

Impacts of Kenya's Infrastructural Development occasioned by U.S Energy Technology Transfer

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Recommended Reference: Ogutu, N. O., Okoth, P. G., & Odhiambo, E. O. S. (2026). Impacts of Kenya's infrastructural development occasioned by U.S. energy technology transfer. *African Quarterly Social Science Review*, 3(4), 601–617. <https://doi.org/10.51867/AQSSR.3.4.48>

ABSTRACT

The impact of the transfer of U.S. energy technology to Kenya's infrastructural development was analyzed in six dimensions with regard to renewable energy capacity, employment creation, technical skills development, infrastructure modernization, environmental sustainability and green diplomacy alignment and innovation promotion. The study was guided by modernization theory. Conducted in a mixed-method descriptive research design, the study was based on 362 respondents through Cochran's formula. The target population included the government ministers of Kenya, energy sector players, international institutions, USA ambassador to Kenya, USTDA, USAID, judiciary, security officers, university academicians and civil society. Questionnaires were adopted and the key informant interviews were done quantitatively and qualitatively using descriptive statistics and thematic analysis. The results showed that a complete majority of the people had positive attitudes in economic and technical areas: renewable energy capacity (79.3%), employment creation (85.2%), technical skills development (84.5%), infrastructure modernization (74.8%), and innovation promotion (80.3%). More importantly, 81% of those surveyed were sceptical about environmental sustainability and Kenya's green diplomacy agenda. This paradox is the main point of the study, and shows the tension between tangible economic gains and the ecological costs of technology transfer. The study proves that in reality the success of technology transfer cannot be measured purely on financial grounds; environmental sustainability, local adaptation, and strategic fit are also key factors. Recommendations include further strengthening local content requirements in terms of environmental safeguards, ownership of research agendas, and leveraging Kenya's regional leadership to negotiate terms that prioritize developmental goals and environmental stewardship in technology transfer terms.

Keywords: energy transfer, technology, infrastructural development, diplomacy

I. INTRODUCTION

The transfer of energy technology is critical to the development of the economy in the Global South, where access to advanced energy technologies can lead to industrial growth and sustainability. Both the acquisition and dissemination of energy technologies drive productivity and energy security. Amuhaya and Degterev (2019) have noted that modern energy technologies are developed mainly by the Global North countries (especially in the OECD), leading to the production of modern energy technologies. As a consequence, many Global South nations are dependent on imported energy technologies for the development of their technology and to meet development needs. In the meantime, as Dolan and Clark (2020) point out, the development of renewable energy, energy storage, and efficiency technologies is highest in these technologically driven countries (especially in those developed nations), and these technologies influence global energy transitions. In order to advance and accelerate the process of energy technology transfer, the Global South countries are adopting domestic policies and international agreements to modernize the energy infrastructure, promote sustainable development, and reduce socio-economic disparities (Dolan & Clark, 2020).

The transfer of energy technology from the Global North to Africa has transformed the development of the economy, the sustainability of the energy sector, and energy security (UNDP, 2000). The transfer is done through national development agencies, private companies, and bilateral aid agreements. Energy technology transfer is mainly in renewable energy, electrification, and energy efficiency. For instance, through the U.S. Power Africa program, an increase in electricity access can be achieved in the world by funding solar, wind, and hydroelectric power (USAID, 2020). European-led projects have also helped build off-grid energy solutions and smart-grid technologies to increase energy access in rural communities in Africa. These improvements contribute to the development of the economy, jobs, and quality of life for millions of people (African Union Development Agency-NEPAD [AUDA-NEPAD], 2024).

Beyond technology transfer, financial aid from the Global North has supported critical energy infrastructure projects, including power grids, sustainable energy programs, and clean cooking solutions (South African Institute of International Affairs, 2024). Bilateral aid from the United States and the European Union has funded large-scale renewable energy projects, promoting Africa's transition to a low-carbon economy. Additionally, organizations such as the African Development Bank (AfDB) and the World Bank have facilitated public-private partnerships to scale up energy investments, particularly in sub-Saharan Africa, where energy access remains a significant challenge (AUDA-NEPAD, 2024). However, despite these contributions, several challenges hinder the effectiveness of energy technology transfer.

In the Global South, Kenya has positioned herself as a significant and strategic partner in energy technology transfer and foreign investment in Africa (Iannantuoni, 2025). This exemplifies itself through the Kenya-America partnership in renewable energy development. Through initiatives like Power Africa, the U.S. has played a significant role in expanding Kenya's energy sector, particularly in geothermal and off-grid solar power. American firms and agencies have provided technology, expertise, and funding to enhance Kenya's energy infrastructure, boosting electricity access and promoting economic growth (AUDA-NEPAD, 2024; USAID, 2020). However, like other Global North-African partnerships, challenges remain, including concerns over financing models, technology dependence, and the equitable distribution of benefits (Amuhaya & Degterev, 2019). Therefore, the aim of this study was to assess the impacts of Kenya's infrastructural development occasioned by U.S energy technology transfer.

1.1 Problem statement

Kenya's progress on the development path and its energy sector is a paradox that deserves serious research. Despite decades of foreign aid and energy technology transfer cooperation with developed countries (the US, the UK, etc.), the country still faces a set of key development challenges that these interventions are supposed to solve. This is particularly obvious by simply being located in Nairobi, the economic capital of Kenya and the center of foreign aid coordination, where the disconnect between development rhetoric and reality has never been more acute. Kenya has experienced remarkable growth in energy infrastructure and service delivery, but the ways energy technology transfer interventions are successful and sustainable have not been recognized and understood (Rotich et al., 2024). This knowledge gap has serious implications: without empirical evaluation, foreign energy assistance programs may only reinforce these cycles of dependency and make them more likely to be a time-loop of self-reinforcing development rather than a sustainable system. More importantly for this study, the researchers found that "short-term project achievements seldom translated into anticipated longer-term changes due to the inadequacy of the underlying Theory of Change, revealing oversimplified and overly optimistic assumptions about how project activities would impact the reality on the ground" (Lazell & Petrikova, 2024). This is directly related to the viability question at the heart of the present study: If aid-funded projects fail to produce sustainable outcomes even when they achieve short-term outputs, then the entire model of technology transfer as development needs systematic re-evaluation.

1.2 Objective

The objective of the study was to assess the impacts of Kenya's infrastructural development occasioned by U.S energy technology transfer.

LITERATURE REVIEW

2.1 Theoretical Framework

This study was anchored on modernization theory as discussed in the subsequent section.

2.1.1 Modernization Theory

Modernization theory, articulated by Rostow (1960), Parsons (1951), and Huntington (1968), posits that development follows a linear trajectory from traditional to modern societies through technological adoption, institutional transformation, and economic growth. The theory's core tenets emphasize that technology transfer, capital inflows, and knowledge sharing from industrialized nations serve as catalysts for developing countries to progress through sequential stages toward high mass consumption. Rostow's stages of growth model specifically identify foreign aid and technological diffusion as essential drivers for achieving "takeoff" into sustained development.

Applying this framework to Kenya's infrastructural development through U.S. energy technology transfer reveals that modernization theory provides a lens for assessing how external technological assistance facilitates energy sector transformation. The theory suggests that adopting advanced U.S. energy technologies—such as renewable energy systems, grid modernization, and energy efficiency innovations—can accelerate Kenya's transition from traditional

energy dependence toward modern, sustainable energy infrastructure. Proponents argue that technological transfer fosters productivity gains, industrial growth, and improved living standards, aligning with Kenya's development aspirations.

However, the theory's ethnocentric assumptions and linear progression model face criticism for overlooking contextual complexities, power imbalances, and potential dependency creation. Despite these limitations, modernization theory remains relevant for evaluating how U.S. energy technology transfer contributes to Kenya's infrastructural modernization, emphasizing the transformative potential of technological adoption while necessitating attention to local adaptation, institutional capacity building, and sustainable implementation frameworks.

2.2 Empirical Review

The transfer of energy technology has been a subject of extensive scholarly debate and research (Dunning, 2002). Energy technology transfer refers to the movement of knowledge, skills, and innovations related to energy production, distribution, and efficiency from one entity to another, often across national borders. It plays a pivotal role in advancing economic development, promoting sustainability, and enhancing industrial capabilities, particularly in Global South economies. Despite its recognized importance, gaps remain in understanding the full impact of energy technology transfer, particularly concerning local adaptation and implementation challenges.

Bazilian et al. (2013) emphasize that technology transfer in renewable energy plays a vital role in bridging the technological gap in developing countries. In Kenya, adoption of U.S.-backed smart-grid systems and solar PV technologies has improved reliability and expanded access to marginalized regions. Gallagher (2014) similarly notes that successful technology transfer requires not just hardware but also development of local absorptive capacity—an area where U.S. programs have made notable contributions through training and institutional partnerships. Ockwell and Byrne (2016) warn that technology transfer, if poorly adapted, risks creating dependency rather than empowering local innovation.

The International Renewable Energy Agency (IRENA, 2021) estimates that renewable energy projects create up to 30% more jobs per unit of electricity generated compared to fossil fuels, largely due to their decentralized nature. In Kenya, U.S.-funded projects have particularly contributed to employment in solar and geothermal industries, where technical expertise and on-the-ground labor are critical.

Beyond direct jobs, U.S. energy projects stimulate indirect employment through improved energy access enabling SME growth, particularly in rural areas. Karekezi et al. (2012) argue that access to reliable electricity reduces business costs and opens opportunities in agro-processing, digital services, and manufacturing. The World Bank (2021) highlights that electrification projects in Sub-Saharan Africa have been linked to increased employment opportunities for women and youth by enabling microenterprises.

The USAID and USTDA have sponsored short courses and exchange programs allowing Kenyan professionals exposure to cutting-edge energy technologies (USTDA, 2021). Such initiatives complement direct project support by equipping Kenyans with skills to sustain and expand renewable energy systems. The International Labour Organization (ILO, 2019) highlights Kenya as an emerging hub for renewable energy expertise in Africa, partly due to international technology partnerships.

As Ockwell and Mallet (2013) emphasize, building local innovation systems is critical for ensuring that technology transfer becomes a driver of self-reliant development. Power Africa has mobilized financing and technical assistance for projects expanding electricity access to millions of Kenyans (Power Africa, 2020). Investments in solar mini-grids, wind farms, and geothermal plants have directly increased Kenya's generation capacity while diversifying the energy mix. The USTDA has sponsored feasibility studies for upgrading transmission infrastructure, enabling integration of renewable power (USTDA, 2019).

Eberhard and Godinho (2017) argue that international partnerships have been crucial in overcoming Africa's power deficits by providing financing, technology, and governance support. The African Development Bank (AfDB, 2018) highlights Kenya as a renewable energy hub in Sub-Saharan Africa due to international technology transfers and donor-backed investments.

RESEARCH METHODOLOGY

3.1 Research Design

This research adopted descriptive research design with a mixed-methods approach spanning Kenya's post-independence period from 1963 to the present, thereby capturing the full historical trajectory of U.S.-Kenya energy technology transfer relations. The study was conducted in Nairobi County, Kenya. Nairobi hosts the regional headquarters of major U.S. energy technology firms that have no physical presence elsewhere in Kenya. General Electric (GE) operates its East Africa Power & Grid division from Nairobi's Westlands district, managing technology transfer

contracts for geothermal and wind projects across the country (GE, 2022). Powerhive, a U.S.-based minigrid developer, launched its Kenyan operations in Nairobi before deploying peripheral projects. Renewvia Energy's Kenyan subsidiary is registered and managed from Nairobi. This concentration means that decisions regarding technology selection, transfer modalities, training programmes, and partnership agreements are all made within Nairobi County, rendering the capital the actual site of transfer governance even when physical infrastructure is located elsewhere.

3.2 Study area

Kenya is situated in the eastern region of Africa. It shares borders with Sudan and South Sudan in the northwest, Ethiopia in the north, Somalia in the northeast, the Indian Ocean in the east, Tanzania in the south, and Uganda in the west. It is located on the equator at a longitude of 40 degrees East of the prime meridian and comprises 582,650 square kilometers (Keskinen, 2007). The researcher's targeted institutions/projects are primarily situated in Nairobi County, where they serve as the project's pioneer implementation sites. Thousands of miles separate the United States from Europe.

Nairobi is Kenya's capital and biggest city. The name "Nairobi" is derived from the Maasai word "Enkare Nairobi," meaning "place of cool waters." This refers to the presence of the Nairobi River that runs through the city. According to the 2019 census, the city itself has a population of 4,397,073, while the surrounding metropolitan region has a population of 9,354,580 (KNBS, 2019).

Nairobi hosts the regional headquarters of major U.S. energy technology firms that have no physical presence elsewhere in Kenya. General Electric (GE) operates its East Africa Power & Grid division from Nairobi's Westlands district, managing technology transfer contracts for geothermal and wind projects across the country (GE, 2022). Powerhive, a U.S.-based minigrid developer, launched its Kenyan operations in Nairobi before deploying peripheral projects. Renewvia Energy's Kenyan subsidiary is registered and managed from Nairobi.

3.3 Target Population

As Mugenda and Mugenda (1999) describe it, population is a group of people, events and things that are indicative of the same characteristics. The research sample was divided into two groups: Kenyan-side respondents and United States-side respondents. This split was required because the attractiveness of energy technology transfer assistance can't be judged from an individual point of view. It should be looked at in both a national and international perspective. Specifically, the study looked at the way in which aid is structured and conditionalized by the donor and how it is delivered, absorbed and maintained by the recipient. In the first group of respondents who were chosen based on their knowledge in the field of energy technology transfer, foreign aid management, and international economic relations in Kenya. These respondents comprised state corporations, regulatory agencies, investment promotion organizations, industry groups, the judiciary and private energy companies in Nairobi County. The rationale behind the selection of these institutions was that they had a formal mandate on different aspects of the energy technology transfer process.

From the Ministry of Energy, four senior managers were selected and recruited from the four major agencies involved in energy policy, renewable energy development, and energy infrastructure development. They were asked to shed light on how U.S. energy technologies are selected, procured, integrated into national grid plans and monitored over the course of time. The Ministry of Agriculture had four senior managers in agricultural-energy integration including bioenergy schemes and sustainable farming technologies that depend on U.S.-supplied irrigation equipment and power generation equipment. The inclusion of the Ministry of Agriculture was justified by the empirical relationship between energy technologies and agricultural productivity, particularly in the areas where U.S. aid has funded solar-powered irrigation and biomass energy systems that directly contribute to the development of rural and peri-urban areas in Nairobi. Senior officers from the Economic Section and the Energy and Environment Office at the U.S. Embassy in Nairobi were targeted. They were to negotiate bilateral energy agreements, monitor U.S. energy projects and report back to Washington on the success of technology transfer programs. They also collected internal evaluations not publicly available and reported on how aid conditionalities have changed from 1963 to 2025 with different presidents.

3.4 Sampling and Sample Size

Purposive sampling is optimal for this research as it allows the researcher to choose such people or organizations to be chosen if they are knowledgeable, experienced, and relevant to the research. In this case, key informants (e.g., officials from ministries of government, diplomats, project managers of US-based energy companies, regulatory officers) are targeted and as such they are ideally equipped to draw up detailed and relevant information on the processes and challenges of energy technology transfer and foreign aid. Since the purpose of this study is to understand policy dynamics, institutional structures and implementation processes, the participants must be experts and the data collected are therefore credible and contextually grounded.

Stratified random sampling is used for groups in larger institutions, such as employees of energy companies (KenGen, KPLC, GDC) or academic researchers and civil society members involved in energy-related activities. The populations in these cases are distributed and may include various departments, roles or levels of involvement. By dividing the population into groups or subgroups and then randomly selecting members from each group, the researcher ensures that all relevant points of view are represented. This methodology makes the sample more representative on an overall level and avoids sampling bias (even when the report is only based on perceptions and efficiency but not viability). The study chose respondents from both national contexts and aimed to examine the full aid chain from Washington policy making to Nairobi implementation.

The first category of respondents was key informants based on their vast knowledge of energy technology transfer, foreign aid management and international economic relations in Kenya. These respondents were drawn from state corporations, regulatory agencies, investment promotion bodies, industry associations, the judiciary, and private energy firms in Nairobi County. The second category of respondents included the United States-side and were important because they were needed to understand the donor perspective on aid conditionalities, technology transfer and the criteria for assessing the viability of the project.

The concentration of U.S. foreign aid infrastructure in Nairobi (U.S. Embassy, USAID Kenya, U.S. Trade and Development Agency (USTDA) and Power Africa's Kenya coordination desk) means that Nairobi is the only place available for these respondents. The sample size for this study is calculated by Cochran's formula and is statistically robust for finite and heterogeneous populations. This formula was chosen since it was used to obtain the confidence level (i.e. margin of error) and estimated variability in population. As the target population is diverse from government ministries, parastatals, development agencies and U.S.-funded project beneficiaries, stratified random sampling was used and the sample size for each stratum was calculated according to the group. The sample size was 362 as presented in Table 1. It was obtained using the Cochran's (1977) formula.

Table 1
Sample Size Distribution

Stakeholder Category	Sub-Category	Target Population	Sample Size (n)	Sampling Technique
Government Ministries and Agencies	Ministry of Energy	800	40	Purposive Sampling
	Ministry of Agriculture	600	30	Purposive Sampling
	Ministry of Foreign Affairs & International Trade	450	22	Purposive Sampling
	National Treasury	350	18	Purposive Sampling
	National Environment Management Authority (NEMA)	350	18	Purposive Sampling
	Kenya National Bureau of Statistics	240	12	Purposive Sampling
	Kenya Investment Authority	540	27	Purposive Sampling
Energy Sector Stakeholders	Kenya Power and Lighting Company (KPLC)	600	30	Stratified Random Sampling
	KenGen	450	22	Stratified Random Sampling
	Geothermal Development Company (GDC)	450	22	Stratified Random Sampling
	United States-affiliated Firms (GE, Tesla, Powerhive)	720	36	Stratified Random Sampling
Foreign Diplomats & International Agencies	United States Embassy / USAID / USTDA / Power Africa Officials	450	22	Purposive Sampling
	Global Energy Diplomacy Experts	280	14	Purposive Sampling
Academia & Researchers	University Researchers (Energy Policy) – University of Nairobi, Kenyatta University, Strathmore University	500	25	Stratified Random Sampling
Civil Society	Renewable Energy NGOs & Think Tanks – Kenya Climate Change Working Group, Institute for Law and Environmental Governance, Africa Centre for Energy Policy (Nairobi office)	620	29	Purposive Sampling
Total		7,200	362	

Source: Researcher 2024

3.5 Data Collection Instruments and Procedures

The study adopted both primary including questionnaire, interview schedules and secondary data. The questionnaire was administered to 330 respondents across categories where the study sought measurable, comparable data on the operationalized viability indicators—specifically, operational continuity (percentage of designed energy output maintained), financial sustainability (local budget allocation for maintenance), and capacity retention (proportion of trained personnel remaining in sector employment). Questionnaire respondents were selected from categories with sufficiently large target populations to justify statistical treatment and where individual respondents within a category could reasonably be expected to hold similar types of information.

Within the Ministry of Energy, 40 respondents received questionnaires covering the frequency of U.S. technology breakdowns, availability of spare parts from local suppliers, and the number of Kenyan technicians trained but subsequently departed from U.S.-funded projects. The Ministry of Agriculture contributed 30 questionnaire respondents focused on bioenergy and solar irrigation technologies transferred from the United States. The Ministry of Foreign Affairs and International Trade contributed 22 questionnaire respondents providing data on the documented conditionalities attached to U.S. energy aid agreements since 1963. The National Treasury contributed 18 questionnaire respondents reporting on budget lines for counterpart funding and maintenance expenditures. The National Environment Management Authority contributed 18 questionnaire respondents documenting environmental compliance records of U.S.-funded energy projects. The Kenya National Bureau of Statistics contributed 12 questionnaire respondents providing secondary data on energy sector employment and technology adoption rates. The Kenya Investment Authority contributed 27 questionnaire respondents recording the terms of investment agreements signed between the Kenyan government and U.S. energy firms.

Kenya Power and Lighting Company contributed 30 questionnaire respondents reporting on grid integration challenges, frequency of outages linked to U.S.-supplied equipment, and maintenance costs borne by the utility. KenGen contributed 22 questionnaire respondents providing data on generation capacity contributed by U.S.-transferred technologies and the proportion of revenue allocated to servicing U.S.-sourced equipment. The Geothermal Development Company contributed 22 questionnaire respondents documenting the performance of U.S.-supplied drilling and monitoring technologies. United States-affiliated firms (General Electric, Tesla, Powerhive) contributed 36 questionnaire respondents, comprising project managers and technical leads who reported on training delivery, technology adaptation to Kenyan conditions, and post-installation support provided.

The researcher and key informants were engaged in verbal and telephonic communication during the interviews. The interview was conducted in the manner of a semi-structured focus interview, in which the interviewer maintained a high level of control over the interview while allowing the interviewee's opinions to arise as they respond to the questions (Saunders *et al.*, 2021). The structured queries were developed to guarantee the reliability and certainty of the responses obtained from the interviews.

The remaining 32 respondents from the total sample of 362 were designated for semi-structured key informant interviews rather than questionnaires. This decision was based on the recognition that certain categories of respondents possess unique, non-standardizable institutional knowledge that cannot be captured through closed-ended questionnaire items. Key informant interviews allowed for in-depth exploration of causal mechanisms, historical decision-making processes, and sensitive information that respondents would be unwilling to commit to written questionnaires.

3.6 Data Analysis

The data obtained from surveys and interviews was systematically arranged and categorized based on the precise research objectives and questions. According to Kothari (2011), coding involves the assignment of numerical or symbolic representations to replies in order to categorize them into a limited number of classes. This study adopted descriptive statistics. Descriptive statistics, a type of quantitative data analysis, is used to describe or present data in an easily accessible, quantitative form (Mohajan, 2018). Qualitative data was collected through face-to-face interviews. Participants and sites were identified based on people that could best assist with understanding the central phenomenon of viability of energy technology transfer and granting of foreign aid by the US to Kenya. During the empirical study, the researcher made descriptive and reflective notes based on the interviews.

3.7 Ethical Considerations

The researcher adhered to rigorous ethical guidelines that govern research. The study guaranteed the confidentiality and privacy of individuals and organizations engaged. Any information obtained during the research was not disclosed to any third parties, regardless of the circumstances. The study commenced only upon getting authorization and consent from relevant parties and authorized authorities. To receive authorization, a letter was acquired from the Directorate Postgraduate Studies of Masinde Muliro University of Science and Technology. The purpose of this letter is to request a research permission and authorization from the National Commission of Science and Technology and Innovation (NACOSTI) before beginning the study. The researcher approached the County

Commissioners and the Director of Education to obtain their consent, as mandated by NACOSTI. Prior to commencing the research, the study's objectives and interview methods were communicated and clarified to the participants. This served to reinforce the information provided in the request letter that accompanies each questionnaire and key informant interview guide. The individuals being interviewed, providing information, and responding to the research was approached with politeness and respect

FINDINGS AND DISCUSSION

4.1 Renewable Energy Capacity Enhancement

The study assessed whether U.S. energy technologies have impacted Kenya's capacity for clean and renewable energy development. Findings revealed that 79.3% of respondents (75.8% agreed, 3.5% strongly agreed) affirmed the positive impact, while 18.1% disagreed and 2.6% remained neutral.

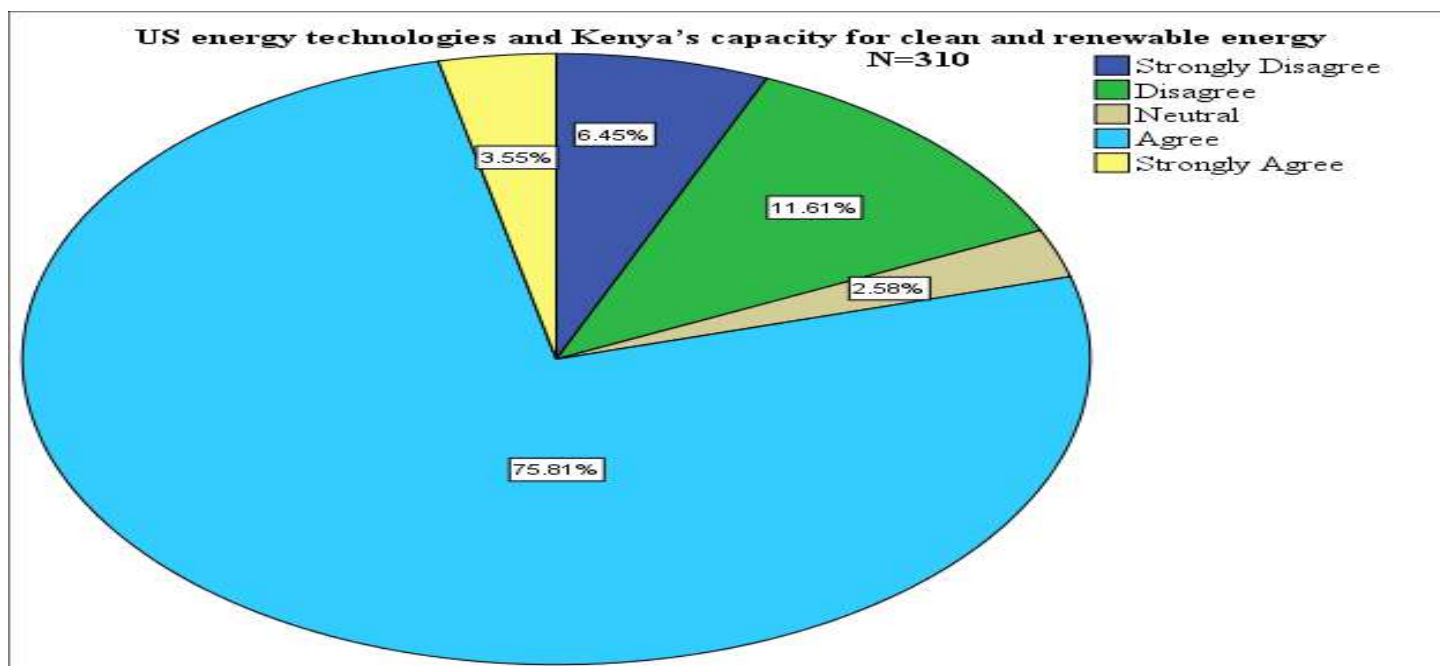


Figure 1

U.S. Energy Technologies and Kenya's Capacity for Clean and Renewable Energy

Source: Field Data (2024)

The overwhelming agreement reflects visible improvements in Kenya's energy landscape. Kenya has long been recognized as a leader in renewable energy in Africa, with geothermal, wind, and solar constituting over 70% of its electricity generation mix (World Bank, 2020). U.S. assistance has accelerated this trajectory through access to advanced technologies, financing mechanisms, and technical expertise. The Lake Turkana Wind Power Project, one of Africa's largest, received U.S.-linked financing and expertise, while USAID's Power Africa initiative has expanded solar mini-grids in underserved counties (USAID, 2021).

Qualitative data corroborated these findings. A senior energy official explained:

"The U.S. has been instrumental in our geothermal expansion. Through technical assistance from USTDA and partnerships with American firms, we've been able to tap into resources that were previously beyond our technical reach. The Menengai Geothermal Project, for instance, benefited significantly from U.S. drilling expertise." (KII with Energy Official, Nairobi, 15.10.2025)

A renewable energy consultant further elaborated:

"What the U.S. brought was not just money but cutting-edge technology. The smart-grid systems we're now deploying in rural areas are based on American innovations that have been adapted to our context. This has improved reliability and reduced transmission losses significantly." (KII with Energy Consultant, Nairobi, 18.10.2025)

The strong consensus aligns with scholarly evidence. Bazilian et al. (2013) emphasize that technology transfer in renewable energy plays a vital role in bridging the technological gap in developing countries. In Kenya, adoption of U.S.-backed smart-grid systems and solar PV technologies has improved reliability and expanded access to marginalized regions. Gallagher (2014) similarly notes that successful technology transfer requires not just hardware but also development of local absorptive capacity—an area where U.S. programs have made notable contributions through training and institutional partnerships.

The 18.1% disagreement reflects challenges identified in previous chapters—conditionalities, limited adaptability to Kenya's socio-economic context, and uneven distribution of benefits. Some U.S. technologies have been criticized for being ill-suited to local realities due to cost, maintenance requirements, or incompatibility with local supply chains. Ockwell and Byrne (2016) warn that technology transfer, if poorly adapted, risks creating dependency rather than empowering local innovation. A policy analyst captured this tension:

"While we appreciate the technology, some of the systems require specialized parts and expertise that aren't available locally. When something breaks, we're dependent on foreign technicians. That's not sustainable development—that's dependency." (KII with Policy Analyst, Nairobi, 20.10.2025)

The findings demonstrate that while U.S. transfers have undeniably enhanced Kenya's renewable energy capacity, challenges of adaptability and sustainability persist. Kenya must leverage these transfers not only as developmental tools but also as catalysts for self-reliance and regional leadership in renewable energy.

4.2 Employment Creation

The study assessed whether U.S.-funded energy projects have created employment opportunities in Kenya. Findings revealed that 85.2% of respondents (75.2% agreed, 10% strongly agreed) affirmed job creation, while 12.3% disagreed and 2.6% remained neutral.

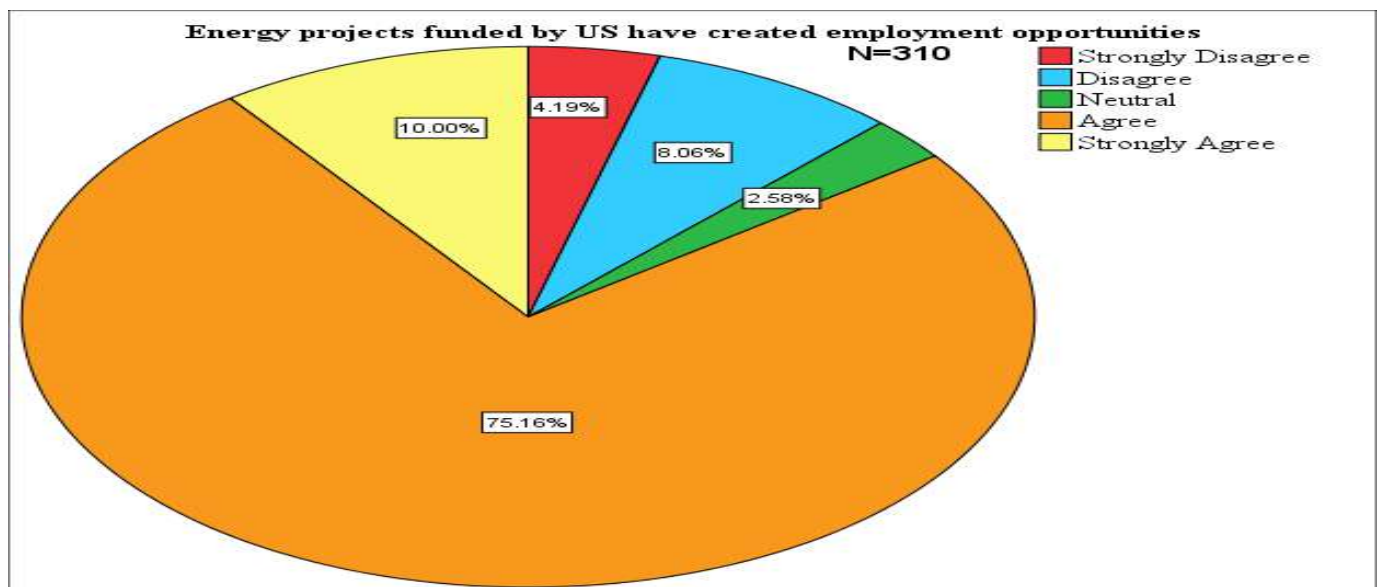


Figure 2

Energy Projects Funded by U.S. Have Created Employment Opportunities

Source: Field Data 2025

The overwhelming consensus demonstrates that U.S.-supported energy projects have been significant contributors to job creation, both directly in the energy sector and indirectly through broader economic spillovers. Employment is a key metric for evaluating the socio-economic impact of foreign aid and technology transfer. According to UNDP (2017), energy access and infrastructure projects are among the most employment-intensive sectors in developing economies, particularly during construction and installation phases.

Qualitative data provided rich insights into employment impacts. A project manager with an off-grid solar company explained:

"When we received funding through Power Africa, we were able to expand our operations from two to fifteen counties. That meant hiring over 200 local technicians, sales agents, and customer service staff. These are permanent

jobs, not just casual labor. People can now support their families." (KII with Solar Company Manager, Nairobi, 22.10.2025)

A community leader from a rural electrification project area added:

"Before the solar mini-grid came, our young people had nothing to do. Now, many of them work as technicians maintaining the system, or they've started small businesses powered by reliable electricity—welding shops, phone-charging kiosks, even a small cold storage facility for farmers. The jobs have transformed our community." (FGD with Community Leader, Kisumu County, 25.10.2025)

The International Renewable Energy Agency (IRENA, 2021) estimates that renewable energy projects create up to 30% more jobs per unit of electricity generated compared to fossil fuels, largely due to their decentralized nature. In Kenya, U.S.-funded projects have particularly contributed to employment in solar and geothermal industries, where technical expertise and on-the-ground labor are critical.

Beyond direct jobs, U.S. energy projects stimulate indirect employment through improved energy access enabling SME growth, particularly in rural areas. Karekezi *et al.* (2012) argue that access to reliable electricity reduces business costs and opens opportunities in agro-processing, digital services, and manufacturing. The World Bank (2021) highlights that electrification projects in Sub-Saharan Africa have been linked to increased employment opportunities for women and youth by enabling microenterprises.

Despite strong consensus, 12.3% disagreement reflects concerns about sustainability and inclusivity. Sovacool (2013) notes that renewable energy projects often produce "boom-and-bust" employment patterns, with most jobs concentrated in installation rather than long-term operations. A labor expert captured these concerns:

"Yes, jobs are created, but many are temporary. Once construction ends, what happens to those workers? We need to be thinking about long-term employment, not just project-based work. Also, most of the skilled jobs go to foreigners or people from Nairobi—local communities often get only the casual work." (KII with Labor Expert, Nairobi, 27.10.2025)

The findings reveal that employment creation is one of the most important development outcomes of U.S. technology transfers. However, ensuring sustainability, inclusivity, and local content requires stronger policies linking foreign aid with national employment strategies.

4.3 Improvement of Local Technical Skills and Knowledge

The study assessed whether local technical skills and knowledge have improved due to energy technology transfer from the United States. Findings revealed that 84.5% of respondents (77.7% agreed, 6.8% strongly agreed) affirmed skills improvement, while 13.2% disagreed and 2.3% remained neutral.

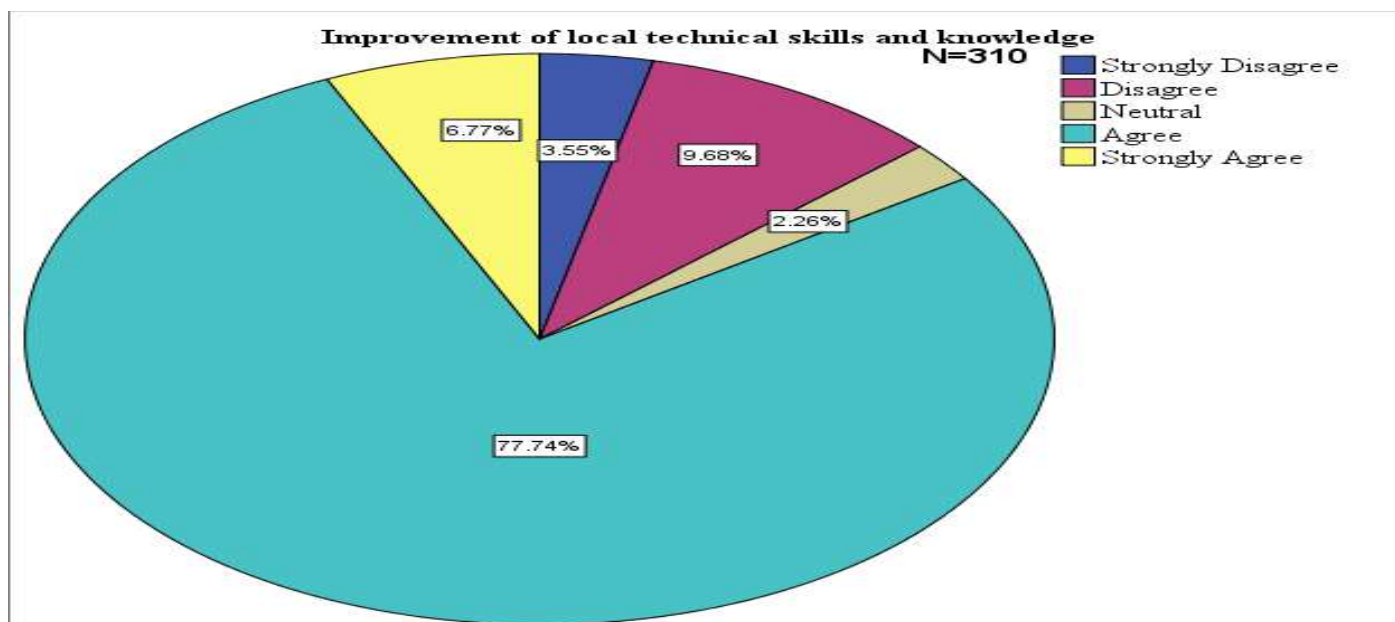


Figure 3

Improvement of Local Technical Skills and Knowledge

Source: Field Data (2025)

Energy technology transfer is not just about delivering hardware but ensuring that recipient countries have the technical know-how to use, adapt, and sustain technologies. Sagar and van der Zwaan (2006) argue that long-term success depends on building local capacity, which enhances absorptive capability and reduces dependency on external expertise.

Qualitative data strongly supported these findings. A training coordinator at Geothermal Development Company explained:

"Our partnership with American geothermal firms has transformed our technical capacity. We've had engineers trained in advanced drilling techniques and reservoir management. Five years ago, we relied entirely on foreign consultants for geothermal exploration. Now, we have a team of Kenyan engineers who can handle these complex tasks independently." (KII with GDC Training Coordinator, Nairobi, 28.10.2025)

A university researcher elaborated:

"Technology transfer without skills transfer is incomplete. What the U.S. has done is ensure that Kenyans are not just consumers of imported systems but also co-creators of technical solutions. Through programs like the Kenya-U.S. University Partnership Initiative, our students have access to world-class research facilities and exchange programs." (KII with University Researcher, Strathmore University, 22.10.2025)

The USAID and USTDA have sponsored short courses and exchange programs allowing Kenyan professionals exposure to cutting-edge energy technologies (USTDA, 2021). Such initiatives complement direct project support by equipping Kenyans with skills to sustain and expand renewable energy systems. The International Labour Organization (ILO, 2019) highlights Kenya as an emerging hub for renewable energy expertise in Africa, partly due to international technology partnerships.

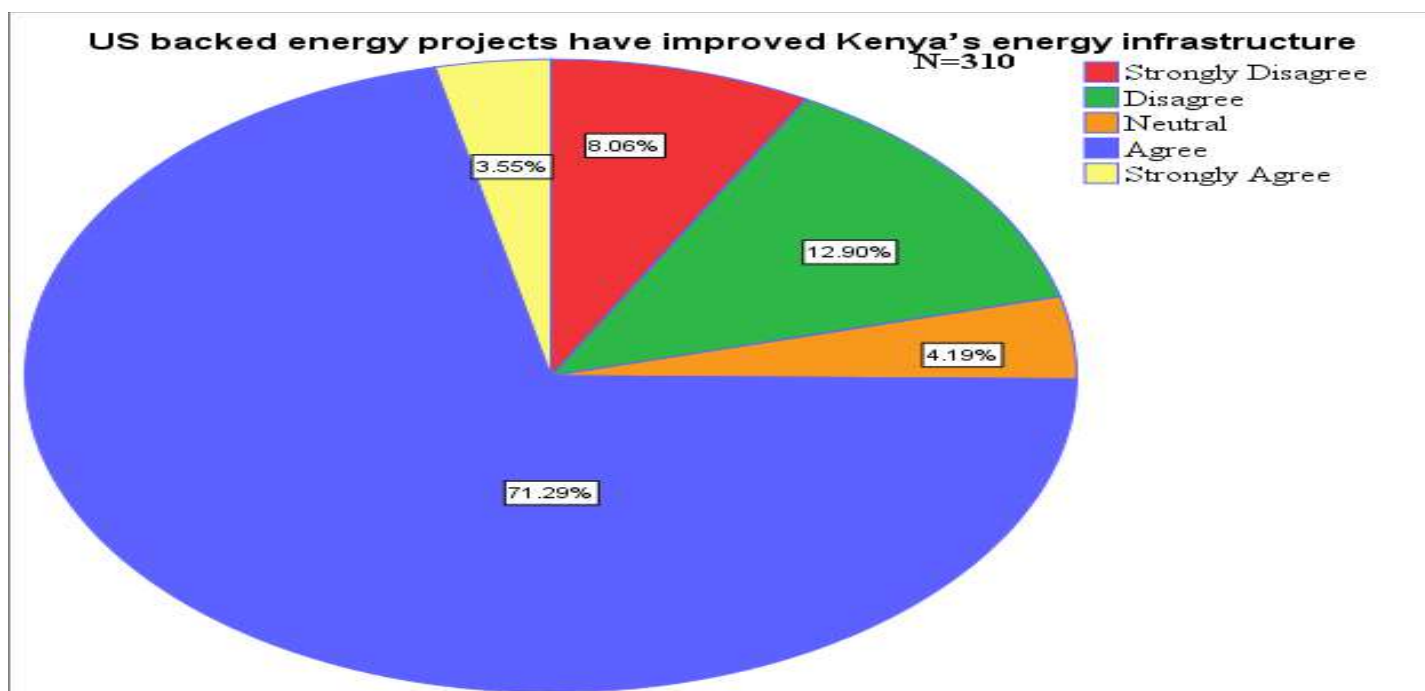
However, 13.2% disagreement reflects challenges in localization. Some U.S. technologies require advanced knowledge that local institutions struggle to absorb. Byrne et al. (2012) caution that without deliberate investment in capacity-building, developing countries risk becoming dependent on external experts. A technical trainer noted:

"We're training people, but the advanced systems still require foreign technicians for major maintenance. The training is often too short, and the equipment is too complex. We need deeper, longer-term programs that really embed knowledge, not just brief workshops." (KII with Technical Trainer, Nakuru, 30.10.2025)

The strengthening of Kenya's technical capacity has ripple effects across development sectors, allowing Kenya to localize renewable energy production and foster homegrown innovation. As Ockwell and Mallet (2013) emphasize, building local innovation systems is critical for ensuring that technology transfer becomes a driver of self-reliant development.

4.4 Energy Infrastructure Modernization

The study examined whether U.S.-backed energy projects have contributed to improvements in Kenya's energy infrastructure. Findings revealed that 74.8% of respondents (71.3% agreed, 3.5% strongly agreed) affirmed infrastructure improvement, while 21% disagreed and 4.2% remained neutral.

**Figure 4**

U.S.-Backed Energy Projects Have Improved Kenya's Energy Infrastructure

Source: Field Data (2025)

Energy infrastructure—comprising generation facilities, transmission networks, and distribution systems—is the backbone of national development. U.S.-backed projects have been instrumental in addressing Kenya's infrastructural bottlenecks, particularly in expanding access, modernizing the grid, and diversifying energy sources. Qualitative data provided compelling evidence. A senior engineer at Kenya Power explained:

"The Lake Turkana Wind Power Project wouldn't have been possible without U.S. financing and technical expertise. It added 310 MW to our grid. Similarly, the U.S.-supported transmission upgrades have allowed us to evacuate power from remote generation sites to load centers. We've gone from frequent blackouts to stable supply in most areas." (KII with Kenya Power Engineer, Nairobi, 02.11.2025).

A rural electrification officer added:

"The off-grid solar projects supported by Power Africa have transformed rural areas. Previously, these communities relied on kerosene lamps or diesel generators. Now they have reliable, clean electricity for lighting, phone charging, and small businesses. This is infrastructure that directly improves people's lives." (KII with Rural Electrification Officer, Isiolo, 05.11.2025)

Respondents' strong consensus can be explained by tangible projects visible across the country. Power Africa has mobilized financing and technical assistance for projects expanding electricity access to millions of Kenyans (Power Africa, 2020). Investments in solar mini-grids, wind farms, and geothermal plants have directly increased Kenya's generation capacity while diversifying the energy mix. The USTDA has sponsored feasibility studies for upgrading transmission infrastructure, enabling integration of renewable power (USTDA, 2019).

Eberhard and Godinho (2017) argue that international partnerships have been crucial in overcoming Africa's power deficits by providing financing, technology, and governance support. The African Development Bank (AfDB, 2018) highlights Kenya as a renewable energy hub in Sub-Saharan Africa due to international technology transfers and donor-backed investments.

The 21% disagreement highlights important caveats. Some large-scale projects face delays, high tariffs, or environmental and social impacts. Sovacool et al. (2016) note that large donor-backed infrastructure often struggles with community acceptance and long-term sustainability. A community representative noted:

"Yes, the wind farm is impressive, but what about the communities around it? Some people lost grazing land, and the compensation was inadequate. The benefits—the electricity—goes to cities, not to us. Infrastructure is not just

about megawatts; it's about people." (FGD with Community Representative, Marsabit, 08.11.2025)

Improved energy infrastructure has produced multiplier effects across Kenya's economy, supporting industrialization, increasing rural electrification, and reducing reliance on costly fossil fuel imports. According to the World Bank (2019), Kenya's energy infrastructure improvements have directly supported economic growth by lowering energy costs and increasing reliability. Additionally, Kenya is now a net exporter of electricity to neighboring countries, enhancing its strategic role in East Africa's energy diplomacy.

4.5 Environmental Sustainability and Green Diplomacy Alignment

The study examined whether transferred technologies are environmentally sustainable and supportive of Kenya's green diplomacy agenda. Findings revealed a stark contrast: 81% of respondents (76.5% disagreed, 4.5% strongly disagreed) expressed skepticism, while only 15.8% agreed and 3.2% remained neutral.

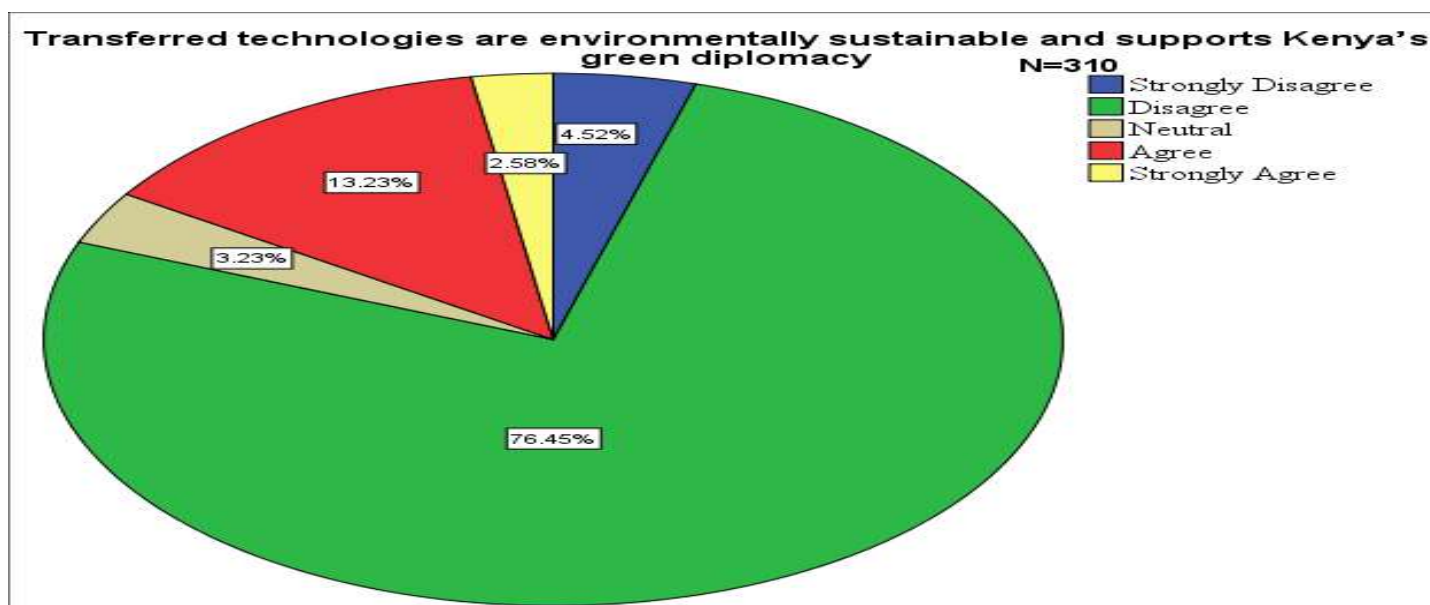


Figure 5

Transferred Technologies Are Environmentally Sustainable and Support Kenya's Green Diplomacy

Source: Field Data (2025)

This finding is significant because it contrasts sharply with other dimensions where respondents expressed overwhelming support. The majority view is that U.S. technologies, though useful in some respects, fall short of supporting Kenya's environmental diplomacy objectives.

Qualitative data revealed deep concerns. An environmental policy expert explained:

"Kenya has positioned itself as a leader in green diplomacy—we're seen as champions of climate justice. But some U.S.-backed projects don't reflect that ambition. The focus seems to be on energy access and investment, not on genuine environmental stewardship. There are projects with questionable environmental records—land degradation, community displacement, inadequate waste management." (KII with Environmental Policy Expert, Nairobi, 10.11.2025)

A community representative from a geothermal project area added:

"They call it renewable, but what about the land? Steam wells require vast areas. The noise, the drilling, the impact on water resources—these aren't discussed. We need energy, yes, but not at the expense of our environment. The U.S. should be helping us do this better, not just faster." (FGD with Community Representative, Nakuru, 12.11.2025)

The skepticism reflects that while U.S.-backed projects include renewable energy investments such as geothermal and solar, they have also supported large-scale infrastructure with environmental risks. Geothermal development, though renewable, is associated with land degradation and localized ecological damage (Kammen et al., 2015). Similarly, solar and wind projects have environmental footprints in terms of land use, waste management of panels, and ecosystem

disruption. Sovacool and Dworkin (2015) caution that renewable energy technologies, if not carefully managed, can create new sustainability challenges.

A climate diplomat elaborated:

"Kenya's green diplomacy is not just about carbon reduction. It's about justice, resilience, and ecological stewardship. Projects that displace communities or degrade sensitive ecosystems undermine these broader goals. The U.S. needs to understand that our green diplomacy is holistic—it includes people and their relationship with the land." (KII with Climate Diplomat, Nairobi, 14.11.2025).

This finding resonates with scholarly critiques. Newell and Phillips (2016) highlight how energy aid sometimes leans toward geopolitical or commercial interests, limiting environmental contribution. Byrne and Toly (2006) argue that technology transfers are often embedded in donor-recipient power asymmetries constraining full integration of environmental concerns. Baker (2015) notes that African countries' renewable energy transitions are shaped by external interests that can dilute national green policy ambitions.

The 15.8% minority agreeing likely focuses on off-grid solar initiatives enabling rural electrification without reliance on diesel generators. These projects clearly align with Kenya's commitments to reduce carbon emissions while increasing clean energy access. However, the overwhelming skepticism suggests that Kenya must assert stronger ownership over its green agenda in partnerships with the U.S.

4.6 Innovation and Research Promotion

The study examined whether U.S. technology transfer has promoted innovation and research in Kenya's energy sector. Findings revealed that 80.3% of respondents (74.8% agreed, 5.5% strongly agreed) affirmed innovation and research promotion, while 17.1% disagreed and 2.6% remained neutral.

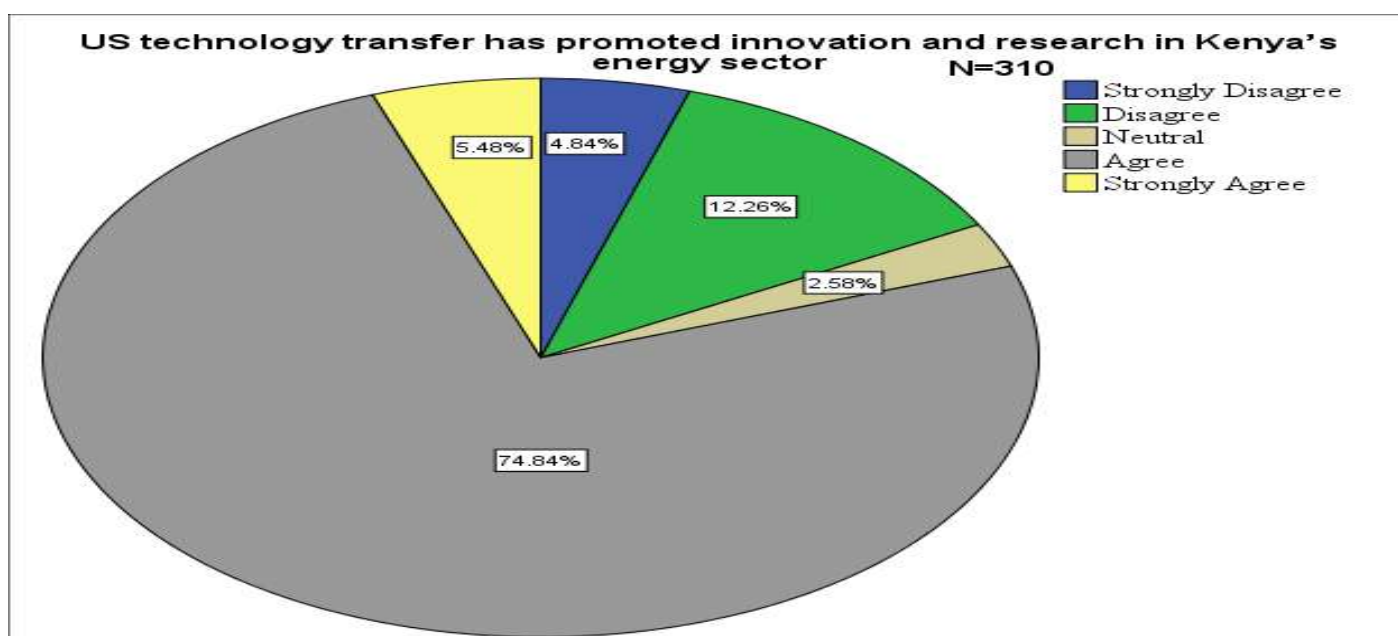


Figure 6

U.S. Technology Transfer Has Promoted Innovation and Research in Kenya's Energy Sector

Source: Field Data (2025)

U.S. involvement in technology transfer has supported development of innovation ecosystems in Kenya through funding projects, partnerships between universities and the introduction of new technology that is suited to the local market. The strong agreement shows the real impact of these activities in Kenya's energy research environment. Qualitative data has verified these effects. As a university researcher told stated:

"Our research center has benefited enormously from U.S. partnerships. We are working on solar PV efficiency, grid integration solutions and battery storage technologies. The funding we have received from the U.S. has enabled us to acquire research equipment and take students abroad for training. We are now contributing to global knowledge rather than just consuming it" (KII with University Researcher, Nairobi, 16.11.2025).

“The pay-as-you-go solar model that has revolutionized off-grid energy in Kenya was inspired by U.S. innovations. American companies brought the technology and business models but Kenyan entrepreneurs adapted them to local conditions—mobile money integration, local languages and community-based distribution. That's innovation” (KII with Energy Entrepreneur, Nairobi, 18.11.2025).

In energy development innovation is essential for access, reliability, sustainability and cost-effectiveness. Musiitwa (2019) points out that technology transfer in Sub-Saharan Africa is often the incubator for local innovation, with research support and knowledge exchange. Kenya has received technical and financial assistance for feasibility studies, technology trials and demonstration programs through Power Africa and USDA grants (USDA, 2020). The partnership between the USA and Kenya has contributed to capacity building in the field of innovation through educational exchanges, joint research grants and training. Freeman and Soete (1997) argue that innovation systems in developing countries are strengthened by international collaborations that expose local researchers to new territory. Kenya is the leader in off-grid solar innovation (Rockefeller Foundation, 2021) because of U.S. partnerships that allow experimentation with pay-as-you-go models and smart-grid solutions. But 17.1% of disagreement points to ongoing problems. According to Altenburg (2009), technology transfers risk entrenching countries into ‘technology paths’ to fund donors.

An academic said:

“In many ways, the research agenda is often driven by American interests—what technologies are they trying to commercialize? We need more research that addresses Kenya’s specific challenges, not only tests U.S. products. The collaboration is good, but we need to own our research priorities” (KII with Research Scientist, Nairobi, 20.11.2025)

Another difficulty is the uneven distribution of benefits. Most of the U.S.-supported research is done at Nairobi-based universities and think tanks so rural institutions are left out of the picture. Maskus (2012) notes that intellectual property protections make it difficult for local researchers to access or adapt to some of the most advanced technologies. The positive effects of innovation are obvious. By bringing in advanced technologies, sharing knowledge and pilot projects, U.S. partnerships have helped Kenya move from passive adoption to active adaptation and co-creation of energy solutions. Today Kenya is a center of expertise for neighboring countries in geothermal development and off-grid solar systems (Eberhard et al., 2019). This regional leadership is a strong endorsement of Kenya's diplomatic and economic standing. The study's findings highlight a complex and paradoxical story of U.S. energy technology transfer and Kenya's development. In spite of high levels of positive outcomes in renewable energy capacity (79.3%), employment creation (85.2%), technical skills development (84.5%), infrastructure modernization (74.8%) and innovation promotion (80.3%), 81% of those who were surveyed were also against environmental sustainability and green diplomacy.

This paradox is really at the core of the study. A pattern of high agreement across economic and technical dimensions indicates that U.S. technology transfers have brought concrete results that are widely understood by the people. And the most positive dimensions of employment creation and skills development seem to be the most recognized as human capital and most sustainable. The environmental sustainability aspect however explains the gap: U.S. projects generate jobs and infrastructure; however, scale and strategic purposes are more important than they are environmental considerations and Kenya’s green diplomacy identity. These findings are important for much more than just economic productivity. The gap between economic benefits and environmental concerns means Kenya is in place to deal with a kind of uneven development scenario: it has an advantage in terms of infrastructure and human capital but at the cost of its environmental priorities and diplomatic position. The skepticism regarding green diplomacy alignment also indicates that the transfer of technological services by the US is undermining Kenya’s global leadership on climate change. These findings underscore the necessity of transforming from donor-driven technology delivery to a partnership which is based on Kenya’s developmental needs and environmental needs and aspirations for technological self-reliance. The result is clear: without a focus on the environmental and diplomatic aspects, the undeniable progress on infrastructure, employment and skills development in Kenya could be undermined by sustainability problems and geopolitical disputes.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The study examined the impact of US energy technology transfer on Kenya's infrastructure development in six dimensions. The results highlight a complex duality: U.S.-backed projects have increased renewable energy capacity,

created jobs, developed technical skills, modernized infrastructure and stimulated innovation but thus far have failed to align with Kenya's environmental sustainability and green diplomacy goals. The strong rejection of environmental sustainability (81%) is the most important finding in the study. It exposes the fundamental tension between tangible economic benefits of technology transfer versus the perceived ecological costs. Projects that create jobs and infrastructure are also criticised for land degradation, displacement of people, and insufficient environmental protection, and therefore Kenya's carefully cultivated image as a green diplomacy champion becomes less credible. This paradox has a significant impact on Kenya's development path. The research shows that technology transfer's effectiveness cannot be measured only by GDP but by environmental sustainability, local adaptation and strategic alignment as well for sustained development success. Without addressing these aspects, the considerable gains in infrastructure, employment and skills will be undermined by sustainability gaps and geopolitical frictions.

5.2 Recommendations

Based on the findings of the study suggest the following recommendations. First, Kenya should strengthen local content requirements in energy technology transfer agreements that ensure employment creation goes beyond project-based work and that it is sustainable long-term jobs in the domestic industry. Second, the government should enhance environmental safeguards and community engagement in project design to address the widespread skepticism regarding ecological sustainability and to match U.S.-backed projects with Kenya's green diplomacy goals. Third, Kenya should take on more responsibility for research and innovation goals, so as to ensure that technology transfer creates local adaptation and self-reliance rather than dependency. And finally, the institutional framework for technology transfer should involve a complete set of skills development programs targeting rural and marginalized communities so that all benefits are shared. And Kenya can use its regional leadership to work out a way of setting up technology transfer terms that are sustainable, development-oriented and aligned with regard to the environment and long-term technological sovereignty.

Declaration of Interest

The authors declare that they do not have any known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding Declaration

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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