AI and ICT sectors. This involves addressing entrenched gender bias and stereotypes that dissuade women from pursuing these disciplines. Additionally, integrating sustainable energy infrastructure into educational settings is crucial to enhancing student engagement and success across all educational programmes.[6]

To meet the growing demand for skilled labour needed to support the energy transition, ensuring women enter and stay in the energy workforce is paramount. Companies, organizations and governments can play a pivotal role by implementing targeted strategies such as inclusive recruitment practices, supportive workplace policies addressing gender-based violence and harassment, mentorship initiatives and creating networking opportunities. Collaborating with educational institutions to encourage young women to pursue STEM education and careers in energy is essential, alongside providing robust retraining and upskilling programmes.

Retraining and upskilling women in STEM fields, including in the technology and energy sectors, is crucial amid ongoing disruptions caused by AI technologies. The gender gap persistent in the STEM workforce has had a disproportionately negative impact on AI systems and energy access for women and girls. In addition to their systemic workforce underrepresentation, women are also more likely to experience job displacement because of AI technologies and to be left out of the energy transition. As AI technologies continue to disrupt the job market, it is crucial to help women and girls acquire the skills necessary to succeed in new jobs and tasks.[7] Women face systemic obstacles when it comes to retraining and upskilling for the workforce. One root cause is the disproportionate burden of unpaid household labour and caregiving responsibilities.[8] Addressing these root inequalities requires not only access to educational and training opportunities but also policy interventions that alleviate the time poverty faced by women, including initiatives to automate domestic tasks through technologies enabled by reliable electricity access. Moreover, the digital gender gap and lack of energy access pose significant challenges, particularly for women in low-income countries, limiting their participation in online training programmes. Financial implications such as tuition fees and accommodation and transportation costs further reduce women's access to these opportunities.

3 Project F: Unleashing The Power of Gender Balance in AI and ML

4 Meyers West, S.: Discriminating systems: Gender, race, and power in AI – Report

5 Papathanasiou, D. & Brixi, H.: The energy transition fueled by women's participation & leadership

6 United Nations: Policy brief 4: Energy and SDG 4 quality education

7 OCED: The effects of AI on the working lives of women

8 European Institute for Gender Equality: Gender differences on household chores entrenched from childhood

Addressing these barriers requires holistic approaches that consider financial incentives, flexible programme formats and policies supporting women's mobility and decision-making autonomy. There is a significant opportunity to pass policies and legislation to alleviate the disproportionate impact on time of informal and unpaid work, such as parental leave policies, family sick leave, universal childcare or childcare subsidies and flexible working schedules, supported by increasing women's representation in decision-making roles.

Offering a wide range of retraining and upskilling programmes, including at differing hours of the day, via in-person or online formats, in a team setting or a self-paced setting, and across various levels of experience, provides flexible opportunities for women to opt in to participate, particularly those whose current jobs may be disrupted by AI.[9] Financial incentives for women, who have less control over household capital, to participate in retraining and upskilling programmes can also further empowerment and ensure women's presence. Finally, there is an opportunity for workplaces to pay increased attention to retention strategies, including pay equity, access to healthcare, mentorship opportunities and sponsorship programmes to ensure that women who retrain and upskill remain within the workforce.[10] These benefits will have a long-lasting effect on women's lives and the productivity of companies and societies, resulting in a cyclical benefit to the AI and energy sectors.

Increasing the representation of women across the STEM workforce, including in the technical innovation process, can contribute to the development of solutions to address

9 Kreacic, A. & Stone, T.: Women are falling behind on generative AI in the workplace. Here's how to change that

10 Kreacic, A. & Stone, T.: Women are falling behind on generative AI in the workplace. Here's how to change that

Box 3.
AI's impact on the household

Basic household appliances and equipment such as washing machines, refrigerators and vacuum cleaners enabled by reliable electricity access and emerging technologies like robotic vacuum cleaners and automated cooking devices could help alleviate domestic workloads that typically fall to women and girls, freeing up time for those who can afford them and have the electricity and connectivity to operate them from several domestic tasks.

However, a concerning gender divide exists in how this potential is perceived. Female experts are enthusiastic about the prospect of automating domestic tasks, while male experts are more likely to identify the automation of domestic tasks as expensive and not of interest to consumers.[1]

This difference in opinions highlights a dual-edged sword. For women with access and means, including energy access, AI-powered domestic automation in addition to basic household appliances could free up time for retraining. Yet the lack of women in STEM fields creating these technologies risks underinvesting in solutions explicitly benefitting women.

Social transformation that occurs when electricity access enabling household appliances frees women from domestic labour has happened in developed economies since the 1920s and was one of the driving forces behind women participating in the non-domestic, formal and paid labour force.

However, women in LMICs are currently facing much stronger cultural, economic and social resistance than earlier generations. Overcoming workforce retraining barriers for women will require addressing the root inequalities in unpaid labour distribution and associated social norms in many countries.

1 Oxford University: AI, automation in the home and its impact on women

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and raise awareness around climate change and the development of sustainable technologies and practices.[11]

Initiatives like the Sustainable Energy for All (SEforALL) STEM Traineeship programme, which provides women with activity-based technical training to advance in STEM roles within the energy sector, are a step in the right direction.[12] Establishing and enhancing similar programmes with AI for recruitment, training on predictive maintenance, smart grids and data analysis can further support women's participation and advancement in the AI and energy fields. Retraining and upskilling women in the sector will work to meet the increased demand for AI skills, basic and digital literacy, STEM technical skills and leadership skills.[13]

Beyond workforce development, properly designed AI systems developed by gender-diverse teams offer promising avenues to mitigate gender biases in the workplace. AI-powered tools can anonymize job applications and remove human biases from the hiring process, supplemented by human oversight and audits to detect and correct biases.[14] AI-driven analytics can also enhance human resources practices by providing insights into promotion and termination decisions, thereby supporting fairer outcomes.[15]

Individual companies can leverage AI applications intentionally to increase gender parity within the workforce, counteracting biases inherent in historical data. By implementing inclusive AI solutions and ensuring rigorous oversight, organizations can foster more equitable work environments and enhance overall workplace diversity.

Advancing women's representation in STEM fields, supported by inclusive AI applications and robust workforce policies, not only addresses current disparities but also drives innovation and sustainable development. By empowering women through education, training and supportive workplace environments, societies can harness the full potential of diverse talent to tackle global challenges effectively.

11 See Loarne-Lemaire, S. L., et al.: Women in innovation processes as a solution to climate change: A systematic literature review and an agenda for future research; 2X: Ways to gender-smart climate finance: Sustainable energy

12 Sustainable Energy for All: SEforALL helping young women build renewable energy careers in Sierra Leone

13 OCED: The effects of AI on the working lives of women

14 Polli, F.: Using AI to eliminate bias from hiring

15 Zhang, H., et al: The role of AI in mitigating bias to enhance diversity and inclusion

IMPLEMENTING GENDER-RESPONSIVE DECISION-MAKING & POLICY STANDARDS

Ensuring effective leadership and decision-making in the development and deployment of AI technologies within the energy sector requires more than just technical expertise; it necessitates empowering women in leadership roles. Research consistently underscores that integrating women into political and decision-making arenas results in more inclusive and gender-sensitive policies.[16] Women contribute diverse perspectives and experiences correlating with more ambitious climate policies and corporate sustainability priorities.[17] Extending this principle to the development of AI regulations is vital to ensuring an equitable transition to AI-powered technologies in the energy sector. Women's involvement in setting AI standards can help address the specific needs and concerns of those disproportionately affected by energy issues.

To enhance women's participation in decision-making across the energy, ICT and AI sectors, several key strategies are essential. These include early encouragement of girls to pursue STEM education and careers; active promotion of gender equality within these sectors; the removal of barriers hindering women's advancement; implementation of work-life balance policies; mitigation of unconscious biases in hiring and promotion; establishment of targets for women's representation in leadership; and provision of equal opportunities in pay, training and career development.

Moreover, women in leadership roles must contribute to the development of comprehensive regulatory frameworks for AI in the energy sector. These regulations should encompass establishing environmental standards to mitigate the impact of AI on energy consumption, emissions and resource use; implementing legal frameworks ensuring AI system sustainability throughout their lifecycle;[18] and addressing ethical concerns such as transparency and accountability in AI decision-making.

Transparency measures are crucial, indicating clear documentation of AI systems' decision-making processes, disclosure of biases and limitations, audits to verify compliance with regulations and standards, and public reporting on AI system impacts. Accountability mechanisms should define responsibilities and liabilities for AI-driven decisions, provide grievance and redressal mechanisms for affected individuals and communities, ensure human oversight in critical scenarios, mandate robust testing and validation processes, and enforce penalties for violations of AI regulations or misuse of systems.

Further, regulations must confront ethical challenges, considering impacts on marginalized communities and actively involving diverse stakeholders in their development. This includes establishing rigorous standards to eliminate gender stereotypes, promote the meaningful and equal participation of women across workforces and decision-making spaces, and prevent biases against marginalized groups in AI development and deployment. Moreover, it necessitates ensuring informed consent, particularly for those most vulnerable to privacy violations, surveillance and data exploitation. Mechanisms must also be in place to provide redress for communities affected by resource diversion, job loss or displacement due to infrastructure projects. Addressing these ethical imperatives demands a comprehensive approach that integrates diverse perspectives, enhances transparency and prioritizes fairness and equity in AI development and deployment. Proactive measures are essential to mitigate risks and ensure that AI technologies contribute positively to societal well-being and foster inclusive growth.

Involving women and diverse stakeholders in shaping AI regulations and standards for the energy sector is crucial to ensuring these frameworks reflect their perspectives and concerns. Comprehensive regulations should strike a balance between fostering innovation and safeguarding the public interest, particularly for marginalized groups disproportionately impacted by energy-related issues.

16 See generally Goetz, A. M.: Women in politics & gender equity in policy: South Africa & Uganda; Franceschet, S. & Piscopo, J. M.: Gender quotas and women's substantive representation: Lessons from Argentina. See further EIGE: Energy; Feenstra, M.: Gender just energy policy engendering the energy transition in Europe

17 OECD: Women's leadership in environmental action

18 Dhar, P.: The carbon impact of artificial intelligence

APPLYING A GENDER LENS TO AI & ENERGY SOLUTIONS

Applying a gender lens to the development and implementation of AI applications and energy solutions holds significant promise. For instance, women play crucial roles as primary household energy consumers and drivers of sustainable energy practices, influencing the adoption of energy-efficient solutions and renewable energy sources.[19] Understanding women's specific energy needs is necessary for making informed pricing decisions and devising effective sales and marketing strategies for clean energy products. This approach enhances existing clean energy markets and opens doors for new opportunities, leading to improved environmental outcomes and reduced energy poverty. AI-powered technologies, including smart home systems and digital platforms, can be intentionally designed to engage women and support their participation in the energy transition.[20]

Gender-responsive policy, programme and project planning involves several key components. It necessitates conducting gender analysis and the collection and analysis of sex-disaggregated data to comprehensively understand how women, men, boys and girls are differently affected by specific issues.[21] These data are instrumental in developing AI applications that address the needs of all genders equitably. In the energy sector, understanding how men and women use energy differently can lead to more effective and inclusive energy policies and technologies.

19 OECD: 11. Women and SDG 12 – Responsible consumption and production: Ensure sustainable consumption and production patterns

20 UN Women: Gender equality in the sustainable energy transition

21 EIGE: Gender analysis

A participatory approach is essential throughout the design, implementation and monitoring of AI policies, programmes and projects. Engaging women and other marginalized groups throughout these processes ensures their voices are heard and their needs prioritized. Gender-responsive and women-led initiatives and projects have demonstrated that they can be successful across the energy space by providing sustainable energy solutions at different levels.[22] For instance, involving women in planning initiatives of smart energy grids can lead to solutions that address women's specific energy needs, such as improved lighting for safety and efficient cooking technologies.

Gender-responsive planning requires creating policies and frameworks that promote gender equality. This includes supporting women in STEM fields, providing training and mentorship programmes and ensuring equal opportunities for women in AI and technology industries.

Central to effective gender-responsive planning is strengthened data and analytics through the collection of sex-disaggregated data. The key to developing effective, gender-responsive energy policies, programmes and projects lies in accessing comprehensive, disaggregated data on energy access, consumption and impacts.[23] AI applications can be harnessed to aid in the collection, analysis and visualization of these data. AI-powered tools and techniques can gather granular, gender-specific data on energy usage patterns, barriers to access and the differentiated impacts of energy policies and interventions. Gathering gender-specific data could be accomplished through AI-enabled sensors, surveys and other data sources to capture disaggregated information at the individual and household level. Advanced AI-based analytics can then be applied to these gender-disaggregated data to uncover important insights and trends, including identifying disparities in energy access and usage between men and women and understanding the unique challenges and needs of different demographic groups. However, a persistent challenge lies in the underrepresentation of women's needs and experiences in the data used to train AI models, potentially leading to biased outcomes as discussed earlier.

High quality disaggregated data is fundamental to develop and implement better policy solutions. By leveraging these AI-powered data and analytics capabilities, policymakers and energy-sector stakeholders can gain a deeper, more nuanced understanding of the gender dynamics at play. Decision-makers and sector leaders can then use this knowledge to inform the development of energy policies, programmes and interventions that are specifically tailored to address the unique needs and barriers faced by women and other marginalized groups.

Energy mapping and modelling programmes, such as those developed by SEforALL, provide an inlet for creating sex-disaggregated data and addressing women's unique and differentiated needs from the supply and demand sides of the energy sector. For instance, SEforALL's Integrated Energy Access Plans (IEAPs) developed for Madagascar, Malawi and Nigeria provide gender-disaggregated results pertaining to clean cooking; the Integrated Clean Cooking Planning Tool (ICCPT, under development), currently being applied in Rwanda, computes the gender-related time savings opportunity costs of transitioning to cleaner fuels for cooking; and the Clean Cooking Economic Co-benefits Toolkit (under development), currently being piloted in Kenya and Malawi, provides gender- and age-disaggregated results for the health, economic and social benefits of transitioning to cleaner fuels for cooking.[24]

By identifying areas where women are most affected by a lack of energy access, or lack of appliances and equipment, these platforms can provide valuable insight into the critical needs of communities, informing programmatic and policy decisions.

Bringing energy access to women and empowering them as household managers of energy, as well as energy consumers, producers and users, can significantly impact their lives and the well-being of their families. AI-driven platforms can be leveraged to support this empowerment by providing networking and mentorship opportunities for women in the energy sector; connecting women-led organizations with funding sources; offering online learning platforms for capacity-building and skill development; addressing gender gaps in the energy transition; and leveraging AI for energy mapping and modelling.

By designing AI-enabled energy efficiency and access solutions with a gender-responsive approach, the sector can address the unique challenges and barriers to energy access and participation faced by women. The effective creation of solutions includes considering factors such as access to information and decision-making power within households, time and resource constraints women face and cultural and social norms that may limit women's participation. Incorporating these considerations into the development of AI-powered energy solutions can help ensure that the benefits of the energy transition are equitably distributed and that women are empowered as active participants in the process.

22 UN Women: Gender equality in the sustainable energy transition

23 Sustainable Energy for All: Webinar: Gender responsive cooling: Using data to build resilient livelihoods

24 Sustainable Energy for All: Universal Integrated Energy Planning

UNLOCKING GENDER & ENERGY FINANCING

Investing in women-led and women-centred businesses within the energy and AI sectors presents a significant opportunity for transformative impact. Organizations such as 2X advocate for applying a gender lens to technological and AI investments to ensure these technologies drive progress while mitigating social disparities.[25] According to UN Women, gender lens investing involves deliberately considering gender factors in investment decisions to enhance social and business outcomes. This approach encompasses investments in women-owned or women-led businesses, those promoting workplace equity and those offering products or services beneficial to women and girls, thereby ensuring that AI technologies not only foster innovation but also promote equitable distribution of benefits across genders.[26] Research underscores the economic benefits of gender lens investing, demonstrating its positive impact on productivity, efficiency and investment on return. For instance, studies have demonstrated that gender-diverse senior leadership teams within investment and portfolio companies correlate with higher returns compared to companies with less gender diversity in leadership roles.[27]

However, the gender financing gap, or inequalities between women and men in their ability to access capital and markets, persists.[28] Women-founded AI companies raise on average six times less capital than their all-male founder counterparts, highlighting a stark disparity in funding allocation.[29] Additionally, women face limited economic opportunities and access to financial resources, often exacerbated by biased lending practices and perceived risks, particularly in LMICs.[30]

To address these challenges, a multifaceted approach involving public, private and blended finance is crucial. Public finance remains essential for bridging funding gaps across the energy sector, particular in countries and regions not yet considered investable by the private sector.[31] Public finance is essential for empowering women-led

25 2X & Sagana: Project Catalyst: Tracking gender lens investment activity in private markets

26 UN Women: Gender equality in the sustainable energy transition; 2X & Sagana: Project Catalyst: Tracking gender lens investment activity in private markets

27 UN Women: Gender equality in the sustainable energy transition

28 International Finance Corporation: Closing the gender finance gap through the use of blended finance

29 2X & Sagana: Project Catalyst: Tracking gender lens investment activity in private markets

30 Randall, T.: How can 'blended finance' help fund climate action and development goals

31 IRENA: Optimising the role of public finance will advance universal energy access

businesses in the energy and AI sectors, supporting initiatives in overcoming barriers such as biased lending practices that result in limited access to capital. Private finance can provide significant economic opportunities while promoting equity goals when incorporating inclusive actions across all levels of the renewable energy value chain.[32] Blended finance, which strategically uses public capital to attract private investment,[33] plays a key role in addressing the gender finance gap by reducing actual and perceived risks of investing in women-led SMEs and addressing unconscious biases, particularly within the energy and digital transitions.[34]

Furthermore, achieving equity in capital distribution between AI companies founded by women and those founded by men is crucial for advancing gender equality in the energy sector and technology innovation. Key pathways for improvement include prioritizing funding for companies with gender-diverse leadership and development teams, adopting policies to enhance women's representation in technical roles, and integrating gender-smart criteria into investment decision-making processes. Supporting gender-inclusive design in AI and technology products and advocating for transparent reporting on AI development practices are also crucial steps to prevent gender biases and ensure accountability.[35] These measures are essential for driving gender-responsive investment in the AI and broader technology sectors, thereby maximizing the gender impact potential of investments and addressing existing knowledge gaps.

The path forward requires integrating gender lens investing across all finance types, producing more data to drive informed decision-making, increasing women's representation in financial decision-making roles and fostering collaboration between gender equality and financing communities.[36] Strengthening women's access to financing is imperative to ensure that AI and energy technologies foster innovation and promote equitable distribution of benefits for all.

32 ENERGIA: Building the business case for women's inclusive financing in last-mile renewable energy markers in Sub-Saharan Africa

33 Randall, T.: How can 'blended finance' help fund climate action and development goals

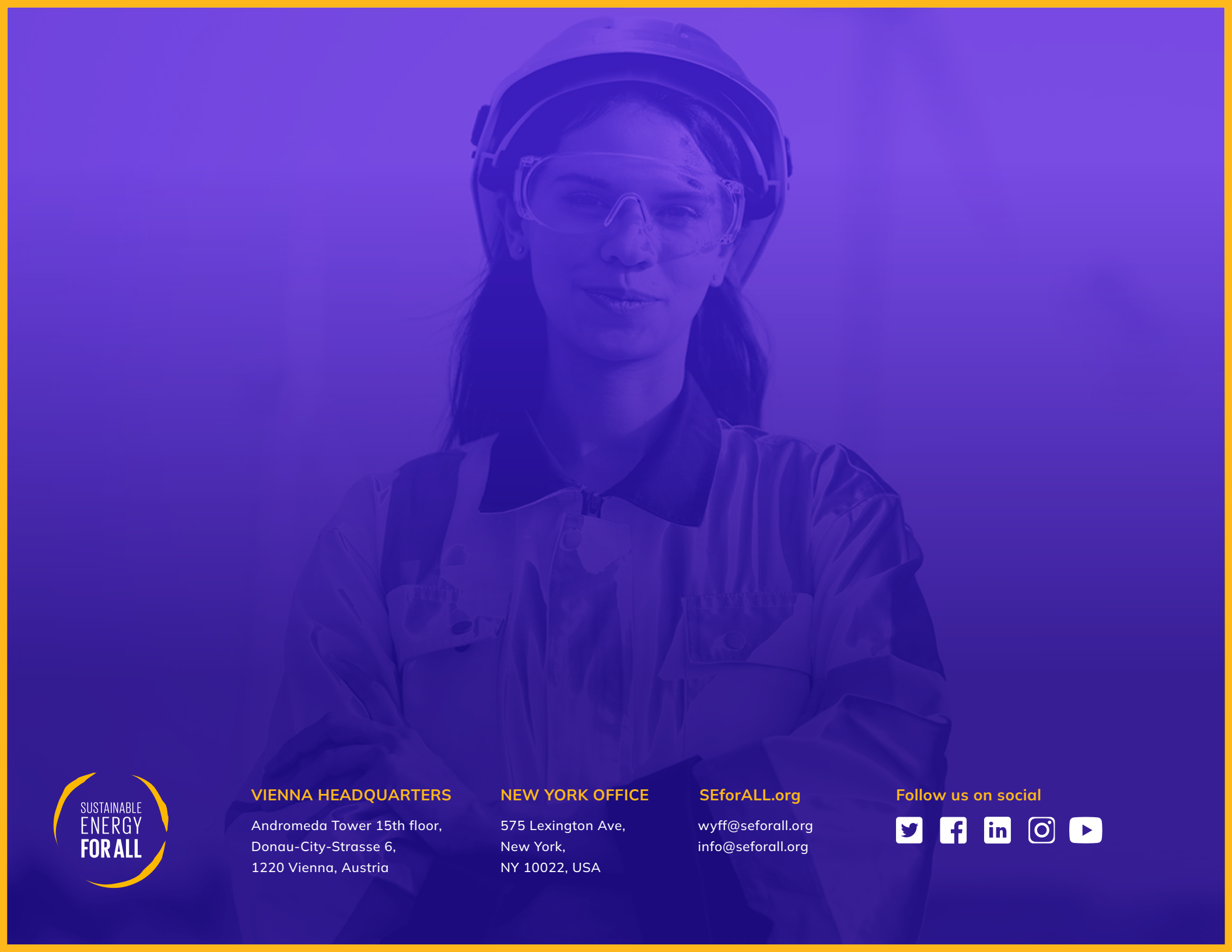
34 International Finance Corporation: Closing the gender finance gap through the use of blended finance; United Nations: Blended finance must be mobilized for 'energy transition, digital transition, food systems transition', Deputy Secretary-General tells alliance

35 2X & Sagana: Project Catalyst: Tracking gender lens investment activity in private markets

36 OECD: Blended finance for gender equality and the empowerment of women and girls

RECOMMENDATIONS

- Ensure women's involvement as decision-makers in the drafting and adopting of policies/legislation and regulatory frameworks guiding AI development and implementation.
- Adopt environmental standards regulating AI development and operation with the input of women and diverse communities
- Ensure transparency and accountability in deploying AI applications for energy.
- Increase women's access to digital literacy training opportunities at all ages and levels.
- Expand opportunities, such as SEforALL's STEM Traineeship programmes, and pathways for women to enter and advance in STEM positions within the energy sector.
- Provide retraining and upskilling opportunities targeted at increasing women's representation in STEM technical positions, including in the energy and AI workforces, to promote women's participation in capacity-building activities around energy access planning and data management.
- Commit to targeted job recruitment and implementing retention strategies, including networking opportunities and mentorship, to encourage women's employment, retention and advancement in STEM technical jobs.
- Address gender bias in AI systems by integrating more women into the STEM workforce and ensuring ongoing monitoring and human oversight of AI applications.
- Collect and analyze sex- and age-disaggregated data to ensure inputs/outcomes of AI do not reflect biases and that the needs and experiences of women, including young women, are addressed through energy policies, projects and programmes.
- Map energy access to identify communities where it is lacking, focusing on areas where a lack of energy access disproportionately affects women and youth.
- Scale up women-led energy solutions through increased financing and collaborations/partnerships.



SUSTAINABLE ENERGY FOR ALL

VIENNA HEADQUARTERS

Andromeda Tower 15th floor,
Donau-City-Strasse 6,
1220 Vienna, Austria

NEW YORK OFFICE

575 Lexington Ave,
New York,
NY 10022, USA

SEforALL.org

wyff@seforall.org
info@seforall.org

Follow us on social