
ISSUES RELATED TRANSITIONING TO ELECTROMOBILITY:
REGIONAL AND SPATIAL ASPECTS

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Abstract. In recent years, the interest in electromobility among the public has been growing. In order to determine the impact of the development of electromobility on the increase in innovation of the supply network, it is necessary to analyze the situation of the potential use of electric vehicles in the supply network, presenting their advantages and disadvantages. The article presents the characteristics of electromobility in the supply network in the region and the SWOT analysis. Electromobility is becoming a key element in the transformation of the transport sector, contributing to more sustainable and green communities.

Keywords: electromobility; innovation; logistics; analysis; sustainability

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1. Introduction

The events of the last several months have unequivocally confirmed that unpredictability and instability are becoming an everyday reality in transport and logistics management. Transport and logistics systems have faced massive disruptions due to Russia's aggression against Ukraine, the COVID-19 pandemic, escalating trade tensions and large-scale cyberattacks. Record global oil prices, combined with unsustainable energy consumption by transport, environmental degradation and climate change, are factors that confirm the need to move away from the „Business as Usual” strategy with regard to, the development of transport.

Electromobility in the region represents a landmark step towards a sustainable and efficient transport system, aimed at minimizing the negative impact of the transport sector on the environment (Zavorka, Paar, 2022; Chehabeddine, Grabowska, Adekola, 2022; Marotta et al., 2023; Graesner & Vogt, 2023).

As environmental awareness grows and the need to reduce greenhouse gas emissions, regions around the

world are focusing on promoting and implementing modern electromobility solutions (Alogdianakis, Dimitriou, 2023). Electric vehicles, as an innovative solution, not only reduce pollutant emissions but also reduce dependence on traditional fossil fuels (Global EV, 2022, p. 17).

Recent years have seen a significant increase in interest in electromobility among the public. In order to determine the impact of the development of electromobility on the innovativeness of the supply network, it is necessary to analyze the potential use of electric vehicles in logistics, taking into account their advantages and disadvantages (Grzesiak, Sulich, 2023).

The goal of global companies is to minimize the negative impact on the environment through the use of electromobility solutions. The development of modern technologies has a huge impact on the functioning of enterprises, regardless of the area and scope of their activity. Investments in new technologies are essential for all organizations, because every entity that wants to optimize its processes, adapt to market requirements and gain a competitive advantage over others is obliged to continuous development. A lack of development of a given entity could cause the competition to distance itself and at the same time reduce the attractiveness and competitiveness of the non-developing company (EU-China, 2019; Ranaweera, 2022).

Electromobility is one of the technologies determining the development of many sectors of the economy, at the national, European or global level. Often referred to as the technology of tomorrow, it significantly contributes to the growth of innovation in areas such as logistics (Electric Vehicle, 2022, p. 4).

In this article, we will look at the main aspects of the development of electromobility in the region, analysing government initiatives, charging infrastructure, and cooperation between the public and private sectors. Electromobility is becoming a key element in the transformation of the transport sector, contributing to more sustainable and green communities.

2. The essence of the supply network and electromobility

Nowadays, the constant increase in customer pressure and requirements affects all functioning organizations, forcing them to constantly look for new solutions to improve and enable efficient and effective implementation of material and information flow processes.

The concept of a network is defined as a set of nodes connected to each other by specific relationships. However, despite its simple definition, the term is interpreted in many different ways, such as a railway network, a food network, a network of commercial relationships, or a network of nerve cells (Helmers, Dietz, Weiss, 2020, p. 18). Broad interpretations of the web arise when a concept is considered in the aspect of a specific field, such as logistics, medicine, etc. Considering the concept of the network in terms of logistics, it can be noted that the main goal of companies is the continuous development of the sphere of supply, production and distribution, while increasing flexibility and taking advantage of additional benefits resulting from cooperation with individual network links, the so-called synergy effects (www.auto-swiat.pl, 07.04.2020). A. Spruce in his scientific article „From the supply chain to the supply network” explained the concept of a logistics network using one of the fields of mathematics, namely the theory of graphs. According to the aforementioned author: „A logistic network in the mathematical sense can therefore be defined as a directed graph $G = (V, E)$ (where: V is a set of nodes and E is a set of edges), in which each edge has a non-negative bearing capacity $c(u, v) \geq 0$ ” (Motowidlak, Witkowski, Wiśniewski, 2018, pp. 22–23). According to graph theory, the logistic network is represented graphically in Figure 1.

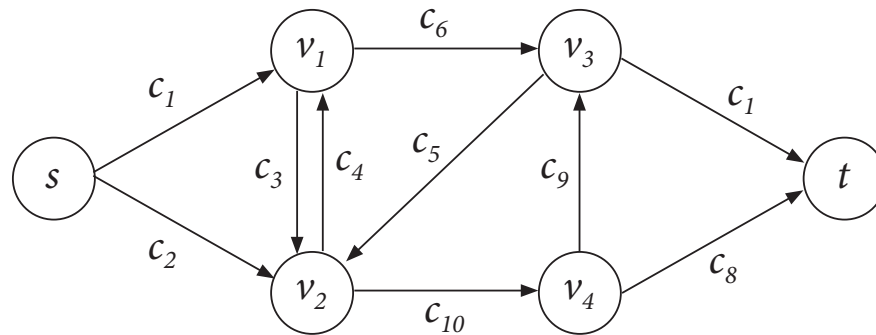


Figure 1. Example of a logistics network.

Source: A. Świerczek: *From the supply chain to the supply network*, „Logistyka” 1/2007, p. 74.

According to graph theory, a logistics network is defined as a group of nodes connected to each other by lines that reflect mutual logistic relationships. Each edge is defined as a channel with a fixed bandwidth through which the flow of materials and information is carried out. The relationships between the individual links within the network are characterized by the tension between autonomy and interdependence, loyalty and individuality towards the group, competitiveness and cooperation (www.rynek-energii-elektrycznej.cire.pl, 07.04.2020). The flow of materials and information within a given logistics network is characterized by different sizes and diversity due to the area of occurrence of a given flow, from the moment of obtaining raw materials to the delivery of products to the end user. For this reason, the logistics network is considered as a set of direct logistics links between companies, creating interdependencies and links between them, while giving specific functions to the individual links. This means that a well-functioning supply network has more potential than individual supply chains.

The development of the entire power grid depends on the development of all connections operating within the network. The development of individual entities operating within a given network results from broader cooperation between them and the implementation of modern solutions contributing to the growth of innovation in the supply network.

Electromobility, on the other hand, is sometimes referred to as e-mobility and covers all issues related to the use of electric vehicles, which include electric cars, electric bicycles, e-buses and e-vehicles. The main feature of these vehicles is that they are partially or entirely electrically propelled, have energy storage facilities on board and derive their energy mainly from the electricity grid. Today, there are many categories of electric vehicles in the transportation sector. These include (Gajewski, Paprocki, Pieriegud, 2019, pp. 13-14):

- BEV (Battery Electric Vehicle) is a category that includes battery-only electric cars (electric). Cars in this category do not have an internal combustion engine, and they use only electricity stored in batteries (accumulators) for propulsion. Their current range is between 120 and 400 km.
- PHEVs (Plug-in Hybrid Electric Vehicles) are plug-in hybrid electric vehicles that can be charged from an external outlet („plug-in”). Vehicles in this category have two types of propulsion: an internal combustion engine and an electric motor. In PHEVs, the electric motor and internal combustion engine can operate separately or in parallel, so with frequent enough charging, they can be powered solely by electricity, similar to BEVs. The batteries can be charged from a classic socket or a special charging station for faster charging. The range of this type of vehicle is from 500 to 1000 km (www.gov.pl, 09.04.2020);
- HEV (Hybrid Electric Vehicle) – Hybrid electric vehicles include vehicles equipped with both gasoline and electric engines. In the HEV category, the electric motor is usually only supported by the combustion engine, while newer models (PHEVs) enable emission-free operation and drive the vehicle exclusively with the electric motor. The batteries in classic hybrid vehicles are charged using recuperative braking systems and engine energy;
- REEV (Range Extended Electric Vehicle) is an electric car with an extended range. In addition to the electric motor, which is the basic power unit, they are equipped with internal combustion engines. In this type of car,

the internal combustion engine only starts when the energy needed to charge the battery for electric propulsion is needed. Thanks to this solution, the range of the vehicle can be increased to 300-500 km;

– FCEV (Fuel Cell Electric Vehicles) – This category includes electric vehicles equipped with fuel cells. The battery function is performed by fuel cells powered by, for example, hydrogen.

The first three types of electric vehicles comprise the majority of electric vehicles on the road, especially in Poland.

3. Electromobility in the supply network

Nowadays, the main place where innovations are most often created is the enterprise. The innovative activity of a given entity is to lead the enterprise to the development of its innovative potential enabling the collection and implementation of innovative processes (Urbanek, Walińska, 2016, p.172). In highly developed countries, there is a model of system integration and networking through specialized IT programs. System integration is also necessary for the efficient functioning of a given supply network, ultimately affecting the quality of customer service (Drożdż, Kuczkowski, 2018, p. 15; Burinskienė, 2023). Currently, innovative enterprises are organizations that are based on knowledge, learn and conduct their business with the use of innovative solutions, such as modern IT systems.

New technologies definitely contribute to the growth of innovation in all companies implementing innovative processes. Investments in new technologies of individual entities result in an increase in the innovativeness of the entire supply network. One of the reasons for this is the closer cooperation between the individual links in the network, which determines their development and the use of their potential. Optimising the processes carried out in a given supply network is essential for the proper functioning of the entire network and meeting the growing expectations of customers. Examples of technologies that have contributed to the growth of supply network innovation are modern IT systems, which have optimized many processes carried out in many areas and at different levels, and as a result, have contributed to a more efficient flow of materials and information. Called the technology of tomorrow, electromobility will also increase the innovativeness of the supply network, but mainly in the area of transport. The transport process plays one of the most important roles in the supply network, as it is responsible for the flow of materials within the entire network.

Today, many companies are using electric vehicles for in-house transportation, and these are electric forklifts. It is one of the first transport areas where electric vehicles are used. Electrically powered lift trucks are most commonly used in confined spaces because they meet the highest safety standards. There are also IC and gas lift trucks, which are mainly used in open spaces due to exhaust emissions (www.herakles.biz.pl, 09.04.2020). However, they are being systematically replaced by electric trucks every year (www.trans.info/pl, 14.04.2020). Many manufacturers already offer electric vans and trucks with different GVW s¹, production of which began in 2018.

Observing the situation of electromobility, the emergence of more and more restrictive exhaust emission standards and the increase in the share of electric vehicles in the modern transport system, it can be concluded that in the coming years the transport of both goods and passengers will be carried out exclusively with the use of zero-emission electric vehicles. Clean transport also depends on sources of electricity production. Coal currently plays a key role in the energy sector of many countries. However, coal's share of electricity generation will continue to decline in the future as countries increasingly invest in renewables.

However, environmentally friendly transport depends not only on the availability of electric vehicles or sources of electricity production, but also on the policies of logistics companies operating within specific supply networks (Rakauskienė, Petkevičiūtė – Stručko, 2022; Vennemo, 2023; Zecca et al., 2023).

Global companies are planning, to significantly reduce greenhouse gas emissions generated by logistics processes using electric vehicles. A prime example is the global courier company UPS, where by 2020 one out of four vehicles purchased was electric or powered by alternative fuels. In 2018, UPS had 8.5 thousand vehicles

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of this type, i.e. powered by, fully electric, hybrid, CNG, LNG, LPG or biomethane. In Europe, however, Germany's Deutsche Post intends to use only zero-emission vehicles as electric vehicles. In 2018, the company had 7,000 such vehicles. (www.pspa.com.pl, 14.04.2020).

The implementation of modern electromobility technologies by companies is a good solution, as the world's largest economies are moving towards zero-emission transport, which will ultimately contribute to the reduction of pollutant emissions. The main reason for achieving this goal is the significant increase in environmental pressure on the world, which is becoming the driving force behind the development of electromobility. Despite many shortcomings and deficiencies, e.g. in infrastructure, electromobility is a good way to increase the innovation of the supply network, because in the long term electric vehicles will be a key link in the modern transport system.

4. Methodology: SWOT analysis

We employ SWOT analysis to identify the issues related transitioning to electromobility.

Strengths

Strengths within a SWOT analysis include all the beneficial internal factors that can be used to achieve the goal and that you should pay attention to. In the context of the decarbonisation of transport and the electrification of fleets in the West Pomeranian Voivodeship, the growing environmental awareness of the society, government support, growing demand and the knowledge and presence of highly qualified specialists are an important asset.

From the survey of environmental awareness and behavior of the region's residents, seven main thematic areas were determined:

1. the biggest challenges for Poland vs. problems environment
2. the environment and its protection
3. air quality
4. waste management
5. climate change
6. environmentally supportive actions individual and consumer behavior
7. image of the Ministry of Environment

The approach to environmental awareness is thus comprehensive - it shows both the general attitudes of Poles toward environmental issues, but also tests their knowledge or asks about the pro-environmental behaviors they perform (or don't perform) on a daily basis.

The survey of ecological awareness and behavior of the region's residents was carried out as part of the Omnibus multi-topic project:

- by computer-assisted individual interview (CAPI) method;
- on a random nationwide representative sample of 1,000 residents of the region aged 15 and older.

The maximum estimation error for a random sample of 1,000 people is +/-3.1%.

Analogous surveys have been conducted in previous years, the current data will be compared with those of previous years.

The survey shows that respondents identify the problem of environmental protection as one of the main challenges (24%). However, it is worth noting that compared to the previous survey in 2020, there were half as many such responses, in favor of the problem of energy security (30%), which the researchers attribute to the effects of the war in Ukraine. Among the environmental problems, poor air quality is particularly noticeable.

A third of respondents said they were planning additional measures to increase energy efficiency, an increase of 3% compared to the previous wave and the highest ever recorded. Two-thirds of respondents are ready to use

clean energy, even if it comes at a higher cost. This is a 12% lower result compared to the 2020 measurement, which suggests that the inhabitants of the West Pomeranian Voivodeship are open to the energy transition, supporting the development of electromobility.

There is also a growing interest in green alternatives in transport, such as electric vehicles. The strengths of the development of electromobility also include existing government incentives. The electromobility market has great potential and can contribute to the development of other sectors of the economy. That is why measures are being taken at the European Union level to support electric vehicles in the context of climate and energy policy aimed at reducing greenhouse gas emissions and increasing the share of energy from renewable sources (Andryeyeva et al., 2021).

In the results presented below, we will see that some of the observed results and changes may be due not so much to changes in environmental awareness itself, but to a deterioration or improvement in the financial situation of households, or a decrease or increase in social optimism. The results also show what impact changing regulations can have on opinions and behavior. An excellent example of this is the entry into force of the amendments to the Law on Maintaining Cleanliness in Municipalities. Respondents not only segregate waste to a greater extent segregate waste, but also have a much better assessment of the current state of waste management. Nonetheless, the level of environmental awareness among re-sellers is still not satisfactory, and the answers given by respondents are sometimes inconsistent. For example, on the one hand, we are convinced of individual responsibility for the state of the natural environment, on the other hand, the popularity of consumer behavior that supports environmental protection is still limited. In the actions we take, saving money is still a priority, and ecological solutions are associated with higher costs.

Unfortunately, despite the growing interest, electric vehicles remain expensive, which does not allow everyone to buy them. That is why governments, including Polish, have introduced programs enabling obtaining subsidies for electric cars, such as the „My Electrician” program and „Support for electric vehicle charging infrastructure and hydrogen refueling infrastructure”. In addition, it is possible to drive electric cars on bus lanes, and the local government may exempt from parking fees.

As a result of these programs, reliefs and growing public awareness, there is a significant increase in demand for electric vehicles in Poland. This growth is also the result of technological progress, the competitiveness of the sector, numerous studies and the introduction of new technologies, which results in lower prices of electromobility solutions. Nevertheless, the problem of insufficient access to charging infrastructure persists, which is a brake on the demand for electromobility.

Weaknesses

There are still some challenges related to electrification in the West Pomeranian Voivodeship, and one of them is the insufficient public knowledge about electromobility. Despite growing environmental awareness, many people are still not adequately familiar with the benefits of using electric vehicles, which can delay the adoption process.

In the transport sector, a key obstacle is the lack of legislation that would oblige municipalities to introduce low emission zones. The current regulations allow for the designation of zones for at least 5 years, but at the same time leave considerable freedom in determining which vehicles are allowed to enter the zone.

The paucity of local spatial development plans is another major problem, which makes it difficult to introduce a coherent transport policy, especially in the context of changing the nature of the goods supply chain (Adeniran et al., 2023). This leads to uneven urban development and widespread spatial chaos (Pčelina et al., 2023), which in turn makes it difficult to introduce new concepts to improve transport.

The charging infrastructure for electric vehicles in the West Pomeranian Voivodeship is also insufficiently developed, which is another challenge for the development of the emobility market. The need for the energy tran-

sition to meet the growing demand for electricity infrastructure and the need to adapt to the growing number of electric vehicles generates additional costs and technical challenges.

Opportunities

Above all, electromobility is a significant prospect for the economic development of the region. As the industry of vehicles with alternative drives progresses, Poland has the opportunity to significantly increase its expenditure on research and development. These measures have the potential to increase the competitiveness of the economy. Financial investments, directed both to the production of the vehicles themselves (e.g. Izera, eVanPL), as well as to components and semi-finished products, can effectively stimulate domestic technological thought. This is important because the development of electromobility will continue, and neglecting investments in new, zero-emission technologies may adversely affect the country's competitiveness.

Threats

Focusing on future-oriented technologies, especially the creation of innovative players and brands, can make a significant contribution to maintaining the role of the automotive industry as an important sector of the economy. The current challenge is insufficient investment in new technologies by Polish technology companies and start-ups. Despite local initiatives and growing interest in electric vehicles, there is a real risk that our country will become dependent on imports of key components, technologies and raw materials. This, in turn, may have a negative impact on our energy independence and economic situation.

5. Summary and conclusions

In today's fast-paced business environment, characterized by increasing customer pressures and demands, organizations are forced to constantly look for new solutions to improve material and information flow processes. The concept of a supply network, defined as a set of nodes connected by relationships, is becoming a key element in effective logistics management and meeting growing customer expectations.

A logistics network, according to graph theory, is represented as a directed graph, where nodes and edges represent the elements of the supply chain. This concept aims to increase flexibility, efficiency and synergy between the different links of the network. Electromobility, including electric vehicles, is becoming an important part of the transformation in the transport sector, also influencing the innovation of supply networks.

The development of electromobility depends on cooperation between enterprises, investments in modern technologies and flexible adaptation to the changing environment. Electric vehicles such as BEVs, PHEVs, and HEVs are gaining popularity, supported by government initiatives and global companies. However, the charging infrastructure and the price of electric vehicles pose challenges for the full implementation of electromobility.

A SWOT analysis for electromobility in the West Pomeranian region reveals numerous strengths, such as environmental awareness of the public, government support, growing demand and R&D potential. However, there are also weaknesses, such as a lack of public knowledge, a lack of legislation on low emission zones and insufficient charging infrastructure.

Opportunities for electromobility include the economic development of the region, investments in research and development, and an increase in the competitiveness of the economy. On the other hand, the risks include dependence on imports of key components and technologies and the lack of investment in new technologies by local companies.

In conclusion, electromobility is a key element of the transformation in the transport and logistics sector, requiring a coordinated approach, investment and education of the public. The implementation of this concept can contribute to sustainable development, increased innovation and meeting environmental expectations.

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