

Sectoral diagnosis on photovoltaic energy in the Basic Unit of Cooperative Production "José Vázquez Martínez"

Diagnóstico sectorial sobre energía fotovoltaica en la Unidad Básica de Producción Cooperativa "José Vázquez Martínez"

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ABSTRACT: The sectoral diagnosis focused on the economic aspects of photovoltaic energy at the "José Vázquez Martínez" Basic Unit of Cooperative Production reveals the existing difficulties in implementing an efficient photovoltaic system. This research was framed within a national project of the Agrarian University of Havana aimed at building capacity in photovoltaic energy management within AZCUBA cooperatives. Managing this energy source is presented as a sustainable solution to optimize consumption in various applications, especially in the agricultural sector. The overall objective of the study is to evaluate the feasibility of incorporating photovoltaic energy into an agricultural cooperative that currently lacks such a system. To this end, a methodology was applied that included analyzing the unit's water and energy consumption, as well as designing technical, socioeconomic, and environmental indicators. These indicators were organized into a decision matrix that facilitated comprehensive analysis and strategic decision-making. The results allowed for the identification of areas for improvement and opportunities to implement a photovoltaic system aligned with the principles of the circular economy. By adopting a circular economy approach, the aim is not only to optimize the use of available resources but also to foster sustainable practices that benefit both the cooperative and its surrounding community. The assessment reveals significant potential for implementing sustainable energy solutions that will contribute to transforming the cooperative's energy mix.

Keywords: Photovoltaic Implementation, Agricultural Energy Management, Energy Mix, Agricultural Photovoltaic Systems.

RESUMEN: El diagnóstico sectorial enfocado en el aspecto económico de la energía fotovoltaica en la Unidad Básica de Producción Cooperativa "José Vázquez Martínez" evidencia las dificultades existentes para implementar un sistema fotovoltaico eficiente. Esta investigación se enmarcó en un proyecto nacional de la Universidad Agraria de La Habana para la creación de capacidades en gestión de energía fotovoltaica en cooperativas de AZCUBA. La gestión de esta fuente energética se plantea como una solución sostenible para optimizar el consumo en diversas aplicaciones, especialmente en el ámbito agrícola. El objetivo general del estudio es evaluar la viabilidad de incorporar energía fotovoltaica en una cooperativa agrícola que actualmente no dispone de dicho sistema. Para ello, se aplicó una metodología que incluyó el análisis del consumo de agua y energía de la unidad, así como el diseño de indicadores técnicos, socioeconómicos y ambientales. Estos indicadores fueron organizados en una matriz de decisión que facilitó el análisis integral y la toma de decisiones estratégicas. Los resultados permitieron identificar áreas de mejora y oportunidades para implementar un sistema fotovoltaico alineado con los principios de la economía circular. Al adoptar un enfoque basado en la economía circular, se busca no solo optimizar el uso de los recursos disponibles, sino también fomentar prácticas sostenibles que beneficien tanto a la cooperativa como a su entorno comunitario. La evaluación realizada revela un alto potencial para implementar soluciones energéticas sostenibles que contribuyan a transformar la matriz energética de la cooperativa.

Palabras clave: implementación fotovoltaica, gestión energética agrícola, matriz energética, sistemas fotovoltaicos agrícolas.

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INTRODUCTION

In 2021, global primary energy demand increased by approximately 6%, surpassing the levels recorded in 2019. This growth was primarily driven by emerging economies, such as India and China, while developed economies showed more stable or even declining demand in some cases (World Economic Forum, 2022). In 2023, global primary energy consumption reached a new record, with an additional 2% increase compared to the previous year (Fernández, 2024a). This upward trend is projected to continue in the coming decades, as a result of global economic growth and increasing energy demand in developing countries.

Oil remains the predominant fossil fuel worldwide, followed by coal and natural gas. China leads primary energy consumption with 170.7 exaJoules, surpassing the United States and positioning itself as the main player in the global energy mix (Fernández, 2024b).

Growing concerns about climate change and pressure from international organizations have spurred the transition to cleaner energy sources, such as renewables. Although this process is progressing slowly in some regions, significant progress has been made. According to the International Renewable Energy Agency (IRENA) (2024), renewable sources accounted for 29.1% of global electricity generation in 2022, totaling 8,440 TWh. The remaining 70.9% (20,591 TWh) came from fossil fuels, nuclear energy, and other non-renewable sources, reaching a total generation of 29,031 TWh.

This growth is particularly evident in solar and wind technologies, which registered a combined increase of 18.20% in 2021 (IRENA, 2024). China, the United States, and Brazil stand out as leaders in installed renewable energy capacity in 2023. China tops the ranking with approximately 1,453 GW, followed by the United States, while Brazil leads in South America and ranks third globally (Fernández, 2024a; 2024b).

In this global context, the adoption of sustainable alternatives becomes essential. Renewable energy emerges as a key solution to address current energy challenges (Arencibia, 2016). In Cuba, the energy crisis affecting strategic sectors such as agribusiness demands an urgent rethinking of energy sources. Solar photovoltaic energy is positioned as a viable option for self-sufficiency and sustainability, according to Rivera and Bayona (2022), and is fundamental for resilient development in the face of global crises (UNDP, 2022).

Photovoltaic technology, based on the conversion of sunlight into electricity through the movement of electrons between semiconductor plates, has evolved significantly. There are also solar concentration systems that use mirrors to raise the temperature of a thermal fluid, generating steam and electricity (Santos et al., 2017). Photovoltaic cells have improved their performance, optimizing energy production based on radiation levels (Santos et al., 2017).

The integration of solar energy into agriculture seeks to stimulate the use of clean energy, maximize natural

resources, improve productivity, and generate added value in agricultural production (Navarro et al., 2022). Examples such as solar greenhouses, drying systems, and purification or desalination plants demonstrate its applicability without the need for fossil fuels.

Cuba possesses high solar potential thanks to its geographic location and high solar radiation. This represents a strategic opportunity to diversify the energy matrix and promote rural development, according to the Cuban Ministry of Energy and Mines (MINEM-Cuba, 2023). However, barriers persist, such as a lack of infrastructure, limited access to advanced technologies, and the need for technical training.

Effective management of photovoltaic solar energy requires not only the installation of panels but also a comprehensive framework that encompasses everything from planning to maintenance (Abella, 2014). This holistic approach allows for maximizing performance and ensuring the sustainability of the systems, according to García et al. (2021), strengthening energy resilience and community well-being.

This diagnostic study analyzes the opportunities and challenges in photovoltaic solar energy management at the "José Vázquez Martínez" Basic Unit of Cooperative Production (UBPC), with the aim of proposing strategies that optimize its use and contribute to the sustainable development of the agro-industrial sector in Cuba. This research falls within the framework of National Project PN3602VC002-096 of the Agrarian University of Havana, aimed at building capacity for photovoltaic energy management in AZCUBA cooperatives. The research seeks to generate a replicable model that will inspire other institutions to adopt similar practices, promoting a.

MATERIALS AND METHODS

The study was designed as a single-case experimental study, applied at the "José Vázquez Martínez" Basic Unit of Cooperative Production (UBPC), intentionally selected for its productive characteristics and potential for incorporating photovoltaic energy. The total population consisted of 60 members, from which a purposive sample of 35 participants (58%) was taken, including workers, technicians, and others, to ensure representativeness and diversity of perspectives. The research was based on the Multicriteria Evaluation Methodology for renewable projects according to Martín et al. (2023), designing nine indicators grouped into three main dimensions: Technical/Infrastructure, Governance/Sustainability, and Socioeconomic.

Structured surveys and semi-structured interviews were used to collect information on the three main dimensions, each comprised of key indicators. The data were normalized on a scale of 0 to 1, and an overall viability index was constructed using a combined weighting method: equal weighting of all indicators and complementary adjustment through factor analysis. This allowed for the identification of the variability explained by each dimension and the refinement of the relative importance of the criteria.

Several decision-support techniques were used for the analysis, such as:

- Ishikawa diagram (cause-and-effect): This was used to identify the root causes of energy management problems, classifying them into categories that facilitate analysis.
- Decision matrix: This allowed for the comparison of alternatives based on multiple criteria, supporting strategic decision-making.
- Critical path: This was used to define the sequence of activities that determines the total duration of the project, identifying tasks that cannot be delayed without affecting the completion date.

The variables considered included energy consumption, investment costs, social perception, job creation, emissions reduction, and availability of technical resources. Quantitative data processing was performed using the PSPP program for descriptive statistical analysis (means and standard deviations). The final analysis integrated the statistical and qualitative results to evaluate the feasibility of the photovoltaic project at the UBPC (Basic Unit of Cooperative Production) using a multi-criteria approach.

Energy Characterization of the Unit

Current Energy Sources:

- Electrical grid (70%): used for irrigation pumping, offices, warehouse, and cafeteria. Monthly consumption: 13,539 kWh. Monthly cost: \$24,370 USD.
- Diesel (25%): used for heavy machinery. Its use has generated a 30% increase in energy costs over the last two years.

Frequent Problems:

- Power outages 2-3 times a day.
- Diesel pollution, with complaints from neighboring communities.

Available Infrastructure:

- Warehouse roofs: 300 m².

- Non-cultivable land: 710,000 m²
- Total area available for panels: 710,300 m²

Technical Knowledge and Training

- Current technical level: Only 20% of technicians have basic knowledge of photovoltaic energy.
- Interest in training: 90% of the team is willing to receive training, prioritizing practical maintenance of solar panels.

RESULTS AND DISCUSSION

The analysis of the information obtained allowed for the construction of a decision matrix that integrated the nine indicators grouped into the Socioeconomic, Technical, and Governance dimensions. Weighting was performed using a combined scheme: balanced and complemented with factor analysis, which adjusted the weights according to the variability explained by each dimension.

Indicator Evaluation

Nine key indicators were designed, grouped into three dimensions: Technical/Infrastructure, Governance/Sustainability, and Socioeconomic. These indicators allow for the evaluation of the viability and potential impact of photovoltaic projects before their implementation, prioritizing those with the greatest economic and social return.

Socioeconomic Indicators

These indicators allow for the evaluation of the viability and potential impact of photovoltaic projects before their installation, focusing on social and economic aspects. They are key for strategic decision-making. A rigorous evaluation using these indicators identified opportunities and risks, prioritizing projects with the greatest social impact and economic return, even without physical implementation (Figure 1).

The survey was administered to 35 workers, including laborers (48.57%), technicians (28.57%), and other roles (22.86%). Regarding investment, the most common range was \$500-\$1,000 USD (42.90%), while 85.80% invest less than \$30,000 USD. Only 14.30% exceed that amount.

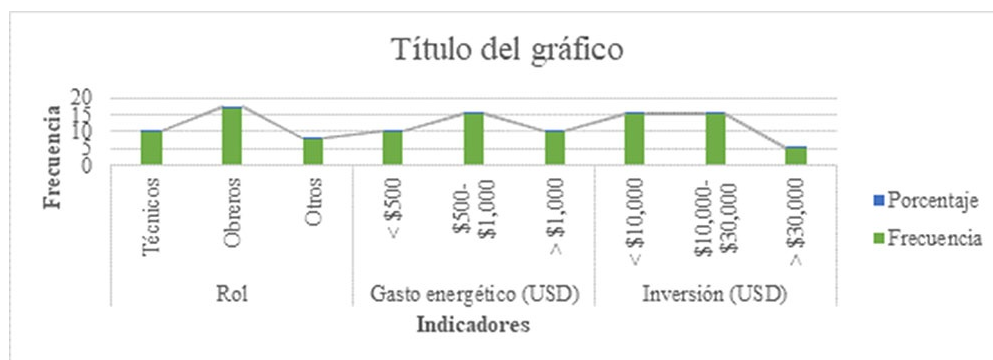


Figure 1. Behavior of Socioeconomic Indicators. Source: Author's own elaboration

The low proportion of technicians could limit technology adoption, which underscores the need for training policies.

Technicians/Infrastructure

These indicators (Figure 2) assess the territory's capacity to support solar projects. The main limitations identified were:

- Lack of arable land (65.7%)
- High implementation costs (85.7%)

The opportunity in underutilized infrastructure is that 20% have available warehouse roofs, a strategic resource for installing solar panels; leading to a potential benefit such as mitigating power outages (affecting 71.4%) and generating energy savings in the medium term. Frequent power outages affect productivity, generating daily losses of \$812.00 USD. Pollution is a secondary concern, with only 34.3% considering it relevant compared to economic/energy problems.

Governance and Sustainability

These indicators (Figure 3) measure institutional support and long-term sustainability. Projects without municipal support and without impact studies have a 68% higher probability of community conflicts (IRENA, 2024). The following findings were identified:

- Lack of financing (71.40%) as the main obstacle.
- Low priority given to environmental sustainability (14.30%), compared to cost reduction (57.10%).
- Limited technical knowledge (51.40%), although 71.40% are willing to receive training.

The limitation identified by 71.40% is a lack of financing as the main obstacle. This correlates with only 14.30% who prioritize environmental sustainability. Therefore, 71.40% respond "Yes" to implementing solutions, but 51.40% lack technical knowledge. Furthermore, cost reduction is the economic priority (57.10%), tripling the priority of sustainability (14.30%),

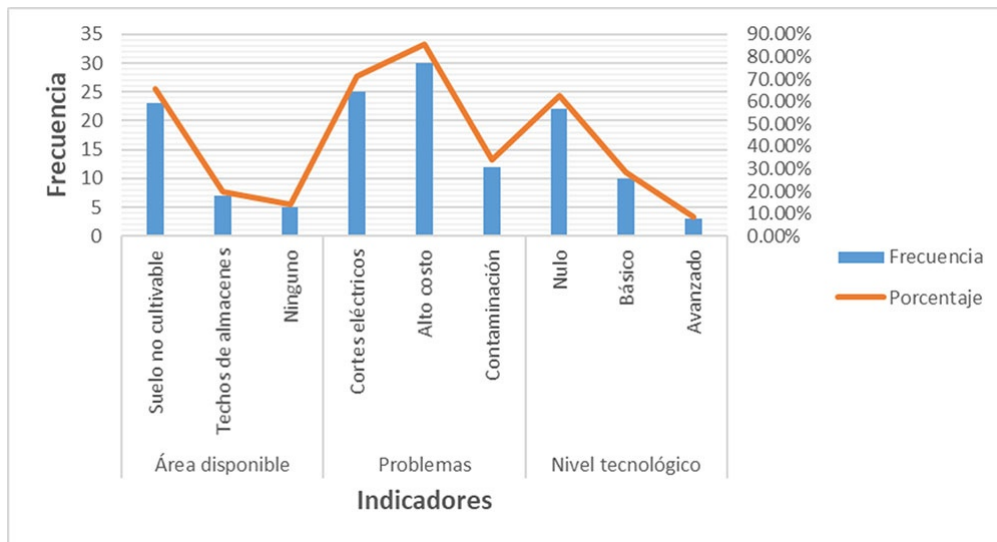


Figure 2. Behavior of Technical/Infrastructure Indicators. Source: Author's own elaboration

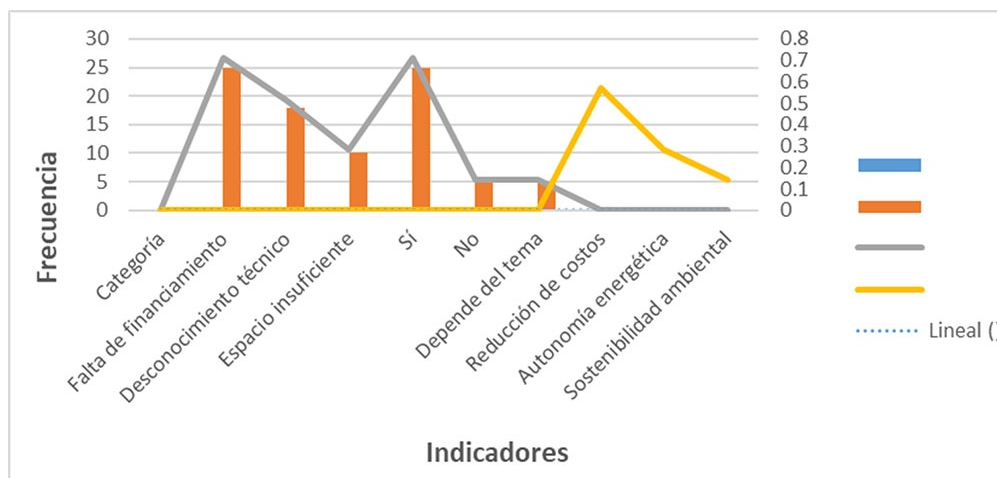
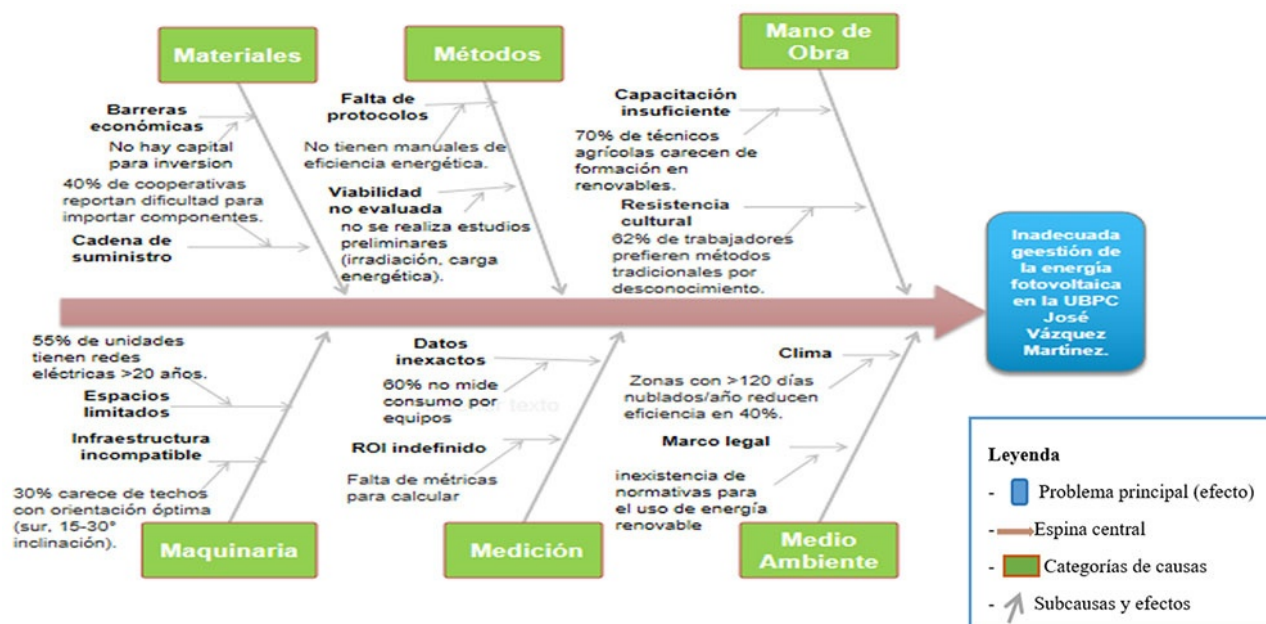


Figure 3. Behavior of Governance and Sustainability Indicators. Source: Author's own elaboration

Table 1. Statistical Summary

Dimension	Key Indicator	Average (%)	Deviation
Socioeconomic	Spending >\$1,000 USD	28.60%	±4.20%
Technical	Rooftop space	65.70%	±6.10%
Governance	Willingness to train	71.40%	±5.80%

Source: Own elaboration

**Figure 4.** Cause and Effect Diagram. Source: Author's own work

reinforcing the urgency of viable financial models. The sample demonstrates high technical feasibility (65.70% of available space) and collective commitment, but requires viable financial solutions to move forward (Table 1).

Photovoltaic (PV) energy The sample shows high technical feasibility (65.70% of available space) and collective commitment (71.40% willing to undergo training), but requires financing solutions (identified as a critical barrier by 71.40%).

Is key to agricultural sustainability, but its inadequate management generates critical problems. These are the main factors and consequences. Using the 6Ms (Ishikawa Methodology), the root causes that hinder efficient management are identified (Figure 4):

Explanation by Category

1. Labor

- Insufficient training: 70% of agricultural technicians lack training in renewable energy.
- Cultural resistance: 62% of workers prefer traditional methods due to lack of knowledge.

2. Methods

- Lack of protocols: They do not have energy efficiency manuals.
- Feasibility not assessed: Preliminary studies are not conducted (irradiation, energy load).

3. Materials

- Economic barriers: Average initial investment: \$25,000 - \$50,000 (return in >7 years).
- Supply chain: 40% of cooperatives report difficulty importing components.

4. Machinery

- Incompatible infrastructure: 55% of units have electrical networks > 20 years old.
- Limited space: 30% lack roofs with optimal orientation (south, 15-30° slope).

5. Measurement

- Inaccurate data: 60% does not measure consumption by equipment (pumping).
- Undefined ROI: Lack of metrics for calculation.
- Savings = Current cost – Photovoltaic cost.

6. Environment

- Climate: Areas with > 120 cloudy days/year reduce efficiency by 40%.
- Legal framework: Lack of regulations for the use of renewable energy.

A decision matrix (Table 2) was developed for decision-making, which evaluates and compares different alternatives based on multiple criteria in the UBPC (Basic Unit of Cooperative Production),

assigning a score. This matrix is specifically designed for the evaluation of photovoltaic projects with the objective of assigning scores (0-10) to 12 technical, economic, and environmental indicators to prioritize photovoltaic projects in agricultural cooperatives.

Evaluation Key

Maximum score per dimension: Technical: 40 points, Economic: 40 points, and Environmental: 40 points. Maximum total: 120 points

Interpretation: ≥ 90 points: High feasibility (prioritize project), 60-89 points: Medium feasibility (requires adjustments), and < 60 points: Low feasibility (rethink strategy).

This matrix transforms 12 complex variables into a clear viability index, facilitating decision-making in cooperatives. The high viability score of 93 indicates that the UBPC (Basic Unit of Cooperative Production) has favorable conditions for operation and development in terms of the evaluated criteria. Opportunities exist that can be effectively leveraged, and there is support from cooperative members and potentially the community.

These measures aim to balance the three dimensions, guaranteeing the project's comprehensive sustainability.

Based on the evaluated socioeconomic, technical, and governance indicators, improvements aimed at comprehensive sustainability were proposed.

Based on the results, the following improvements are proposed:

- Strengthen training programs.
- Create local employment related to the operation and maintenance of photovoltaic systems.
- Implement preventive maintenance plans and improve efficiency by incorporating more advanced technologies.
- Consolidate community participation mechanisms and establish internal environmental management policies that reinforce emissions reduction and

the rational use of land. • Pilot Agrivoltaics: Install elevated structures on 0.5 hectares of farmland, monitoring: Microclimate under panels (humidity/temperature).

- Agricultural yield vs. areas without panels.
- Circular Economy Plan: Agreement with manufacturers for future panel disposal.

Therefore, a critical path was designed for the sequence of activities that determines the total duration of the project. This included tasks that cannot be delayed without affecting the project completion date.

Critical Path (12 months)

The chart below summarizes the main phases and their estimated duration, from the preliminary study to the signing of agreements (Figure 5).

Some activities are carried out in parallel; the critical path includes obtaining permits and community participation.

Expected impact:

- Year 1: 30% reduction in energy costs in administrative areas.
- Year 3: Self-sufficiency in water pumping for irrigation (using only solar energy).
- Year 5: Complete conversion to agrivoltaics on 50% of arable land.

Circular economy actions are strategies that leverage existing resources, minimize waste, and prepare for the energy transition:

- Integrating the biomaterials cycle into the circular economy with photovoltaic energy management represents an opportunity to move towards a more sustainable energy model. This approach not only promotes the efficient use of resources but also contributes to reducing environmental impact and developing innovative solutions for energy production and management, as shown in Table 3.

Table 2. Decision matrix for the UBPC José Vázquez Martínez

Indicator	Value	score	Justification
Available space	1885 m ²	10	Available rooftops not used for agriculture
Solar radiation	20.9 kWh/m ² /day	10	Data validated with a homemade pyranometer
Grid status	15 years	0	Expandable transformer
Technical knowledge	25% basic level	7	1 workshop conducted
Energy expenditure	1,885 USD/month	10	High cost of electric irrigation
Annual ROI	18%	10	Viability limit (5.5 years)
Financing	60% Subsidy	7	Current state program
Payback period	6.2 years	8	Investment recoverable in 74 months
Carbon footprint	420 t CO ₂ /year	7	Diesel fuel used in machinery
Emissions reduction	120 t CO ₂ /year	7	Equivalent to 2,900 trees/year
Resource impact	0% agricultural land	10	Panels only on rooftops
SDG alignment	SDGs 7, 12, 13	7	Clean energy, sustainable production
TOTAL		93	HIGH Viability

Source: own elaboration

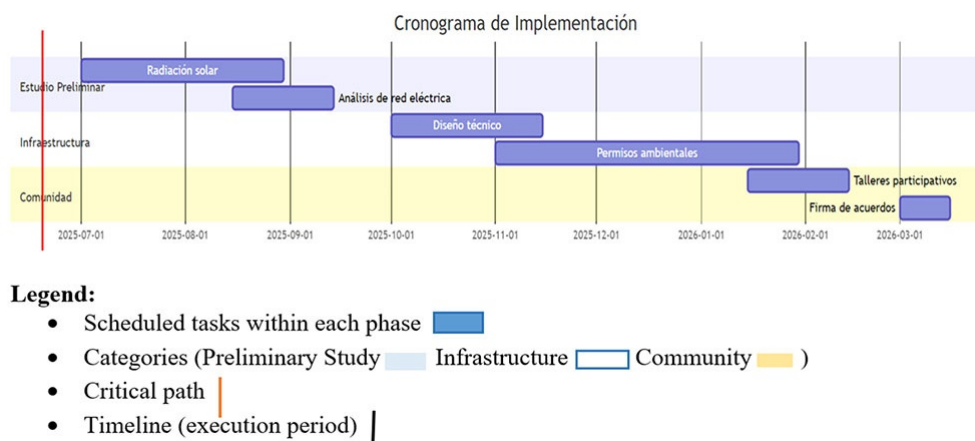


Figure 5. Proposed critical path. Source: Author's own elaboration

Table 3. Biomaterials

Action	Implementation	Circular Benefit
Biofertilizers	Anaerobic digesters to transform manure/waste into fertilizer.	Reduces chemical purchases (+40% recycled nutrients).
Agricultural bioplastics	Use of biodegradable plastics made from cassava or banana starch.	Eliminates 8 tons/year of conventional non-recyclable plastics.
Soil amendments	Composting of prunings and crop residues using vermiculture.	Improves water retention (+30%) and CO ₂ capture.

Source: own elaboration

- The water-energy symbiosis linked to the circular economy in agricultural practices represents a significant opportunity to transform agricultural production towards a more sustainable model. By integrating the efficient use of water and energy, more resilient, productive, and environmentally friendly agricultural systems can be achieved.
- Impact: Recirculates 90% of the water and reduces pumping energy by 75% (prepared for solar energy). Resource efficiency contributes to the integration of water and energy systems, enabling more efficient use of water and energy, reducing costs, and increasing agricultural productivity.
- The synergistic value chain is fundamental to advancing towards an effective circular economy. By fostering collaboration, optimizing resource use, and closing loops, a more sustainable production system can be achieved that benefits both businesses and the environment, as shown in Table 4.

Implementing this approach requires a joint commitment from all stakeholders, as well as a regulatory framework that supports these initiatives.

Table 4. Synergistic value chain

Underutilized resource	Circular product	Target market
Sugarcane bagasse	Particleboard for construction	Neighboring cooperatives
Coffee pulp	Biofuel for dryers	Local processing plants
Fruit pits	Activated carbon for filters	Rural water systems

Source: own elaboration

The results confirm the viability of the photovoltaic project at the UBPC, highlighting the strength of the socioeconomic and governance dimensions, and pointing to areas for improvement in the technical dimension. The combination of equal and factorial weighting strengthened the analysis, reducing subjectivity and reflecting the actual variability of the data. The application of the decision matrix, along with the improvement measures and critical path planning, provides a comprehensive framework for advancing energy sustainability within the cooperative sector.

CONCLUSIONS

- The diagnostic assessment conducted at the "José Vázquez Martínez" Basic Unit of Cooperative Production (UBPC) revealed multiple deficiencies hindering the proper management of photovoltaic energy. These include the limited technical knowledge of the staff, the absence of energy assessment metrics, and the lack of specific regulations on solar energy. However, significant strengths were also identified that can be transformed into strategic opportunities for the implementation of a photovoltaic system.

- Based on the designed technical, economic, and environmental indicators, a decision matrix was developed, a critical path of activities was defined, and three improvement phases were structured along with four actions focused on the circular economy. Decision-making tools (matrix, critical path) were developed, and improvement phases and circular economy actions were proposed that address comprehensive sustainability and contribute to the UBPC's viability in adopting sustainable energy solutions.
- The assessment demonstrates that, despite current limitations, the cooperative has favorable conditions to move toward a more efficient and resilient energy model. The implementation of photovoltaic systems would not only contribute to reducing operating costs and mitigating power outages, but would also strengthen environmental sustainability and the agro-industrial development of the region. The methodology applied, based on multi-criteria indicators and participatory analysis techniques, offers a replicable framework for future evaluations of renewable energy projects in the cooperative sector.

REFERENCES

- ABELLA, M.A.: "Dimensionado de sistemas fotovoltaicos", *Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas*. Tesis para optar al título de maestría, Departamento de Energías Renovables. Escuela de organización industrial, 2014.
- ARENCIBIA, C., G.: "La importancia del uso de paneles solares en la generación de energía eléctrica", *REDVET. Revista Electrónica de Veterinaria*, 17(9): 1-4, 2016, ISSN: 1695-7504.
- FERNÁNDEZ, L.: *Países líderes en capacidad instalada de energía renovable a nivel mundial en 2023 (en GigaVolt)*, [en línea], Statista, 2024a, Disponible en: <https://www.statista.com/statistics/267233/renewable-energy-capacity-worldwide-by-country/>.
- FERNÁNDEZ, L.: *Países líderes en consumo de energía renovable a nivel mundial en 2023 (en exaJoule)*, [en línea], Statista, 2024b, Disponible en: <https://www.statista.com/statistics/237090/renewable-energy-consumption-of-the-top-15-countries/>.
- GARCÍA, J.; PÉREZ, M.; LÓPEZ, R.: "Gestión de recursos energéticos renovables: Un enfoque práctico", *Revista Cubana de Energía*, 12(3): 45-60, 2021.
- IRENA: *Estadísticas de energía renovable 2024*, [en línea], Inst. Agencia Internacional de Energías Renovables (IRENA), 2024, Disponible en: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Jul/IRENA_Renewable_Energy_Statistics_2024.pdf.
- MARTÍN, B.A.M.; LEYVA, F.G.; HERNÁNDEZ, R.G.: "Criterio de expertos para fundamentar un procedimiento que evalúe la sostenibilidad económica de la inversión energética renovable en Sancti Spíritus, Cuba", *Cofin Habana*, 17(2), 2023, ISSN: 2073-6061.
- MINEM-CUBA: *Informe sobre Energías Renovables en Cuba*, [en línea], Inst. Ministerio de Energía y Minas, La Habana, Cuba, 2023, Disponible en: <http://www.minem.gob.cu>.
- NAVARRO, N.D.A.; VILLAMIL, C.J.E.; GARNICA, M.J.P.; JARAMILLO, B.C.: "Evaluación de un enfoque modificado de escuelas de campo en la apropiación de conocimientos en agricultores de arracacha", *Revista Ciencia y Agricultura*, 19(3): 1-16, 2022, ISSN: 0122-8420.
- PNUD: *Informe sobre desarrollo humano*, [en línea], Inst. PNUD, 2022, Disponible en: <https://www.undp.org>.
- RIVERA, J.S.; BAYONA, W.N.: "Estudio de viabilidad de sistemas fotovoltaicos como fuente de energía: caso Universidad San Gregorio Portoviejo", *Conciencia Digital*, 5(2): 162-183, 2022, ISSN: 2600-5859.
- SANTOS, A.; HERNÁNDEZ, Y.; DÍAZ, R.: *Diseño de un sistema fotovoltaico para alimentar una vivienda*, Inst. Poder Popular La Tunas, Cuba, Las Tunas, Cuba, 5 p., 2017.
- WORLD ECONOMIC FORUM: *Estado de la energía mundial: en gráficos*, [en línea], Inst. World Economic Forum, 2022, Disponible en: <https://es.weforum.org/stories/2022/08/este-es-el-estado-de-la-energia-mundial-en-graficos/>.