

Adrian Sliwa
**ECONOMIC CONDITIONS FOR THE DEVELOPMENT OF ELECTRIC
ROAD VEHICLES**

Doctoral thesis written under the supervision of Prof. dr hab. Jan Burnewicz
at the Department of Transport Economics of the University of Gdańsk, April 2020

Co-supervisor: dr Michał Suchanek

Summary

Keywords: *phenomenon of road electromobility; production of electric cars; sales of electric cars; environmental performance of the electric and combustion cars; current operation costs of the electric and combustions cars; public promotion of road electromobility*

The thesis was aimed at a multi-faceted explanation of the newly emerging phenomenon – road electromobility. The research question is the development of factors determining the emergence and implementation of electromobility in road transport. The framework for the study is a thesis on the long-term transition of economic and social development – from a resource-raw material based form to a technological and organisational form in which electric road vehicles become one of the driving forces. Five key questions have been formulated relating to the possibilities and prospects for mass development of these vehicles. The answers to these questions are the research hypotheses of the thesis, which were verified on the basis of a set of the latest analytical and statistical data.

The scientific approach in this thesis is empirical and consists of processing a wide range of information using the method defined in the introduction of inductive inference. The starting point of the research is the well-established and acknowledged in economic sciences selected theories on the economic maturity of technical changes (inventions and innovations), long-term business cycles, use of non-renewable resources and the principle of sustainable development. These statements were the inspiration for the deduction of the hypotheses considered in the thesis. There are many detailed conditions of modern economic and social life not described in economic theories, and for this reason, it was necessary to conduct a survey of about 1000 users of combustion and electric cars. The

survey was not random, but it was expert, as electric cars are not yet widespread across the full demographic, social and spatial spectrum.

Chapter I. REASONS FOR ELECTRIFICATION OF ROAD TRANSPORT

This chapter identifies and characterises the most important reasons for moving away from combustion vehicles. The objective factors behind this process are the inexorable prospect of depletion of the world's oil reserves, the environmental nuisance of combustion vehicles, the strong preparation of the automotive industry for the production of electric cars, and their new utility values. Also, there are also subjective factors, which are: changes in political and economic concepts of countries that support electromobility, growing awareness and social acceptance of electric cars. This is supported by the failure to promote alternative fuels in road transport. The analyses and considerations carried out in this chapter allowed to verify the first research hypothesis of the thesis and to conclude that it is correct to assume that in the long run, the development of road electromobility is an objective and significant trend, although in the initial stage it was only a theoretical concept.

Chapter II. CONCEPTS, PRODUCTION AND MANUFACTURING COSTS OF ELECTRIC CARS

This chapter is devoted to verifying the hypothesis that the electric car models developed so far represent a good technological basis for the development of electromobility in the road sector. In order to verify the validity of this assumption, the information from the last few years on the technical and operational advantages of electric car models offered by the automotive industry, their production costs, and sales prices have been analysed. These analyses show that the production of electric cars is becoming less and less expensive and becomes profitable with long production runs. The breakthrough factor is a more than 10-fold reduction in production costs and battery prices, whose proportion in the price of a car has fallen from more than 50% to below 30%. There is a risk of stopping the decline in these costs in the event of a disturbance occurred in the extraction of the lithium and cobalt needed to produce batteries. The performance characteristics of these cars meet users' expectations with increasing accuracy, their range is growing (the standard is about 300 km), there is an increasing variety of models, and the durability and reliability of the traction batteries are guaranteed under various operating conditions. On

this basis, analysts predict that in 2040 more than 40% of global sales volume will be made up of electric cars and about 10% of hybrid cars.

Chapter III. COMPARISON OF PERFORMANCE CHARACTERISTICS OF ELECTRIC AND COMBUSTION CARS

In this chapter, the latest data have been collected, and comparative analyses have been carried out to assess the accuracy of the hypothesis that there is a tendency for the performance characteristics of electric cars to come closer to those of combustion cars. The subject of these analyses were the following features and parameters of both types of passenger cars: range, unit energy consumption, usage specification, environmental performance, safety, current operation costs, the maturity of recycling and disposal. The key social importance is the environmental performance of the cars, which was assessed using the WTW (*well-to-wheel*) methodology consisting in the accumulation of CO₂ emissions over the entire life cycle of a car (200,000 km) starting from the acquisition of raw materials for its production, through the production of the vehicle and energy and fuel used, to disposal. This methodology takes into account the diversity of the global structure of primary energy sources used in electricity generation and industry. In countries relying heavily on renewable energy, cumulative CO₂ emissions from compact electric cars are around 22 t and from combustion cars around 37-38 t, in favour of promoting electric cars. For users of passenger cars, the unit costs of their current operation are crucial. They have been analysed in North America, China and the European Union, revealing a wide variety of car classes, age and usage intensity (annual mileage). In the USA, there are electric car models that are slightly cheaper than the average combustion car, but most electric models are a few to several dozen per cent more expensive to run than a similar class of combustion car. Many electric models in China are cheaper to run than combustion cars, as a result of the existing government subsidies for their purchase. In the European Union, all models of electric cars used so far have had higher running costs than combustion cars, but in some countries (the Netherlands, Denmark, Norway) there is a tendency for these costs to equalise. The results of the analyses allow us to conclude that the automotive industry in the USA, China and Europe has broken down the technological barrier to producing efficient and effective electric cars. Breaking this barrier has opened the way for the mass production and sale of these vehicles, which entails a reduction in selling prices and operating costs and makes them

a good alternative to new combustion vehicles, which will become increasingly expensive to produce as a result of tightening environmental standards.

Chapter IV PUBLIC AND SOCIAL CONDITIONS FOR THE DEVELOPMENT OF ROAD ELECTROMOBILITY

This chapter is aimed at verifying the hypothesis that an active policy of supporting this phenomenon and shaping new user attitudes is necessary for the initial phase of mass road electromobility. The validity of this hypothesis has been assessed on the basis of a very detailed review of the public incentives for purchasing electric cars and investing in recharging infrastructure used in different countries over the past decade. The analysis of the collected information proved that so far such forms of support as subsidies for the purchase of electric cars, environmental bonuses, tax breaks, infrastructural privileges for the users of these cars and subsidies for the infrastructure for recharging traction batteries have proved effective. The effectiveness of this support is confirmed by the statistics on the growing volume of sales of these cars in individual countries, and these statistics show that the greatest effectiveness was achieved when a set of user-accepted, coherent financial, fiscal and administrative instruments with a comprehensible and measurable user-friendly effect was used. In addition to the promotion of road electromobility by public authorities, its development is influenced by public acceptance. This factor was explained on the basis of published results of selected surveys carried out in the USA, China and Europe, and on the basis of an online survey conducted by the author of this dissertation. The information collected shows an increasing acceptance of electric cars, as long as their prices are not higher by a certain percentage than those of combustion cars and their recharging time along the route is relatively short. The most important conclusion of the own survey is that for over 57% of the respondents, the price was an important factor taken into account when deciding to buy an electric car, but other factors were also taken into account, as 43% of the respondents did not consider price to be a decisive factor in their decision to buy. Among the total number of respondents, the majority (84.3%) were satisfied with the possession of an electric car and at the same time convinced that buying it again is sensible and that recommending it to others is justified.

CONCLUSION

The five research hypotheses formulated in the introduction can be considered pertinent in the light of the collected and analysed data from the global road electromobility sector of the last decade. After 2015, the economic, technological and social conditions stimulating the development of this phenomenon intensified worldwide. Their emergence is a logical element and the expected phase of the diffusion process of important innovations, which undoubtedly include electric cars.