Journal Innovative Design 8[18]1-6: e4818106
Article

Design of a two-seater solar car for urban-suburban transportation

Diseño de auto Solar biplaza para transporte urbano-suburbano

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CONAHCYT classification:

Area: Engineering
Field: Engineering
Discipline: Energy engineering
Subdiscipline: Solar energy

https://doi.org/10.35429/JID.2024.8.18.1.6
History of the article:
Received: August 28, 2024
Accepted: December 01, 2024

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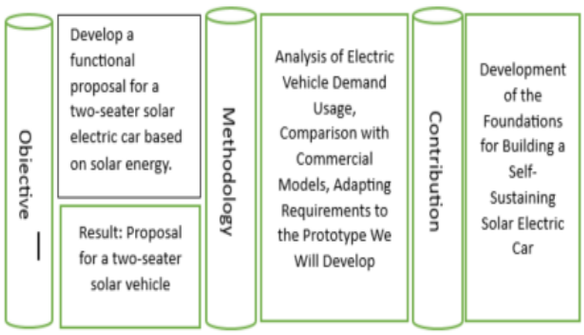
Abstract

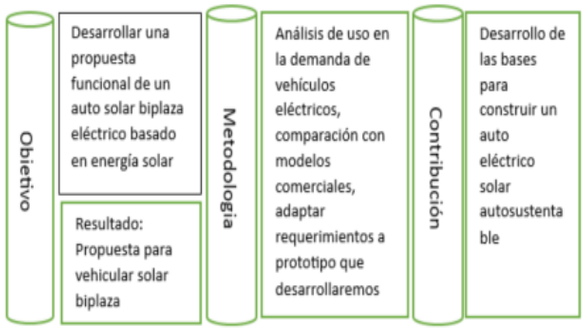
There is a trend towards using electric vehicles, which aim to reduce carbon dioxide (CO2) emissions, a major contributor to global warming and other consequences of environmental pollution. Therefore, developing autonomous vehicles that can generate energy without relying on external infrastructure is important. This drives research to create functional prototypes that can serve as a foundation for developing a type of vehicle that meets the requirements of self-sustainability, mobility, safety, and efficiency demanded by potential users, paving the way for future commercialization. Through this research, we aim to subsequently develop a self-sustaining solar vehicle prototype that enables efficient, reliable, and safe mobility for people, based on the studies conducted.



Sustainable Electric Mobility

Resumen

Actualmente, existe una tendencia hacia el uso de vehículos eléctricos para reducir las emisiones de dióxido de carbono (CO2), principal causante del calentamiento global y otros problemas de contaminación ambiental. Por ello, es crucial desarrollar vehículos autosustentables que puedan generar su propia energía sin depender de infraestructura externa. Esta investigación busca desarrollar prototipos funcionales que sirvan como base para crear vehículos que cumplan con los requisitos de auto sustentabilidad, movilidad, seguridad y eficiencia necesarios para los usuarios potenciales, con miras a su futura comercialización. A través de esta investigación, nos proponemos desarrollar un prototipo de vehículo solar autosustentable que permita la movilidad de personas con eficiencia, confiabilidad y seguridad, basándonos en los estudios realizados.



Movilidad eléctrica sustentable

Citation: Arellano-Yáñez, Ricardo & Moreno-Vázquez, Pedro. [2024]. Design of a two-seater solar car for urban-suburban transportation. Journal Innovative Design. 8[18]1-6: e4818106.

Introduction

This research project focuses on the development of a prototype two-seater solar-powered electric car designed for use in urban and suburban areas.

The main objective is to encourage the adoption of sustainable electric vehicles that generate their own energy, thereby reducing the environmental impact associated with the CO2 emissions of petrol and diesel vehicles.

To achieve this, a detailed analysis of the statistics on the use of electric and hybrid vehicles in Mexico is carried out in order to determine their impact and application in the country.

In addition, functional proposals that can be adapted to the growing demand for sustainable mobility in urban and suburban areas of Mexico are reviewed.

Based on the information gathered, a proposal for a prototype is developed that is both sustainable and functional, and that fits the needs of the electric vehicle market in Mexico in the medium term. This project is based on the existing 'UTNA Solar O' prototype.

Background

Electric vehicles have gained an increasingly prominent position in automotive markets, which have traditionally been dominated by internal combustion engine vehicles. In the short term, it is anticipated that electric vehicles will largely replace combustion vehicles, due to their potential to reduce emissions and improve energy efficiency.

This article aims to explore the integration of electric vehicles with solar energy, focusing on the supply of these vehicles by solar sources. It will examine the current technologies involved in this integration, analyse the progress made to date and identify areas requiring further development.

The aim is to assess the feasibility of using solar-powered charging stations to supply electric vehicles, highlighting the innovations and challenges that need to be addressed to make this sustainable combination a reality (Gélio, L. G., & César, F. I. G. 2022).

Means of transport have been considered indispensable for global development since time immemorial, as they are used to move people, goods, animals and raw materials, among others.

Most means of transport are powered by burning fossil fuels derived from petroleum, such as petrol and diesel. These types of fuels have been the predominant primary energy source in the world due to their high energy density and availability (Goldenstein; Azevedo, 2006).

However, the burning of fossil fuels is the main cause of carbon dioxide emissions, which is a significant precursor of greenhouse gases.

These gases contribute to global warming and generate a range of environmental problems, such as climate change, ocean acidification and biodiversity loss (Drumm et al., 2014).

Dependence on these fossil fuels also raises public health concerns due to air pollution, which is associated with respiratory and cardiovascular diseases in exposed populations. In 2018, global oil consumption reached 99.8 million barrels per day, a significant value that represented an increase of 1.5% over 2017, equivalent to an additional 1.4 million barrels per day.

This increase reflects a continued reliance on fossil fuels globally and highlights the urgent need to seek more sustainable alternative energy sources. The United States, China and India were the top oil-consuming countries in 2018.

This data shows an increase of 1% compared to 2017 (Petróleo; Biocombustíveis, 2019). The concentration of consumption in these countries suggests a high demand for energy for industrial development and transport, and underlines the importance of seeking energy alternatives to mitigate the environmental impacts associated with intensive oil use.

Justification

Growing concerns about climate change and environmental degradation have led to an urgent search for sustainable solutions in the field of transport.

ISSN: 2523-6830.
RENIECYT-CONAHCYT: 1702902

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The use of internal combustion vehicles has been a major contributor to CO2 emissions and other pollutants, making it imperative to explore cleaner and more efficient alternatives. This article justifies its relevance by addressing the design of a solar-powered two-seater electric car, an innovative solution that not only aims to reduce emissions, but also to promote the energy autonomy of vehicles.

Through a comprehensive analysis of statistics on the use of electric and hybrid vehicles in Mexico, this study not only aligns with global trends towards the electrification of transport, but also responds to the specific needs of the Mexican market.

With a significant increase in the demand for sustainable mobility, the proposal of a solar car prototype is presented as a viable and relevant response to urban and suburban transport challenges in the country.

In addition, the research examines the feasibility of integrating solar technologies into electric vehicle charging infrastructure, highlighting the innovations and challenges facing this approach.

The importance of developing solar-powered charging stations lies in their ability to offer a sustainable solution that minimises dependence on fossil fuels while addressing public health issues associated with air pollution. In this context, the project builds on the 'UTNA Solar One' prototype, serving as a basis for further development to optimise the functionality and sustainability of the proposed vehicle.

The research not only contributes to the existing literature on electric vehicles, but also offers a practical model that can be replicated in other regions with similar characteristics.

The combination of a two-seater electric car with solar energy represents not only a technological innovation, but also a commitment to sustainable development and public health.

By encouraging the adoption of this technology, we are moving towards a future where urban and suburban transport can be cleaner, more efficient and more accessible.

Problem Statement

How do user perceptions of electric and solar vehicles influence the acceptance and adoption of a two-seater prototype car in urban and suburban areas of Mexico?

Research Hypothesis

H0: Positive public perception of the environmental benefits of electric and solar vehicles increases the likelihood of acceptance and adoption of the two-seater car prototype in urban and suburban areas of Mexico.

H1: Positive public perception of the environmental benefits of electric and solar vehicles does not increase the likelihood of acceptance and adoption of the two-seater car prototype in urban and suburban areas of Mexico.

Methodology

As a first step, a survey of statistics on the use of electric and hybrid vehicles in Mexico is carried out to define the prototype design and assess its impact. Current proposals that are functional for sustainable mobility in urban and suburban areas of the country are reviewed.

To complement this analysis, functional prototypes available in the market are researched and compared in order to understand market behaviour and competition.

Based on this information, a detailed analysis of the characteristics necessary to categorise the expectations of the proposed vehicle design is carried out.

Next, an initial design proposal is elaborated, including the selection of the necessary hardware and software, considering both commercial elements and in-house developments.

Finally, we proceed with the design of the initial prototype using SolidWorks, the development of the electromechanical drive system and the creation of the electronic control system for the prototype.

Results

After carrying out this research, the null hypothesis ($_{H0}$) is accepted.

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The use of electric and hybrid vehicles in Mexico was studied to define the design of the prototype and its impact, observing an increase in the last year (Figure 1:

Box 1

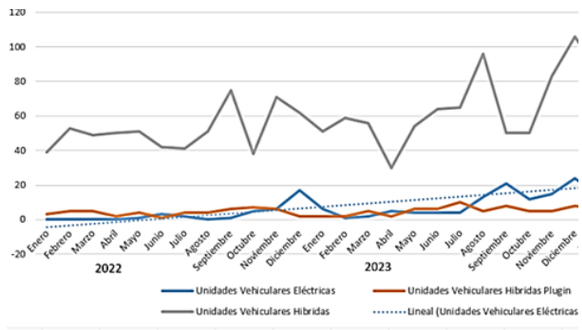

Figure 1
Electric vehicle sales trends

In Mexico, 13 major companies offer electric vehicles: Audi, BMW, BYD, Ford, Hyundai, JAC, Mercedes Benz, Nissan, Mitsubishi, Mini, Renault, Toyota and Volvo.Mexico is in the Latin American regional average in terms of electric vehicle brands present, with Colombia leading with 21 brands, followed by Costa Rica (19) and Panama (15).(Figure 2)

Box 2

Figure 2
Number of Electro Mobility companies in Latin America

The demand for sustainable mobility in urban and suburban areas of Mexico was analysed.

The participants, students from rural and suburban areas of Aguascalientes and Zacatecas suburban areas of Aguascalientes and Zacatecas, discussed and documented the key features of electric vehicles: lithium-ion batteries, optimised charging, smooth and silent driving, lower maintenance cost, capacity for two persons, luggage space and emergency equipment.

These features will be considered in UTNA's new solar car design.

Functional prototypes were researched online and their characteristics were compared to identify the market and competition. Initially, solar cars were extremely light and covered with solar panels, resulting in peculiar designs.

Today, solar panels generate electricity to power the car and extend the autonomy, allowing on-board equipment not to consume the battery charged through the grid.

The models analysed are the following: The Lightyear 0 model, (Figure 3) designed in the Netherlands, charges its lithium-ion battery from the grid and can extend its range up to 650 km, running up to 70 km per day on solar power alone: (https://lightyear.one/lightyear-layer).

Box 3

Figure 3
Cars Lightyear O

The Hyundai Ioniq 5, (Figure 1.4) incorporates solar panels on the panoramic roof, extending the hybrid battery range to 1,100 km.

These panels also increase the efficiency of the electric car, providing approximately 1,500 km of additional range per year.

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Box 4

Figure 4
Hyundai Ioniq 5

The Aptera, (Figure 1.5) is a futuristic three-wheeled, teardrop-shaped solar electric vehicle.

Currently in production, it offers 136 hp and 200 hp options. Its daily range is 64 km, and it can achieve up to 1,600 km per year as a battery charge extender. (https://aptera.us/)

Box 5

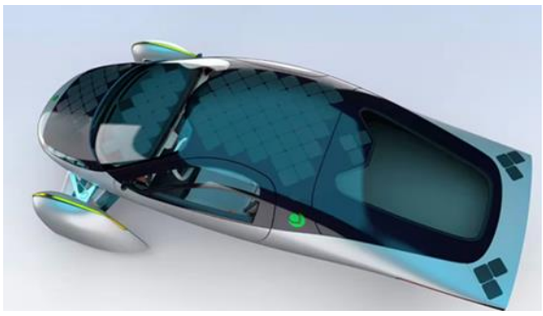

Figure 5
Aptera

The expectations of the proposed design were categorised, highlighting the following features: aerodynamic design, lightweight composite materials, efficient mechanical transmission, solar-charged batteries, solar electro-mobility, 70-80 km daily performance, smooth and silent driving, lower maintenance cost, capacity to transport people and luggage, and emergency equipment.

An initial design proposal was developed (Figure 6) considering the characteristics established in previous activities. This preliminary design will be adjusted according to the necessary improvements when verifying the available technological elements for its final assembly at the UTNA.

Box 6

Figure 6
Initial Proposal

With the initial proposal, technological elements of hardware and software available on the market were sought to determine which ones to buy and which ones to develop. This will help to define the design, considering the assembly of commercial elements and the developments in the UTNA.

Technological elements considered:

- Differential with integrated motor. (Figure 7)
- Brushless motor.
- Controller for brushless motor.
- Hand or foot throttle, bakelite connectors, and support for spring or shock absorber with spring.

Box 7

Figure 7
Differential with integrated motor

As a continuation of this research, a SolidWorks design will be carried out to establish the initial prototype, incorporating all previous considerations. The electromechanical traction system of the initial prototype will be designed, taking into account all the previous considerations and the electronic design of the control system to be used by the initial prototype will be developed, following all the considerations previously established.

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Conclusions

We have been able to partly prove the null hypothesis, as we now realise that the use of electric vehicles is a medium to long-term trend.

However, there are still areas of opportunity for these vehicles to generate their own electricity and meet the demands of a market where comfort and utility remain important factors.

Our prototype is currently a basic development compared to these demands. Even so, it is important to work towards developing, in the medium term, a vehicle with our design, based on current and future trends.

Declarations

Conflict of interest

We, the authors, declare that we have no conflicts of interest. We have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

Authors' contribution

Ricardo Arellano Yáñez, contribution to this article has been the original idea for the topic, as well as conducting research on the subject of this article.

Pedro Moreno Vázquez, co-author of this article has contributed in the research of information sources as well as in part of the writing of this article based on the research being carried out.

Availability of data and materials

The results of this research have not yet been published, as it is still under development and is currently at the stage of characterising the possible prototype of the solar car.

Funding

This research is being financed by the Universidad Tecnológica del Norte de Aguascalientes (UTNA), as well as the publications derived from it.

Acknowledgements

Both author and co-author are grateful to UTNA for the time and funding we received to carry out this research.

Abbreviations

UTNA: Universidad Tecnológica del Norte de Aguascalientes.

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