EVALUATION OF THE IMPACT OF PUBLIC POLICY MEASURES ON CALIFORNIA'S FUEL CELL ELECTRIC VEHICLE MARKET DEVELOPMENT.

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Overview

Governments, states, and regional authorities recognize the importance of supporting the decarbonization of the transportation sector to mitigate climate change. This process can be empowered by the higher utilization of so-called *renewable* (or *green*) hydrogen (hydrogen produced with the use of electricity generated from renewable sources) [**1**,**2**]. Transitioning to higher exploitation of *green* hydrogen in the transportation sector requires changes in the public policies and strategies enacted by regional and central/federal authorities [**3**]. Simultaneously, the need to decarbonize the transportation sector resulted in the rapid development of the automotive industry in the area of zero- or low-emission vehicles, demonstrating a wide range of constructions, including Plug-in Hybrid Electric Vehicles (PHEVs), Battery Electric Vehicles (BEVs), and Fuel Cell Electric Vehicles (FCEVs). Since each of these constructions differs significantly and represents competitive markets, it is crucial to consider each type of vehicle individually. Undoubtedly, both PHEVs and BEVs dominate the global market of electric cars [**4**], so I decided to focus on FCEVs, which offer worth considering potential for transportation sector decarbonization. Indeed, individual countries and regions have applied diverse public policy incentives and introduced more or less effective strategies to promote FCEVs [**5**]. In the last decade, California has been presenting a gradually growing market potential for FCEVs, including light-duty passenger vehicles, buses, as well as medium- and heavy-duty vehicles used, for instance, in the freight movement in Los Angeles. This process was accompanied by developing publicly available hydrogen refueling infrastructure and increasing *green* hydrogen production, transport, and storage. In this context, the identified research problem can be formulated as a question – **How did the state policy instruments impact the fuel cell electric vehicle market development in California from 2012 to 2022?**

Literature review

Electrification of the transportation sector is a significant action in making economy-wide decarbonization possible in California by 2030 and beyond. Research shows that the development of reliable hydrogen fueling stations will be required for the successful commercialization of fuel cell vehicles in this state [**6**]. The growth of the FCEV market and increasing demand for *green* hydrogen observed nowadays can be filled through commercial electrolysis using excess renewable energy [**7**]. However, despite the growing popularity of FCEVs in different ZEV market segments, the observed growth is still far lower than expected or predicted (considering the implemented policies and the adopted objectives) due to the significant institutional, technological, as well as demand- and supply-side market barriers [**8**]. The enacted policies and introduced instruments aim to overcome those barriers and accelerate the decarbonization of the transportation sector shortly. Moreover, recent studies show that the potential of hydrogen and fuel cell technologies applied in vehicles for medium- and heavy-duty sectors in California is substantial [**9**,**10**].
A comprehensive evaluation of California's public policy focused on the decarbonization of the transportation sector by promoting hydrogen and fuel cell technologies has not been made yet by applying a qualitative method with individual highly structured interviews. While a case study focused on the barriers to the FCEVs diffusion in California was already done in the past [**8**], my case study will cover a more extended period and scope (considering the most up-to-date data) and will be specifically focused on evaluating individual policy instruments. In undertaking this, I am focused on the effectiveness of selected public policy instruments (introduced on the state level) in deploying FCEVs in California in the last decade.

Methods

I analyze and critically review the available scientific literature to systematize the state-of-the-art studies about public policy instruments used to shape California's fuel cell electric vehicle market development in the last decade. To extend the studies, I analyze the recent secondary data (through desk research), especially statistics, reports, and market publications related to the research problem. The identified key FCEV market indicators allow me to present an overview of the changes from 2012 to 2022. In addition, the comparative analysis of the public policy statements, bills, and directives on the state level allowed me to study the adopted assumptions deeply and review the implemented instruments. Last but not least, I conduct individual highly structured interviews with policymakers, researchers, and representatives of the companies and organizations that are FCEV market stakeholders, such as firms related to sustainable and low-carbon production of hydrogen as a fuel, operators of the hydrogen refueling infrastructure, supply-side market actors, and demand-side market actors. The interviews are transcribed and evaluated using the NVivo software to generate results.

Results

The research results allow the evaluation of public policy instruments implemented in California from 2012 to 2022. The fundamentally effective instruments were those implemented on the state level. I identified four strategic objectives and matching policy instruments which are as follows: **(1) sustainable and low-cost production of hydrogen** (most effective policy instruments were: *Hydrogen Fuel Specifications and the 33% Green Hydrogen Requirement* as regulations and standards*; Low Carbon Fuel Standard* as tradebale permits), **(2) developing accessible and reliable refuelling infrastructure** (most effective policy instruments were: *AFV and Fuelling Infrastructure Grants* as subsidies; *Station Building Standards and Safety Codes* as regulations and standards; and *ZEV Infrastructure Support, Hydrogen Fuelling Station Evaluation* as the information policies), **(3) growth of market supply for FCEV** (most effective policy instruments were: *Light-, Medium-, and Heavy-Duty ZEV Requirements* as regulations and standards*, and ZEV Production Requirements* as tradeble credits), and last but no least objective **(4) growth of market demand for FCEV** (most effective policy instruments were: *Advanced Transportation Tax Exclusion, Zero Emission Transit Bus Tax Exemption, and ZEV Fee* as tax incentives, *Purchase requirements for Zero-Emission Transit Bus, Airport Shuttle, and Public Fleet Vehicles* as regulations and standards, *Bus Replacement Grants, LD-ZEV Rebates, HVIP Vouchers, and Emissions Reductions Grants* as subsidies, and *High Occupancy Vehicle and High Occupancy Toll Lane Exemption* as information policies). The strength of impact and effectiveness of these individual policy instruments were also evaluated with the quantitative approach during the interviews by assigning the weights of impact to present the overall road map for FCEV market growth in these four critical strategic development areas. The research also discusses and demonstrates the essential role of demonstration projects, such as the example of the Port of Los Angeles, where heavy-duty FCEVs are operating. The research results contribute to a better understanding of the applied public policy instruments' effectiveness in deploying hydrogen and fuel cell technologies in California's transportation sector.

Conclusions

The substantial quantitative and qualitative changes in California's fuel cell electric vehicle market were mainly policy-driven in the last decade. It was possible thanks to the implementation of effective public policy instruments such as subsidies, fiscal allocations, and institutional support in the field of R&D activities as well as infrastructural development initiatives. These actions blazed the trail for the FCEVs in California's transportation sector, which is responsible for nearly two-thirds of this state's total annual CO2 emissions. These incentives have resulted in an increasing number of hydrogen-powered cars operating in California and the development of a renewable hydrogen-generating infrastructure, making economy-wide decarbonization possible in this state by 2030 and beyond. However, the decarbonization of the transportation sector with the use of FCEVs presents a challenge for some U.S. states and other countries and regions worldwide. Therefore, it was crucial to determine which public policy instruments and projects successfully promoted the deployment of FCEVs in California. The intent of doing so was to serve as evidence-based examples for less-prosperous regions and states. It will be a great honor to present these research results and confront them with the opinion of experts at the 44th IAEE International Conference in Riyadh.

IAEE Codes:

10.6. Transportation – Policy Issues,
10.3. Transportation - Electric vehicles & systems.

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