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Economic, Social and Environmental Effects of Electric Traction

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Abstract

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This study highlights the most important social, economic and environmental effects of the electric traction. There had been revealed the economic and social benefits, but also the costs involved by the introduction of electric traction in rail and road transport. In rail transport, there are highlighted the additional impacts of electrification on the performance of rail operators. Regarding the environmental impact, it is emphasized also the extent to which the introduction of transport with electric vehicles helps to reduce pollution of the environment and, in particular, of the urban air quality.

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1. Introduction

In the current context, in which pollution growth has gained alarming levels, there are looking for solutions to reduce it. The transport sector, in terms of pollution, is the second greenhouse gas emitting sector. Meanwhile, transport ranks first position in terms of NO_x and CO and the second position on CO₂ emissions, in 2014 accounting for 29% of these emissions (OECD / IEA, 2016).

Introduction or extension of electric traction can significantly reduce emissions, but also generates a number of other benefits including economic and social ones.

This study revealed also, besides the most important positive effects of electric traction, the problems facing it.

2. Literature review

There are many researches in the field of electric traction, most of them regarding technical aspects and solutions (Alfonsin & al, 2015; Knowles & Morris, 2014). Most of the studies have focused on rail and urban transport public, who have used and developed electric traction since the late nineteenth century.

Feng & al. (2013) review energy-saving research focusing on the optimizations of train coasting schemes, the rational designs and utilizations of track alignments, the ameliorations of train attributes, and the improvements of system operations. Capasso & al. (1998) analyzed the effect of electric traction systems on power quality. Battistelli & al. (2004) has studied the interaction between AC and DC electric railway systems, which cause turbulence and reduce the quality of the network. Feng & al. (2013) study the energy-saving effect of regenerative braking of metro trains, highlighting also another positive effect of that, namely preventing the tunnel temperature rising in underground railways to minimize the energy consumption in air conditioning or ventilating.

There are also some papers that realize comparative analysis regarding different types of vehicles, respectively between battery electric, hybrid and hydrogen fuel cell vehicles (Offer & al., 2010). The control strategies used in a hybrid vehicle have a profound impact on the performance and efficiency of the vehicle (Koch & al., 2011). According to Santiago & al. (2012) study, electric motors are about three times more efficient than IC engines. Shanglou & al. (2010) presents a rule-based energy management strategy for a four-wheel drive HEV. Van Vliet & al. (2011) reveal that total cost of ownership of current electric vehicles is uncompetitive with regular cars and series hybrid cars, but this cost could become competitive for future wheel motor PHEV.

3. Economic, environmental and social effects of electric traction

3.1. Benefits and drawbacks of electric traction in rail transport

Electric traction railway history is quite long, starting from 1835, when Davenport built the first car with electric motor, powered by a battery of galvanic elements. But unfortunately, it is not fully valued for a long period of time, despite its real benefits. But even from its beginnings, it has been exploited in

electric traction rail. This is the reason why it is used on large scale, based on studies conducted on electric traction profitability compared with the steam and Diesel traction.

In railway traction widespread use of electric locomotives currently is determined by their several advantages:

- Do not generate emissions;
- Use electricity generated by different forms of energy, which represents an increasingly part is renewable energy: hydropower, solar, nuclear, wind, etc;
- They are silent;
- Lower energy costs;
- High efficiency of electric motors;
- Possibility of feeding with required energy for driving from the electricity grid;
- Regenerative braking that returns energy in the supply system, which increases energy efficiency;
- Lighter than diesel locomotives because they no longer have to incorporate fuel tanks;
- Lower maintenance costs;
- Slight starting easier because the engine develops maximum torque at startup;
- They are more suitable for routes with frequent stops.

Besides other already mentioned benefits, electric traction determines increase in rail traffic speed and reduces the duration of transport.

During winter, the electrified rail reduces operating costs, by heating with electricity and replacing the heating oil consumption.

The period of construction and commissioning of the electrification facilities generates a large number of jobs for these activities.

It should be noted also the drawbacks of introducing electric traction in public urban transport and rail. The most important problem is that of the costs, especially the high costs caused by investments in infrastructure and its maintenance and operation.

Regarding costs, rail transport is a major consumer of electricity, which causes a high energy cost. The highest electricity costs are determined by vehicle traction, but should not be neglected also energy consumption arising from the infrastructure management activities: lighting, maintenance, operation of the rail network.

There is a risk of a cost per passenger-km higher in public transport than the cost of own car, if the use of vehicles for urban transport, like metro, tram, trolley or the railway interurban is low. Hence, there derives the need, at least in Romania, to educate urban population for the use of public transport.

3.2. Current and future impacts of electric traction in road transport

In Europe there is a policy of developing environmentally friendly transport, which supports, among other things, the widespread introduction of hybrid and electric vehicles. At Member State level, this policy is materialized through subsidies to purchase vehicles of this type and tax reductions for owners of HEVs and EV.

Some countries offer incentives to encourage the use of electric vehicles, resulting in an easier transition to electric vehicles. In some European countries the grant awarded for holding electric

vehicles can reach values up to 25-30% of the vehicle. In Romania, the maximum subsidy is only about 2100 Euros, in the car scrappage scheme.

In urban areas there can be significantly reduced CO₂ emissions by increasing the number of vehicles based on electric traction. Reducing emissions will have positive effects on human health by improving air quality in inhabited areas.

Besides the environmental positive effects, there are many other benefits of using electric or hybrid vehicles (table 1).

Table 1. Main benefits and drawbacks of electric vehicles

Benefits	Drawbacks
<ul style="list-style-type: none"> • Reducing energy costs to less than a quarter compared to classic vehicles. • The lower cost of maintenance, due to fewer moving parts; • Lower costs with energy than conventional vehicles, given that the value of electricity consumed is less than the value of liquid fuel; • Reducing emissions in populated areas, especially in urban areas; • Reducing noise pollution due to structural characteristics; • Eliminate the consumption of oil fuels, fossil fuels, polluting and expensive; • At national level, decreased demand for import of petroleum products; • Do not produce emissions, unlike conventional vehicles and hybrids; • The risks are smaller in case of accidents than in the case of vehicles with oil fuels, battery power being interrupted; 	<ul style="list-style-type: none"> • Still underdeveloped or non-existent network of power supply, recharging points in the public space; • In most of current models reduced autonomy and limitations in terms of speed; • Lengthy recharging; • Quietness can be a disadvantage, representing a danger as it can contribute to the generation of accidents, especially among people with eye disorders; • Dimensions, generally, reduced, with a limited number of places (2 places); • Relatively short battery life (shorter than ten years); • High battery costs yet; • Acquisition costs still quite high; • A number of problems to be solved, in terms of technical characteristics of batteries: their durability, loading speed, their ability and materials used for production; • Transfer of emissions into areas where power is produced if the electricity supplied to the vehicles is obtained in thermoelectric power plants;

Electric vehicle manufacturing sector is one of those are hiring. The same trend is found in the production of rechargeable batteries for such vehicles, as well as in other kinds of companies that performs additional activities for the production of vehicles or their operation.

Last but not least, companies in these sectors, and government institutions, invest in applied research, in testing and developing innovations. In the center of interest there are projects aimed at power electronics, rechargeable batteries improvement and creation of new materials for the automotive sector.

Unfortunately, these types of vehicles have also a number of drawbacks (table 1), most of them being related to technological limitations.

Currently on the market there are three types of cars that are based on electric traction:

- Vehicles with batteries;
- Hybrid vehicles;
- Fuel cell vehicles.

Hybrid vehicles operate using as source of energy electricity and gas, which means that emissions are reduced only without being eliminated. Most vehicle manufacturers have at least one model of such a vehicle.

If there are taken into account the effects of using rechargeable electric vehicles on the national power grid, the impact is not a major one in terms of energy production. Given that most recharging will be done during the night, in own garages or parking spaces, when there are loading gaps and no risk of overloading the network, even with a substantial increase in the number of vehicles of this type, there will be no negative effects. Problems may arise in some economies of countries with a high level of industrialization if it significantly increases the number of quick recharge during the day, during periods of peak loads.

On these vehicles the additional space needed for batteries or hydrogen tanks caused their various constructive changes. One of the solutions is to integrate the electric motor into the wheel hub.

Phinergy and Alcoa tested a new type of battery made of air and aluminum, which weighs about 100 kg and allows a vehicle to travel more than 1,000 miles after a single charge (Grush, 2014). The proposed solution currently is a dual system consisting of two batteries, one based on lithium-ion battery for short distances, for urban areas and the other on air and aluminum for long distances. The main disadvantage of these batteries is that the air-aluminum battery cannot be recharged. But if users every or two months refill the water tank, the battery has a shelf life of 20 to 30 years, according to the designer.

Based on electromagnetic induction, wireless charging is foreseen as a possible solution for recharging electric vehicle batteries. In 2012, Utah State University has developed a wireless charging with electric bus prototype with 20% efficiency and 25 kW power load. In Xiangyang, Hubei ZTE launched in 2014 a route for electric buses with wireless charging efficiency of 90%. In 2013, the South Korean city of Gumi opened the first route for buses with wireless charging in movement, based on technology of magnetic fields in resonance.

4. Conclusions

If in terms of electric traction in rail transport the most acute problems are those related to investments and costs, in road transport an important part of drawbacks are generated by the limitations given by existing technologies.

On the market there are many models of hybrid and electric vehicles. Most electric vehicles are mainly dedicated and used for urban and suburban traffic, given that the autonomy of them is relatively low. The main concerns of producers are related to increase the efficiency of electric motors and to shorten the duration of batteries loading. Normal charging is preferable to be accomplished overnight, providing the necessary energy for driving during the day. But, at the special charging stations, depending on their power, loading times are significantly lower than the normal load. Unfortunately, in many countries, the network of recharging points is underdeveloped or non-existent. For this reason it is necessary to invest in the necessary equipment for rapid loading of vehicles.

But these drawbacks are counterbalanced by the benefits brought by electric traction: savings from lower costs of electricity and maintenance and benefits resulting from subsidies, elimination or

reduction the consumption of liquid fossil fuels, reduced noise pollution, and safer operation. More, in order to reduce pollution, governments provide subsidies to people who buy electric vehicles.

The field of electric vehicles generates also new jobs as those in the production of vehicles and batteries, in sales and maintenance of them. In the last years, research in this field has made important steps forward, providing solutions for many problems facing this field.

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