

INTRODUCTION OF ELECTRIC VEHICLES IN SAUDI ARABIA: IMPACTS ON OIL CONSUMPTION, CO₂ EMISSIONS, AND ELECTRICITY DEMAND

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Overview

The transport sector plays a vital role in shaping economic development and energy consumption globally, particularly in resource-rich countries like Saudi Arabia. As the world moves toward sustainability, the transport sector stands out as one of the largest contributors to global oil demand and CO₂ emissions. This presents a dual challenge for Saudi Arabia: maintaining its position as a leading oil exporter while transitioning to a diversified, sustainable economy. Addressing this challenge is crucial for meeting both domestic and international environmental goals.

This study addresses a critical gap in the existing literature by providing long-term projections of vehicle ownership, oil demand, and CO₂ emissions specific to Saudi Arabia's transport sector. Utilizing advanced econometric modeling, including the Gompertz model for vehicle ownership projections and an oil demand model incorporating fuel efficiency improvements, the study offers a comprehensive analysis of current trends and future pathways. Furthermore, it explores the transformative potential of electric vehicles (EVs) in reducing oil dependency and emissions while increasing electricity demand.

The primary objective is to forecast the number of internal combustion engine (ICE) vehicles up to 2050, estimate the associated energy and environmental impacts, and evaluate the implications of varying EV adoption scenarios. The findings provide actionable insights for policymakers, urban planners, and energy stakeholders, contributing to a sustainable and efficient transition in Saudi Arabia's transport sector.

Methods

The methodology integrates a Gompertz model to project ICE vehicle ownership trends based on GDP per capita, providing foundational data for the oil demand model. The oil demand model uses these projections, along with fuel prices and efficiency, to estimate transport energy needs. Scenario analysis then evaluates EV adoption's impact on reducing oil demand, CO₂ emissions, and increasing electricity requirements, linking each model to deliver a cohesive assessment of Saudi Arabia's transport sector dynamics.

The methods include:

Gompertz Model for Vehicle Ownership Projection:

This model captures the non-linear S-shaped relationship between income and vehicle ownership, allowing for long-term projections of ICE vehicles.

Equation: $V = \gamma * \exp(-\exp(-\beta * (\ln(\text{GDP}) - \ln(\text{GDP}_0))))$

Where:

- V: Vehicle ownership per 1000 population
- γ : Saturation level of vehicle ownership per 1000 population
- GDP: GDP per capita (constant prices)
- β : Speed of adjustment parameter
- GDP_0: Reference GDP per capita for vehicle ownership takeoff

Transport Oil Demand Model:

The number of vehicles on the road, projected using the Gompertz model, serves as a critical input for this oil demand equation. Fuel efficiency improvements are incorporated to account for policy measures such as Corporate Average Fuel Economy (CAFE) standards, which aim to reduce energy consumption. The model also adjusts for structural breaks caused by energy price reforms.

Equation: $\ln(\text{Oil}) = \alpha + \delta_1 * \ln(\text{Price}) + \delta_2 * \ln(\text{Vehicles}) + \delta_3 * \ln(\text{Efficiency}) + \varepsilon$

Where:

- Oil: Transport sector oil demand (sum of gasoline and diesel consumption)
- Price: Weighted average price of gasoline and diesel
- Vehicles: Total number of active vehicles on the road (projected using the Gompertz model)
- Efficiency: Fuel efficiency in the transport sector (ratio of value added to oil consumption)
- ε : Error term

3. **Scenario Analysis for EV Adoption:**

This analysis develops low, moderate, and high-growth scenarios for EV penetration, assessing their impact on oil demand, CO2 emissions, and electricity requirements.

These methodologies are interlinked to provide a comprehensive understanding of transport sector dynamics in the context of Saudi Arabia's Vision 2030 goals.

Results

Projections indicate that ICE vehicles in Saudi Arabia could reach 29.6 million by 2050, with EV adoption potentially reaching 14.8 million in a high-growth scenario. EV adoption could reduce transport oil demand by up to 20.2%, CO2 emissions by 20 million tonnes, and electricity demand for EVs is estimated to reach 47.7 TWh annually by 2050 in a high-growth scenario.

Conclusions

This study underscores the critical role of vehicle electrification in achieving Saudi Arabia's economic and environmental goals under Vision 2030. It highlights the need for robust policies, infrastructure development, and renewable energy integration to support the transition to EVs.

References

1. International Energy Agency (2023). "World Energy Outlook."
2. Dargay, J., & Gately, D. (1999). "Income's effect on car and vehicle ownership, worldwide: 1960–2015."