Empowering Female Engineers through Renewable Energy and Energy Efficiency Awareness: A Community-based Approach

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ABSTRACT

This article presents the methodology, implementation, and outcomes of community awareness campaigns on renewable energy (RE) and energy efficiency (EE) conducted in Jenin Governorate, Palestine. This initiative empowered female engineers and promoted sustainable energy practices at the community level. Key activities included the training of female RE/EE ambassadors, the delivery of awareness sessions, and the distribution of energy-saving light emitting diode (LED) lamps. The impact of the campaign was assessed through participant feedback and energy consumption data. The initiative was designed and conducted to empower female engineers; the project involved training 30 young female engineers to become RE/EE ambassadors.

Key activities included rigorous training sessions for the ambassadors, who then led a series of structured community outreach events. These events featured 62 awareness sessions across five communities, reaching approximately 392 participants with the majority being women. The ambassadors provided practical guidance on energy-saving practices, solar energy applications, and the use of LED lighting, along with the distribution of 2,400 energy-saving LED lamps. The impact of the campaign was assessed through participant feedback and energy consumption data, revealing substantial knowledge acquisition and a strong commitment to adopting energy-efficient practices.

Overall, the findings highlight the important role of female engineers in driving community-based energy initiatives and underscores the potential of grassroot campaigns that foster sustainable energy practices. This project offers valuable lessons and serves as a model for

similar initiatives in other regions aiming to enhance energy efficiency and promote renewable energy adoption at the community level.

INTODUCTION

The growing need for sustainable energy solutions in Palestine, coupled with the underrepresentation of women in engineering, necessitates innovative approaches to community engagement and female empowerment. This led to an examination of the effectiveness of a community awareness campaign designed to address these issues by training female engineers as RE/EE ambassadors.

The ambassador training program started by selecting 25 female engineers as ambassadors to lead and conduct the awareness sessions. To facilitate the awareness sessions more effectively and ensure proper delivery, the ambassadors were divided into two groups. Six ambassadors were tasked with arranging and organizing the sessions, as well as preparing all necessary documentation. The remaining 19 ambassadors

Figure 1. Female engineer ambassador during an awareness session in Silet Al Harthiyeh.

directly conducted the awareness sessions and were responsible for delivering session materials to the communities. Figure 1 shows an example all-female training session.

LITERATURE REVIEW

The are numerous energy-related challenges in Palestine. Like many other developing nations, the country confronts substantial hurdles in energy supply, infrastructure development, and accessibility [1]. The region's geopolitical complexities further complicate energy governance and investment in infrastructure [2]. High energy costs, dependence on imported fossil fuels, and unreliable electricity grids underscore the urgent need for sustainable energy solutions.

Renewable energy potential: Palestine possesses considerable renewable energy potential, particularly in solar and wind resources. Leveraging these resources enhance energy security, mitigate greenhouse gas emissions, and stimulate economic development [2]. However, realizing these potential demands supportive policies, regulatory frameworks, and investments in renewable energy infrastructure.

Energy efficiency initiatives: Energy efficiency has a pivotal role in addressing energy challenges in Palestine and other developing countries. Enhancing energy efficiency across buildings, industries, and transportation sectors diminish energy consumption, reduce costs, and mitigate environmental impacts [3]. Implementation of energy-efficient measures, such as building retrofits and promoting energy-efficient appliances, is crucial for sustainable development.

Community-based approaches: Community engagement is important for the success of energy projects in developing countries. Local participation enhances project acceptance, sustainability, and equitable distribution of benefits [4]. Initiatives involving communities in decision-making and implementation, like those observed in rural Palestine, illustrate potential in fostering sustainable energy practices and empowering local stakeholders [5].

Gender dimensions in energy: The intersection of gender and energy is increasingly recognized as vital for achieving sustainable development goals. The United Nations Sustainable Development Goal 5, Subpart 5 calls to

ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life. Women often have important roles in energy access, management, and conservation at the household level [6]. Empowering women in the energy sector enhances their socioeconomic status and contributes to inclusive and effective energy policies and projects [7].

Barriers to female participation in engineering: Women face persistent barriers in engineering fields, including gender stereotypes, limited access to education and training, and workplace discrimination [8]. These barriers contribute to underrepresentation in technical roles globally, necessitating targeted interventions to promote gender diversity in the energy sector [9].

METHODOLOGY

The methodology employed in this research involved a collaborative approach with several key stakeholders. It followed a structured process to design, implement, and evaluate community awareness campaigns on RE and EE in the Jenin Governorate, Palestine. The Ministry of Local Government (MoLG), Environment Quality Authority (EQA), Association of Energy Engineers (AEE), and Council on Women in Energy and Environmental Leadership (CWEEL) had integral roles in guiding and supporting the initiative.

Partnership formation: Partnerships created with MoLG, EQA, AEE, and CWEEL.

- Collaborative planning and strategy development.

Ambassador selection and training:

- Recruitment identified 30 female engineers.
- Training: Comprehensive sessions covering technical knowledge (RE/EE), communication skills, gender sensitivity, and community engagement.

Campaign planning:

- Awareness session design: Structuring sessions on RE benefits, EE practices, and LED lighting technologies.
- Logistics: Coordination with local councils for session scheduling and participant outreach.

Implementation:

- Awareness sessions: Conducting 62 sessions across selected villages (Al-Taybeh, Seilat Al Harthiyeh, Ti'inik, Zububa, Rommaneh).
- LED distribution: Providing 2,400 energy-saving LED lamps to promote EE adoption.

RESULTS

Thirty female engineers and two male engineers participated in the ambassador training program. Candidates were selected from the Generating Revenue Opportunities for Women and Youth (GROW) beneficiary pool, AEE-affiliated universities, and partner local government units (LGUs) in locations where awareness campaigns would be targeted.

Intensive coaching and training sessions: Subsequently, the selected participants (see Figure 2) underwent two days of coaching and training sessions covering various topics, including practical applications of renewable energy, advocacy and soft skills. Following the training, 25 female engineers were selected to lead awareness sessions and conduct field visits. These ambassadors were supported by AEE's coordination with LGUs and a gender training session to ensure inclusivity and effectiveness in session delivery. Three additional sessions were conducted with the selected ambassadors to organize logistics, assign roles, and familiarize them with the villages where sessions would be conducted. Ambassadors were equipped with evaluation forms, tests, attendance sheets, LED units, and other necessary tools to be utilized during the awareness sessions.

Awareness sessions: The 25 female energy ambassadors were selected based on an evaluation exam designed to assess their comprehension of both technical issues related to energy and the gender principles essential for engaging with community members' sensitively and inclusively during awareness sessions. The examination results revealed a robust understanding of the topics covered during the training. Specifically, 85% of participants demonstrated proficiency in energy efficiency topics, while 70% showed proficiency in energy resources and solar energy

applications. Moreover, 98% of participants exhibited a strong grasp of gender-sensitive approaches; 71% demonstrated proficiency in soft skills and effective communication techniques crucial for conducting successful awareness sessions.

Furthermore, the evaluations demonstrated a notable level of satisfaction among participants, with 37% expressing that the sessions were highly suitable, and 59% indicating they found them suitable. Participants emphasized the sessions' effectiveness in introducing energy-saving concepts, highlighting the significance of solar systems for households, discussing various types of LED lighting, and offering guidance on purchasing and selecting energy-efficient equipment.

Moreover, the training evaluation indicated that participants exhibited a notably high level of satisfaction with logistical arrangements, training materials, and the effectiveness of the training delivery. For example, participants praised the promptness of the arrangements, the comprehensiveness of the materials provided, and the engaging way the training content was delivered.

Post-awareness sessions review: Participants knowledge about renewable energy improved after the community awareness sessions. Their knowledge was rated as follows: excellent (68%), very good (22%), good (7%), and medium (3%).

Evaluations: The analysis the evaluations of participant feedback (both overall and by training area) is summarized as follows. For the overall evaluation, 31% were rated as highly suitable, 59% as suitable, 0% unsuitable, and 0% highly unsuitable. The evaluation ratings by training area are:

- Logistics: 31% highly suitable, 62% suitable, 7% unsuitable, and 0% highly unsuitable.
- Training materials: 33% highly suitable, 65% suitable, 2% unsuitable, and 0% highly unsuitable.
- Trainer education: 47% highly suitable, 45% suitable, 4% unsuitable, 0% highly unsuitable, and 4% with no response.
- General evaluation: 31% highly suitable, 64% suitable, 4% unsuitable, and 1% highly unsuitable.

Upon completion of the ambassadors' training and prior to commencing the awareness sessions, the 25 ambassadors were divided into two groups to enhance facilitation and ensure effective program delivery. Six ambassadors were designated to arrange and organize the sessions, as well as prepare all necessary documents. These six ambassadors were registered with the AEE and managed the awareness sessions as representative members of the AEE team. The remaining 19 ambassadors conducted the awareness sessions directly and were responsible for delivering session materials to the communities.

Awareness sessions were closely organized with members of the local village councils that comprise the Rommaneh village cluster. Sixty-two awareness-raising sessions on clean energy solutions and energy efficiency practices across five communities were conducted.

The awareness sessions reached approximately 392 community members, with 92% of attendees being females. It is noteworthy that the sessions specifically targeted households within the jurisdiction area of the Rommaneh village cluster, encompassing the LGUs of Al-Taybeh, Seilat Al Harthiyeh, Ti'inik, Zububa, and Rommaneh village councils. This strategic focus aimed to engage household heads, who hold significant influence over household practices, thereby facilitating the adoption of more energy-efficient and environmentally friendly behaviors. As a result, the majority of the session participants were female adults.

During these sessions, a total of 2,400 LED lamps were distributed to participants in the awareness sessions to facilitate awareness and adoption of green energy practices by the communities; the quantities of LED units distributed are show in Table 1.

Participant Feedback and Energy Consumption Data

The results of the community awareness campaigns were assessed through participant feedback and energy consumption data, providing insights into the effectiveness and impact of the initiatives:

- *Participant engagement*: Approximately 392 community members participated, with a strong representation of females (92%).
- *Knowledge acquisition*: High levels of awareness and understanding was gained in RE technologies, EE practices, and the benefits of LEDs.

Table 1.
Community awareness sessions organized, and LED units distributed.

Village Council	# of awareness sessions	Total # of participants disaggregated by sex		Total # of participants disaggregated by group & sex				Total # of LED units distributed
				Adults		Youth		
		F	M	F	M	F	M	
Al-Taybeh	11	52	6	40	5	12	1	400
Ti'inik	9	56	5	50	5	6	0	404
Seilat Al Harthiyeh	20	116	10	96	9	20	1	760
Zububa	11	53	7	48	7	5	0	436
Rommaneh	11	82	5	70	4	12	1	400
Total	62	359	33	304	30	55	3	2400

- *Behavioral change*: Participants expressed enthusiasm (99.7%) for integrating energy-saving measures into their households.

- *Energy consumption*: Initial data suggest potential reductions in energy use because of campaign activities.

Financial Prize for the Top Energy Savers

Participants indicated that the sessions were beneficial in familiarizing them with various energy saving concepts that can be easily incorporated into daily activities and practices. They gained insights into the significance of solar photovoltaic systems for household energy efficiency, learned about different types of LED lighting, and received guidance on purchasing and selecting energy-saving equipment.

Following these sessions, 312 of the 392 participants either owned electricity subscriptions or attended as representatives of these subscriptions. Among these 312 participants, about 60 will be selected to receive a financial prize as the top energy savers among the awareness session attendees. This prize will be directly granted to the LGU where the winners are registered and will be used to pay for their electricity bills.

This competition also serves as an evaluation tool to assess and monitor the effectiveness of the awareness sessions, measuring the extent to which attendees' knowledge increased following their participation.

DISCUSSION

The energy ambassador training program highlights the importance of female engineers in driving community-based initiatives and challenging societal norms. This program explored how grassroots campaigns can effectively promote sustainable energy practices, enhance gender equality in technical fields, and empower communities to adopt environmentally friendly behaviors. Comprehensive training and equipping ambassadors with essential skills enables them to effectively engage and educate community members.

The program's collaborative approach included partnering with MoLG, EQA, AEE, and CWEEL. It underscored the importance of multi-sectoral partnerships in achieving local sustainable development goals. Challenges such as cultural barriers and logistical complexities are also addressed, with recommendations for future initiatives to further strengthen community involvement and sustainability efforts. This integrated approach advances knowledge in RE and EE and sets a precedent for similar initiatives worldwide. The energy ambassador program emphasized the transformative impacts of gender-inclusive and community-driven energy projects.

CONCLUSIONS

This research examined the multifaceted challenges and potential solutions concerning energy in Palestine and developing countries, emphasizing the critical roles of renewable energy, energy efficiency, community engagement, gender inclusivity, and overcoming barriers to female participation in engineering. The findings underscore the urgent need for integrated approaches that prioritize sustainable energy transitions through supportive policies, investments in renewable energy infrastructure, and inclusive strategies.

Palestine, like many developing nations, faces challenging hurdles in energy supply and infrastructure development exacerbated by geopolitical complexities [1]. The region's dependence on imported fossil fuels and unreliable electricity grids underscores the pressing demand for sustainable energy solutions [2]. Leveraging abundant solar and

wind resources present opportunities to enhance energy security, reduce greenhouse gas emissions, and stimulate economic growth [2].

Energy efficiency emerges as a crucial lever for addressing energy challenges across buildings, industries, and transportation sectors [3]. Implementing energy efficiency measures not only reduced energy consumption and costs but also mitigated environmental impacts and contributed to sustainable development goals.

Community engagement proves pivotal for the successful implementation of energy projects in developing countries [4]. Initiatives that involve local communities in decision-making and project implementation, such as those observed in rural Palestine, demonstrate the potential to foster sustainable energy practices and empower local stakeholders [5].

The intersection of gender and energy is important for achieving sustainable development goals. The active involvement of women in energy access, management, and conservation at the household level is vital for promoting inclusive and effective energy policies and projects [6]. However, persistent barriers to female participation in engineering, such as gender stereotypes and limited access to education and training, underscore the need for targeted interventions to promote gender diversity in the energy sector [8,9].

Successful case studies highlight the transformative impact of female-led energy initiatives, such as the Solar Sister program in Africa, which empowers women entrepreneurs to deliver clean energy solutions and promote economic empowerment [10,11]. These initiatives improve energy access and contribute to improved health outcomes and environmental sustainability in local communities.

Addressing energy challenges in Palestine and other developing countries requires holistic approaches that integrate renewable energy deployment, energy efficiency improvements, community engagement, and gender equality. By prioritizing supportive policies and investments in renewable energy infrastructure while overcoming barriers to female participation in engineering, sustainable energy transitions can be achieved. Future research should continue to explore innovative solutions and scale successful models to accelerate progress towards global sustainable development goals.

RECOMMENDATIONS

The following recommendations provide actionable steps to address energy challenges in Palestine and developing countries. They emphasize policy support for renewable energy incentives, increased investment in infrastructure, promotion of energy efficiency, community engagement in decisionmaking, gender inclusivity in energy sectors, capacity building through education, and fostering international cooperation and knowledge sharing. These actions are crucial for achieving sustainable energy solutions and promoting inclusive economic growth. Our key recommendations are:

- Develop and implement supportive policies and regulatory frameworks to incentivize renewable energy investments, including feed-in tariffs and tax incentives.
- Increase investment in renewable energy infrastructure, leveraging solar, wind, and other resources through international collaboration and financing mechanisms.
- Empower local communities through capacity building and participation in decision-making processes for sustainable energy projects to ensure acceptance and sustainability.
- Promote energy efficiency across sectors with awareness campaigns, subsidies for energy-efficient technologies, and mandatory standards for new constructions and appliances.
- Integrate gender-sensitive approaches into energy policies and projects to enhance women's participation in the energy sector through training, mentorship, and support for women-led enterprises.

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