ECONOMIC AND ENVIRONMENTAL IMPACTS OF LONG-TERM SCENARIOS OF LOW EMMISIONS MOBILITY IN SPAIN

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Overview

This paper presents a methodology and its application to analyze the economic and environmental impacts of long term scenarios for road transport transition to low emission technologies in Spain. For this purpose a long term simulation model for the aging of vehicles is developed, together with the renewal of fleets with new traction technologies. Detailed historical data of the fleets together characterization of the vehicles based on their manufacturing year provides accurate results.

Results show the evolution of environmental and energy consumption indices in the long term, allowing policy makers to understand the impact of different road transportation strategies with targets for specific time periods.

Methods

For studying the scenario, a simulation based tool models the evolution of the vehicle fleet for every year. This includes the aging of the fleet, considering the average life of vehicles and average millage/year as a function of the age and technology of the vehicle. To estimate the impact of emmisions of road transportation, the milage is characterized per technology and age for urban and non-urban travels. The renewal of the fleet is defined with new vehicles sales for different traction technologies: battery electric vehicle (BEV), plug-in hybrid electric vehicle (PHEV), hybrid electric vehicle HEV compressed natural gas CNG, liquified natural gas LNG, diesel and petrol. The ratio of new vehicle sales of each technology can be defined by an external tool that evaluates the consumer behaviour based on pricing, which is out of the scope of this paper. As the average lifespan of vehicles is usually over 10 years, in the simulation of the aging model it is important to characterize accurately the different existing road transport fleets by technology and age so results at the start of the simulation can be tuned with current reports.

For every year, once the portfolio of all technologies of available vehicles is defined, an optimization model obtaines the milage per vehicle technology. The main assumption of the model is that the number and distance of travels with a specific type of vehicles remains constant over the years, both in urban and non-urban areas.

Once the fleet and the milage for urban and non-urban areas is obtained for every year, the model calculates the energy use for each traction technology. The calculation of the emissions is based on the ratio of CO_2, CO, NO_x, $PM_{2.5}$ and PM_{10} emited per 100 km travelled as a function of the age.

The electrical generation simplified model consideres the planned upgrading of the generation mix in the evaluated region. To assess the total impact of vehicle use, both emissions and energy consumption take into account tank-to-wheel (TTW) and well-to-wheel (WTW) values. The TTW value consideres the efficiencies of the fueling the tank and traction technologies, while WTW adds to TTW values the full value chain starting in the extraction process of the primary energy, shipping, processing and transportation to the gas-stations or, transmission through energy networks to the charging stations. Thus, the results can show, for a specific region or country, the effect in internal and external emissions and energy use or energy dependency.

Results

This methodology is applied to passenger car fleet in Spain to study the periods 2030 and 2050 and to evaluate policies for the transition of transportation into a low carbon and therefore comply with national and European Green Deal targets. The Spanish case is representative of several European countries where the car industry has a realative importance in its GDP. For that purpose we considere a single scenario that assumes that 40% and 80% of sales in 2030 and 2050, respectively, will be of EV (including BEV and PHEV). That means that 9% of cars running in 2030 should be EV and some 70% in 2050. In addition a detailed characterization of the Spanish car fleet since the year 1990 is considered, and the model is run until 2060. The technological trends of the different traction alternatives, including efficiencies and emissions are obtained from different sources. Finally, the detailed transition of the Spanish electrical production system for all generation technologies consideres, based on national plans, a share of renewable generation for 2030 of around 70%, slightly below the official plans (74%).

The results obtained from the simulation show the evolution of the passanger car fleet for each traction technology. In Fig. 1 we can observe that although electrification incentives are set for today, changes in the fleet will need almost 15 years to be representative. A full transformation of the passanger car fleet will require more than 30 years. The transition to new technologies is limited by the sales of vehicles every year -between 1.3 and 1.5 million cars-, associated with the purchasing power and needs of consumers.

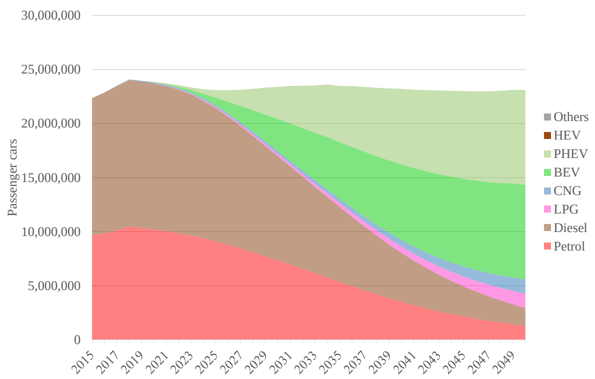

Figure 1. Passenger car fleet evolution in Spain

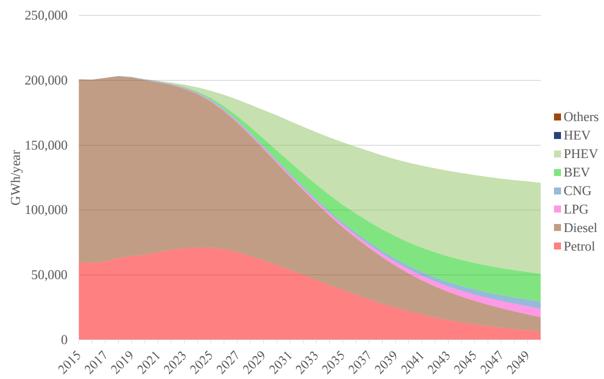

Figure 2. Energy imports for in passenger road transportation in Spain

The effect on the primary energy consumption trends is associated with the integration of new technologies in the fleet but also with the improving of conventional fuel based vehicles with higher efficiencies and lower emissions (incorporating the updated European regulations on this issue). Under the hypothesis of this electro mobility scenario by 2050, Spain could reduce by a half the imports of energy dedicated to passenger cars, while the energy produced by own resources, mainly renewable (wind 62%, solar 17% and hydro 15%), reaches the maximum near 2050.

Finally relevant results on emissions due to passenger cars show that NO_x are reduced 91% in 2050 from a starting value of almost 150 ktonnes/year, which brings clear benefits for urban areas. Similarly, reduction on CO_2 emmisions in the period 2020-2050 is 71%, a bit lower as it is encompassed with the power generation conversion on renewable sources.

Conclusions

The proposed modelling of the transportation sector adequately allows to analyze the long term effects on the economic and environmental indices. As the electrication of the transportation is expected to be the predominant technological option in the mid and long terms, WTW analysis requires the characterization of the power generation portfolio. The proposed model requires accurate technical information of the different fleets and technological trends for transportation.

According to the results of the Spanish case study, the expected transition to a more sustainable transportation takes time, although a price parity between combustion an electric technologies, as the replacement ratio of passenger cars is still long, in the range of 10 years, giving enough time for policy makers to prepare the transition. Consequently, the impact on energy imports and Spanish energy dependency becomes relevant after a decade towards electro mobility, which emphasizes the need of national agreements with a long term vision. Environmental benefits are also identified, both globally as 71% of CO_2 emmissions reductions, and locally with 91% NO_x less emmsions in urban areas.

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