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ENCOURAGING THE ELECTRIFICATION OF ROAD TRANSPORT AT THE REGIONAL LEVEL BY CREATING AN APPROPRIATELY DESIGNED LOGISTICS CENTRE

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Abstract: *The purpose of this paper is to examine how the more intensive electrification of urban and regional freight transport could be promoted with the help of a logistics centre to be created specifically for this purpose. Electrification requires more and more attention to make the transport of goods sustainable and to reduce harmful emissions. Besides, the advantages of electric freight transport can be, for example, the lighter regulations for electric cars and the tender resources that can be used for their purchase. However, while the technological capabilities of electric road freight transport vehicles are rapidly evolving careful infrastructural planning and expansion are still required to aid their wider adoption. For electric goods transport to be realized in an efficient way, the location of a possible logistics centre in the examined region – the city of Miskolc and its surroundings – is presented, based on the analysis of the local infrastructural conditions.*

Keywords: *electrification, freight transport, sustainability, logistics centres*

1. INTRODUCTION

In modern cities, as a result of urbanization and the growth of economic activity, urban goods transport plays an increasingly important and larger role. The sustainable and efficient delivery of goods to the area of use is given greater emphasis and is a fundamental element of goods transport. However, urban freight transport faces major challenges, the main of which is reducing the impact on the environment. Although many couriers and transport companies have electric cars, they mostly operate vehicles with internal combustion engines, which have a significantly harmful effect on the human body and the environment.

The carbon dioxide emissions of internal combustion engines can be up to 4.5 times that of an electric car [1]. The electric car does not emit harmful substances when it is in operation, but its manufacturing process and the production of electricity do (though it must be mentioned that the spread of the use of renewable energy sources can reduce the extent of the latter as well). However, it is also worth noting that the electric car also emits less noise than traditional internal combustion engine vehicles. The European Union wants to achieve climate-neutral transport by 2050 by reducing greenhouse gas emissions by at least 55% by 2030. By 2030, they want to put at least 30 million zero-emission vehicles into operation, and in the case of trips that are shorter than 500 kilometres, they also want to achieve carbon neutrality [2].

Both the municipality of Miskolc and the Miskolc Városi Közlekedesi Zrt. (the public transport company in Miskolc) are equally committed to the development of sustainable public transport. The city's mobility plan (SUMP) prioritizes sustainable city and transport development. In order to achieve this goal, MVK Zrt. plans to purchase nearly fifty gas-powered and approximately twenty electrically driven buses. In addition, the city administration wants to ensure that two-thirds of the Modal Split is represented by public

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transport and one-third by private transport, thereby promoting more sustainable transport. [3]

Since Hungary is also part of the European Union and Miskolc is the 4th most densely populated city of Hungary [4], it is also subject to the latest regulations. As a result, this study shows what opportunities Miskolc urban freight transport has and what challenges it has to face, based on the electric charging network and other conditions in order to make the use of electric vehicles more efficient and sustainable. In connection with the latter endeavours, an examination of where a suitably designed logistics centre could be established to support electrified goods transport at the regional level is also presented.

2. THE NUMBER OF ELECTRIC VEHICLES IN THE EU AND WORLDWIDE

Nowadays, electric vehicles are becoming more and more common, as shown in the following diagram (Fig. 1). This shows that the number of electric vehicles in the European Union member states has increased greatly in recent years. In 2021, there were more than ten times as many electric vehicles on the roads as in 2015 [5]. Electric cars are gradually becoming more accessible thanks to the development of battery technology and incentive applications. Based on the diagram, it can also be assumed that the global number of electric vehicles will increase significantly. If the numbers show a similar trend, it can be concluded that the number of electric cars will increase exponentially in the future [5]. As a result, the charging network and infrastructure require continuous improvements to enable faster and simpler charging for both average users and goods suppliers [6]. In 2020, the number of electric cars worldwide already exceeded 10 million units, this number increased by more than five million in one year.

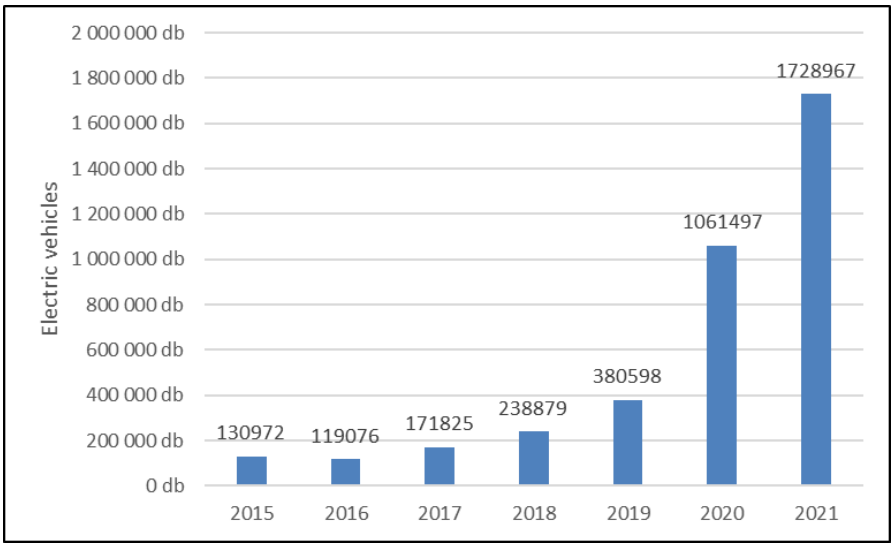

Figure 1. *Number of electric vehicles in operation in EU countries, based on reference [5].*

3. ECONOMIC AND OPERATIONAL BENEFITS OF ELECTRIC VEHICLES

3.1. Incentive programs

In the electrification of cargo traffic, the states of the countries have an extremely large influence by somehow promoting the purchase of electric goods transport vehicles and supporting the development of charging stations with sustainable and renewable energy. Primarily, these can be monetary benefits through tenders. Hungary plans to use HUF 60 billion in support in a 50-50 ratio (HUF 30-30 billion) for the purchase of electric cars and the construction of charging stations [7].

Currently, starting from 02.05.2024 until 03.31.2025, it is possible to submit tenders for electric cars to Hungarian companies that have their headquarters in the European Economic Area and a branch in Hungary. Companies and individual enterprises, whose corporate form is indicated in the tender notice, can also apply for the tender. During the tender, it is only possible to apply for a purely electric car. According to the announcement, the amount of the subsidy can be affected by the performance of the battery. The higher the battery capacity, the higher the obtainable amount is in the tender.

The support does not only serve to increase the number of electric vehicles. They would like to use the other half of the grant amount to develop the charging infrastructure in Hungary. From half of the specified amount, 170 new, high-performance charging stations are planned to be created across the country, so that they are located along the busier routes [7]. The plan contributes to the reduction of greenhouse gas emissions, promotes energy independence and supports the transition to a green economy. Developments and subsidies are also of great importance from the point of view of environmental protection, because a large part of the emission of harmful substances on Earth is generated by road traffic and goods transport. The development and expansion of the charging infrastructure is essential to create an environmentally friendly and sustainable transport system.

3.2. Lighter regulations for electric vehicles

With an electric vehicle, it is typically possible to drive into many protected zones where conventional internal combustion vehicles are not allowed, as electric vehicles have less noise and do not emit greenhouse gases locally during their operation (as it was mentioned, their global greenhouse gas emission is also lower and can be further reduced with the increasing adoption of renewable energy sources). In addition, electric cars can also benefit from parking discounts.

In many countries, discounts are also provided for electric vehicles in terms of highway tolls, which also reduces operating costs and thus encourages the use of electric cars.

Electric company vehicles also benefit from a number of tax benefits, and those cars that have an environmentally friendly car classification are exempt from the registration tax, which must be paid upon commissioning. They are also exempt from paying vehicle tax and property transfer tax. In addition to the costs mentioned above, companies with electric cars also receive discounts on corporate tax for their vehicles [8].

Based on the above, the reductions may differ depending on the country, region, or city in which one is driving. Vehicle owners are advised to check the latest information and regulations so that they can take full advantage of the discounts and benefits associated with an electric car.

3.3. Operational advantages of electric vehicles

In relation to the area of goods transport, it is especially worth noting that from a purely operational and economic point of view, one of the great advantages of all-electric powertrains compared to trucks with an internal combustion engine lies primarily in energy efficiency (and secondarily in the lower need for maintenance resulting from the simpler mechanical structure). It is a well-known fact that while the efficiency of modern internal combustion engines is on average around 40%, the efficiency of electric motors is over 90% and this advantage is largely preserved for the entire drive chain, even considering other losses.

This means that by using the same amount of energy, theoretically an electric truck with the same mass can cover slightly more than twice the distance as its counterpart equipped with an internal combustion engine, naturally assuming the same load. Of course, in reality electric cargo vehicles are still at a significant disadvantage in terms of the maximum travel distance, given that even the energy density achieved by current batteries is considerably lower than the energy density of petroleum-based fuels. However, at the same time it clearly follows from the previous that, looking at the specific fuel cost alone, the electric vehicle, even if electricity and diesel costs the same in terms of energy content, would be more than twice as economical (in reality, the specific price of electricity is usually more favourable than the price of diesel fuel, but of course this can depend on a lot of factors at can also vary according to the specific location).

In connection with maintenance and repair costs, it can be said that in these areas, fully electric vehicles usually also have an advantage, since the electric motor is a significantly simpler structure compared to the internal combustion engine, and due to the nature of the electric operation, the wear of certain parts, such as brake pads, is slower thanks to the use of regenerative braking.

4. POSSIBLE PLACEMENT OPTIONS OF A REGIONAL LOGISTICS CENTRE

4.1. Case study of logistics distribution and consolidation centres

In order to make urban goods transport more sustainable, three different methods are possible. For the development of sustainable urban freight transport to actually take place, all three methods just mentioned must be applied at the same time. These methods are: logistical and technical developments, as well as regulatory measures. Since carriers have little or no influence on the regulations, they can only improve the sustainability of freight transport through technical and logistical developments. Regarding the latter, one of the appropriate solutions is the establishment of consolidation and distribution centres. Logistics centres are mostly set up on the outskirts of cities, because heavy and long goods transport vehicles can usually be affected by regulations and therefore cannot use certain roads. A properly designed centre can enable the delivery of goods to operate with sufficient volume [9].

There are cases when the establishment of a centre does not boost logistics processes, but rather reduces its efficiency. An example of this is the distribution centre created in the Dutch city of Leiden, where they wanted to improve the quality of life in the historic part of the city. This project ultimately failed due to several important impediments. There were not enough customers to sustain such a centre, the distribution centre was located very far from the city centre, which would have been the target audience [10]. In addition, the vehicles used were not suitable for the road environment. They used electric freight cars that were capable of a maximum speed of twenty-five kilometres per hour, which greatly hindered not only freight

transport, but also road traffic [11]. In the end, the project was not continued and later stopped.

Another case shows a good example of how a consolidation and distribution centre can create an efficient and sustainable delivery if it is designed and designed according to the needs. This is the centre also serving the Dutch city of Nijmegen, which was created by Binnenstadservice.nl. Goods are transported with electric bicycles and natural gas-powered goods transport vehicles, and electric bicycles can also perform their tasks extremely efficiently, as the logistics centre was established one and a half kilometres away from the city centre. There are many small and independent businesses in the city, which is why it is important that Binnenstadservice.nl focuses mainly on these businesses and not on carriers or suppliers. Binnenstadservice.nl provides a number of different services to its partners, for example, the desired products of businesses are collected at the centre and later delivered at the desired time. It is also possible for companies to collect orders from several suppliers and deliver them to their partners at the same time. It provides this service for free, and it is also possible to use paid services, such as product storage and home delivery of larger products [11].

4.2. Aspects to be considered for the design of the logistics centre

In order for the electrified goods transport in Miskolc and its region to function properly, the establishment of a centre would be necessary. It would be worthwhile to do this at a point that is located in a well-frequented place, taking into account both the city of Miskolc and its region, as well as smaller settlements that do not have a charging infrastructure. In this way, they can also be served appropriately.

The primary consideration is that the centre should be located along main routes and near industrial parks. The importance of the more fundamentally important routes, the highways, is reduced to some extent, since the study takes into account the 40-kilometer area of Miskolc. High-traffic roads, such as highways 3, 37, E79 and the M30 highway section that connects Miskolc with Kassa, may play a greater role in the future. These roads connect Miskolc with the economically more significant cities of North-East Hungary, for example: Szerencs, Tokaj, Szikszó, Kazincbarcika, etc. The industrial parks in Miskolc are located on the northern and southern axis of the city, at its two ends. It is worth considering the smaller industrial enterprises located in the area of the old Iron Works, which may also play a role in the selection of the centre.

The centres must be established in a location that is equipped with an adequate energy network, because it is important that the capacity of the network can serve even several high-performance electric car chargers operating at the same time. In the event that there is no such location, the area requires improvements, or a suitable network can be created to fulfil the task. In this case, it is necessary to consider which option would be more economical in order to achieve the future goal.

In order to be able to designate such a centre, accurate data would have to be collected and based on that, the right location should be determined to create an optimal centre so that electric commercial vehicles can serve people and ensure proper operation for drivers.

It may be worthwhile to create the centre in an adaptive way, so that it can adapt to the constantly developing technology in the infrastructure of the centre and the already existing technology can be used. Nowadays, suitable high-performance electric cargo transporters are able to charge the battery from a fifteen percent charge level to an eighty percent charge level in almost half an hour. The need for the use of high-performance charging stations is highest when a freight vehicle must stop during peak hours to absorb the energy required for

operation. When people aren't working and freight vehicles aren't in use (usually at night), high-speed charging ports are underutilized. In this case, it may be worth using a more cost-effective and slower technology that charges a vehicle's battery overnight. These methods are called overnight charging [12]. To be able to charge electric commercial vehicles in a sustainable way, a lot of attention should be paid to green logistics solutions, such as using energy-efficient buildings and renewable energy sources to charge the vehicles. An excellent solution for these could be the use of solar and wind energy.

For the establishment of a centre, it may be advisable to establish cooperation between smaller or larger local businesses and regional authorities, thereby reducing the costs associated with the construction and operation of the centre. At the same time, this cooperation can facilitate the successful operation of the freight centre.

4.3. Designation of the location of the logistics centre

In the study, the examined area is approx. 1707 square kilometres, which can be seen in the picture below (Fig. 2). The borders are formed by the cities and settlements that are nearby. They are located 40 kilometres away in terms of the goods delivery route. In this part of the text, several proposals are presented as to where a logistics centre could be established in the examined area, which would be able to serve customer needs efficiently and sustainably.

A possible logistics centre in the region should be established in Miskolc or on the outskirts of the city. The city has several industrial parks in different parts of the city. It is worth developing the centre along the north-south axis of the city, due to the industrial parks present at both ends of the axis. It would be useful to plan the centre at the southern end of the axis, and the middle of the axis may prove to be an optimal solution for various reasons, but these may differ significantly. The role of the logistics centre to be developed is essential for the electrification and sustainability of goods transport in Miskolc and its region. For this reason, the logistics centre should be equipped with low environmental impact technologies and charging infrastructure for electric goods transport vehicles.

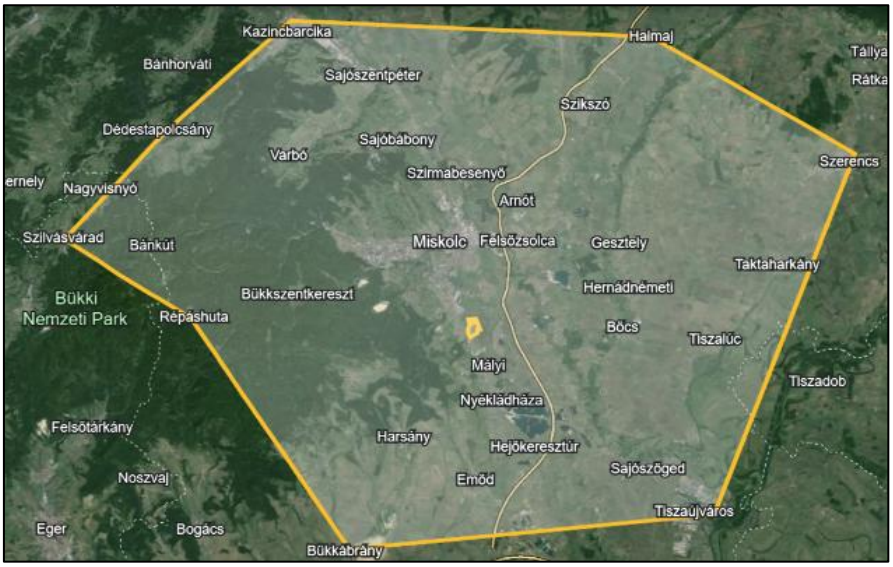

Figure 2. *The area examined in the study is shown on the Google Earth satellite image*

The Gömör railway station in Miskolc can be very influential in ensuring that the logistics hub is located in the central part of the city. Gömör Railway Station can play an important role in creating an intermodal logistics centre in the centre of the city. This would significantly promote the distribution of goods transport vehicles, which would enable multimodal goods transport in Miskolc and its region. Taking advantage of the connection between electric freight vehicles and railways, which would enable the development of sustainable freight transport. However, this centre could be located near a residential area (see Fig. 3), which may be hindered by legal restrictions. In addition to these, a significant investment would be required to ensure the basic tasks of the intermodal centre's activities. With the renovation of the Gömör railway station, an intermodal centre would be created, although no exact information can be found as to when the development is planned to begin [13].

Figure 3. *The surroundings of the Gömöri Railway Station (designated as "Miskolc Gömöri" on the map) [14]*

Another possible location for the establishment of the logistics centre could be the Miskolc South Technology Park located in the southern part of the city (see Fig. 4). A major advantage of this area is that it provides direct access to the M30 motorway and the E79, which would allow fast and efficient freight transport. In contrast to the proposal mentioned in the previous paragraph, since it is not located next to a residential area and the spatial capacity that would be necessary for the establishment of the centre is given. In the planning processes, much less attention should be paid to the regulations related to the facility to be built next to the residential areas, as this could be realized within the city limits.

Figure 4. *The surroundings of the Miskolc South Technology Park (designated as "Miskolc Déli Technológiai Park" on the map) [14]*

In the area of the Technology Park located in the southern part of Miskolc, eighty-five hectares of green field area (see Fig. 5) is currently available, which is currently waiting for investors. The Park is equipped with basic infrastructure (car and bicycle paths, street lighting, drinking water supply, sewage disposal, street lighting, etc.). In order to implement a logistics centre, a number of regulations must be met, for example: the permitted minimum plot size is ten hectares, the maximum built-up area is fifty percent, the buildings maximum height is sixteen meters and the green area must be twenty-five percent of the lot size. The Miskolc Municipal Regulation (MÉSZ) provides for these regulations [15].

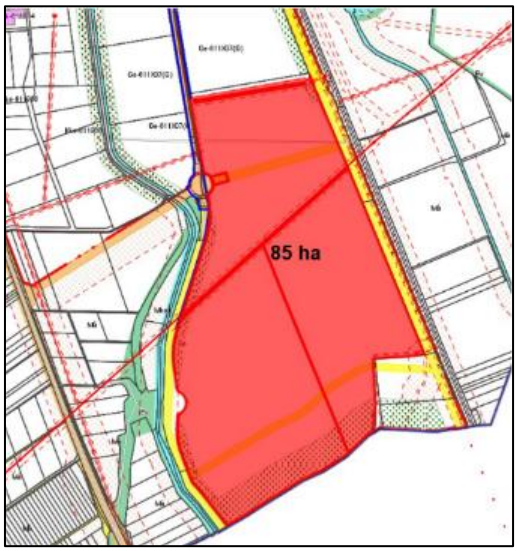

Figure 5. *Currently available free space in the Miskolc South Technology Park [15]*

The routes must be designed according to the available data, taking into account the average range currently characteristic of the vehicles in question. In the following, it is possible to create two types of route, circular route and return route. In the latter case, the commercial vehicle takes the same route to the claim and back to the centre. Both options have their own advantages, so it may be worthwhile to consider them before each planning phase to decide which solution suits best the task of transporting goods. The round trip provides the opportunity to serve several customers in a single trip, thus saving time and increasing the utilization of commercial vehicles. The advantage of the return route is that planning the route is a simpler task and since it serves fewer customers, it can also simplify administrative tasks.

If our goal is to protect the batteries of goods transport vehicles and maximize their service life, it is recommended to keep the charge level in an optimal range, for example between 80 and 30 percent, which is a widely recommended interval. Considering the current level of technology, this means that it is worth counting on a journey length of approximately 150 kilometres. Figures 6 and 7 show one possible route each, based on the previously mentioned route length. The routes shown in the pictures show one possibility of what types of routes can be planned within the examined area, which are still within the range of a typical electric freight vehicle.

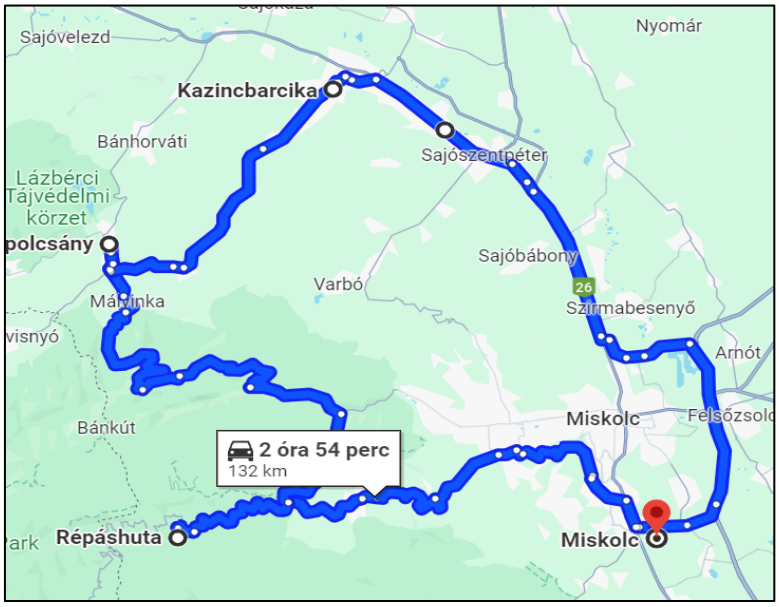

Figure 6. *The duration of this route is 2 hours and 54 minutes (Source: Google Maps)*

In Fig. 8 on the next page, we can see the zones that an electric freight vehicle can serve. In the centre of the zones there is a potential centre designated in the Miskolc South Technology Park. The green zone represents the area where you can perform logistics tasks smoothly and without problems. The goods transport vehicle can still serve the yellow zone without running down, but the battery charge may presumably drop below the previously mentioned best charge level. The areas marked in brown and red those where electric goods transport vehicles are no longer able to serve without additional charging (based on the current technological level), so it may become necessary to charge the battery on the way.

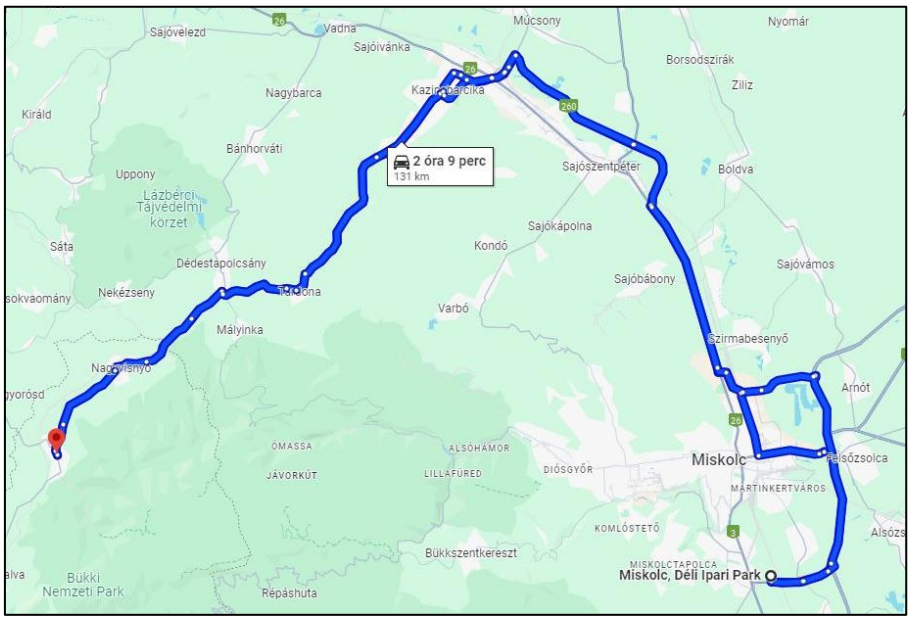

Figure 7. *The duration of this route is 2 hours and 9 minutes (Source: Google Maps)*

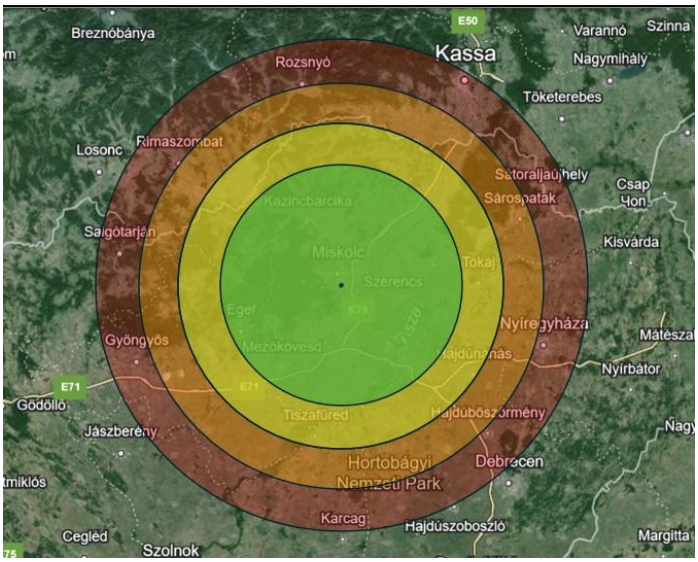

Figure 8. *Range zones of electric freight vehicles without charging, shown on a Google Earth satellite image (Source: Google Earth)*

In order for the electric commercial vehicles to always be ready for their task, it is recommended to build an electrical infrastructure in the area of the logistics centre. Since the Type 2 connector is the most common in the city and its region, it is therefore recommended to equip the complex with such connectors. In the future, it is worth supplementing the centre with CCS/SAE and CHAdeMO charging connectors, thereby ensuring wider compatibility

and smooth charging of different types of electric goods transport vehicles. In order to have the appropriate energy needs for the infrastructure, the construction of a solar park in the area of the logistics centre should be considered.

For the logistics centre to be successful, it is not enough to create and operate it. The support of the authorities and companies is also essential. In both cases, cooperation and building industrial relations between companies would be key. According to the previously mentioned successful Dutch example, it would be possible to provide a similar service to independent small businesses, thereby promoting their competitiveness. In addition to these, it is worthwhile to involve larger multinational and transport companies in the cooperation. By providing logistics services to multinational companies, while providing location and premises to transport companies.

5. SUMMARY

In the study, first the benefits from the use of electrified freight transport were presented in summary. After that, through presenting a few case studies, it was outlined how the electrification and sustainability of freight transport could be established. Based on these, a possible idea was presented regarding Miskolc and its catchment area, taking into account various aspects. With a hypothetical logistics centre, which would be established in the Miskolc South Technology Park, it would be possible to realize the electrified transport of goods in Miskolc and its region. In addition to these, it is also necessary to ensure the energy supply of the vehicles, for the implementation of which various methods are available.
In order to be able to choose the exact location of a logistics centre, thorough quantitative research should be carried out. The future goal is to ascertain whether the location determined in the study is really optimal for a logistics centre by collecting and analysing the data and using a centre search method. In the event that there is no more available capacity for this purpose in the Miskolc South Technology Park, the task would be to find a near-optimal location for the logistics centre in the vicinity.

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