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Exploring the effectiveness of green energy in Lucena City: Basis for developing an educational campaign program

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Abstract

The effectiveness of green energy is paramount to addressing global challenges such as climate change. Green energy sources such as solar, wind, hydropower, geothermal, and biomass offer renewable alternatives to fossil fuels, reducing greenhouse gas emissions and mitigating environmental degradation. Lucena City, Philippines faces challenges like many other urban areas due to increased utility costs and pollution. This quantitative research study employed a descriptive research design that explored the effectiveness and current state of green energy adoptions and initiatives in Lucena City as a precursor to developing an educational campaign program. Key metrics include residents' awareness levels, utilization, and perceptions of green energy. Moreover, the study delves into the impact of green energy initiatives on reducing carbon emissions and fostering the economic benefits of residents within the city. To present a clearer picture of the study, solar panels emerge as the most popular and widely used green energy source in households, demonstrating the ability to support high-energy appliances and a viable alternative energy source at homes. However, the study reveals a lack of knowledge about various types of green energy, doubts about its unlimited use, and mixed perceptions regarding its cost and affordability. These findings are a foundation for developing an education campaign program that promotes sustainable practices and increases awareness among the students and the community.

Keywords: *renewable energy, solar energy, sustainability awareness, environmental education*

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1. Introduction

Green energy, characterized by its renewable and environmentally sustainable nature, has emerged as a key solution to the growing demand for energy and the urgent need to address climate change. Renewable energy sources such as solar, wind, hydropower, geothermal, and biomass provide viable alternatives to fossil fuels by reducing greenhouse gas emissions and minimizing environmental degradation (Paraschiv & Paraschiv, 2023; Okeke et al., 2025). Due to technological advancements and increasing policy support, green energy has become more accessible to households and communities, particularly in urban settings (Almihat & Munda, 2025; Mo & Liu, 2025; Jayabal, 2024).

Renewable energy offers significant environmental and economic benefits, including reduced reliance on fossil fuels, lower carbon emissions, and long-term cost savings (Li et al., 2023; Wei et al., 2023). Recent studies highlight that renewable energy technologies can effectively replace conventional energy sources in electricity generation and household consumption while supporting climate change mitigation efforts (Osman et al., 2023; Ang et al., 2022; Attanayake et al., 2024; Suman, 2021). In addition, solar energy has become the most widely adopted renewable technology at the residential level due to declining installation costs, favorable climate conditions, and supportive policies such as net metering (Palanca-Tan, 2024).

Education plays a crucial role in strengthening public understanding of renewable energy and promoting sustainable energy practices. Integrating green energy concepts into science education can enhance environmental literacy, empower learners to make informed decisions, and encourage community engagement toward sustainability (Johnson et al., 2025). Educational campaigns, in particular, have been identified as effective tools for increasing awareness, correcting misconceptions, and influencing positive attitudes toward renewable energy adoption.

In the Philippine context, household adoption of green energy is increasing, yet challenges remain. Lucena City, with over 66,905 households (Philippine Statistics Authority, 2025), faces rising electricity costs and environmental concerns that motivate interest in alternative energy sources. While solar energy systems are increasingly considered by households, perceptions regarding affordability, effectiveness, and long-term benefits vary (Zakeri et al., 2021). Despite declining technology costs, misconceptions regarding installation expenses and savings persist, limiting broader adoption.

Moreover, empirical studies focusing on household-level awareness, utilization, and perceptions of green energy in provincial urban areas such as Lucena City remain limited. This gap underscores the need for research that not only assesses the effectiveness of green energy adoption but also translates findings into evidence-based educational initiatives. Thus, this study aims to examine household utilization, awareness, cost perceptions, and benefits of green energy in Lucena City as a basis for developing an educational campaign program that promotes informed decision-making and sustainable energy practices. Specifically, the study attempted to meet the following questions:

1. What is the utilization level of green energy at home?
2. What are the benefits of green energy?

2. Literature Review

2.1. Theoretical Framework

This study is anchored on Social Learning Theory, Diffusion of Innovations Theory, and Cognitive Load Theory, which collectively explain how individuals acquire knowledge, form perceptions, and adopt new technologies such as green energy.

Social Learning Theory (Bandura, 1977) emphasizes that individuals learn through observation, imitation, and social interaction. In the context of green energy adoption, households are more likely to adopt renewable technologies when they observe successful implementation by peers and communities, particularly when benefits such as cost savings and environmental improvement are visible (Ali et al., 2023). This theory supports the use of educational campaigns that showcase real-life applications of renewable energy to influence attitudes and behaviors.

Diffusion of Innovations Theory (Rogers, 1962) explains how new technologies spread within a social system over time through communication channels. Renewable energy technologies, particularly solar energy, diffuse more rapidly when individuals perceive them as advantageous, compatible with existing practices, and economically viable (Torro et al., 2024). This theory is highly relevant to the present study as it explains why solar energy is more widely adopted than other renewable technologies in household settings.

Cognitive Load Theory (Sweller, 1988) supports the design of effective educational materials by emphasizing the importance of presenting information in a clear, manageable manner to enhance comprehension and retention. Educational campaigns that simplify

complex energy concepts can improve understanding and decision-making, particularly among students and community members with limited technical backgrounds.

2.2. Green Energy

Green energy refers to energy derived from renewable and naturally replenishing resources such as solar, wind, hydropower, geothermal, and biomass. Unlike fossil fuels, renewable energy sources generate electricity with minimal greenhouse gas emissions, contributing to environmental sustainability and climate change mitigation (Li et al., 2023). Recent studies highlight that renewable energy adoption plays a crucial role in reducing environmental degradation while meeting increasing global energy demand (Wei et al., 2023). Solar energy, in particular, has gained prominence at the household level due to its scalability, accessibility, and suitability for residential use (IEA, 2023). In urban and semi-urban contexts, solar photovoltaic systems are often preferred because they can be installed on rooftops without major infrastructure changes.

In the Philippine context, renewable energy adoption has been steadily increasing, supported by favorable geographic conditions and policy initiatives (Palanca-Tan, 2024). However, studies also indicate that household awareness of renewable energy often focuses heavily on solar energy, with limited understanding of alternative renewable technologies such as wind, hydropower, and biomass (Catubay et al., 2024). This limited awareness underscores the need for educational interventions that broaden public understanding of green energy options.

2.3. Awareness and Utilization of Green Energy

Public awareness is a critical determinant of renewable energy adoption. Studies demonstrate that households with higher levels of awareness are more likely to support and invest in renewable energy technologies (Sabroso et al., 2024). Awareness influences not only acceptance but also perceptions of reliability, affordability, and environmental impact. Despite increasing exposure to renewable energy information, gaps in understanding remain. Torro et al. (2024) found that while many households recognize the environmental benefits of renewable energy, fewer understand its technical aspects and long-term economic implications. This partial awareness may explain why households often adopt only one form of renewable energy, typically solar, while overlooking other viable options.

Utilization of green energy at the household level is also shaped by contextual factors such as housing ownership, income level, and access to technology (Haq et al., 2024; Gaspari et al., 2021; Peng & Klöckner, 2025; Guta, 2020). In the Philippines, residential solar adoption is often associated with middle-income and homeowner households who have greater autonomy over infrastructure investments (Bunda et al., 2023). These findings align with the need to examine utilization patterns within specific urban communities such as Lucena City.

2.4. Cost and Benefits of Green Energy

Cost remains one of the most influential factors affecting renewable energy adoption. While the initial installation cost of green energy systems is often perceived as high, recent evidence indicates a significant decline in renewable energy costs due to technological advancements and economies of scale (Elia et al., 2021; Haghi & Thompson, 2022; Wyszomierski et al., 2025). Studies show that households increasingly recognize the long-term financial benefits of renewable energy, particularly through reduced electricity bills (García-López, 2023). However, perceptions of affordability vary widely. Espinoza et al. (2024) found that perceived cost barriers can negatively influence behavioral intentions toward renewable energy adoption, even when long-term benefits are acknowledged. In the Philippine setting, financing options and awareness of economic incentives play a crucial role in mitigating cost concerns (Palanca-Tan, 2024). These findings suggest that improving financial literacy and providing clear cost-benefit information can enhance household confidence in green energy investments, an issue directly addressed in the present study.

The benefits of green energy extend beyond environmental sustainability to include economic and social advantages. Empirical studies confirm that increased renewable energy use significantly reduces carbon emissions, improves air quality, and supports climate change mitigation efforts (Li et al., 2023; Wei et al., 2023). At the household level, renewable energy adoption contributes to long-term electricity savings and greater energy independence. Residential solar photovoltaic systems, in particular, allow households to offset grid electricity consumption and reduce vulnerability to fluctuating energy prices (Nakaishi et al., 2026; Mutule et al., 2025; Piazza et al., 2025). In the Philippine context, renewable energy systems also enhance resilience during power interruptions and natural disasters, reinforcing their value as both an environmental and practical solution (Catubay et al., 2024). These

combined benefits highlight the importance of understanding household perceptions of green energy effectiveness.

3. Methodology

3.1. Research Design

This study was guided by a quantitative research design employing a descriptive approach. The descriptive design was deemed appropriate as it allowed the researchers to systematically assess the effectiveness of green energy adoption among households in terms of utilization, cost, and perceived benefits. This approach enabled the collection of numerical data that describe existing conditions without manipulating variables, making it suitable for examining current household practices and perceptions related to green energy.

Using survey data gathered from household participants, the researchers analyzed patterns of awareness, usage, affordability, and benefits of green energy technologies, particularly solar energy systems. The descriptive quantitative design facilitated an objective assessment of variables, providing a factual basis for interpretation. Furthermore, the findings derived from this descriptive process served as the empirical foundation for the development of an educational campaign program. By identifying knowledge gaps, misconceptions, and areas of limited adoption, the research design supported the formulation of targeted educational strategies aimed at promoting informed decision-making and sustainable energy practices among students and the wider community.

3.2. Participants of the Study

The participants of this study consisted of households that utilize green energy technologies in selected barangays in Lucena City, Philippines. Purposive sampling technique was employed to select households that met the inclusion criteria of using green energy technologies, being present at the time of data collection, and voluntarily providing informed consent to participate in the study. This approach ensured that the respondents possessed direct experience relevant to the objectives of the research.

A total of one hundred three (103) households participated in the study: 59 or 57% from Barangay Ibabang Dupay and 44 or 42.72% are from Barangay Mayao Crossing. According to the Philippine Statistics Authority (2020), Lucena City has a total of 66,905 households, which served as the reference population of the study. These two barangays were

selected due to their higher rates of green energy adoption, as identified through an initial survey and consultations with local installers. Table 1 shows the demographics of the participants.

Table 1

Demographics of the participants

Indicators	f	%
Type of house		
Owned	95	92.23%
Rented	8	7.77%
Monthly household income		
above ₱50,000	20	19.42%
₱40,000 - ₱50,000	22	21.36%
₱30,000 - ₱40,000	27	26.21%
₱20,000 - ₱30,000	18	17.48%
below ₱20,000	16	15.53%
Total	**103**	**100%**

Table 1 displays the predominance of homeowners (92.23%) among respondents which suggests that ownership status plays a critical role in green energy adoption, as homeowners possess greater autonomy in making long-term infrastructure investments. Studies showed that renters often face institutional and contractual barriers to installing renewable energy systems (Mutule et al., 2025; Piazza et al., 2025). On the other hand, a substantial proportion of participants fall within the middle-income bracket (₱30,000–₱40,000), indicating that green energy adoption is not limited to high-income households. Lower-income households remain underrepresented, suggesting persistent financial constraints that may limit broader adoption.

The selected participants provided quantitative data on the utilization, cost, and perceived benefits of green energy, which served as the empirical basis for data analysis and the subsequent development of an educational campaign program.

3.3. Instrumentation and Data Gathering Process

The primary instrument used in this study was a survey questionnaire. The questionnaire was designed to gather quantitative data aligned with the study objectives, specifically focusing on household awareness, utilization, cost, and perceived benefits of green energy. The instrument employed a four-point Likert scale to measure respondents' levels of agreement and perceptions. To ensure content validity, the questionnaire was reviewed and validated by three (3) experts with relevant academic and professional backgrounds. Revisions were made based on their comments and recommendations prior to data collection.

An initial online survey was conducted to identify barangays in Lucena City with higher rates of household green energy usage. This preliminary survey was administered and disseminated through e-mail and social media platforms. In addition, the researchers consulted with local green energy contractors to validate survey findings and to identify barangays with a higher number of green energy installations, which informed the selection of Barangay Ibabang Dupay and Barangay Mayao Crossing as study sites. The final survey questionnaires were administered then to households that use green energy technologies and met the inclusion criteria of availability and voluntary participation. Data collection was conducted with due consideration for ethical standards, ensuring informed consent and respondent confidentiality throughout the process.

3.4. Data Analysis

The data collected from the study were systematically tabulated and presented using tables and figures to facilitate clear data organization and accurate interpretation. Descriptive statistical tools were employed to analyze the quantitative data gathered through the survey questionnaire. Weighted mean was utilized to determine the levels of awareness, utilization, cost, and perceived benefits of green energy. The results were interpreted using Likert scale intervals to provide meaningful descriptions of the respondents' perceptions based on the computed weighted means.

3.5. Research Ethics

This study adhered to established ethical standards in the conduct of survey-based research. Prior to data collection, all respondents were provided with a letter of informed

consent, which explained the purpose, scope, and procedures of the study. Participation was strictly voluntary, and respondents were informed that they could decline or withdraw from the study at any time without penalty. Before the administration of the survey questionnaire, respondents were clearly informed of the objectives of the study, the identity of the researchers, and the intended use of the data collected. Participants were assured that all information provided would be treated with strict confidentiality and used solely for academic research purposes. In addition, respondents were informed that no compensation or incentives would be provided for their participation. Throughout the research process, the researchers maintained professionalism, respect, and transparency, and all inquiries from participants were addressed appropriately to ensure the integrity and objectivity of the study.

4. Findings and Discussion

Table 2

Level of awareness on green energy

Indicators	WM	Description
I am aware of the difference between renewable and non-renewable energy	3.38	Strongly Agree
I am aware that green energy is more environmentally friendly.	3.76	Strongly Agree
I am aware of the different types of green energy.	2.38	Disagree
I participated in green energy-related events, workshops, and educational programs.	2.16	Disagree
When we live in a natural environment, the supply of our energy needs from natural resources is more suitable.	2.50	Agree
Green energy resources should be effectively used to meet the rapid increase in energy demand.	3.53	Strongly Agree
I strongly support the use of green energy resources.	3.64	Strongly Agree
I find using unlimited clean energy resources useful.	3.60	Strongly Agree
I believe using green energy resources would save energy.	3.60	Strongly Agree
The use of green energy resources is unlimited compared to traditional energy resources.	3.62	Strongly Agree
Overall	**3.22**	**Agree**

Legend: 3.25 – 4.00 Strongly Agree; 2.50 – 3.24 Agree; 1.75 – 2.49 Disagree; 1.00 – 1.74 Strongly Disagree

The results show that respondents generally demonstrated awareness of green energy, especially solar energy, though gaps remain in knowledge about less common technologies. This aligns with findings from Sabroso et al. (2024), who reported that higher levels of awareness significantly relate to attitudes toward renewable energy adoption among households, highlighting awareness as a key factor influencing acceptance and willingness to

engage with renewable technologies. Similarly, Catubay et al. (2024) found that while many participants were familiar with renewable energy sources like solar and wind, knowledge of specific local initiatives and incentives was limited, underscoring the need for targeted public education. These findings support that awareness alone does not ensure full understanding of green energy options, reinforcing the importance of educational campaigns tailored to household contexts.

Table 3

Types of green energy used at home

Green Energy Type	f	%
Solar panels	103	100

Table 3 shows the percentage of the type of green energy the respondents use at home. The data shows that 100% of respondents use solar panels at home. Solar energy emerged as the predominant green energy technology among households in Lucena City. This is consistent with research showing that solar photovoltaic systems remain the most widely adopted renewable technology at the residential level in the Philippines, due to favorable climatic conditions, government support like net-metering, and relatively accessible technology costs.

Bunda et al. (2023) described how residential solar adoption often follows a staged process from awareness to installation, with policy incentives influencing transitions between stages. On the other hand, Palanca-Tan (2024) reported that economic factors, particularly reduced electricity costs, are among the strongest determinants encouraging households to adopt rooftop solar, further explaining why adoption is concentrated around solar solutions despite barriers.

Table 4 shows the weighted means and rankings of the appliances used by participants who utilize green energy at home. The data show that inverter air conditioners and LED lights have weighted means of 3.25 and 3.69, respectively, which fall under the Strongly Agree category. Refrigerators have a weighted mean of 2.54, which falls under the Agree category. Meanwhile, ovens, heaters, dryers, and washing machines have weighted means of 1.79, 1.82, 1.93, and 1.83, respectively, all of which fall under the Disagree

category. Overall, the weighted average is 2.41, which generally falls under the Agree category.

Table 4

Appliances used at home powered by green energy technology

Indicators	WM	Description
I use green energy on inverter air conditioners.	3.25	Strongly Agree
I use green energy in refrigerators.	2.54	Agree
I use green energy in ovens.	1.79	Disagree
I use green energy on heaters.	1.82	Disagree
I use green energy on LED lights.	3.69	Strongly Agree
I use green energy on dyers.	1.93	Disagree
I use green energy on washing machines.	1.83	Disagree
Overall	**2.41**	**Agree**

Legend: 3.25 – 4.00 Strongly Agree; 2.50 – 3.24 Agree; 1.75 – 2.49 Disagree; 1.00 – 1.74 Strongly Disagree

These appliances can operate efficiently using green energy sources, such as solar energy. LED lights are the most commonly used green energy appliances. According to Chen et al. (2025), LED lights have become increasingly popular in recent years because of their numerous advantages and the growing trend toward sustainability. These lights use solar panels to convert sunlight into energy that powers LED lighting systems. This is followed by inverter air conditioners and refrigerators, which are among the major appliances that consume high amounts of electricity in Philippine households.

Table 5 shows the weighted average for responses to the cost of green energy in terms of its affordability, electricity reduction and environmental impact. Respondents expressed mixed perceptions about the cost and affordability of green energy systems. This mirrors broader findings in household energy adoption literature where high initial costs are commonly perceived as barriers, even when long-term savings are recognized. For example, research examining behavioral intentions toward renewable energy adoption highlights how perceived costs can negatively influence adoption intentions, while perceived benefits often strengthen motivation to adopt clean energy solutions (Gatri, 2026; Yii et al., 2026; Shabbir, 2025; Espinoza et al., 2024). The growing body of evidence from both global and local studies suggests that economic incentives, financing programs, and awareness of long-term

savings can mitigate cost concerns and play a critical role in expanding household adoption (Yii et al., 2026; Espinoza et al., 2024).

Table 5

Benefits of green energy

Indicators	WM	Description
Affordability		
I prefer green energy systems because they are cheaper.	2.94	Agree
I believe that green energy technologies are becoming increasingly affordable for households	3.08	Agree
Green energy has a low installation cost.	3.8	Strongly Agree
Green energy has a high installation cost	1.76	Disagree
Green energy systems are expensive.	2.51	Agree
Green energy systems are not affordable for households.	2.21	Disagree
Weighted Average	**2.72**	**Agree**
Electricity Reduction		
I have noticed a significant decrease in electricity bills since implementing green energy-saving measures at home.	3.6	Strongly Agree
I invest in green energy technologies to reduce my electricity bill.	3.57	Strongly Agree
I saved a lot on my electricity bills since installing a green energy system at home	3.44	Strongly Agree
I believe that using green energy technologies is one of the most effective ways to save money.	3.36	Strongly Agree
I am satisfied with the electricity reduction savings achieved through my adaptation of green energy technologies at home.	3.46	Strongly Agree
I noticed that only a small amount was deducted from my electricity bill	2.85	Agree
Weighted Average	**2.98**	**Agree**
Environmental Impact		
I believe green energy systems help lessen climate change's effects	3.46	Strongly agree
I believe that green energy helps to sustain our environment.	3.65	Strongly agree
I believe that green energy contributes to improved air quality.	3.65	Strongly agree
I believe that using green energy systems helps to preserve our natural resources.	3.68	Strongly agree
I believe that green energy helps to reduce pollution.	3.6	Strongly agree
I believe that green energy systems are less environmentally harmful.	3.63	Strongly agree
I believe that green energy systems are less harmful to humans.	3.7	Strongly agree
I believe that green energy initiatives contribute to preserving natural habitats.	3.74	Strongly agree
I believe implementing green energy technologies will reduce carbon emissions.	3.72	Strongly agree
I believe using green energy systems reduces greenhouse gas emissions.	3.77	Strongly agree
Weighted Average	**3.66**	**Strongly agree**

Legend: 3.25 – 4.00 Strongly Agree; 2.50 – 3.24 Agree; 1.75 – 2.49 Disagree; 1.00 – 1.74 Strongly Disagree

Participants generally agreed that green energy systems, especially solar energy, have contributed to electricity savings within their households. This result aligns with empirical evidence showing that household self-consumption of energy through residential solar photovoltaic (PV) systems is a key strategy for reducing electricity bills and energy burden. García-López et al. (2023) noted that solar PV self-consumption significantly lowers household electricity expenditures and greenhouse gas emissions, highlighting the economic value of on-site renewable generation for residential users. Similarly, studies examining rooftop solar economics suggest that residential PV installations can lower net electricity costs, particularly when systems offset consumption during peak demand periods (Agdas & Barooah, 2023; Khati et al., 2026). Although the exact magnitude of savings varies by policy environment and electricity rate structure (e.g., net metering, tariffs), the general trend supports the lived experiences of the respondents in this study, who reported noticeable reductions in their monthly electricity expenses. Beyond purely economic savings, solar energy adoption is often framed as contributing to broader energy independence and resilience (Paraschiv & Paraschiv, 2023; Piazza et al., 2025), allowing households to reduce reliance on grid power and mitigate exposure to price volatility. For example, renewable energy advocacy and policy frameworks within the Philippines emphasize solar power's potential to enable sustainable savings and energy security (Palanca-Tan, 2024), reinforcing the idea that on-site generation supports both financial and resilience outcomes for households.

Participants strongly agree that green energy contributes to environmental sustainability, particularly in reducing carbon emissions and mitigating pollution. This finding is consistent with broader empirical research indicating that renewable energy sources significantly lower environmental degradation by displacing fossil fuel use, which in turn reduces greenhouse gas emissions and air pollutants. For example, Li et al. (2023) found that increased use of green energy in China and Japan led to measurable decreases in environmental deterioration, especially in carbon dioxide emissions, as renewable technologies replaced higher-emission fossil fuels. Renewable energy's role in environmental mitigation is further supported by studies showing that clean energy technologies such as solar, wind, and biomass contribute to climate change mitigation and overall ecosystem health by minimizing harmful emissions compared with conventional energy sources. Research conducted by Wei et al. (2023) emphasized that renewable energy resources help

minimize carbon dioxide emissions and support environmental sustainability, which aligns with respondents' perceptions that green energy contributes to climate protection.

In the context of public perception, environmental benefits are often key drivers of social support for renewable energy adoption. Catubay et al. (2024) documented strong community approval for renewable energy in the Philippines, noting that a majority of survey participants recognize environmental improvements as a primary advantage of renewable energy technologies. Households not only perceive the economic advantages of green energy but also strongly associate its use with positive environmental outcomes, such as reduced air pollution, lower emissions, and enhanced sustainability.

5. Educational Campaign Program for High School Students

Environmental sustainability through green energy plays a vital role in contemporary education, particularly in raising awareness of the environmental and economic impacts of traditional energy sources. In the context of climate change, rising energy demand, and environmental degradation, there is a growing need to equip students with accurate knowledge and responsible attitudes toward energy use and sustainability.

Based on the results of a household-level study conducted in Lucena City, participants generally have high level of awareness of green energy but limited knowledge of renewable energy types beyond solar energy, mixed perceptions regarding affordability, and strong recognition of environmental and economic benefits. While green energy adoption was observed at the household level, particularly among solar energy users, misconceptions and information gaps persist. These findings highlight the need for structured educational interventions that address not only awareness but also understanding, application, and informed decision-making. Although the research focused on household adoption, the campaign needs to strategically target high school students as future decision-makers and information multipliers within their families and communities. By integrating green energy education into existing science and social studies topics, this can strengthen environmental literacy, promote sustainability, and encourage long-term adoption of responsible energy practices.

Introduction to green energy. The inclusion of an introductory component on green energy directly responds to the study's findings indicating that, while households demonstrate a general awareness of green energy, understanding remains largely superficial.

Results from the awareness indicators suggest that respondents are familiar with the concept of green energy but lack comprehensive knowledge regarding its scope and practical applications. By establishing foundational concepts at the secondary education level, this can address early misconceptions and strengthen conceptual clarity. Introducing green energy concepts within the science curriculum provides students with a structured understanding that can serve as a basis for more advanced discussions on sustainability and energy transitions.

Targeting high school students is particularly strategic, as students serve not only as learners but also as information conduits within their households and communities. Strengthening foundational knowledge at this stage supports long-term behavioral change and informed decision-making, which the household-level findings indicate are necessary for broader and more inclusive green energy adoption.

Types of green energy. The emphasis on different types of green energy addresses a key gap identified in the study. Although respondents generally expressed awareness of green energy, results revealed that solar energy is the only renewable technology currently adopted by households. Other renewable sources, such as wind, hydropower, geothermal, and biomass, remain largely unfamiliar or unconsidered. This limited adoption suggests that household decisions may be influenced by lack of exposure rather than lack of interest.

By educating students on the full range of renewable energy technologies, the campaign aims to expand understanding beyond solar energy and challenge the perception that green energy is limited to a single option. Presenting comparative case studies and real-world applications encourages critical thinking and allows students to evaluate the feasibility and relevance of different renewable technologies. This approach supports the study's recommendation to address knowledge gaps and diversify understanding of renewable energy solutions.

Environmental benefits of green energy. Findings indicate that respondents strongly recognize the environmental benefits of green energy, including reduced pollution, mitigation of climate change effects, conservation of natural resources, and decreased reliance on fossil fuels. This strong agreement suggests that environmental considerations are a major motivating factor for green energy acceptance at the household level. Building on this positive perception, the focus on environmental benefits reinforces existing awareness while deepening students' understanding of the scientific and ecological mechanisms behind these benefits. By linking renewable energy use to tangible environmental outcomes, such as

cleaner air and reduced carbon emissions, this can strengthen environmental literacy and promotes pro-environmental attitudes. Reflective discussions and real-world examples further encourage students to internalize sustainability values and recognize their role in environmental stewardship.

Economic benefits of green energy. The inclusion of economic benefits as a key area is grounded in the study's findings on cost and savings. Results revealed mixed perceptions regarding affordability, with some households viewing green energy systems as costly while others recognized their long-term financial advantages. Despite these differences, respondents generally agreed that green energy contributes to electricity bill reduction, affirming its economic value over time. Addressing economic considerations helps students understand the distinction between initial investment costs and long-term savings. By presenting comparative analyses of renewable and non-renewable energy expenses, students can be equipped with basic economic reasoning skills related to energy choices. This approach aligns with the understanding that cost-effectiveness can influence adoption decisions and reduce misconceptions surrounding affordability.

The four key areas of the educational campaign, introduction to green energy, types of green energy, environmental benefits, and economic benefits, are closely aligned with the empirical findings of the study. This systematically addresses the awareness gaps, adoption limitations, cost perceptions, and recognized benefits identified. By translating household-level findings into age-appropriate educational interventions, this serves as a practical application of the research outcomes.

This alignment ensures that the educational campaign is not merely advocacy-based but is evidence-driven, reinforcing the study's contribution to both academic knowledge and practical sustainability initiatives. Through early education and structured engagement, the program has the potential to foster long-term behavioral change and support broader community adoption of green energy practices.

5. Conclusion

This study examined the effectiveness of green energy adoption among households in Lucena City in terms of utilization, cost, awareness, and perceived benefits. The findings indicate that green energy adoption is most prevalent in Barangay Ibabang Dupay and Barangay Mayao Crossing, confirming the appropriateness of these barangays as the focus of

the study. Homeownership and household income emerged as important factors influencing adoption, while declining technology costs suggest increasing accessibility of green energy systems to a broader range of households. The results further revealed that respondents generally demonstrate awareness of green energy, particularly its environmental benefits; however, gaps persist regarding knowledge of different renewable energy types and common misconceptions about clean energy. Solar energy remains the only green energy technology adopted by households, reflecting its practicality and suitability for local conditions. Green energy systems were also found to support both low- and high-energy household appliances, indicating their reliability as alternative energy sources.

Despite mixed perceptions regarding affordability, respondents acknowledged significant electricity savings and strong environmental benefits associated with green energy use, including reduced pollution, lower carbon emissions, and conservation of natural resources. These findings affirm the study's main argument that green energy is a cost-effective and environmentally sustainable solution for household energy needs.

Based on these findings, an educational campaign program was developed to address the identified knowledge gaps, correct misconceptions, and promote informed decision-making regarding green energy adoption. The results of the study highlight the need to consider the implementation of this program within educational institutions and in collaboration with local government units and community stakeholders, as a strategic approach to strengthening awareness, encouraging diversified renewable energy options, and supporting long-term sustainability initiatives.

This study was limited to selected barangays in Lucena City and relied on self-reported data from household respondents, which may affect the generalizability of the results. Future research may expand the scope to other barangays or cities, employ larger sample sizes, or utilize mixed-methods or longitudinal designs to further examine behavioral changes and the long-term impacts of green energy adoption.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Institutional Review Board Statement

This study was conducted in accordance with the ethical guidelines set by the Calayan Educational Foundation, Inc. (CEFI). The conduct of this study has been approved and given relevant clearances by the CEFI Research and Publication Office.

AI Declaration

The authors declare that Artificial Intelligence (AI) tools were used solely as writing support during the preparation of this research. ChatGPT was utilized for language refinement, structural organization, and clarity improvement. All academic judgments, interpretations, and final content decisions were made by the authors, who take full responsibility for the research.

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