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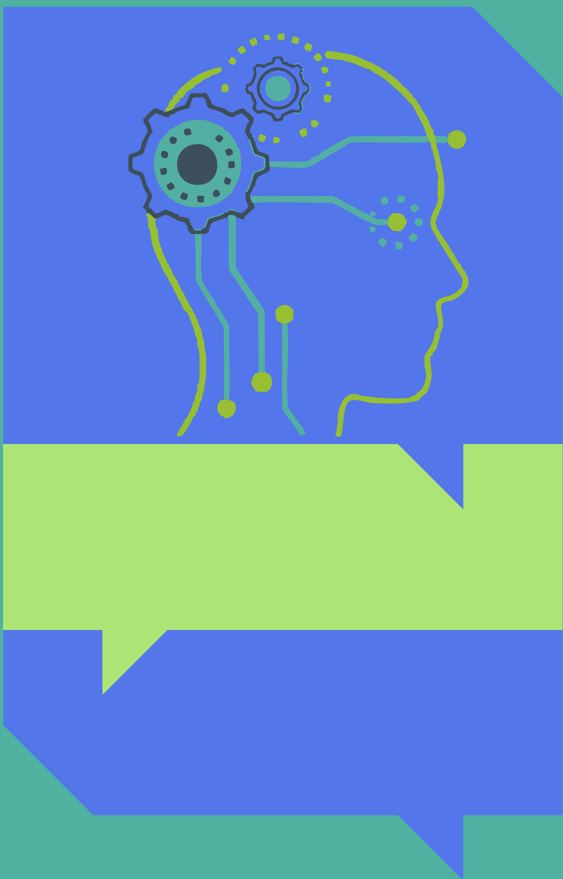

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Contenido

Evaluación del desempeño de la automatización de una granja avícola

Hernán Humberto Espinosa Cano[1], Huber Arbey Úsuga Torres[2], Luis Fernando Cardona Sepúlveda[3], Erwin López Martínez[4], Fredy Castro Celis[5], Fabián Vargas Álvarez[6]

Palabras clave: automatización, producción avícola, pollo de engorde, sistema de crianza, producción sostenible

Temática: Desarrollo sostenible

Introducción

La avicultura es un sector muy dinámico y constituye una fuente clave de proteína animal. La producción avícola enfrenta desafíos relacionados con la sostenibilidad y bienestar animal, ya que la creciente demanda de carne de pollo exige sistemas más eficaces. La producción tradicional requiere la intervención de numerosas personas en el proceso, lo que implica altos costos, riesgo de errores y tiempos prolongados [1]. En Ecuador [2] y Brasil [3] se han reportado mejoras en indicadores de desempeño para plantas automatizadas, pero en Colombia existe un vacío al respecto. Por lo tanto, el problema de investigación es:

> ¿en qué medida la automatización mejora el desempeño productivo y el uso eficiente de recursos frente a un sistema convencional bajo condiciones reales de operación en Colombia? Para responderlo, este estudio compara dos galpones (uno convencionaly otro automatizado) y evalúa variables clave con el fin de estimar impactos en el desempeño.

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Metodología

El estudio comparó dos sistemas de producción, uno convencional y otro automatizado de la misma empresa. El sistema *convencional*, mostrado en la Figura 1, consiste en un galpón con alimentación manual, ventilación natural y por ventiladores de función fija, con mano de obra permanente. El sistema *automatizado*, mostrado en la Figura 2, consiste en un galpón con extractores regulados por temperatura, alimentación continua por medio de líneas automatizadas de comederos y con iluminación regulable. Se evaluaron 7 variables para cada caso: alimentación, hidratación, climatización, iluminación, mano de obra, consumo de agua y producción.

Mano de obra	1 trabajador / 15.000 aves	1 trabajador / 55.000 aves
Consumo de agua	5–6 L/ave/ciclo	3–4 L/ave/ciclo
Producción	29-32 kg/m²	40-46 kg/m²

Figura 1: Granja avícola *convencional*

Figura 2: Granja avícola *automatizada*

Resultados

La Tabla 1 presenta los principales resultados obtenidos en este trabajo. El sistema *automatizado* supera al *convencional* en casi todas las variables evaluadas.

Tabla 1: Comparación entre la planta de producción convencional y la automatizada

Variable	Planta convencional	Planta automatizada
Alimentación	Manual, riesgo de desperdicio (5–7%)	Automática, desperdicio <1%
Hidratación	Bebederos manuales	Líneas automáticas
Climatización	Ventilación natural	Sensores y ventilación forzada
Iluminación	Bombillos tradicionales	LED regulable

La reducción en desperdicio de alimentos y agua contribuye significativamente a la sostenibilidad ambiental. El uso de sensores y sistemas digitales disminuye la mortalidad y mejora la uniformidad del lote, lo cual es clave para el mercado de carne de pollo. El tiempo de engorde de las aves baja un 20%, lo cual disminuye los gastos operativos. La optimización del ciclo productivo y la mejora en la calidad final del producto permiten una recuperación más rápida de la inversión y mayor rentabilidad en el mediano plazo.

Discusión

La granja avícola automatizada supera a la convencional, reduce los desperdicios de alimento, agua y recurso humano, disminuye la mortalidad y eleva la productividad por m². Estas mejoras fortalecen la sostenibilidad y el bienestar animal, aumentan la rentabilidad y aceleran la recuperación de la inversión, respaldando su adopción y evaluación a escala comercial en Colombia.

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Manufacturing design methodologies and analysis tools for the development of sustainable energy solutions

Mateo Zapata[1], Mateo Ortiz[2], Juan Camilo Isaza[3], J. A. Patiño[4], Gabriel Espitia Mesa[5], Juan Pablo Giraldo[6], Gilberto Osorio Gómez[7]

Keywords: Prototypes, electronic manufacturing, data visualization, sustainable solutions, power generation.

Topic: Energy Management

Introduction

The development of sustainable energy solutions requires practical skills in manufacturing, experimental validation, and data analysis [1][2][3]. This study aimed to strengthen technological maturity through the application of manufacturing methodologies and analytical tools in the design and evaluation of three prototypes: a solar facade, a solar brick, and a wind turbine. These devices served as experimental platforms for acquiring the applied skills necessary for the transition to clean and viable energy solutions [4].

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Methodology

A practical approach based on project-based learning was adopted, applying electronic manufacturing processes such as PCB routing and painting, component soldering, and the development of test protocols for each prototype. For data analysis, platforms such as data management and visualization were used, which allowed for the processing and visualization of experimental results. The tests included electrical measurements under limitations encountered, such as losses due to shading, welding quality, or difficulties in data quality, guide different lighting conditions (for the solar prototypes) and generation tests under different wind speeds (for the wind turbine). Construction aspects were also documented, and different material and assembly alternatives were compared.

Results

The development of the three prototypes facilitated the consolidation of technical skills in electronic manufacturing, data management, and functional validation. The construction and testing of variable measurement devices for the prototypes, with basic operational functionalities, was achieved. The visualizations generated made it possible to detect anomalies, identify opportunities for improvement, and support redesign decisions.

Discussion

The work highlighted the importance of integrating manufacturing methodologies with data analysis tools to improve the quality of design and validation of sustainable energy solutions. Acquiring skills in electronic manufacturing not only facilitated the construction of prototypes but also enhanced understanding of the technical challenges associated with the efficiency, stability, and maintenance of these systems. Similarly, the use of tools such as data management and visualization promoted a culture of data-driven decision-making, a key aspect in technological innovation environments. The future iterations toward more efficient and robust solutions.

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A systematic framework for evaluating solar panels with active cooling

Albeiro Ceballos[1], Miguel Vargas[2], Santiago Molina[3], Gabriel Espitia[4], Gilberto Osorio[5]

Palabras clave: Photovoltaic-Thermal (PV/T) System, active cooling, solar panel efficiency, CFD simulation, FEM Analysis, methodological framewok

Topic: Gestión Energética

Introduction

In response to the world's growing energy demand, solar energy is presented as one of the most promising sources due to its renewable nature, cost accessibility and availability around the globe [1]. However, the efficiency of photovoltaic modules decreases significantly as their operating temperature increases, since electrical conversion losses occur mainly due to heat accumulated on the surface, which limits their performance in hot climates and high temperature conditions [2]. For this reason, it is necessary to implement a hybrid photovoltaic-thermal (PV/T) system that not only generate electricity but also harness or dissipate heat to improve the overall performance of system. This paper presents a systematic approach to evaluate the efficiency of a solar panel cooled by an active cooling system by constant fluid circulation through pipes. The use of SolidWorks Flow simulation for CFD simulations and SolidWorks Simulation for thermal studies using FEM is proposed. A case study was performed for the refrigerant R134a entering at -26°C and 1.017 bar. The results obtained indicate a decrease of approximately

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40 °C of the surface of the cooled model compared to the uncooled model, obtaining an improvement in efficiency.

Methodology

This section presents the proposed methodology for selecting a cooling system for a PV/T system. The factors that can be considered for each process and/or decision are presented below.

- Initial requirements: environmental conditions, operation, materials, and irradiance are considered.
- Energy improvement requirements: efficiency to be achieved, low consumption, heat gain, additional functions.
- Identification of cooling system: active or passive system
- Selection of cooling system
- Validation with computational tools: CFD simulation, thermal simulation, scripts
- Analysis of results

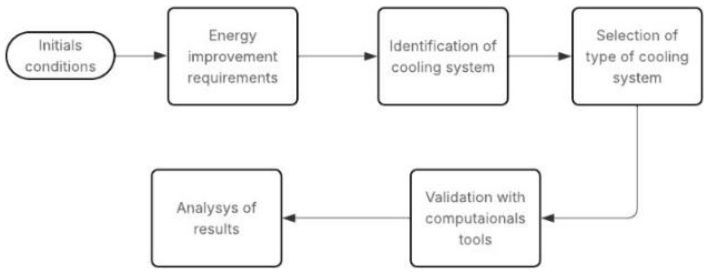

Figura 1. Flowchart

Case Study

Figure 2 shows the CAD model of the PV/T system, which consists of silicon cells, an aluminum body (cover and box), and a copper coil.

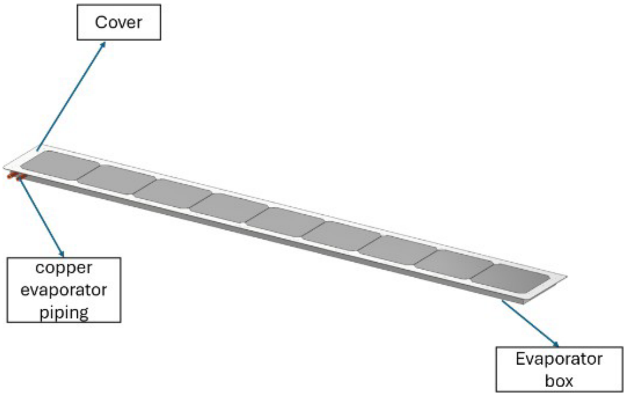

Figura 2. PV/T system

Results

Figura 3 shows the temperature distribution across the panel with active cooling.

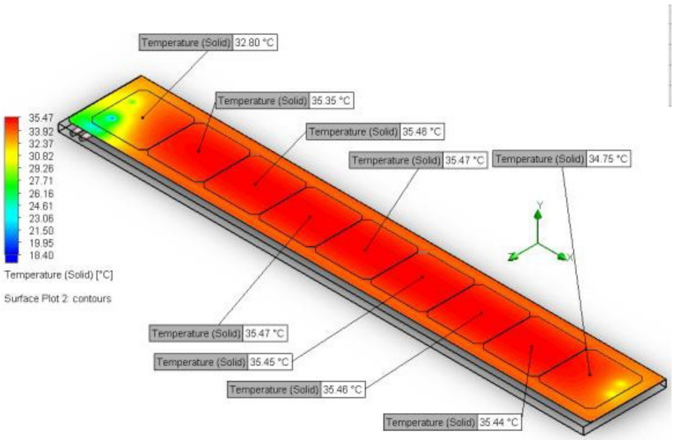

Figura 3. Temperature of the refrigerated panel

Discussion

The temperature distribution illustrated in Figure 3 demonstrates the effectiveness of the proposed active cooling strategy in extracting heat from the solar panel structure. The contour map reveals a clear thermal gradient along the fluid circulation path, with the lowest temperatures concentrated near the refrigerant inlet region and progressively increasing toward the outlet. This behavior is consistent with the expected heat absorption profile of R134a, which enters at –26 °C and 1.017 bar, gradually warming as it absorbs thermal energy from the panel. Notably, the CFD and FEM results show that the cooled configuration achieves surface temperatures approximately 40 °C lower than the uncooled panel, confirming a substantial reduction in thermal stress and an improvement in operating conditions. The uniformity of the intermediate temperature zones also suggests efficient convective heat transfer within the embedded piping, minimizing localized hotspots commonly observed in passive systems. Overall, the figure supports the conclusion that integrating an active cooling loop significantly enhances the thermal management and potential energy conversion efficiency of the solar panel

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Design and analysis of a cooking device based on concentrating solar-thermal energy

Cesar Enrique Cadavid Arango[1], Dylan Osorio Hernández[2], Edwin Hoyos Agudelo[3], María Hernández Noriega[4], Miguel Gallego Osorno[5], William Vásquez[6], Gabriel Espitia[7], Manuel Fula Rojas[8]

Keywords: Concentrating solar power, solar cooking, solar thermal, sustainability, energy poverty, food security

Topic: Energy management

Introduction

In Colombia, more than one million people live in Non-Interconnected Zones (ZNI). The absence of electrical infrastructure in these areas, characterized by remoteness and low population density, represents a significant barrier to development and results in multiple unmet needs, including food security. A case of relevance is the department of San Andrés and Providencia, which accounts for 56.42% of the total energy demand of the ZNI [1]. Due to its geographic isolation, liquefied petroleum gas (LPG) prices in this territory are higher than those on the Colombian mainland and must be subsidized. At the same time, an increasing number of households resort to firewood for cooking, a

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practice that generates negative impacts on both community health and the environment [2][3][4]. Considering this problem, Colombia possesses vast renewable energy potential, with solar energy standing out as a resource available in most remote communities. However, its implementation remains limited despite this significant opportunity. In this context, the present work aims to develop an energy access system for cooking based on the principle of solar concentration, oriented toward reducing the costs associated with food preparation in remote areas of Colombia, with specific application in the department of San Andrés and Providencia.

Methodology

The research consists in the main stages of designing a solar thermal concentrator prototype, including analytical and numerical simulations of irradiance and concentration, structural analysis using the finite element method, and innovation methodologies oriented toward a functional prototype adapted to the community's needs.

Results

The results show validation between the concentration simulations, revealing a dependence between solar intensity and time of day with respect to the percentage error of numerical simulations compared to the analytical model. The remaining simulations and models had a positive effect on the design functions and were validated in the prototype, which meets the identified requirements and achieves, on average, up to a 27% reduction in the annual daily cost of cooking.

Discussion

The findings obtained from the prototype development and simulation stages highlight the feasibility of concentrating solar-thermal energy as a practical cooking alternative for remote communities in Colombia. The observed agreement between analytical and numerical concentration models demonstrates that the system can reliably predict and harness solar irradiance under varying environmental conditions, an essential requirement for operational stability in non-interconnected zones. Moreover, the structural and functional validations confirm that the design can withstand typical outdoor operating loads while maintaining adequate thermal performance for cooking tasks

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Design tool for wind resource assessment using aviation standards and open meteorological data

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Keywords: Wind Turbine Feasibility, Design tool, Meteorological Analysis, Sustainable Development, Renewable Energy Communities).

Topic: Sustainable Development

Introduction

Assessing wind resources for small-scale projects often faces the challenge of limited site-specific measurements. This study presents a methodological framework to evaluate the feasibility of a micro horizontal-axis wind turbine (HAWT) using long-term meteorological records from Colombia's IDEAM network, complemented by aviation standards for wind characterization. More than ten years of minute-level data from a nearby station (SELVA, 5.5 km from the site) were analysed through exploratory statistics, Weibull and von Mises distributions, and validation against airport climatological records. Results indicated mean wind speeds of 0.97 m/s, with a turbine cut-in threshold of 1.5 m/s exceeded around 19% of the time. Directional stability during midday suggested the adequacy of a passive yaw system, while seasonal intensification (June–Sept.) revealed windows of improved operation. Building on aviation practices for wind roses and directional analysis [1] [2], the framework demonstrates how publicly available datasets can

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substitute for costly measurement campaigns in early feasibility. In doing so, it provides a replicable, low-cost screening tool for community and rural renewable projects, aligned with similar calls in the literature for adapting reanalysis and public station data to energy applications [3][4][5].

Methodology

The analysis followed a structured pipeline using the SELVA station dataset (2013--2023). Quality control routines capped implausible outliers ($3 \times \sigma$) above mean, up to 52.7 m/s) and removed flat-line records. Exploratory data analysis revealed diurnal and seasonal cycles, with peak medians around 1.8 m/s at midday and greater stability from June to September. Wind speeds were fitted to a Weibull distribution ($k = 1.57$, $c = 1.09$), consistent with recommended practices for energy yield estimation (Shi, 2021). Wind direction was modeled with a von Mises distribution ($\mu = 57.5°$ and $\kappa = 0.5$), supporting yaw design. Validation with SKRG airport records confirmed prevailing ENE/ESE winds. The workflow, shown in Fig. 1 adapts aviation-derived methods for renewable feasibility screening.

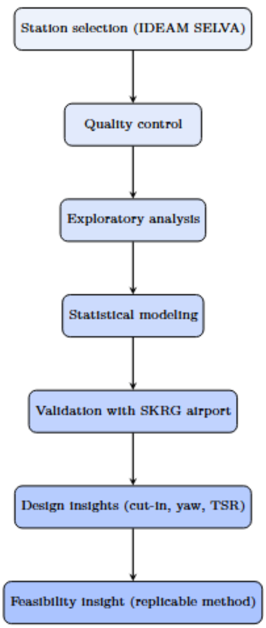

Figure 1: Workflow of the wind feasibility methodology.

Results

The cleaned dataset (2013–2023) yielded:

- Mean wind speed 0.97 m/s, median 0.7 m/s, std. dev. 0.69 m/s.
- Weibull parameters: (k = 1.57, c = 1.09),
- Operational potential: cut-in speed (1.5 m/s) exceeded 18.95% of the time.
- Prevailing winds ENE/ESE; stable midday window, stronger June–Sept.
- These results imply limited but usable operation, justifying passive yaw but suggesting design adaptations (e.g., tip speed ratio, alternative rotor).

Discussion

This study demonstrates that long-term meteorological records, combined with aviation-based analysis, provide a valid preliminary assessment tool for small- scale wind projects. By integrating data quality control, probabilistic modeling, and validation against airport observations, the framework supports early decision-making without costly instrumentation. While limitations exist—microclimatic effects and lack of site-specific masts—the methodology remains replicable in other regions where public archives are Available [6][7]. In this way, it contributes to sustainable energy planning for communities, bridging the gap between climatological data and practical turbine design.

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Mechanical design of curved photovoltaic modules using composite materiales

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Keywords: Solar energy, curved photovoltaic module, PV surface

Topic: Curved Photovoltaics

Introduction

Global energy demand is increasing due to population growth and technological expansion. Renewable energy, particularly photovoltaic (PV) technology, offers a sustainable solution to meet this demand while reducing greenhouse gas emissions [1,2]. Solar PV is versatile and environmentally friendly, suitable for both domestic and large-scale applications [3]. Traditional PV modules are mainly flat, limiting integration into curved surfaces because crystalline silicon (c-Si) cells are brittle and prone to stress during bending [4]. Recent advances, including thin c-Si wafers, SunPower IBC cells, and thin-film technologies, allow PV modules to be adapted to curved and non-planar surfaces, enabling applications in building facades, vehicles, and marine systems [5].

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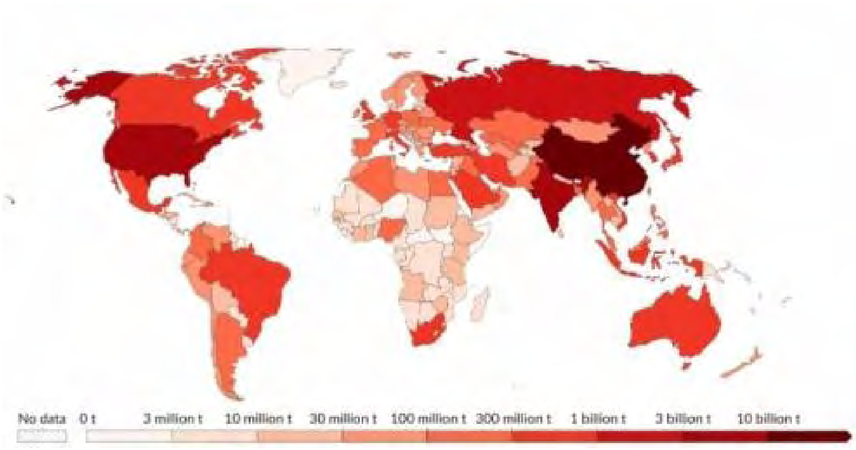

Figure 1. Carbon dioxide (CO2) emissions [3].

Methodology

1. **Curvature Requirements:** Defined the curved surface geometry, including minimum and maximum radii, critical stress. Modeled as simply supported beam under areas, and aesthetic/functional integration considerations.
2. **Material Selection:** Used Granta EduPack to choose materials based on mechanical properties, thermal compatibility, availability, and cost-effectiveness, ensuring durability under bending.
3. **Material Characterization:** Evaluated the laminated composite through mechanical tests (tensile and bending), hardness measurements, and optical transmittance to ensure flexibility and performance.
4. **Structural Validation:** Performed finite element simulations in ANSYS to assess stress, deformation, and critical zones, validating and refining the design iteratively.
5. **Experimental Analysis and Results:** Fabricated prototypes to measure maximum bending tolerance, stress distribution, and electrical performance. Results from simulations and experiments were analyzed to optimize module design and material selection.

Fem Simulations – Curved PV

Modules

1. Analyzed small & large cells with fiberglass + 422T resin. central load.
2. Deflection: Small cells = 23.34 mm, large cells = 39.80 mm.
3. 422T resin shows lower deflection → better stiffness.

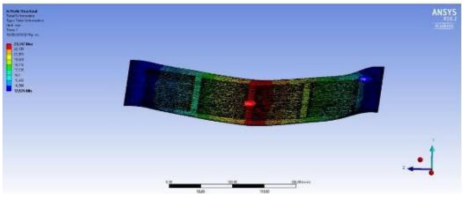

Figure 2. Small cells, fiberglass - 422T resin.

Recent advances, including thin c-Si wafers, SunPower IBC cells, and thin-film technologies, allow PV modules to be adapted to curved and non-planar surfaces, enabling applications in building facades, vehicles, and marine systems [5].

Results

This section summarizes the structural and electrical performance of the evaluated solar cells. Experimental and ANSYS simulation results show that fiberglass-reinforced cells with 422T resin maintain high efficiency while allowing smaller curvature radii. In contrast, Kevlar alters the efficiency ranking between cell types. Overall, the combination of fiberglass and 422T resin provides the best balance between mechanical flexibility and electrical performance for curved PV modules.

Material	Cell 19%				Cell 16%			
	# Exp.	E [%]	RC [mm]	Ansys RC [mm]	# Exp.	E [%]	RC [mm]	Ansys RC [mm]
422T Resin Fiberglass	1	15.162	217.971	232.212	1	12.678	233.576	373.709
	2	15.263	217.606	232.212	2	12.713	230.063	373.709
	3	15.387	168.462	232.212	3	13.837	226.326	373.709
422T Resin Kevlar	1	13.529	202.166	176.765	1	13.744	230.964	352.703
	2	13.377	202.823	176.765	2	14.612	250.049	352.703
	3	13.112	182.814	176.765	3	14.824	252.903	352.703

Figure 3. Experimental and FEM results for 19% and 16% cells with 422T resin (fiberglass and Kevlar reinforcement).

Discussion

The experimental and numerical findings collectively demonstrate that composite-based curved photovoltaic modules can achieve the mechanical flexibility required for non-planar integration without compromising electrical performance. The agreement between FEM simulations and prototype testing confirms that fiberglass reinforced with 422T resin provides superior stiffness and lower deflection under load, enabling tighter curvature radii compared to alternative materials such as Kevlar. This mechanical advantage is particularly relevant for applications in transportation and building-integrated photovoltaics where aerodynamic or architectural constraints demand curved geometries. Furthermore, the results highlight the critical interplay between material selection, laminate configuration, and cell size—factors that directly influence stress distribution and bending tolerance.

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Feasibility analysis for the design of refrigeration systems in PV/T: costs and thermal energy utilization

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Key words: PV/T hybrid systems, Cooling technologies, Energy cost estimation, Thermal energy utilization

Topic: Energy Management

Introduction

With the growing energy demand and the environmental impact of fossil fuels, the adoption of renewable energies has become a global priority for the transition towards a sustainable energy system [1]. Solar energy, in particular, has emerged as a fundamental source for reducing dependency on non- renewable resources due to its availability and low environmental impact [2]. In this context, hybrid systems that integrate photovoltaic and thermal technologies offer a solution to efficiently harness solar radiation, enabling the generation of both electricity and heat within a single unit [3]. This dual utilization capability makes photovoltaic-thermal (PV/T) hybrid systems a powerful tool to meet the energy needs of residential, commercial, and industrial applications.

The utilization of thermal energy generated in PV/T systems is an excellent alternative to reduce fossil fuel dependency and minimize greenhouse gas emissions, contributing significantly to mitigating climate

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Methodology

For the development of this article, the methodology shown in Figure 1 is used. This begins with the identification and selection of solar panel cooling technologies, focusing on those that represent innovations and consistent approaches. Next, a search for recent scientific articles describing each selected technology is conducted, ensuring that each one provides relevant and verifiable data. Finally, energy balances are performed to identify the actual energy gains, and a cost estimation is made for the maximum expenses associated with the implementation, manufacturing, and maintenance of each technology.

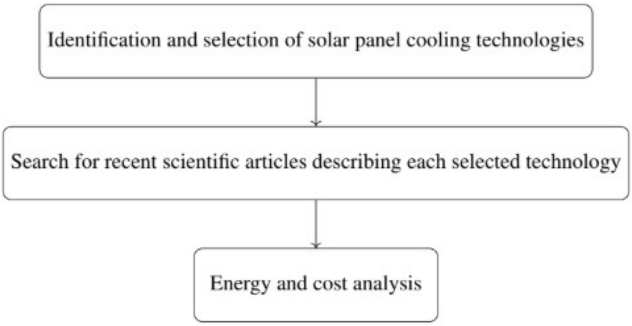

Figure 1. Methodology used

1. Identification and selection of solar panel cooling technologies

In the study conducted by Faddouli et al. (2024), a detailed classification of PV/T hybrid solar panels is presented, which integrate the simultaneous generation of electricity and heat from solar energy.

This classification, illustrated in Figure 2, organizes PV/T systems into two main categories: Standard Systems and Innovation-Based Systems. Standard Systems include technologies that use water, air, or a combination of both fluids (bi-fluid) for thermal management, as well as concentrators that intensify the solar radiation received by the panel, thereby maximizing the capture of both electrical and thermal energy. Innovation-Based Systems, on the other hand, employ advanced technologies such as nanofluids, phase change materials (PCM), and refrigerants, designed to improve heat transfer capacity and regulate the system's temperature.

For this article, a review of recent scientific literature was conducted, analyzing each cooling technology based on the criterion that the generated thermal potential should be quantifiable and usable. Based on this review, the cooling systems selected for analysis were air cooling, water cooling, cooling using nanofluids combined with phase change materials, and cooling with refrigerants.

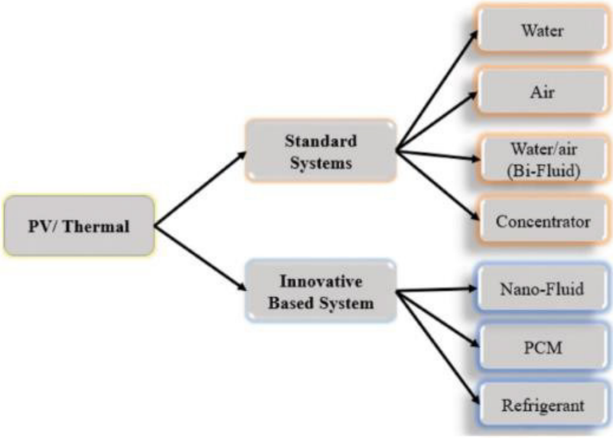

Figure 2. Different existing PV/T collector technologies [4]

Results

The cost estimates presented in this study allow for identifying an economic limit for the implementation of each cooling system analyzed, but these costs are only viable if the thermal energy generated is utilized in practical applications that eliminate the need for other energy sources. The cooling systems, except for the air-based system, heat water up to approximately 35 °C, a temperature that offers multiple practical uses that would not be possible with ambient temperature water. These uses include heating small spaces, preheating water for industrial or domestic processes, and use in specific agricultural applications, contributing to greater energy efficiency in the environments where these systems are applied.

Discussion

This result reinforces the idea that PV/T installations should be conceived not merely as electricity-generating systems but as multifunctional assets capable of supporting space heating, domestic hot-water preheating, or low-temperature industrial and agricultural processes. The cost boundaries identified in the study further suggest that although innovative cooling technologies may entail higher installation and maintenance expenses, these can be justified in contexts where thermal demand is continuous or where fuel costs are high. Overall, the results underscore that the viability of PV/T cooling solutions is maximized when both electrical and thermal outputs are strategically exploited within the energy ecosystem of the end user.

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Optical analysis of the performance of an ellipsoidal concentrator for a bicpv application design

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Key words: BICPV, PV Facade, Solar Energy, Sustainability, Ray-tracing, Design

Topic: Analysis and design of dynamical systems

Introduction

The increase in greenhouse gas emissions [1] has prompted the technical development of devices for using renewable energies. At the residential level, the role of photovoltaic solar energy has become important in recent years, as it allows the generation of prosumer (Producer-Consumer) nodes from applications integrated into the building-integrated concentrator photovoltaic (BICPV)[2], which shortens the energy supply chain centralized in generation plants. This work analyzes the optical performance of an ellipsoidal geometry concentrator for a photovoltaic solar facade through numerical modeling based on the reflection equations.

Methodology

The reflection equations were developed in Python™ using the direction cosine and the $\mathbb{R}^3$ rotation matrix Rm, which are described in the following equation.

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$$Rm = RxRyRz \tag{1}$$

$$R_x = \begin{pmatrix} 1 & 0 & 0 \\ 0 & cos\alpha & -sin\alpha \\ 0 & sin\alpha & cos\alpha \end{pmatrix} \tag{2}$$

$$Ry = \begin{pmatrix} cos\beta & 0 & sin\beta \\ 0 & 1 & 0 \\ -sin\beta & 0 & cos\beta \end{pmatrix} \tag{3}$$

$$R_x = \begin{pmatrix} cos\gamma & -sin\gamma & 0 \\ sin\gamma & cos\gamma & 0 \\ 0 & 0 & 1 \end{pmatrix} \tag{4}$$

$$\alpha = \frac{\vec{v} \cdot e1}{|\vec{v}||\vec{e}|} \tag{5}$$

$$\beta = \frac{\vec{v} \cdot e2}{|\vec{v}||\vec{e}|} \tag{6}$$

$$\gamma = \frac{\vec{v} \cdot e3}{|\vec{v}||\vec{e}|} \tag{7}$$

Based on the above, α, β, and γ are the direction angles on the X, Y, and Z axes respectively; similarly, e_1, e_2, and $e_3$are the X, Y, and Z components of the axis on which the direction cosines are being calculated. It is important to clarify that the axis corresponds to the normal vector on which the ray is incident. Once the rotation angles are calculated, a three-dimensional rotation is applied using rotation matrices as shown in equation 8

$$v' = \begin{pmatrix} v_x' \\ vy' \\ vz' \end{pmatrix} = R_m \begin{pmatrix} vx \\ vy \\ vz \end{pmatrix} \tag{8}$$

Results

A comparison is made between a cylindrical concentrator with respect to the ellipsoidal geometry on the days after each equinox and solstice, obtaining better performances with the latter which is shown in figure 1. Thus, it is shown that the influence of the concentrator geometry is prominent in terms of energy performance, mainly due to the ability of the ellipsoidal surface to concentrate solar rays into two focal points, a property that cylindrical geometries do not possess.

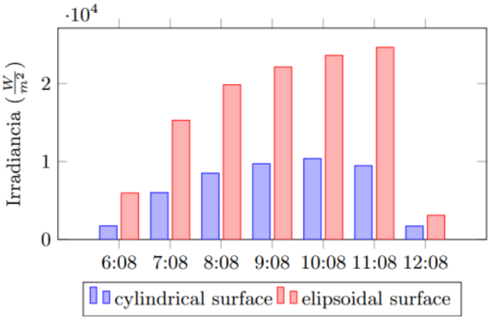

Figure 1. Irradiance for the spring equinox.

Discussion

The enhanced concentration observed in the ellipsoidal model is consistent with its dual-focus property, which enables more effective redirection of incident solar radiation throughout seasonal variations. This behavior is particularly relevant for façade-integrated applications, where the angle of incidence changes significantly during the year and conventional cylindrical concentrators struggle to maintain high concentration ratios. The consistency between the numerical modeling using direction cosines and rotation matrices and the irradiance trends in Figure 1 validates the robustness of the proposed optical simulation methodology. Overall, these results highlight the importance of geometric optimization in concentrator design and suggest that ellipsoidal architectures can substantially improve annual energy capture in BICPV systems

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Design of blades in low wind speed turbines based on bidimensional analysis of NACA 4412 and 4420 profiles

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Keywords: Aerodynamic Profiles; Blades design, NACA 4412–4420; BEM Simulations; Bio- Inspired Geometry; Low Wind Speeds

Topic: Analysis and design of dynamical systems

Introduction

The design of blades for wind turbines capable of operating at low wind speeds typical in countries such as Colombia, where wind speeds below 6 m/s are recorded across much of the territory [1], presents scenarios where the selection of suitable aerodynamic profiles and their distribution and configuration along the blades are key aspects for turbine performance and operation [2][3]. In this work, a two-dimensional analysis of the NACA 4412 and NACA 4420 profiles was performed to characterize their performance using the BEM method in Qblade software.

Methodology

Three stages were carried out. First, the polars of each profile were generated from direct analysis in QBlade, evaluating a range of angles of attack between -20° and 20°. These curves were then extrapolated,

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allowing the lift CL and drag CD information to be extended to the entire angular domain ±180°. In the second stage, the results of both profiles were compared, with particular attention to their behavior in the lift zone. Finally, these results were applied to the design of a bio-inspired wavy blade geometry, inspired by whale fins, with the aim of improving energy capture in low-speed flow regimes.

Results

The results show that the NACA 4412 profile achieves higher lift values, making it more suitable for the inner part of the blade, near the root. In contrast, the NACA 4420 profile offers lower drag losses, making it more suitable for the outer part of the blade, near the tip, which is the most important area for aerodynamic torque generation. The combination of both profiles, with 4412 at the root and 4420 at the tip, allows for the design of a blade that balances lift, drag, and mechanical strength.

Discussion

The wavy geometry also showed advantages, as it generates vortices on the blade surface that delay boundary layer separation, resulting in better performance at low Reynolds numbers. In conclusion, this study demonstrates that the integration of NACA 4412 and 4420 profiles in a bio-inspired radial configuration can be an appropriate strategy for the design of small wind turbines.

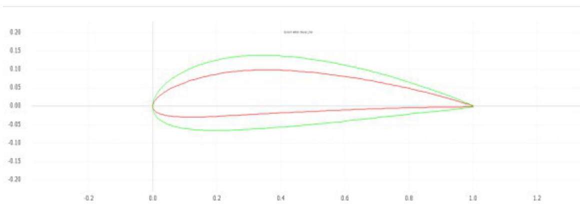

Figura 1. Prefiles NACA 4412 y 4420

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Design of a vi curve circuit for the characterization of photovoltaic surfaces

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Key words: PV surface, Composite Materials, Curved PV module, Manufacturing PV module, Manufacture Framework.

Topic: Materials in Engineering

Introduction

Nowadays, to reach targets for reducing greenhouse gas emissions and make further headway towards end-user-based energy systems based on renewable sources, adoption of solar panels has become a prime method for harnessing clean energy production. Improvements in photovoltaic module efficiency and progress in related technologies have made it possible for research into alternative installation schemes such as Building Integrated Photovoltaics (BIPV), Vehicle Integrated Photovoltaics (VIPV), and, more generally, Product Integrated Photovoltaics (PIPV). It opens possibilities for installation on non-flat substrates such as concave- convex geometries, raising related questions about their performative effectiveness. The first effect of fitting solar panels on curved surfaces is studied in this investigation.

Methodology

A circuit for capturing the I–V characteristics of the panels was set up for this purpose so that their maximum power point would be determinable while their performance for flat, convex, as well as concave settings, would also be feasible [1, 2]. Initial results show that, unlike

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a flat planar surface, convex geometry provides an increased power output of 9.96%, while concave geometry offers a 7.2% improvement. These are greater value than those reported in conventional flat- module assessments, which further suggests that curvature can improve energy production based on a better alignment with solar irradiance.

Results

Three commercial flat modules were tested, connected simultaneously to the acquisition circuit to ensure comparable conditions.

Figure 1. Flat, concave and convex PV modules

Measurements were made on January 24th between 7:40 a.m. and 4:30 p.m. At noon, the recorded irradiance was 1148 W/m². Peak powers of 39.14 W, 38.10 W, and 37.30 W were obtained, which served as the base-line for subsequent comparisons.

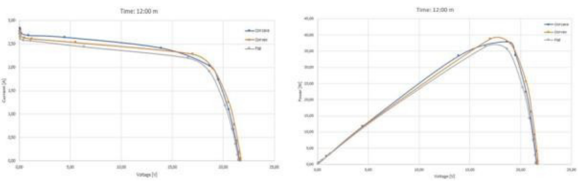

Figure 2. VI curves of flat, concave and convex PV modules

Temperatures were close to 65°C, with minimal differences. The maximum power variations (2.1% and 4.9%) were considered normal, so future increases greater than these could be attributed to the geometric effect.

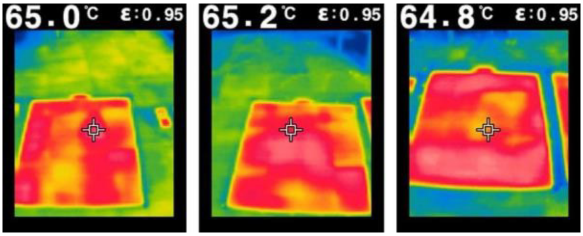

Figure 3. Temperatures in flat, concave and convex PV modules

Conclusions and Discussion

The circuit design enabled reliable, real-time measurements of the electrical variables of the photovoltaic modules, ensuring accurate comparisons of configurations under the same irradiance conditions. The results showed that curved geometry improves the modules electrical performance, with convex geometry showing the best performance and lowest temperature. This confirms that geometric orientation directly influences solar collection efficiency and generated power.

Discussion

The study proves here that the integration of curved surfaces holds great promise for improvement in system performance. At the same time, it advocates experimental tools for technology that help in acquiring performance information in panels set up in a variety of configurations. Such information in later research would form a foundation for deriving mathematical models aiming at optimizing solar panel installation on non-linear surfaces in addition to providing avenues for potential use in architecture, transportation, as well as integrated energy applications

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Methodological deseign of an iot interface for real- time monitoring of renewable energy systems

Juan Camilo Ospino Martínez[1], Santiago Molina Tamayo[1], Juan Camilo Isaza[1], Gabriel Espitia Mesa[1], Juan Pablo Giraldo[1], Gilberto Osorio-Gómez[1]

Keywords: IoT, Energy Management, Renewable Energy, Real-Time Monitoring

Topic: Sustainable Development

Introduction

The transition toward renewable energy highlights the need for reliable, low-cost monitoring solutions capable of integrating diverse technologies into unified frameworks. Previous studies have emphasized the role of IoT in distributed generation, yet most remain limited to single technologies or conceptual frameworks [1][2]. This work presents the methodological design and validation of an IoT interface for real-time monitoring of three renewable prototypes: an electro-solar façade, a photovoltaic brick, and a micro wind turbine. The proposed architecture combines robust industrial communication protocols with open-source tools, emphasizing data integrity, scalability, and cost-effectiveness. A Raspberry Pi consolidates measurements from ESP32-based sensors, storing them in Parquet format and persisting them in a MySQL database. Visualization was implemented through Power BI dashboards, with additional proof- of-concept cloud integration using MATLAB ThingSpeak. Validation with simulated data confirmed acquisition, redundancy, storage, and interoperability. This contributes a replicable academic test-bed and scalable template for distributed renewable monitoring, complementing prior PV- and wind-focused

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works [3][4]. The system lays the foundation for future extensions such as MQTT-based communication, machine learning, and enhanced security for field- ready deployments.

Methodology

Building on prior IoT monitoring pipelines [5][6], the proposed architecture prioritizes persistence and extensibility. ESP32 microcontrollers acquire variables such as temperature, irradiance, wind speed, and pressure. Data are transmitted to a Raspberry Pi via RS485 and One-Wire, recorded in CSV every 30 seconds, aggregated into Parquet every 30 minutes, and uploaded to a normalized MySQL schema. Visualization through Power BI enabled intuitive real- time dashboards, while ThingSpeak connectivity demonstrated interoperability. Unlike earlier cloud-only solutions [7], this design includes local redundancy and prepares for MQTT- based scalability and bidirectional control.

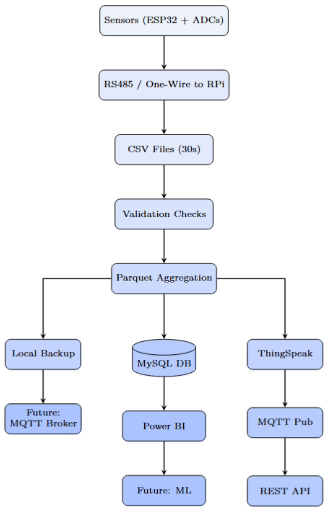

Figure 1. IoT monitoring pipeline from acquisition to visualization.

Results

Validation with simulated data streams confirmed system functionality. Acquisition logs verified CSV creation and Parquet aggregation, ensuring redundancy. The MySQL schema returned consistent queries, while Power BI dashboards displayed heterogeneous data in real time. Cloud connectivity with ThingSpeak validated both MQTT and REST interoperability. Storage tests estimated between 400- 600 MB per month for three projects and 15 sensors, confirming scalability for long-term deployment.

Discussion

The proposed IoT interface establishes a replicable, low-cost pipeline for renewable monitoring. It integrates ESP32 acquisition, Raspberry Pi consolidation, Parquet redundancy, SQL persistence, and accessible visualization. Though field deployment remains pending, validation confirms robustness, scalability, and educational potential. Future work will extend communication with MQTT, enable predictive analytics, and enhance integration with storage systems, reinforcing the role of IoT as a key enabler for distributed renewable energy management.

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Desarrollo de un sistema de monitoreo iot para planta didáctica en generación del hidrógeno verde, sena tecnocademia

José Damián Collazos[1], Erick Mendoza[2], Sebastián Trujillo Pinzón[3], Valery Herrera[4]

Palabras clave: electrolisis, IoT (internet de las cosas), descarbonización, Energía fotovoltaico.

Temática: Energía renovables y transición energética.

Resumen

La creciente demanda energético, junto con la urgencia de mitigar los efectos del cambio climático, ha impulsado la búsqueda de alternativas sostenibles que permitan reducir la dependencia de los combustibles fósiles. El hidrógeno verde emerge como uno de los vectores energéticos prometedores para lograr la descarbonización de sectores industriales, de transporte y generación de energía, gracias a su alto contenido energético, sin emitir gases de efecto invernadero [1]. La hidrólisis, un proceso electroquímico que descompone el agua en hidrógeno y oxígeno mediante la aplicación de corriente eléctrica, presenta un gran potencial en la producción de hidrógeno limpio y sostenible [2][3]. Sin embargo, la eficiencia y la estabilidad de este proceso dependen en gran medida de las características de los electrodos [4][5]. Por lo cual, se plantea realizar un monitoreo de cantidad de hidrogeno y consumo energético a una planta didáctica con electrodos de acero recubierto en titanio acoplado a un sistema autónomo de paneles fotovoltaicos.

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Metodología

Lo anterior conlleva a que el control o monitoreo preciso de los parámetros de proceso es crucial para la optimización de la producción de energía. La tecnología IoT ofrece una solución viable para el La tecnología IoT ofrece una solución viable para el monitoreo y control remoto, permitiendo la recopilación de datos, la seguridad del usuario, el análisis avanzado y la automatización del proceso. monitoreo y control remoto, permitiendo la recopilación de datos, la seguridad del usuario, el análisis avanzado y la automatización del proceso. Considerando que el desarrollo de un sistema de monitoreo IoT para planta **Didáctica en Generación Del Hidrógeno Verde Tecnoacademia**; impacte en los objetivos de desarrollo sostenibles de ciudades energías asequibles y en ciudades y comunidades sostenibles. Por lo tanto, se plantea desarrollar de un sistema de monitoreo IoT de consumo energético y obtención de hidrogeno, para la planta Didáctica en Generación Del Hidrógeno Verde, Sena Tecnoacademia. Para esto se realiza una caracterización del proceso para identificar los parámetros de consumo energético del sistema, dando paso a la clasificación de los sensores, conllevando a un diseño de un dispositivo que usa un ESP32. El segundo proceso es la verificación de los datos de energía y cantidad de hidrogeno obtenidos con instrumento patrón. En tercer proceso es tramitar a una página web implementada que es la de ubidot, conllevado una alerta y control on- off a la sobrecarga de corriente.

Resultados

En la Figura 1, se muestran los datos de caracterización del consumo de la planta de hidrolisis en primera estancia con electrodos de acero, donde se realiza el proceso con la instrumentación y como resultado, se obtiene la parametrización de los datos, del sensor de corriente WSC1800 que tiene un error del 1,14% y la tensión tiene un error absoluto de 0.011: con esto se establece en un muestreo en relación de tiempo para fijar el consumo hora mostrando un valor de error del 1.14%. El consumo por hidrolisis es de 45wh (vatios hora) y una temperatura exterior de 30C°. La medición de la energía se realizó comparando un equipo padrón. En la tabla 1 se muestran los datos de parametrización con herramienta patrón que permitieron obtener el consumo energético, las pruebas se realizaron con (Hidróxido de potasio) y en la figura 2 se muestra la página web.

Figura 1. Consumo energético de la planta hidrolisis.

Figura 2. Primera versión de la página web Ubidot.

Tabla 1. Datos de parametrización de tensión y corriente, con unit-139C

Sensor de Corriente (amperios)	Herramienta parón corriente	Sensor de tensión(voltios)	Tensión Herramienta patrón
0,161290 A	0,134A	2V	2V
0,322580 A	0,299A	4V	4,03V
0,483870 A	0,445A	6V	6,01V
0,6451612 A	0,62A	8,01V	8,02V
0,8064516 A	0,789A	10,02V	10,04V
0,9677419 A	0,95A	12,01V	12,02V
1,1290322 A	1,1A	14,07V	14,12V
1,2903225 A	1,234A	16,04V	16,1V

Discusión

Los resultados obtenidos evidencian que el sistema de monitoreo IoT desarrollado logra un seguimiento confiable de los parámetros críticos del proceso de electrólisis, garantizando coherencia entre las mediciones del prototipo y los valores registrados por los instrumentos patrón. El registro del consumo de 45 Wh para las condiciones operativas evaluadas confirma la utilidad del monitoreo en tiempo real para analizar la eficiencia del proceso y detectar variaciones asociadas al tipo de electrodos, temperatura o concentración del electrolito. La correcta transmisión de datos hacia la plataforma Ubidots y la integración de alertas de sobrecorriente fortalecen la capacidad del sistema para mejorar la seguridad y la toma de decisiones en aplicaciones didácticas. En conjunto, los resultados demuestran que la implementación del sistema IoT no solo facilita la adquisición y trazabilidad de datos, sino que constituye un paso significativo hacia la optimización y gestión inteligente de plantas de producción de hidrógeno verde en entornos académicos y formativos.

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Ecodrive: arquitectura de microservicios para la movilidad sostenible y la reducción de la huella de carbono

Alexandra Guerrero[1], Diana P. Bedoya[2]

Palabras clave: movilidad sostenible, huella de carbono, microservicios, datos en tiempo real, eficiencia energética, innovación tecnológica

Temática: Energías sostenibles y tecnologías para la eficiencia energética

Introducción

El impacto ambiental generado por el transporte urbano exige soluciones innovadoras que integren sostenibilidad, eficiencia energética y transformación digital [1]. En este marco, surge EcoDrive, un sistema modular orientado a la reducción de la huella de carbono y a la optimización del consumo energético en vehículos mediante telemetría y algoritmos de análisis en tiempo real. El proyecto se concibe desde una perspectiva arquitectónica basada en microservicios y principios de escalabilidad, resiliencia y seguridad [2]., lo que permite ofrecer a conductores y administradores métricas accionables, sistemas de recompensas e incentivos para fomentar prácticas de conducción sostenibles.

Metodología

La arquitectura de EcoDrive fue diseñada siguiendo el enfoque de bounded contexts [3], delimitando los dominios de usuarios, viajes, recompensas y configuración de vehículos. Cada dominio se implementa

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como microservicio y se despliega en contenedores Docker, garantizando independencia y capacidad de evolución continua [4].

- Aplicación móvil (React Native): captura datos de conducción y ofrece visualización de métricas y puntos acumulados.
- API Gateway y Backend (FastAPI): gestionan autenticación basada en JWT, lógica de negocio y persistencia en MongoDB [Documentación oficial de Apache Kafka y FastAPI].
- Kafka + Zookeeper: aseguran transmisión confiable de telemetría y eventos de viaje en tiempo real [Documentación oficial de Apache Kafka y FastAPI].
- Consumer Service: procesa datos de polilíneas, aplica algoritmos de reducción y persiste información.
- Redis y RedisInsight: actúan como caché para viajes en curso, mejorando rendimiento.
- Interfaces administrativas (React): permiten gestionar usuarios, vehículos y recompensas.

Se aplicaron pruebas unitarias, de integración y de rendimiento con Pytest y JMeter, además de monitoreo distribuido mediante Kafka-UI y RedisInsight. Las decisiones arquitectónicas se documentaron con énfasis en atributos de calidad: escalabilidad horizontal, consistencia eventual mediante eventos, observabilidad con trazabilidad distribuida y seguridad basada en políticas de roles y tokens expuestos vía Open API [2][3].

Resultados

La implementación permitió alcanzar:

1. Procesamiento en tiempo real de datos de viaje, con reducción de polilíneas para optimizar almacenamiento.
2. Asignación automática de recompensas, disponibles para canje desde la app móvil.
3. Administración eficiente de flotas y usuarios, incluyendo roles, permisos y configuraciones específicas de vehículos.

4. Escalabilidad comprobada, con despliegue independiente de microservicios según demanda.
5. Resiliencia operativa, soportada por colas de mensajes (Kafka), almacenamiento persistente (MongoDB) y caché temporal (Redis).

En pruebas piloto, el sistema mostró estabilidad bajo escenarios de carga concurrente, con baja latencia en el flujo de datos y una experiencia de usuario consistente tanto en la aplicación móvil como en la interfaz administrativa [1].

Discusión

EcoDrive demuestra cómo la arquitectura de microservicios aplicada a la movilidad sostenible posibilita un ecosistema robusto, flexible y replicable en contextos urbanos diversos [2][4]. La separación por dominios y el uso de mensajería distribuida aseguran independencia tecnológica, facilitan el mantenimiento y soportan un escalado progresivo de funcionalidades [3].

La integración de un sistema de recompensas convierte la eficiencia energética en una práctica gamificada, motivando cambios de hábito en los conductores. Desde la visión arquitectónica, la adopción de mecanismos de idempotencia, consistencia eventual y trazabilidad distribuida refuerzan la confiabilidad y observabilidad del sistema. Finalmente, EcoDrive no solo contribuye al cumplimiento de los Objetivos de Desarrollo Sostenible relacionados con energía y clima, sino que abre oportunidades de aplicación en flotas empresariales, transporte público y plataformas de movilidad compartida [1].

Tablas y Figuras

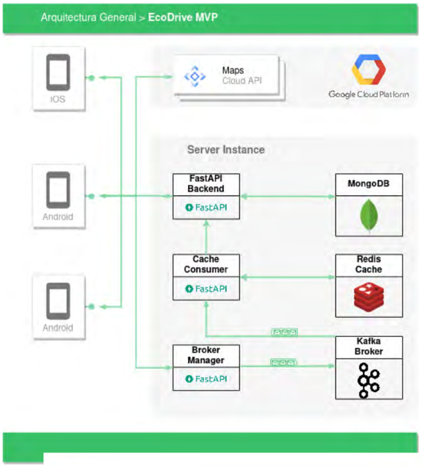

Figura 1. Arquitectura del sistema

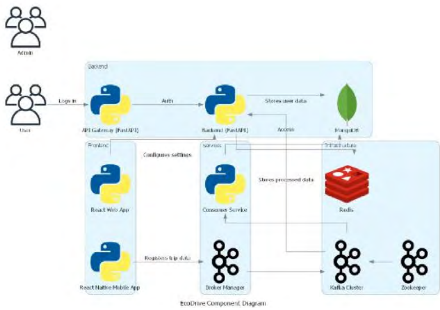

Figura 2. EcoDrive Component Diagram

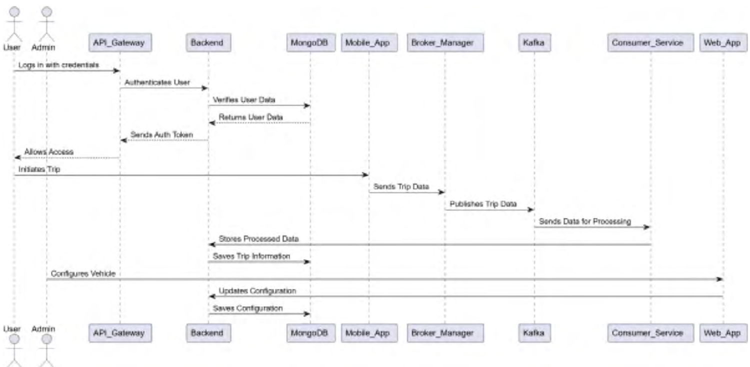

Figura 3. Diagrama de secuencia

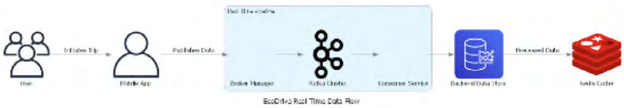

Figura 4. EcoDrive Real-Time Data Flow

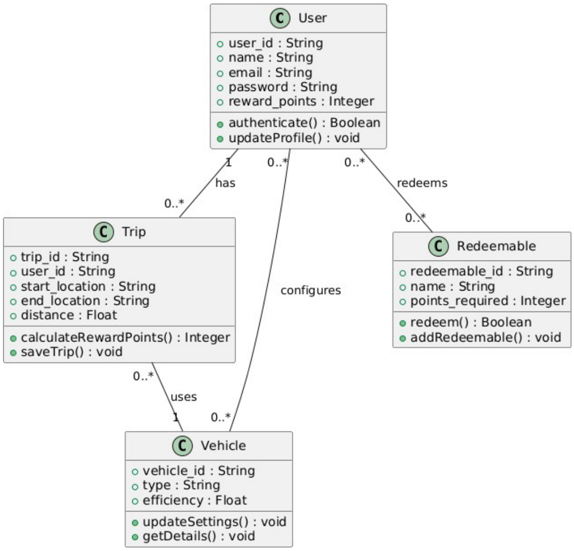

Figura 5. Diagrama de clases

Ecuaciones

1) Emisión por viaje (vehículos a combustión) Aproximación por combustible (Tier IPCC):

$$E_{CO2}^{trip}[kg] = FC[L] \times EF_{CO2',\ y}\left[\frac{kg\ CO2}{L}\right] \tag{1}$$

- FC: combustible consumido en el viaje (EcoDrive lo estima vía consumo medio o ECU/OBD si está disponible).
- EFCO2, fuelEF_{\text{CO2, fuel}}EFCO2, fuel: factor de emisión local (gasolina, diésel).

2) Ahorro por ecoconducción (antes vs. después)

$$\Delta ECO2 = Ebase - Eeco, \qquad \%Reducción = 100 \times \left(1 - \frac{Eeco}{Ebase}\right) \tag{2}$$

- Base: conducción histórica del usuario/ruta.
- Eco: conducción con recomendaciones EcoDrive (menos aceleraciones bruscas, velocidad estable, rutas menos congestionadas).

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Modeling of the lubrication regime for sliding contact of bearings with textured surfaces

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Keywords: Surface texturing, tribological performance, fluid-structure interaction (FSI), eccentricity ratios, Topic: Energy Management

Introduction

The automotive industry aims to significantly reduce friction losses in conventional vehicles, as a combustion engine can lose up to 40% of its efficiency due to the interaction between its mechanical components. In particular, several researchers have focused their efforts on studying the tribological properties of the lubricant film between the crankshaft and bearing shell [1] [2], proposing surface texturing as a promising alternative [3][4][5]. Currently, research related to the effect of surface texturing has taken different approaches: biomimicry, hydrophobicity, lubricant reservoir, among others [6] [7]. This study analyzes the imposition of three types of surface textures, or organized arrangements called deterministic surfaces, on the connecting rod bearing shell of a Diesel engine and analyzes their impact on the performance of the crankshaft-bearing shell tribological pair under transient conditions through in- silico experimentation.

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Methodology

The implemented methodology is presented in Figure 1. The phases that make up the methodology are: Selection of geometries to be textured, geometric design, selection of variables and parameters to guarantee the lubrication regime, design of the computational model, numerical validation based on models presented in specialized literature, simulation of the system under real engine conditions, analysis of results, and conclusions. Each of the previous methodological phases corresponding to the final structure of this work is developed below.

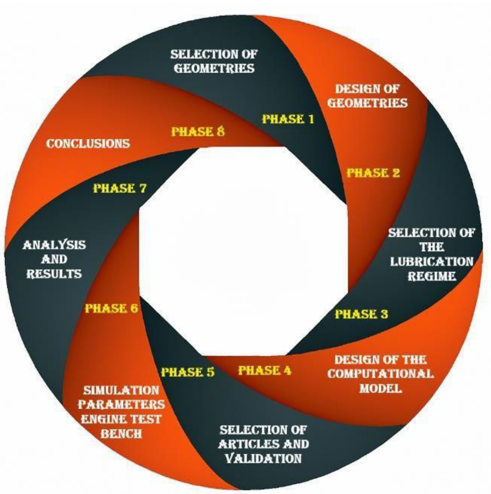

Figure 1. Methodological Phases

Figure 2 shows the relationship between the COF for the evaluated textures according to different eccentricities. It was observed that square and rectangular textures significantly reduce the COF compared to the non- textured surface and the circular texture. The results show a COF reduction of 35.6% and 34.4% for square and rectangular textures, respectively, compared to a non-textured surface at an eccentricity of 0.54. The load-carrying capacity graph (see Figure 8) reveals that square and rectangular textures not only reduce the COF but also increase load-carrying capacity compared to smooth surfaces and circular textures. The square and rectangular textures achieved load- carrying capacity increases of up to 57.1% and 100.5%, respectively, at an eccentricity of 0.87 compared to the smooth surface

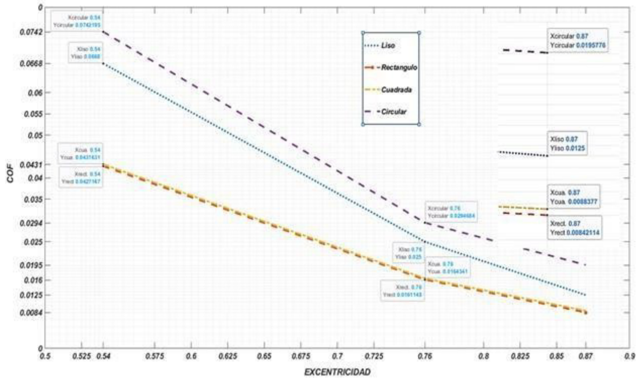

Figure 2. COF vs. Eccentricity for surfaces with different texture elements (circular, square, rectangular) and reference non-textured surface.

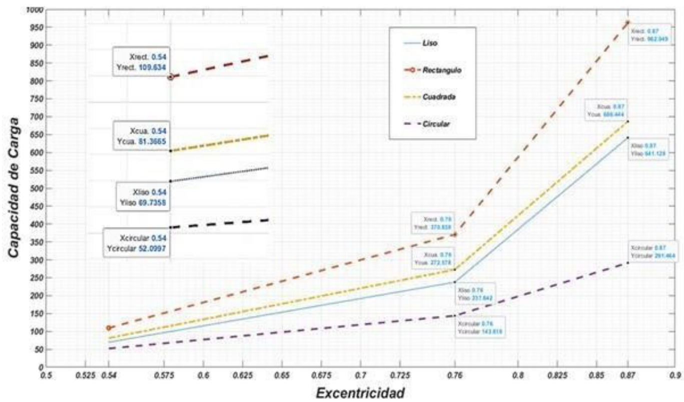

Figure 3. Load Capacity vs. Eccentricity for surfaces with different texture elements (circular, square, rectangular) and reference non-textured surface.

Discussion

The analysis of the lubrication regime as a function of texture showed that the COF varies significantly with eccentricity and texture geometry. Square and rectangular textures tended to operate in the most efficient part of the hydrodynamic regime, reducing friction and improving the stability of the lubricating film. The values of COF, load-carrying capacity, and lubricating film thickness showed significant agreement with previous studies, supporting the accuracy of the computational model used.

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