Driving Towards a Greener Future: Low Carbon Vehicles in Saudi Arabia's Hot Climate

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Abstract

The transportation sector is a major contributor to global carbon emissions, and Saudi Arabia is no exception. This paper explores the challenges and obstacles to implementing clean transportation in Saudi Arabia, with a particular focus on the use of low carbon emission vehicles in hot regions. Hot weather poses unique challenges for the use of low carbon vehicles, as air conditioning systems can significantly reduce their efficiency. This paper proposes a model for choosing the most appropriate low carbon vehicles for hot regions, taking into account factors such as mileage and overall environmental impact. The study examines the current state of transportation in Saudi Arabia and identifies key barriers to the adoption of low carbon vehicles, including a lack of infrastructure, limited consumer awareness, and the dominance of the oil industry. The paper also explores potential solutions to these obstacles, such as government incentives and investment in charging infrastructure. Ultimately, this paper aims to provide insights into the challenges and opportunities surrounding the adoption of low carbon transportation in Saudi Arabia, highlighting the need for a collaborative effort between government, industry, and consumers to drive sustainable change.

***Keywords**: Clean Transportation, Low Carbon Emission Vehicles, Hot Regions, Model.*

1. Introduction

Climate change is a global issue, and reducing carbon emissions from transportation is a crucial step towards mitigating its impact. Saudi Arabia, as one of the world's largest oil producers, has long relied on fossil fuels to power its economy and transportation sector which account about 22% of total CO2 emission [1]. However, in recent years, the country has recognized the need to transition to a low carbon future and reduce its carbon footprint. With the world's growing concern about climate change and the increasing demand for clean transportation, Saudi Arabia has taken steps to promote the adoption of low carbon vehicles and clean transportation.

The Saudi government has set ambitious targets to reduce greenhouse gas emissions, including a goal to generate 50% of the country's electricity from renewable sources by 2030 and reach to carbon neutrality at 2060[2]. In addition, the government has investing in hydrogen production and development of alternative fuels.

Transitioning to a low carbon future and clean transportation presents a significant opportunity for Saudi Arabia to diversify its economy, reduce its carbon footprint, and become a leader in sustainable development. Low carbon emission vehicles have emerged as a promising solution to this problem. Blended fuels internal combustion, electric vehicles, and fuel cell cars are some of the options available to reduce carbon emissions from transportation. .

This paper examines Saudi Arabia's challenges to transition to a low carbon future and promote clean transportation. The paper also suggests a model for comparing and selecting the best option among blended hydrogen fuels internal combustion, electric vehicles, and fuel cell cars based on different criteria taking in consideration the performance in hot regions and the usage to help readers make informed decisions about which option is best suited for their needs.

2. Challenges and Obstacles to Clean Transportation in Saudi Arabia

The adoption of low carbon vehicles and clean transportation in Saudi Arabia faces several challenges and obstacles. However, with the government's commitment to reducing greenhouse gas emissions and promoting sustainable development, there is significant potential for the country to become a leader in low carbon transportation. Addressing the challenges of high cost, limited charging infrastructure, and lack of a comprehensive national strategy will require continued investment and commitment from the government and private sector.

2.1. High Cost of Low Carbon Vehicles

One of the primary challenges to the adoption of low carbon vehicles in Saudi Arabia is the high cost of these vehicles compared to traditional gasoline-powered cars. Electric and hybrid vehicles are still relatively expensive due to their limited production and supply chain. While the government has invested in Electric Vehicles such as CEER and LUCID and building local factories that might lead to lower the cost. Additionally, the lack of tools for cost analysis of low carbon vehicles with internal combustion vehicles considering the cost of hydrogen and electricity, limiting their appeal to consumers [3].

2.2. Limited Charging Infrastructure

The lack of charging infrastructure is another challenge to the adoption of low carbon vehicles in Saudi Arabia. Electric vehicles require charging stations to recharge their batteries, and the limited availability of charging infrastructure can make it difficult for electric vehicle owners to travel long distances. While the private sector has taken steps to build charging infrastructure in the country, it remains less developed than in other countries with higher adoption rates of electric vehicles. To overcome this challenge, the government needs to invest more in charging infrastructure and develop a more comprehensive network of charging stations throughout the country[3,4].

2.3. Need for a Comprehensive National Strategy

While the Saudi government has invested on EV industry to promote low carbon vehicles, there is current general goals in the national strategy of transportation that outlines the country's long-term goals and targets for clean transportation such as clean fleet percentage in 2025 should be 25% and in 2030 50%[5]. A comprehensive strategy would provide clarity and consistency for businesses and consumers, as well as ensure that the country is on track to meet its emissions reduction targets. The strategy should include measures such as investment in research and development of alternative fuels, building charging infrastructure, and offering incentives for low carbon vehicles. A clear strategy would also provide the private sector with a clear direction and encourage investment in low carbon technologies.

3. Low Carbon Emission Vehicles in Hot Regions

It is crucial to consider the performance of low carbon emission vehicles in hot regions when making a decision about which option to use. Blended hydrogen fuels internal combustion, electric vehicles, and fuel cell cars all offer different advantages and disadvantages in warm regions.

3.1. Blended Fuels Internal Combustion (BFICs)

Blended fuels, such as ethanol blends and biodiesel blends, are made by mixing traditional fossil fuels with renewable fuels. These fuels are typically less expensive than pure renewable fuels, and they offer some emissions reductions compared to traditional fossil fuels[6]. However, their performance can vary depending on the type of fuel blend and the vehicle being used. In hot regions, blended fuels can be a good option because they tend to have higher octane ratings, which can improve engine performance [7]. However, blended fuels may not offer the same level of emissions reductions as electric vehicles or fuel cell cars.

3.2. Electric Vehicles (EVs)

Electric vehicles (EVs) are becoming increasingly popular as a low carbon emission transportation option. These vehicles use an electric motor powered by a battery pack to drive the vehicle. EVs emit no tailpipe emissions, and they are highly efficient compared to traditional internal combustion engine vehicles. However, the performance of EVs in hot regions can be affected by the battery's temperature. High temperatures can reduce the battery's capacity, which can decrease the vehicle's range [8]. Despite these challenges, EVs remain a viable option for reducing carbon emissions in warm regions.

3.3. Fuel Cell Vehicle (FCVs)

Fuel cell cars use hydrogen fuel to power an electric motor, emitting only water vapor as a byproduct. These vehicles have the potential to offer zero-emissions transportation, but the availability of hydrogen fueling infrastructure is limited. Additionally, the efficiency of fuel cell cars is less affected by high temperatures, which the fuel cell stack is operates in range 45-85 °C[9]. However, hot weather required cooling which might leads to shorten the range. Despite these challenges, fuel cell cars remain a promising option for low carbon emission transportation in warm regions.

3.4. Criteria to Compare and Evaluate Low Carbon Emission Vehicles

The following criteria can be used to compare and evaluate low carbon emission vehicles, and help consumers make informed decisions about which option is best suited for their needs.

Emissions: The comparison of these vehicles should, therefore, consider their emissions level and the total amount of emissions released throughout their lifecycle, including production, use, and disposal.

Performance: The performance of low carbon emission vehicles can vary depending on the type of vehicle and the conditions in which they are used. Factors such as range, acceleration, speed, and handling should be considered when comparing these vehicles.

Fuel efficiency: Fuel efficiency is an essential consideration when comparing low carbon emission vehicles, as it can have a significant impact on operating costs and environmental impact.

Cost: The cost of low carbon emission vehicles is a crucial factor for many consumers. The comparison of these vehicles should consider their purchase price, operating costs, and the cost of maintenance.

Infrastructure: The comparison should consider the availability of charging stations, hydrogen refueling stations, and blended fuel availability.

Convenience: The convenience of using low carbon emission vehicles should also be considered. Factors such as ease of charging or refueling, vehicle range, and the availability of maintenance services should be considered.

Environmental impact: While low carbon emission vehicles are designed to reduce greenhouse gas emissions, the comparison should also consider their overall impact on the environment. Factors such as the use of sustainable materials, the use of renewable energy in production, and the impact of disposal should be taken into account.

The criteria of comparison of LCVs can be grouped into customer needs (cost of ownership, range, etc.) and environmental impacts (emissions, and life cycle impact).

4. Model to Choose Low Carbon Vehicles for The Hot Regions and High Mileage

There are several initiatives and guides available to help end-users choose the best low carbon emission vehicle based on their usage needs. One such initiative is the "Green Vehicle Guide" provided by the Australian Government Department of Infrastructure, Transport, Regional Development, and Communications [10]. This guide offers online tools that allows users to compare the environmental performance of cars, light commercial vehicles, and motorcycles based on their fuel consumption, greenhouse gas emissions, and air pollution levels. The available calculator tools include fuel life cycle emission calculator, fuel costs and CO2 emissions calculator, and home charging calculator.

Another initiative is provided by the "Alternative Fuels Data Center" provided by the US Department of Energy

[11]. This initiative offers online tools to help users estimate the range, fuel cost savings, and greenhouse gas emissions reductions of electric vehicles based on their driving habits, vehicle type, and location. Please see also: https://theicct.org/region/asia-pacific/

There is a clear need to establish similar tools for the golf region and KSA taking into consideration their particular climate and road conditions. In the present article, a first proposal for such a tool is developed.

To create a model that selects the most suitable low carbon vehicles for hot regions and high mileage, we will use a scoring system. This model will consider factors like carbon emissions, energy efficiency, range, and performance in hot temperatures. Below is a step-by-step guide to create the model:

Identify relevant factors: Begin by listing the factors that are important for vehicle suitability in hot regions and high mileage. Some factors to consider are:

- Carbon emissions
- Energy efficiency
- Range
- Performance in hot temperatures
- Cost

Collect data: Gather data on various low carbon vehicles, such as electric vehicles (EVs), blended fuels, and fuel cell cars, from reliable sources like manufacturers, government agencies, or research institutions. Create a dataset with information on each vehicle's performance in the identified factors.

Normalize the data: Normalize the data for each factor to make them comparable. This can be done by converting the values to a common scale, such as 0 to 1 or 0 to 100.

Determine factor weights: Assign weights to each factor based on their importance. The weights should sum up to 1. For example:

- Carbon emissions (0.35)
- Energy efficiency (0.25)
- Range (0.2)
- Performance in hot temperatures (0.15)
- Cost (0.05)

Calculate the overall score: For each vehicle, multiply the normalized values of each factor by their respective weight and sum the results. This will give you an overall score for each vehicle.

Rank the vehicles: Sort the vehicles by their overall scores in descending order. The higher the score, the better the vehicle's suitability for hot regions and high mileage.

Select the top vehicles: Choose the top-scoring vehicles as the most suitable low carbon options for hot regions and high mileage.

Python model using set of data listed below has been created as simplified version of the model to assist customer to compare and choose best option.

***Table** 1. List of Data to be used in the model.*

	EV1	EV2	BFV	FCV
Carbon emissions	0	50	75	20
Energy efficiency	0.9	0.9	0.6	0.7
Range	300	250	400	350
Performance in hot temperature	0.8	0.8	0.6	0.9
Cost	35000	40000	30000	45000

This model can be adjusted and refined according to your specific requirements, such as including more factors or changing the weights based on the importance of each factor.

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