ELECTRIC VEHICLES AND CRITICAL RAW MATERIALS

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Abstract: *In the 21st century transportation became one of most the most important aspects of our life. People use a lot of ways of travelling to work or having fun. Nowadays, the most popular innovations are electric cars. For this green solution critical raw materials are needed. Production of a lithium-ion battery requires a wide scale of elements and materials, like cobalt. There are several reasons that cobalt is one of the most important elements. One reason is that the main supplier is the politically instable the Democratic Republic of the Congo. In 2017 Fund For Peace ranked the Democtaric Republic of the Congo as the 7th most unstable country in the World. Mol analysts believe that the future of electric cars really depends on the Democtaric Republic of the Congo. The Democratic Republic of the Congo holds a significant porportion (57%) of the cobalt stock. Due to technological improvements in battery production, new types and solutions will become available in the next decade. One of the most anticipated technological developments is the solid battery. Some electric car companies see nickel as a potential solution, but this has both advantages and disadvantages. Attempts are being made to eliminate cobalt from the production process. Another pessimistic survey from DERA shows that cobalt consumption in the area of e-mobility will likely increase. In addition, it is important to note that the raw material market is highly concentrated, with many countries having a monopoly position. To measure market concentration, we selected the Herfindahl-Hirschman index and examined the value of some of the raw materials needed to produce the lithium-ion battery. The price of cobalt has a strong influence on the price of batteries and of electric cars. Forecasts say that if the price of electric cars were more favourable, they would soon become more popular. In summary, critical materials have a serious effect on transportation, and we examine the past, present and the future.*

Keywords: *cobalt; CRM; electric car; transport; economic aspect.*

JEL Classification: *L62.*

1. Introduction

In the 21st century transportation became one most the most important aspects of our life. People use a lot of ways of travelling to go work or have fun. Therefore, wide scale of products transported by countries or companies across planet Earth. The history of transportation began in ancient times, but it became even more important in the last three hundred years. During these centuries, many means of transportation were created and developed, like trains, airplanes and ships.

Moreover, there is a tendency for all possible transportation technologies to evolve to a higher level at an ever faster pace.
The history of trains began in the 19th century. That was when the first horse-drawn carriage came out. Due to the technological innovations a few decades later the people could use steam-powered trains. But the innovation did not stop with steam-powered models. In the first half of the 20th century the maglev technology was patented. "Maglev train, also called magnetic levitation train or maglev, [is] a floating vehicle for land transportation that is supported by either electromagnetic attraction or repulsion" (Encyclopeadia Britannica This technology requires very cold, liquid helium, which is a critical raw material. In recent years the role of the railways in freight transport is growing, which is reflected in the numbers. Between 2009 and 2017 the freight tonnekilometres for railways increased in Hungary. However, the growth tendency does not reach the growth tendency of the total kilometres of goods travelled, so we can talk about a decrease in proportion.
Nowadays, the most popular innovations are electric cars. For this green solution some essential things are needed, called critical elements or critical raw materials, such as graphite and cobalt. Several other critical raw materials are necessary in the production of automobile components, as listed in Figure 1. In other transportation systems, the tendency is the same.

Figure 1. Critical elements used in various components of a modern motor vehicle
Source: Universiteit Leiden (https://www.universiteitleiden.nl/en/research/research-projects/science/cmlrare-earth-supply-chain-and-industrial-ecosystem-a-material-flow-assessment-of-european-union)

The ranking of critical materials is influenced by technological improvements day by day, so the list of these elements continuously changes. The European Committee created surveys in 2011, 2014 and 2017 of materials to be monitored on its list of

critical elements. Based on the survey results, elements labeled critical elements are those that have high significance for the economy and that have high supply risks .

2. Electric cars and cobalt

What is an electric car? The Answer is so simple: a car whose powertrain is operated by an electric engine. When do you think the first electric car was designed? The first electrically powered car was built in the late nineteenth century. In present times the most popular pioneer of this technology is Tesla. This company started the mass production of electric cars in 2008.
The first model, named the Roadster, was followed in 2009 by the Tesla Model S, and then came the next model in 2012, a SUV called the Tesla Model X. The company's latest model is called Model 3. The first of this model was released in 2017. Model 3 soon became a popular model among Americans: in 2018 approximately 140,000 were sold. In terms of sales Tesla Model 3 is the second most popular car in the US. Only sales from Toyota Camry were higher in 2018. But it is not only popular in the United States. Following its European launch in early 2019, it became the best-selling electric car in Europe. Among the luxury SUVs, Tesla ranked high in the U.S. market in 2018. The Model X was the second most popular model. Tesla cars use lithium-ion batteries to store electric charges. The weight of the battery accounts for a significant part of the weight of the car, which is about 1/3 for the Tesla Roadster.
Electric cars are spreading fast due to their zero local carbon-dioxide emissions. As is visible in Figure 2, the number of electric cars has increased dramatically in Hungary, but in spite of this increase, the rate of electric cars was only 0.06 per cent of vehicles on the road in 2017.

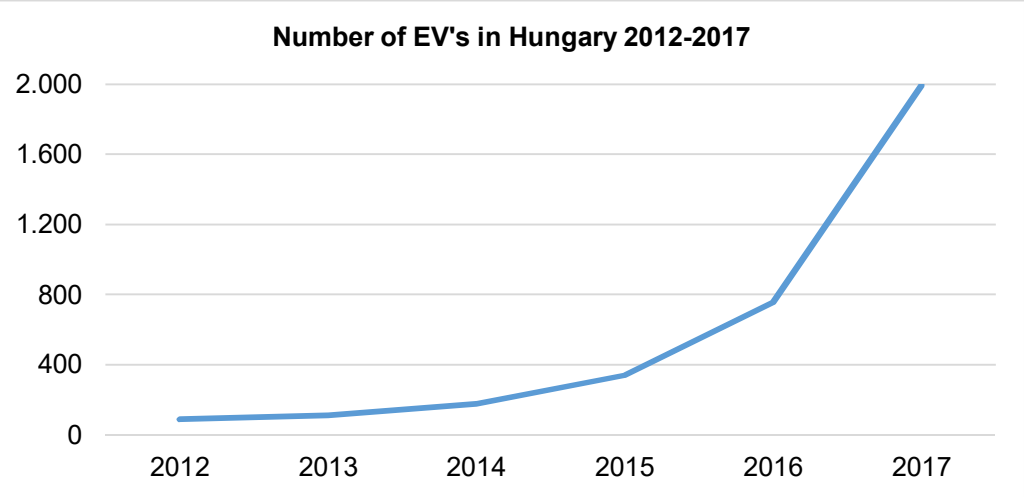

Figure 2. The number of electrical vehicles registered in Hungary, 2012–2017
Source: Eurostat

Other countries are experiencing a similar trend. Figure 3 shows the change in the number of electric cars in Norway and Japan. However, the number of electric cars in these countries is significantly higher than in Hungary.

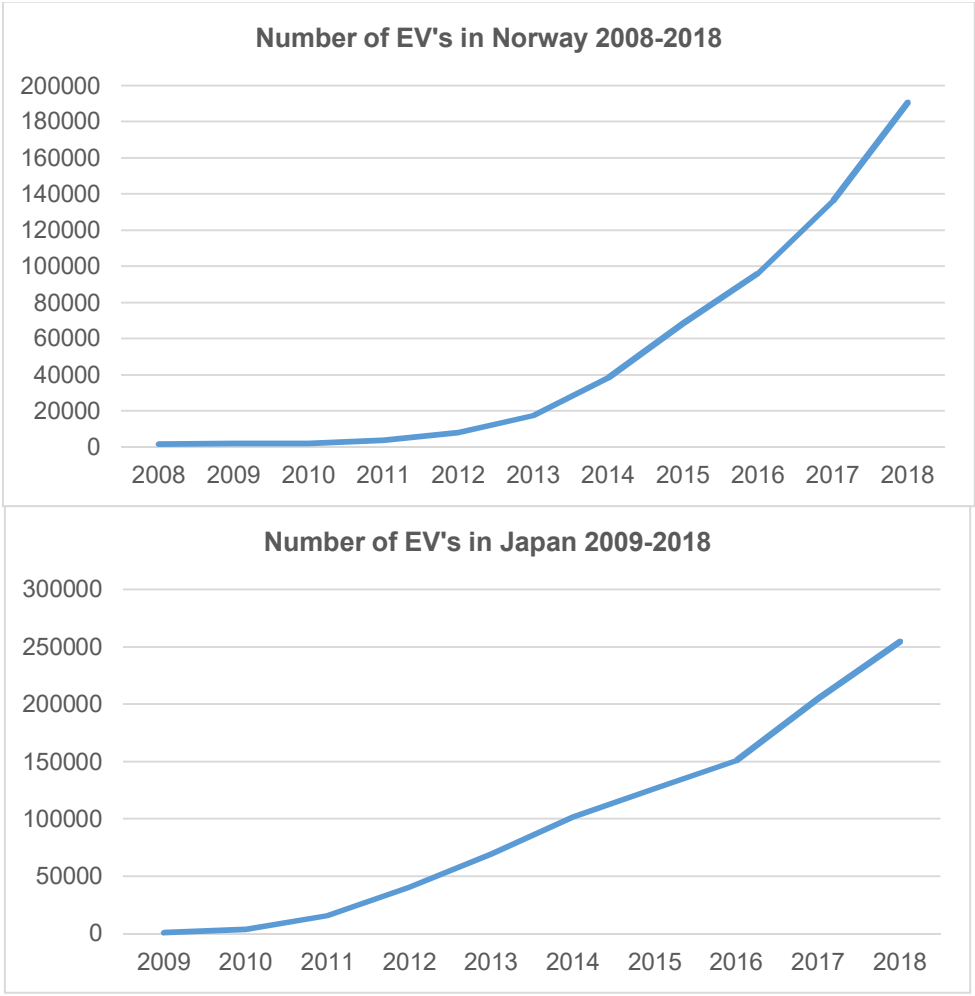

Figure 3. The number of electrical vehicles registered in Norway (left) and Japan, 2008–2018
Source: Statistic Norway, Statista.com

Norway is paying close attention to this green solution, which is supported by the fact that the share of electric cars in cars in Norway reached the highest proportion in 2018 (49.1%). The second on this list was Iceland (19.1%) and the third was Sweden (8.0%). In China only 4.4% of cars are electric, while in the USA the

proportion is only 2.1%. A Reuters article in April 2019 reported that in March 2019 nearly 60% of cars sold in Norway were fully electric. So it can be stated that the Norwegian people treat this area as a priority.
Production of a lithium-ion battery requires a wide scale of elements and materials, like lithium, cobalt, nickel, graphite, aluminium and copper. Many of these elements appear on the 2017 critical materials list of the European Committee. One of the most critical elements is cobalt. There are several reasons that cobalt is one of the most important elements. One reason is that the main supplier is the politically instable the Democratic Republic of the Congo. In 2017 Fund For Peace ranked the Democtaric Republic of the Congo as the 7th most unstable country in the world. Another is that cobalt is mined as a by-product. Figure 4 shows the amount of this element mined worldwide between 2008 and 2018.

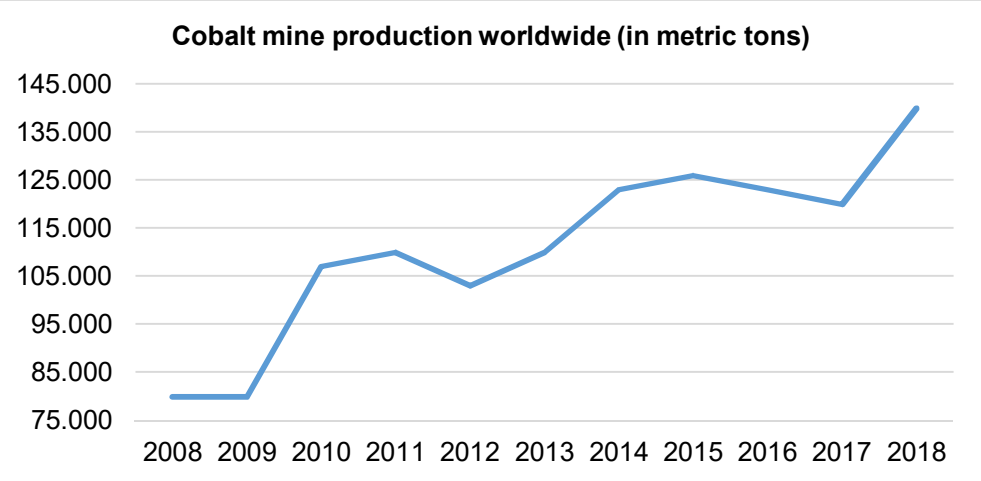

Figure 4. Cobalt production worldwide, 2008-2018
Source: Statista.com

Mol analysts believe that for these reasons above, the future of electric cars really depends on the Democtaric Republic of the Congo. The Democratic Republic of the Congo is the main supplier of cobalt, and this country holds a significant porportion (57%) of the cobalt stock. Most electric car companies require cobalt for the lithium-ion batteries, including Tesla. The world cobalt production in 2018 was about 140,000 metric tons. The production of an electric car requires nearly 10 kg of cobalt, and less than half of the produced cobalt is used to make batteries.
Some electric car companies see nickel as a potential solution, but this has both advantages and disadvantages. One of the advantages is that these batteries have a longer operating time, but one big disadvantage is that they are more flammable. However, optimistic scenarios believe that battery issues will not get in the way of electric cars, because as soon as it becomes a priority, researchers will come up with a better solution.

Due to technological improvements in battery production, new types and solutions will become available in the next decade. One of the most anticipated technological developments is the solid battery. It is important to highlight that the base material of this improvement is lithium. Attempts are being made to eliminate cobalt from the production process due to the problems mentioned above.

3. Environmental and economic aspect

We think that these two areas are closely linked but can be approached from various perspectives. In 2013 and 2014 PwC made a study about the future of electric cars. This includes both environmental and economic aspects, with different scenarios. The study analysed the impact of environmental factors through air and noise pollution. We can divide the effects in two groups. There are local and global effects. In the case of a fully electric car there are zero direct emissions. But in measuring global impacts it is essential to speak about emissions linked to manufacturing, raw material production and processing, and it is important to speak about the source of energy. In our opinion, this is important because some renewable energy devices (solar panels, wind turbines) require the use of critical raw materials, and the mining and processing of these materials imposes additional burdens on the environment. Regarding noise pollution, the PwC survey shows that the use of electric cars is approximately 70% quieter than a petrol- car.
In economic terms, the use of electric cars has both benefits and costs. The first of these is the group of different financial incentives, which in the case of the EU is about 5000 EUR/car, which may include tax breaks and free parking. These incentives are predicted to exceed EUR115 million by 2023. In order for electric cars to become more and more popular, it is necessary to build an appropriate charging station infrastructure; the total cost for this could be close to EUR 120 million. As we mentioned, the use of electric cars may be generate tax benefits, and since these vehicles do not require petrol or gas oil, the tax and revenue from these products is expected to decrease. The expected loss is estimated to be 205 million euro up to 2023. The last measurable factor is the CO2 emissions. As mentioned, the local emissions of electric cars are zero, so CO2 emissions are expected to decrease; this means that the unnecessary CO2 quota can be sold. Figure 5 displays average CO2 emissions per km for new passenger cars. We can see that the values are the best in western and northern Europe.
Overall, it can be concluded that, from an economic viewpoint, many negative effects of electric cars can be observed. However, there are factors that are more difficult to quantify. According to PwC's analysis, these factors are:

- “acquisition of new sources of research and development
- acquisition of infrastructure development sources
- expanding the capacity of the domestic automobile manufacturer
- expansion of the automotive supplier range
- expansion of related technology products
- expansion of non-related technology products
- creating new jobs

- strengthening and building international relations" (PwC, 2014)

To get the full picture, it is important to mention that, in addition to the above, there are analyses that prove that electric cars do not pollute less than cars with internal combustion engines. One study made by German experts was widely attacked. In response, VW conducted its own analysis. They compared the CO2 emissions from an electric and a diesel engine for the same type of car. According to VW, the diesel car has 21g/km higher CO2 emissions.

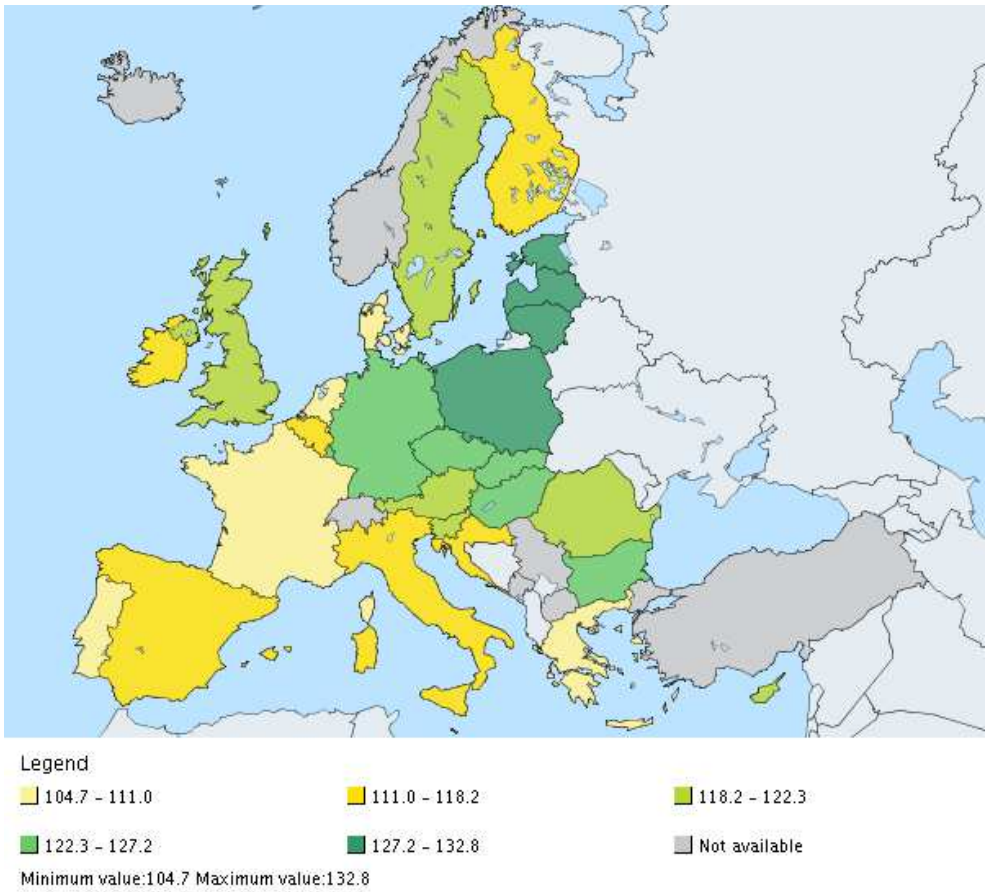

Figure 5. Average CO_2 emissions per km for new passenger cars
Source: Eurostat

In addition, it is important to note that the raw material market is highly concentrated, with many countries having a monopoly position. To measure market concentration, we selected the Herfindahl-Hirschman index and examined the value of some of the raw materials needed to produce the lithium-ion battery. To highlight two, the index for cobalt is 5326 and for natural graphite is 4444. According to the literature, if the index is above 2500, it is a highly concentrated market.

The price of cobalt has a strong influence on the price of batteries and of electric cars. Forecasts say that if the price of electric cars were more favourable, they would soon become more popular. However, the price of cobalt has been very volatile in recent years, which is also confirmed by Figure 6.

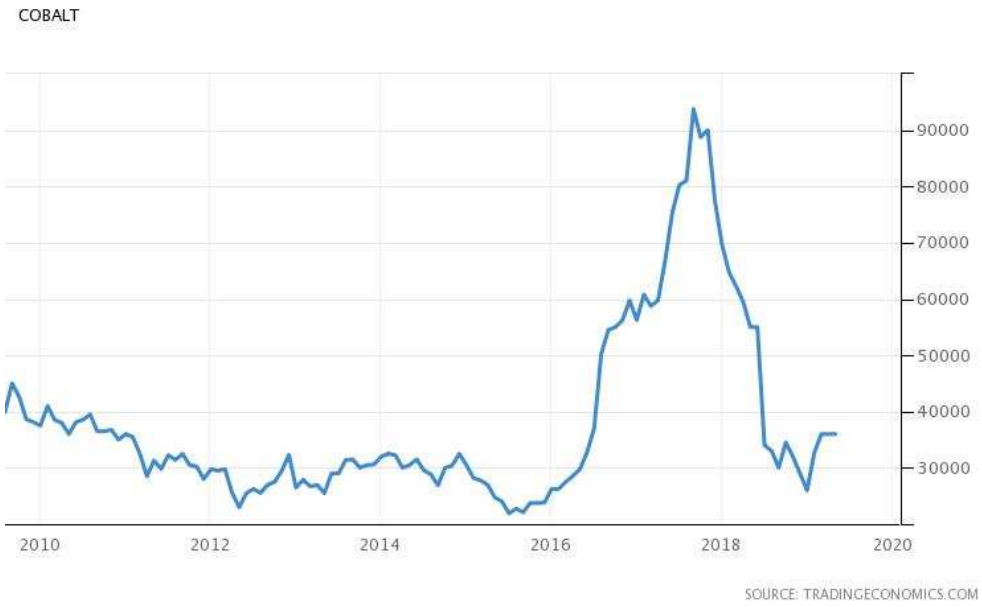

Figure 6. Price of cobalt, 2010-2019 (USD/MT)
Source: Tradingeconomics.com

As a final factor, we would like to write about the impact of electric cars on the labour market. If electric cars become more widespread, this will have repercussions on other areas, including the automobile industry and the labour market, due to the simplicity and shorter time needed to produce electric cars. For an internal combustion engine, the number of hours required to assemble the engine is 3.5, and for an electric motor, it is only 1 hour, according to Alix Partners. The German Automotive Association has calculated what could happen if internal combustion engines are banned in Germany in 10 years. They concluded that as a result more than half million jobs would be lost within 10 years, and two-thirds of the job losses would come from car manufacturers and their suppliers.
In summary the impact of raw materials and electric cars on the economy and the environment is diverse and constantly changing. For this reason it is important to keep track of changes.

4. What is the future?

Many people see one of the biggest disadvantages to electric cars as its low operating range. Another problem is the fact that after its battery is discharged, a lot of time is required for recharging. Battery researchers are focusing on extending the operating range of cars, increasing the capacity of batteries and reducing the charging time. The design of the future by one automotive factory is production of a car with a 640 km operating range and a charging time of nine minutes. If this dream comes true, it means the next step of life of electric cars, because it makes them a sustainable solution to replace traditional cars. Prototypes are expected to be available at the beginning of 2021. The final problem is the price; the cost of such an electric car is around USD 100,000. In spite of the price, forecasts show the market share of electric cars is expected to grow several times higher than the 2017 figure of under 5% in the next 10 years.
A pessimistic survey from DERA shows that cobalt consumption in the area of e-mobility will likely increase from 8.2% to 26% by 2026 and 55% of this consumption will be used in battery production. According to another survey from Bloomberg, consumption of materials like cobalt, graphite and lithium will increase from less than 1,000,000 metric tons in 2018 to 7,000,000 metric tons in 2030. This can be seen in Figure 7. From these predictions, we can assume that in ten years a large number of batteries will be using cobalt and sales of electric vehicles will have increased considerably.

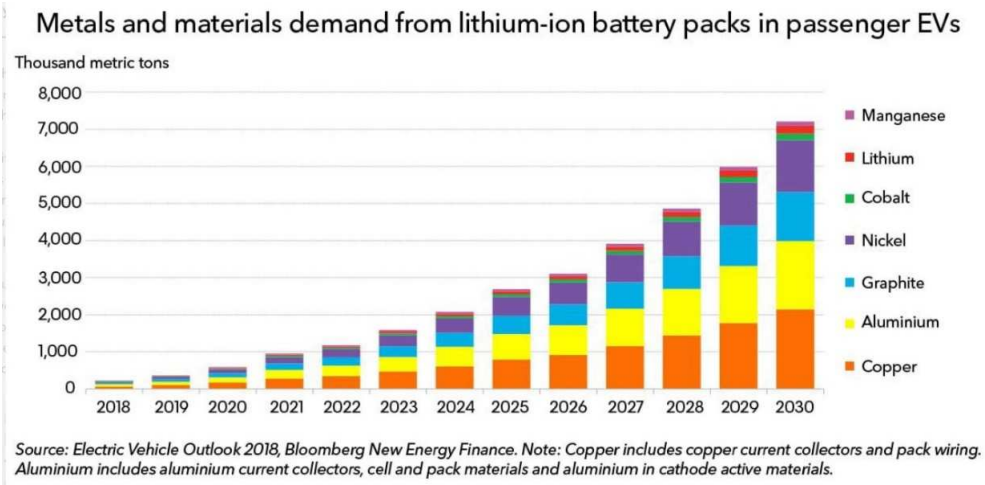

Figure 7. Metals and materials demand from lithium-ion battery packs in passenger EVs
Source: Elektromos autók: lesz-e elég akkumulátor? (2018.12.31.) (https://kiszamolo.hu/elektromos-autok-lesz-e-eleg-akkumulator/)

It is important to consider demand from customers, since the problems described above have a significant effect on the market for electrical cars. An international research study surveyed customers in 2015 and 2018 on their opinions about electric cars. It found that the concerns of customers during the purchase of an electric vehicle. The three main problems are – as mentioned above – the price, the operating range and the charging time. Interestingly, the number of potential customers concerned with the range and price dropped by 10%, while a larger number of people listed charging time as a negative factor in 2018. These factors should be taken into account in the design of electric vehicles.

5. Conclusion

We are living in a world where innovations follow each other day by day. We are eye witnesses to the phenomenon that a now-new technology may be obsolete by tomorrow, replaced by something even newer In our opinion this is true for transportation as well. Scientists are looking for new, better solutions for problems. This tendency affects the constantly changing list of on strategically important materials, elements and countries. Based on forecasts, the lead price of new technologies will decrease and the consumption of expensive critical materials during production will also decrease, contributing to lower prices for electric vehicles In summary, critical materials have a serious effect on transportation, but new research is focusing on improving technology day by day, to find smart solutions and implement their findings that will make this industry more sustainable and will influence (and be influenced by) the list of critical raw materials.

6. Acknowledgements

The described work was carried out as part of the “Sustainable Raw Material Management Thematic Network – RING 2017”, EFOP-3.6.2-16-2017-00010 project in the framework of the Széchenyi 2020 Program. The realization of this project is supported by the European Union, co-financed by the European Social Fund.

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