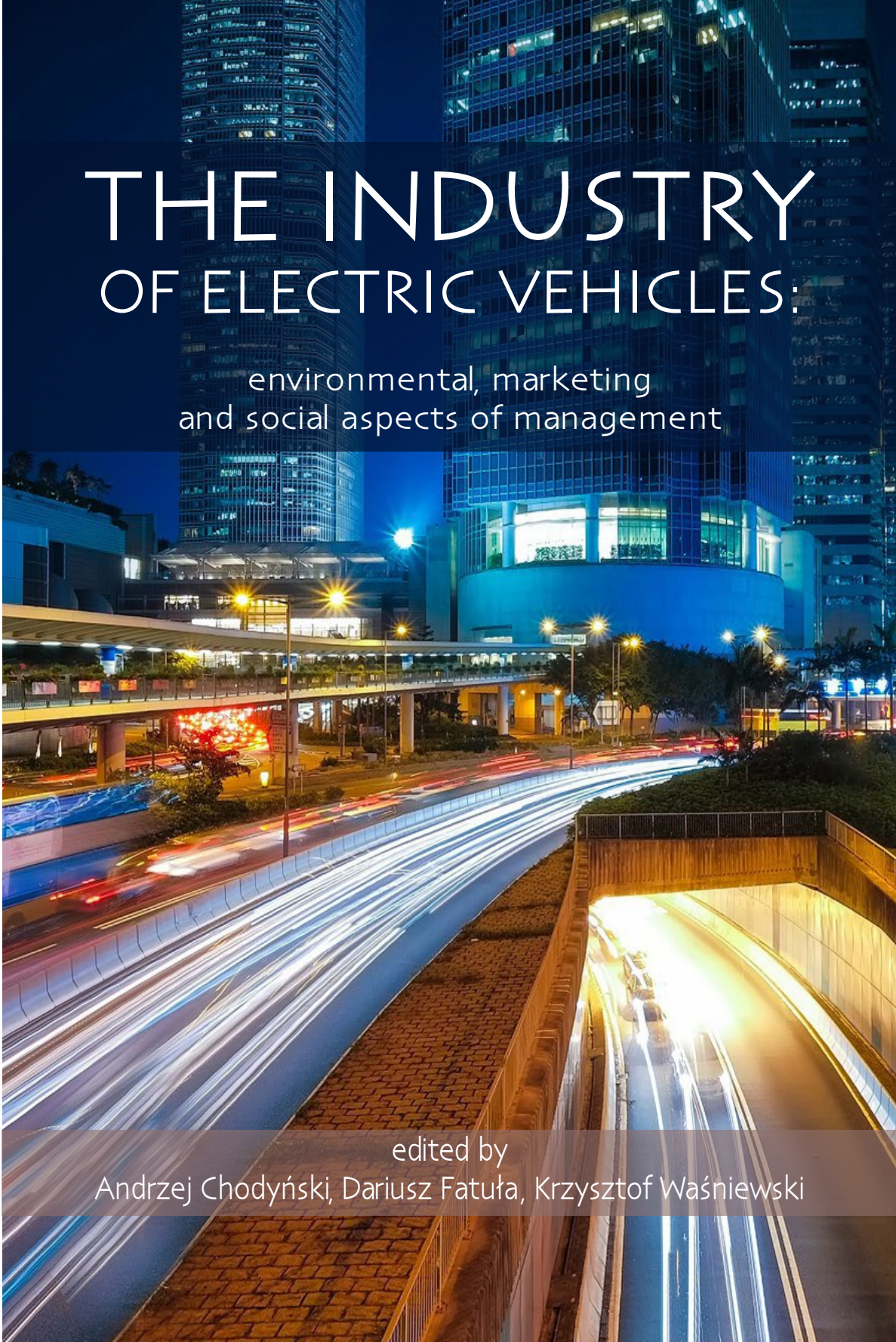
THE INDUSTRY OF ELECTRIC VEHICLES:

environmental, marketing and social aspects of management



edited by
Andrzej Chodyński, Dariusz Fatuła, Krzysztof Waśniewski

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The industry of electric vehicles: environmental, marketing and social aspects of management. Introduction

This monograph addresses the question of management in the broadly defined industry of electric vehicles. Complexity of electromobility in general is being addressed, and prospects for managerial action are discussed as regards business entities active in the sector. Aspects such as law, spatial economics and marketing are being developed, as well as behavioural patterns observable in both the present and the future customers in that rapidly growing market.

The authors, researchers with the Andrzej Frycz Modrzewski Krakow University, come from management science and from related disciplines. Besides studying the present state of the industry, authors point at the managerial action to be taken by the main players of the industry in order to meet the challenges of electromobility, both globally and locally.

In 2021, 5,5 million electric cars were in use. The value of the electromobility market is estimated at $244 billion. The forecasted

dynamics of that market are significant: from 5,5 million cars in 2021 to more than 700 million low-emission cars in 2040, which means 1/3rd of the global automotive fleet. In 2018, Poland had some 0,2% of its automotive fleet electric,[1] and that share is predicted to reach half a million cars in 2025, which encompasses passenger cars as well as utility vehicles, and is supposed to contain some 290 000 electric vehicles, and 225 000 plug-in hybrid ones (PHEV).[2] Norway comes forward as the country with the biggest share of electric cars (full electric and PHEV) in the overall automotive fleet: 10% in 2018.[3]

Electromobility might become an entirely new phase in the technology of road transport. Transitioning from propulsion by combustion engines to the electric ones means fundamental changes in the infrastructure. Should Poland rely exclusively on electromobility, with 100% of its automotive fleet gone electric, the infrastructure of power supply would require complete remodelling. Nuclear power seems indispensable in this context.

Currently available data suggests that charging stations for electric vehicles form a very different spatial structure from that of gas stations. Currently, there are 7856 gas stations in Poland,[4] with a total fleet of combustion-based vehicles around 31 million.[5]

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1 *Wsparcie rozwoju elektromobilności. Informacja o wynikach kontroli*, NIK, Warszawa 2020, https://www.nik.gov.pl/plik/id,23045,vp,25751.pdf [accessed: 16.02.2022].

2 *Rekordy w sektorze elektromobilności*, autoEXPERT, 7.12.2021, https://autoexpert.pl/artykuly/rekordy-w-sektorze-elektromobilnosci [accessed: 9.02.2022]. A separate infographic on the same page provides the data: 677 million passenger and utility ZEV (zero-emission vehicles) will be out on the roads of the world by 2040; the share of ZEVs in worldwide vehicle fleet by 2040: passenger and utility vehicles 36%, passenger vehicles 39%, utility vehicles 24%.

3 *Wsparcie rozwoju elektromobilności…*, *op. cit*.

4 *Wzrosła liczba stacji paliw w Polsce*, WNP.pl, 4.08.2022, https://www.wnp.pl/finanse/wzrosla-liczba-stacji-paliw-w-polsce,608896.html#:~:text=Wed%C5%82ug%20danych%20Polskiej%20Organizacji%20Przemys%C5%82u,%2C%20kiedy%20by%C5%82o%20ich%207772%22 [accessed: 3.12.2022].

5 The actual number of cars on Polish roads can be lower, as the CEPiK registered cars database is not up to date with the damaged, scrapped and out-of-use cars, see K. Brzeziński, *Ile jest samochodów w Polsce? Mamy*

That gives an average of 3946 vehicles per 1 gas station. On the other hand, there were 2494[6] charging stations for electric vehicles in Poland by the end of October 2022 (1992 charging stations by the end of January 2022[7]). With a fleet of some 52 000 electric vehicles on the road, it gives an average ratio of 20–21 vehicles per charging station. Density of the charging stations network is fundamentally different from that of gas stations. The latter remain infrastructural installations, whilst the former seem to evolve towards convenience-type appliances, like vending machines or trash containers. That, in turn, suggests different behavioural patterns in the end-users. Management in the business of electric vehicles and in the connected businesses (charging stations, recycling of batteries etc.) is likely to bring entirely new business models.

The development of electromobility is determined by a range of factors, including markets, social relations and environmental issues. In the market of electric vehicles, customer relations are being built similarly to the general automotive market. Integrative customer relations entail attentive listening to customers' opinions, and individualized approach.[8] First-hand customers' experience

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konkretne dane. Wyglądają naprawdę nieźle, Moto.pl, 26.03.2023, https://moto.pl/MotoPL/7,88389,29596338,ile-jest-samochodow-w-polsce-mamy-konkretne-dane-wygladaja.html; M. Kamiński, *Wiemy ile pojazdów jest w Polsce i jak dużo z nich nie ma OC i badań technicznych*, Auto Świat.pl, 19.01.2023, https://www.auto-swiat.pl/wiadomosci/aktualnosci/wiemy-ile-pojazdow-jest-w-polsce-i-jak-duzo-z-nich-nie-ma-oc-i-badan-technicznych/fjcny5s [accessed: 29.03.2023].

6 Rynek elektryczny.pl, https://www.rynekelektryczny.pl/infrastruktura-ladowania-pojazdow-elektrycznych/#:~:text=Liczba%20stacji%20%C5%82adowania%20pojazd%C3%B3w%20elektrycznych,koniec%20pa%C5%BAdziernika%202022%20r. [accessed: 3.12.2022].

7 *Licznik elektromobilności: rośnie liczba stacji ładowania w Polsce*, PSPA, 17.02.2022, https://pspa.com.pl/2022/informacja/licznik-elektromobilnosci-rosnie-liczba-stacji-ladowania-w-polsce/ [accessed: 3.12.2022].

8 A. Sudolska, *Zarządzanie doświadczeniami klientów jako kluczowy czynnik w procesie budowania ich lojalności*, "Zeszyty Naukowe Uniwersytetu Szczecińskiego. Ekonomiczne Problemy Usług" 2011, no. 72, pp. 275–284, https://bazhum.muzhp.pl/media/files/Ekonomiczne_Problemy_Uslug/Ekonomiczne_Problemy_Uslug-r2011-t-n72/Ekonomiczne_Problemy_Uslug-r2011-t-n72-s275-284/Ekonomiczne_Problemy_Uslug-r2011-t-n72-s275-284.pdf [accessed: 18.12.2021].

and the resulting emotions are principal frames of reference in the process of co-creating and consuming the product.[9] In the automotive market, customers invest in their relations with suppliers just as much as suppliers invest in customer relations. A new vehicle, including a zero-emission one, is an investment for the customer: even without formalized amortization, this is a durable capital good exploited over a lifecycle of many years. In that perspective, in the long term, customers' opinions and behaviour shape electric vehicles as a product.

Road transport is a significant source of CO_2 emissions, thus contributing to the greenhouse effect. In 2021, total emissions of CO_2 from that source were the highest in North America, with Europe coming at the second place, and Asia at the third. Electromobility should contribute to reducing CO_2 emissions.[10] The implications of electromobility in urban agglomerations, the issue of bus lanes, expansion of charging stations, and the implementation of low-emission zones are being studied.[11] Therefore, businesses active in the sector of electric vehicles should display a pro-environmental orientation, which can be interpreted as part of a general pro-social orientation. In that thread of study, broader environmental aspects are taken into account, including the recycling of vehicles and their parts (e.g. batteries).

Legislative action is important for the development of electromobility in Poland, such as the amendment to the Electromobility and Alternative Fuels Act, as of December 2, 2021[12], and a few

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[9] Z. Waśkowski, *Możliwości i ograniczenia wykorzystania koncepcji zarządzania doświadczeniem klientów przez uczelnie wyższe*, "Marketing Instytucji Naukowych i Badawczych" 2017, vol. 24, no. 2, pp. 1–14, http://minib.pl/wp-content/uploads/2017/05/Zygmunt-Waskowski_Mozliwosci-i-ograniczenia-wykorzystania-koncepcji-zarzadzania-doswiadczeniem-klientow.pdf [accessed: 30.11.2022].

[10] *Rekordy w sektorze elektromobilności, op. cit.*

[11] E. Sendek-Matysiak, Z. Łosiewicz, *Analysis of the development of the electromobility market in Poland in the context of the implemented subsidies*, "Energies" 2021, no. 14, 222, https://www.mdpi.com/1996-1073/14/1/222 [accessed: 30.11.2022].

[12] Ustawa z dnia 2 grudnia 2021 r. o zmianie ustawy o elektromobilności i paliwach alternatywnych oraz niektórych innych ustaw, Dz.U. [Journal of Laws of the Republic of Poland] 2021, item 2269.

other acts. These specific legislative changes are relative to such issues as: the creation of low-emission zones, b) installation of new charging points for electric vehicles, c) the use of hydrogen as automotive power source,[13] d) systematic review of legal definitions regarding electric vehicles, hybrid vehicles, LNG-powered vehicles, hydrogen-powered vehicles, charging stations and hydrogen-refuelling stations.[14] Basic definitions of vehicles are also covered by the Road Traffic Act.[15]

Individual chapters of this monograph treat different aspects of market-related changes (including customer awareness), as well as technological changes in the sector of electric cars. Changes in customer behaviour and technological development of electric vehicles as products have been studied from the point of view of opportunities and threats. It is stressed that marketing communication should be addressed to the groups of innovators and early imitators in the first place, including house owners, residents of suburbs and satellite towns, thus persons with a generally good level of education and a high level of environmental awareness (chapter by D. Fatuła).

Managerial action in the sector of electric vehicles is connected to the way that businesses work at the level of manufacturing, as well as the exploitation of those vehicles. Business models have been discussed, in connection with the lifecycle of technologies and the financial aspect. Three case studies are presented (chapter by K. Waśniewski). In their search for excellence, businesses active in the sector of electric vehicles can use the accumulated experience

[13] M. Ćmikiewicz, *Nowe regulacje w przedmiocie „czystego transportu", czyli zmiany w ustawie o elektromobilności*, Sozosfera.pl, https://sozosfera.pl/prawo/nowe-regulacje-w-przedmiocie-czystego-transportu-czyli-zmiany-w-ustawie-o-elektromobilnosci/ [accessed: 10.02.2022]. Consolidated text of the act: Ustawa z dnia 11 stycznia 2018 r. o elektromobilności i paliwach alternatywnych, Dz.U. 2018, item 317.

[14] Ustawa z dnia 11 stycznia 2018 r. o elektromobilności i paliwach alternatywnych, version effective from 24 December 2021 to 30 June 2024, Dz.U. 2021, item 110, https://sip.lex.pl/akty-prawne/dzu-dziennik-ustaw/elektromobilnosc-i-paliwa-alternatywne-18683445 [accessed: 10.02.2022].

[15] Prawo o ruchu drogowym, Dz. U. 2021, item 450, as amended, https://sip.lex.pl/akty-prawne/dzu-dziennik-ustaw/prawo-o-ruchu-drogowym-16798732/art-2 [accessed: 10.02.2022].

as regards environmental, social, and innovative orientations. It is proposed to use the ECSR concept (Environmental Corporate Social Responsibility) to achieve excellence in organization, based on the EFQM model (chapter by A. Chodyński).

Excellence in the sector of electric vehicles can be achieved through process excellence, too. Practical utility has been assessed as regards the concept of process maturity in an organization, with a focus on environmental aspects (chapter by W. Huszlak). Environmental orientation in managerial action, particularly as regards Human Resource Management, has been studied in the sector of electric vehicles (chapter by M. Leśniewski). The importance of electromobility has been studied in connection with the general EU policy of termoemissions, including in the context of the war in Ukraine (chapter by A. Bałamut).

Specific questions regarding marketing strategies, manufacturing, media, and urban planning have been addressed. Modern forms of online education, including informed consumer choices, can contribute to environmental awareness, an important factor of development in the sector of electric vehicles (chapter by M. Woźniak-Zapór). Solutions such as Cost Deployment, in the field of cost management, borrowed from other manufacturing systems, can be used by the producers of electric vehicles (chapter by E. Bąchor).

Household budgets play a significant role for the consumers' purchasing decisions in the market of electric vehicles, which has been documented with specific examples (chapter by B. Oliwkiewicz). Media and their relation to the development of electromobility are an important factor as well, which is studied with a focus on the city of Kraków (chapter by D. Baran). Electric cars also have a role in the planning of urban parking spaces (chapter by A. Damasiewicz).

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Marketing aspects of management of the development of institutions on the electric vehicle market

Abstract
The study discusses the level of development of the electric car market in Poland against the background of Europe and the world. Attention is paid to factors stimulating and impeding the development of the electric vehicle market and challenges faced by institutions interested in the activity in this area. It indicates what marketing activities should be undertaken by institutions related to the production, operation and use of such vehicles.
Keywords: growth management, consumer behaviour, marketing in the electric vehicle market

Introduction

The development of the electric vehicle market, despite many doubts and barriers, seems to be a foregone conclusion. In highly developed countries, sales of electric cars were growing at a triple-digit rate in 2020, with their share of all car sales reaching 10%.

According to a report by Polski Związek Przemysłu Motoryzacyjnego – Licznik Elektromobilności (the Polish Automotive Industry Association – Electromobility Counter), "at the end of November 2021, 35,222 electric passenger cars were on Polish roads. Fully electric vehicles (BEV, battery electric vehicles) accounted for 49% (17,145 units) of this part of the vehicle fleet, with plug-in hybrids (PHEV, plug-in hybrid electric vehicles) accounting for the

remainder (51%), or 18,077 units."[1] The year-on-year increase (I–XI 2020) was 101%. The share of BEV and PHEV sales in Poland at the end of 2021 in relation to all cars was less than 3.5%, which, when compared to the share in the EU as a whole of 10%, indicates numerous barriers, but also opportunities for faster growth in the future.

Such dynamic growth achieved, among other things, thanks to a low base, will have to be supported in the future by intensive marketing activities, not only by the companies producing these vehicles, but also by other companies and institutions connected with the EV market. Ad hoc measures may not be sufficient in view of rapid technological developments, changes in consumer behaviour and regulatory aspects. Effective and multifaceted marketing activities in this area must become part of the development and management strategy of these institutions.

The aim of the study is to analyse opportunities and risks and to identify paths for change and adjustment in the management and development of institutions operating in the EV market in terms of changes in customer behaviour and technological development of the products on offer.

Review of literature and studies

In the literature on consumer behaviour in the passenger car market, studies of factors influencing the purchase of vehicles in general or by their specific characteristics are most frequently presented. Mirosław Sołtysiak[2] studied the planned purchase of a car in 12 months with regard to the level of expenditure, age of the used car, cost of fuel and servicing, type of fuel, gearbox, external and internal appearance of the vehicle, equipment such as air-conditioning and cruise control, opinions of reference groups. The survey took into account the gender and age of 1051 respondents from

[1] *Rynek motoryzacyjny – Licznik elektromobilności*, https://www.pzpm.org.pl/pl/Rynek-motoryzacyjny/Licznik-elektromobilnosci/Listopad-2021 [accessed: 29.12.2021].

[2] M. Sołtysiak, *Preferencje zakupowe konsumentów na rynku pojazdów samochodowych*, "Modern Management Review" 2015, vol. 20, no. 22, pp. 213–232.

south-eastern Poland. Dariusz Surel[3] examined the strength of influence of 25 factors determining the purchasing decisions of car buyers in the podlaskie voivodeship at the time of the survey and in a 5–10 year perspective. The highest influence was on purchase price, driving comfort, safety, equipment and car appearance. In a study[4] conducted in June–July 2020 on a group of more than 400 respondents (consumers and small business owners for the Carsmile online platform offering subscription cars), it emerged that for 72.3% of respondents, the monthly purchase cost is the most important factor. The second most important factor is faultlessness (61.9%) and equipment (44.4%). Mariusz Łapczyński modelled the demand for passenger cars using advanced statistical methods. The study did not confirm the hypotheses regarding the influence of psychological values on car choice. The variable 'being respectable' was highest, but its position was still low.[5]

Surveys indicate that the most important factor that buyers take into account is the price of the car and its equipment influencing driving comfort, possibly an attractive exterior and interior design. Higher values such as ecology are noted, but when confronted with "mundane" considerations they do not determine the choice of vehicle.

Customer needs and behaviour as a determinant of institutions' marketing activities in the EV market

Starting from needs, it is important to consider which ones and how electric cars can satisfy. On the surface, the answer seems

[3] D. Surel, *Czynniki determinujące zachowania konsumentów na rynku samochodów osobowych na przykładzie mieszkańców województwa podlaskiego*, "Przedsiębiorczość i Zarządzanie" 2018, vol. 19, no. 3: *Uwarunkowania rozwoju regionalnego i lokalnego,* edited by J. Paszkowski, E. Stroińska, pp. 263–280.

[4] M. Gis, *Co jest najważniejsze dla klientów przy zakupie auta?*, Moto.pl, 15.08.2020, https://moto.pl/Porady/7,115892,26209254,co-jest-najwazniejsze-dla-klientow-przy-zakupie-auta.html [accessed: 4.01.2022].

[5] M. Łapczyński, *Modelowanie preferencji konsumentów na rynku motoryzacyjnym*, "Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie" 2007, no. 756, pp. 71–88.

simple and obvious – the need to get around. In addition to this, safety and comfort of driving, willingness to use, prestige, the feeling of 'being green', in terms of self-fulfilment and more broadly in a social group are equally important. So here we have basically Maslow's entire pyramid. Does the classic hierarchy remain here? Before answering this question, it is worth considering who is currently buying electric cars. In the vast majority of cases, these are people who in marketing terms can be called innovators or pioneers. They are characterised by high incomes (classically younger people, although current research indicates an increase in the proportion of older people in the pioneer population), above average risk appetite, low price sensitivity. Such people thus have, in the vast majority of cases, their need for mobility, safety and driving comfort already satisfied. What remains then is prestige, a sense of 'being green', in terms of self-fulfilment and recognition more widely within the social group. A lot of comfort and even safety can be sacrificed for self-fulfilment (as travellers to dangerous and poor areas of the world do, for example). At this stage of market development, needs at the top of Maslow's pyramid are decisive for the purchase of an electric car. This will change, however, when more segments of price-sensitive customers, driving comfort and ease of vehicle charging enter the market for these vehicles. Developers of marketing strategies must therefore be aware of the need to constantly change the tools and objectives of their activities.

In the opinion-forming reports of current users of electric cars, there is a lot of information about difficulties in charging cars due to a small number of charging stations, their occupancy, the necessity to wait a long time for one's turn, long charging time, decrease in range during low temperatures in comparison with the range declared by the manufacturer and achieved in good conditions during warm periods of the year. Denying such information or correcting it in the style of 'it is not so bad because the range does not drop so much, and there are more charging stations than it appears from the accounts of disappointed users and they are not always busy' will not have the desired effect – it will not change the perception of the recipients of such accounts. Underneath the online pages about electromobility, the dominant opinion is that 'electrics' are not yet for the average car

user. And if they are, they are only cost-effective and convenient for wealthy people living in their own home with access to an electrical socket in the garage, and preferably with an additional photovoltaic installation.

The perpetuation of such a view will not increase demand even in the marketing segment of the so-called early followers, let alone the early majority, which is estimated to be twice the size of the two previous groups combined. Only the entry of this group of buyers would result in the mass replacement of combustion cars by 'electrics'. So what marketing message strategy to future buyer segments can be effective now? It should not be based on dementing the exaggerated disadvantages of electric vehicles, but rather on changing emotional attitudes based on the usefulness of 'electrics' in specific conditions and applications. Such specific uses include short urban or close-in journeys, and for longer distances with route planning that takes into account charging stations and efficient use of charging-related stopping times. The creation of an image of the electric car as a useful, although still expensive tool, should result in a positive attitude towards such a means of transport in the future, associated as a relatively exclusive, but worthwhile purchase, once prices have fallen due to technological progress.

Separate consideration needs to be given to the need to create marketing messages concerning the view that electric cars are not at all clean, as they use 'dirty' technologies to produce them, are powered by electricity generated using 'dirty' raw materials and will leave behind a lot of 'dirty' waste. The first but not the most important issue is to include in the messages that there are no fully clean technologies, they can only be less 'dirty' or more 'clean'. The transition from the more to the less dirty ones is a necessity and a process that is spread over years. The emission of pollutants from a great many small sources, which include combustion cars, is more dangerous because of its dispersion over a large area, while concentrated in large urban agglomerations, difficult to reduce by filters and absorbers. The same, or even a larger portion of pollution produced by a single source such as an un-environmental (e.g. coal-fired) power plant can be filtered and absorbed with relative ease, giving aggregate lower emissions than cars that will be replaced by 'electrics' charged with

energy from such a power plant. While marketing pioneers are driven more by the idea and the belief in its validity in their purchasing activities, hard data on the cost-effectiveness and environmental impact of switching to another product, in this case electric cars, is playing an increasingly important role with subsequent groups of buyers. Marketing messages should therefore evolve towards a greater proportion of informative versus emotional content. A thorough analysis of the emissions performance of combustion and electric cars would require a separate specialised study. Briefly, on the basis of the available analyses on many specialist portals,[6] it is possible to form the opinion that modern combustion engine cars, e.g. the Toyota Corolla Hybrid, according to the manufacturer's data obtained using the WLTP procedure, emit 99–116 grams of CO_2/km, i.e. 9.9–11.6 kilograms of carbon dioxide per 100 kilometres. Large passenger electric cars, whose average energy consumption per 100 km is approximately 19 kWh, contribute 12.4 kg of carbon dioxide produced by Polish power plants. Assumed here[7] is the structure of electricity production in Poland in November 2021 originating 55% from hard coal, 25% from lignite, 8.5% from gas and the remaining 11.5% from renewable energy sources (hydro, wind, photovoltaic power plants). The result is therefore surprisingly unfavourable for electrics and

[6] *Krajowa emisja CO2 dla energii elektrycznej i cieplnej – wskaźniki KOBiZE za rok 2019 (najnowsze istniejące)*, Elektrowoz.pl, 16.05.2021, https://elektrowoz.pl/porady/krajowa-emisja-co2-dla-energii-elektrycznej-i-cieplnej-wskazniki-kobize-za-rok-2019-najnowsze-istniejace/ [accessed: 3.01.2022]; W. Krzyczkowski, *Ile emituje samochód na prąd z węgla?*, WysokieNapiecie.pl, 29.08.2016, https://wysokienapiecie.pl/1696-ile-emituje-samochod-na-prad-z-wegla/ [accessed: 3.01.2022]; *Długa droga do „elektromobilności" – EV oznacza emisję 155 g CO_2, a w 2021 r. nowe spalinowe samochody w UE mają emitować 95 g CO_2/km*, Związek Zawodowy Inżynierów i Techników Grupy LOTOS, http://www.zzit.pl/dluga-droga-do-elektromobilnosci/ [accessed: 3.01.2022].

[7] 650 grams of carbon dioxide on average for every kWh (kilowatt hour) of energy produced in Poland, *Struktura produkcji energii elektrycznej*, https://www.rynekelektryczny.pl/produkcja-energii-elektrycznej-w-polsce/ [accessed: 3.01.2022]; *Ile CO2 jest ze spalenia litra benzyny, czyli kto jeździ spalinówką, ten jeździ RÓWNOLEGLE elektrykiem*, Elektrowoz.pl, 10.01.2020, https://elektrowoz.pl/porady/ile-co2-jest-ze-spalenia-litra-benzyny-czyli-kto-jezdzi-spalinowka-ten-jezdzi-rownolegle-elektrykiem/ [accessed: 3.01.2022].

indicates that they have a carbon dioxide emission share of around 20% higher than modern combustion cars for travelling a similar distance. The majority of internal combustion cars on Polish roads are not modern hybrids, but older cars (the average is about 14 years old) emitting 2 to 3 times more carbon dioxide per unit of distance travelled than the share of electric vehicles in CO_2 emissions of electricity producers. Smaller electric cars (e.g. Renault Zoe) consume only 13–15 kWh per 100 km, and such will dominate short and medium urban journeys. This result puts the CO_2 emissions of the most modern combustion cars on a par with the emissions share of 'electrics', which have the potential to further reduce energy consumption.

In addition, the share of coal-fired power stations in power generation will decline in the years to come, with the result that electric cars will collectively reduce CO_2 emissions not only in urban areas, but also overall. Attention should also be paid to other pollutants generated to achieve a similar effect for the user of these two types of vehicles. These include nitrogen and sulphur oxides (NOx and SOx), non-methane volatile organic compounds, particulate matter (PM2.5 and PM10), carbon monoxide. Electric cars, in the process of moving, do not generate them at all. Of all the pollutants listed above, only sulphur oxides emissions are higher in combustion processes in the energy production and transformation sector than in road transport. The remaining pollutants are currently generated much more by road transport than by combustion processes in the energy production and transformation sector. Reducing the share of combustion vehicles in favour of electric vehicles will therefore contribute to a significant reduction in emissions of these pollutants, and better filtering of SOx by coal-fired power plants and a reduction in their share in the energy mix will favour a reduction in this component as well.

To conclude the technical comparisons of emissions during the operation of cars, it is worth quoting some more summary data on the energy required to produce 1 litre of petrol or oil. Data from the German Ministry of Economic Affairs and Climate[8] and the

[8] *Energieeffizienz lohnt sich*, Bundesministerium für Wirtschaft und Klimaschutz, https://www.bmwi.de/Redaktion/DE/Dossier/energieeffizienz.html [accessed: 3.01.2022].

BP corporation indicate[9] that this is, depending on the technology, 3–7 kWh per litre. Assuming the lowest combustion values for modern fuel-efficient cars and energy-efficient petrol production, we have an additional approx. 12 kWh of energy for driving 100 km in a petrol car. So while a direct comparison of the so-called carbon footprint of a combustion car and an electric car in Poland gives similar results, taking into account the other processes, shows that combustion cars emit almost twice the carbon footprint of electric cars.

There remains the question of the carbon footprint created by the production and subsequent disposal of combustion and electric vehicles. The biggest difference in carbon footprint between the production of electric and combustion vehicles arises from the manufacture of the batteries of electric vehicles. The other components of these two types of vehicle generate a comparable carbon footprint. Producing a unit of capacity (kWh) of lithium-ion batteries emits approximately 150 kg of carbon dioxide. Batteries for small electric cars with a capacity of around 30 kWh therefore emit around 4.5 tonnes of CO_2, batteries for large electric cars with a capacity of around 100 kWh emit around 15 tonnes of CO_2. This is a value on a par with the emission of this gas from petrol when driven for 45,000 to 150,000 km by a modern combustion car (calculating for the aforementioned Toyota Corolla Hybrid with emissions of about 10 kg of CO_2 per 100 km). The same amount of carbon dioxide is emitted by older, less economical cars driving on Polish roads for half of the aforementioned distance. Taking into account that electric cars currently emit a similar carbon footprint from the use of electricity from Polish power stations as modern combustion cars, and half as much as older cars, and taking into account the emissions required to produce 1 litre of petrol, it should be concluded that the benefits (equalisation of overall emissions) from replacing old combustion cars with electric cars (despite the relatively high emissions from battery production) are already achievable with a mileage of about 11,000 km for small electric cars and about 37,000 km for large electric cars. For the replacement of modern combustion cars, the benefits only level off at a distance of about twice that for older cars. The lower mileage

[9] *BP Energy Outlook 2019*, https://www.bp.com/pl_pl/poland/home/centrum_prasowe/reports/bp_enerygy_outlook_2019.html [accessed: 3.01.2022]

of electric cars over the life cycle of their batteries will not currently give the benefit of reduced overall CO_2 emissions. However, it is legally certain that both the carbon intensity of the power station supplying electricity (the structure of its generation will change) to charge the electrics will decrease, and the energy intensity of battery production will also decrease.[10] Electric cars can already cover distances several times the distance mentioned above before it becomes necessary to replace the batteries with new or reconditioned ones.

At the stage of designing the production of electric cars, co-operative chains should be established, which will be able to accept used components, at least in the amount corresponding to new production. It will then be necessary to implement appropriate legal solutions enforcing the recycling of used parts. This is already being done on a voluntary basis. In future, such solutions should be enforced by law in the case of larger-scale production. A good example is the cooperation between Renault, Solvay and Veolia. "This partnership is intended to ensure that cobalt, nickel and lithium can be sourced easily and cheaply […]. This will shorten the supply chain and reduce the carbon footprint associated with the production of traction batteries."[11]

From a marketing point of view, it is impossible and pointless to provide potential buyers with all the details of the emerging environmental advantages of electric cars over combustion engines. However, the general conclusions should be reliably communicated, without withholding inconvenient information, above all on the current slight advantages of electrics in terms of reducing the global carbon footprint. Future benefits through technical and organisational solutions should be emphasised. It should also be emphasised that the inconvenience of charging electrics will be reduced by the emergence of new charging station infrastructure and the increasing

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[10] L. Lander *et al*, *Cost and carbon footprint reduction of electric vehicle lithium-ion batteries through efficient thermal management*, "Applied Energy" 2021, vol. 289, 116737.

[11] A. Rzędowska, *Baterie z samochodów elektrycznych nie będą trafiać na wysypiska. Trzy koncerny wspólnie pracują nad ich recyklingiem*, Green-news.pl, 12.04.2021, https://www.green-news.pl/1686-utylizacja-bateri-i-to-toksyczny-mit-zobacz-co-stanie-sie-z-bateriami-wymontowanymi-z-samochodow [accessed: 8.01.2022].

range of these cars. It is also worth pointing out that around 80% of passenger car users cover a distance[12] of up to 50 km with their car every day. This is the range achievable by any electric car, even in adverse operating conditions. On a day-to-day basis, changing from a combustion car to an electric car will not result in a loss of mobility comfort. Longer trips taken on an occasional basis will, for the time being, require good planning of stops at charging points. This should be presented as an acceptable cost of 'being green', fitting in with the 'slow travel' style as part of the wider 'slow life' trend.

The Polish Alternative Fuels Association reports that in 2021 32% of Poles would realistically consider buying an electric vehicle in the next 3 years. In 2017, this was declared by only 12% of respondents.[13] Perceived barriers to purchase are high price, low range, lack of charging infrastructure. Incentives to purchase would be subsidies, free parking, possibility to use bus lanes. In the case of durable goods on public display, the imitation effect plays a major role in creating demand. Nationwide research conducted between 1995–2001 and 2018 indicates,[14] that there are more innovators and early imitators in Poland than indicated by Rogers' model.[15] Another interesting result of the research is that 92% of potential electric users would like to charge it under their home.[16] Given that there are approx. 5 million single-family homes[17], with one third of the owners planning

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[12] *Barometr Nowej Mobilności 2021/22*, Polskie Stowarzyszenie Paliw Alternatywnych, Warszawa 2021, p. 7, https://pspa.com.pl/wp-content/uploads/2022/01/barometr_nowej_mobilnosci_2021_raport.pdf [accessed: 8.01.2022].

[13] *Barometr Nowej Mobilności 2019/20*, Polskie Stowarzyszenie Paliw Alternatywnych, Warszawa 2020, https://pspa.com.pl/media/2020/08/barometr_nowej_mobilnosci_2019_raport_S.pdf [accessed: 8.01.2022].

[14] K. Mazurek-Łopacińska, *Zachowania konsumentów na współczesnym rynku. Perspektywa marketingowa.* PWE, Warszawa 2021, p. 87. This research did not include cars, but concerned, inter alia, household appliances, consumer electronics, and tourist equipment.

[15] E.M. Rogers, *Diffusion of Innovations*, 5th edition, Free Press, New York 2003.

[16] *Barometr Nowej Mobilności 2019/20*, Polskie Stowarzyszenie Paliw Alternatywnych, Warszawa 2020, p. 34.

[17] *Zamieszkane budynki. Narodowy Spis Powszechny Ludności i Mieszkań 2011*, GUS, Warszawa 2013.

to purchase an electric vehicle within three years,[18] it can be estimated that the demand in this group could be 1.6 million vehicles within the said period. Spreading such potential demand evenly over 36 months gives more than 44,000 vehicles per month. This is more electric vehicles than there were registered in Poland at the end of 2021. These assumptions, although supported by research, are unattainable in the near term, if only because the realisation of their optimistic plans is postponed by most people until the end of the declared period or pushed back even further in time. Assuming that only a quarter of those declaring their intention will realise it within this period, we obtain a forecast of sales of more than 11,000 electric vehicles per month in about three years.

This outlook should not be significantly altered even by the current international situation associated with Russia's aggression against Ukraine in February 2022. Sanctions imposed on Russia have driven up the price of energy commodities and led to significant increases in fuel prices at petrol stations across Europe. Although all energy sources are becoming more expensive, the psychological impact of high fuel prices at petrol stations may accelerate the decision of potential buyers to purchase an electric car. At the same time, raw materials for electric cars are becoming more expensive, including so-called rare earth metals such as cobalt, nickel, lithium, cadmium, platinum. This will push up the price of electrics and slower relative price reductions compared to combustion cars. However, this should not significantly reduce the demand for electric cars, since, as the cited studies indicate, it is other factors that more significantly influence the decision to purchase such vehicles. Price elasticity for the innovator market segment is low. For other, more price-sensitive buyer groups, surcharges higher in relation to the total price, but nominally lower because they relate to cheaper models, will be necessary. In the case of rising prices, there may even be additional psychological effects inducing the purchase of more expensive goods. The first is the flight from money for fear of inflation and the second is the Veblen effect (also known as the snob effect). The first effect may have a stronger influence on the purchase of cheaper models

[18] Making a simplifying assumption based on the quoted study by the Polish Alternative Fuels Association – *Barometr Nowej Mobilności 2019/20*.

of electric cars and the second on the purchase of more expensive models. The third effect, may be to strengthen the motivation of the wealthy in investing capital[19] in morally justified assets. The morality of such actions should be justified both by the desire to protect the environment, including the immediate environment, and to move away from energy sources linked to Russia, condemned by the world for its aggression against Ukraine. All of these effects can be appropriately used in ad hoc marketing campaigns and long-term public relations activities calculated to build a positive image and attitudes towards ecological solutions, including electric cars.

As mentioned earlier, existing buyers of electric cars can mostly be identified as marketing pioneers. A significant increase in demand will depend on further groups of buyers using their savings and bank loans for this purpose. There are many elements that will influence this demand. At the end of 2021, Polish households held around PLN 900 billion[20] in banks in so-called current accounts, around PLN 170 billion in term deposits, PLN 300 billion in investment fund assets, around PLN 56 billion in Treasury bonds. In addition, households invest their funds in other assets such as real estate, shares bought individually on the stock exchange, jewellery. These, however, are rarely used to purchase cars, so they are of little relevance in this analysis. It is significant that the vast majority of funds are "left" in practically interest-free current accounts. There are many reasons for such decisions by households, but discussing them in detail is beyond the scope of the topic undertaken here. One motive for leaving funds in non-interest-bearing current accounts is the intention to spend them relatively quickly; another reason, equally important in this context, is the inability to manage spare funds. It should be noted here that these funds can be seen in their transactional rather than hoarding character – as they are used to settle current obligations, mainly purchases of goods and services to meet basic household

[19] The investment of capital can be seen as both consumption, saving and/or investment depending on, among other things, the level of wealth of a society, the type of goods, the culture of a country. See: D. Fatuła, *Różnice w postrzeganiu oszczędzania i inwestowania wśród studentów z Polski i USA*, "Zeszyty Naukowe Akademii Ekonomicznej w Krakowie" 2003, no. 640, pp. 91–106.

[20] 1 billion = 10^9.

needs. Seemingly, therefore, they do not constitute savings, as they are spent and renewed on a monthly basis resulting from the wages and salaries earned for work. However, the significant increase in current deposits and the change in their proportion in relation to time deposits over the past six years testifies to their largely savings character. In 2016, households' current deposits reached PLN 330 billion, about the same as time deposits. In 6 years, current deposits have legally tripled, while time deposits have fallen to around half their value of 6 years ago. So while in 2016 the ratio of current deposits to time deposits was about 1:1 it is now about 5:1. Retail sales have increased by about 30% over the period mentioned, current deposit funds are therefore largely surplus to funding current consumption. Without going into the other and more complicated causes and effects of this, it can be forecast that, with inflation rising in late 2021 and early 2022, many households will accelerate their decisions to purchase durable goods, which include cars. Instalment loans for cars at the end of 2021 had a total value of around PLN 6.5 billion and accounted for only around 4% of all consumer loans taken out in Poland. The fact that they are regularly repaid is evidenced by the low value percentage of these impaired loans of less than 2%. Borrowers therefore take a responsible approach to car loan decisions and are able to realistically assess repayment options in the future. Rising inflation resulting in higher interest rates, on the one hand, discourages borrowing, but on the other hand, causes a desire to use savings, whose real value is decreasing, to purchase durable goods. Savers in the absence of funds for purchases resort to credit if they anticipate stability in their employment or an increase in salary. Low unemployment and, in some sectors, even a shortage of skilled workers, currently gives a sense of job security.

The ARC Rynek i Opinia research institute conducted a survey of saving among Poles in May 2021, commissioned by IZFiA (Izba Zarządzających Funduszami i Aktywami, the Chamber of Fund and Asset Management), which shows that 50% of Poles save regularly and 41% admit that they intend to save in the future. The most popular saving goals among Poles are travel (42%), home renovation (37%), car purchase (34%), health/medical (28%) and real estate purchase (28%). In total, there are about 25 million passenger cars

registered in Poland, and their average age[21] is about 14 years, so it should be expected that within such a period cars will be replaced by other cars. These will not, of course, be exclusively electric cars. The share of electric car registrations in 2021 in Poland was only about 3.6% (BEV 1.6% and PHEV 2%) with a European average of 18% (BEV 9.1% and PHEV 8.9%). Assuming an increase in the share of electric car registrations in 3 years in Poland to the current European level, we can expect sales of around 100–120,000 electric cars per year in 2025. This is in line with the earlier forecast presented here (based on purchase declarations and living in one's own home with access to charging) of sales of electric cars in three years' time of approx. 11,000 vehicles per month.

An important incentive to buy an electric car is subsidies. Research presented in the New Mobility Barometer[22] shows that the percentage of people choosing between the purchase of a similar combustion engine car and an electric car legally doubles (e.g. from 24% to 46% for Renault Clio vs Renault ZOE) with a maximum subsidy (PLN 27,000) for the latter. Similar increases in the percentage of people choosing an electric with a subsidy over a comparable combustion car occur for the Volkswagen Golf VIII vs. Volkswagen ID.3. For more expensive cars (e.g. BMW, Mercedes), the increases in such percentages are already noticeably lower. This points to the trivial but worthwhile conclusion in marketing campaigns that for relatively cheap electric cars, subsidies have a greater effect than for expensive models. Marketing activities in such a case should target potential buyers (e.g. by means of so-called sales leads) in order to exploit the heuristics of unavailability and convince the potential customer of the uniqueness of the opportunity and the elite group to which the buyer will belong. In the future, with the proliferation of electric cars, this type of marketing suggestion will already become ineffective or even harmful – for certain segments of buyers who do not aspire to or want to belong to such "groups".

The research cited earlier shows that one of the elements influencing the willingness to purchase an electric car is the availability

[21] Polski Związek Przemysłu Motoryzacyjnego, https://www.pzpm.org.pl/ [accessed: 02.02.2022].

[22] *Barometr Nowej Mobilności 2021/22*, pp. 45–55.

of service and repair workshops for electric cars. Governmental, self-governmental and social institutions, within the scope of their competences and interests, should support the development, conversion, training of personnel of traditional car repair shops. These, in turn, should give priority to customers with electrics, which, even with initially small profits or even losses with such services, should consolidate the position and share of such a company on the market. Similar recommendations should apply to EV intermediaries. At present (early 2022), the secondary market for electric cars is underdeveloped. Buyers of older cars are afraid of buying a car with a worn-out battery, which will significantly reduce the range and need to be replaced quickly. Here, we should count on market mechanisms to foster the development of this market, with possible support in the area of the reliability of the broker, the offer and the traders themselves.

The idea of replacing the entire battery instead of charging it has emerged. For robots adapted to a particular vehicle model, such an exchange could take about 20 minutes, which is much shorter than low-power charging. However, the multiplicity of solutions and vehicle models, as well as issues of ownership of the batteries to be replaced, make this idea unrealistic in wider application for user-owned vehicles. However, for vehicles rented as part of a certain network, the idea could compete with fast charging stations. For a customer renting an electric car to travel a longer distance, it does not matter whether the battery is charged or replaced in a comparable time. Cities should introduce facilities to introduce innovative ideas for companies that make electric cars available to residents and tourists in their area as part of their business. Even the brief use of an electric car as part of a rental or other transport service (taking customers to hotels, stations, airports) can help to break down the barrier of reluctance to this type of vehicle on the part of the potential customer. Many large cities have already introduced the possibility of driving electric cars on busways and parking for free in paid zones. These solutions, with the number of electric cars still small, are appropriate and encouraging for potential buyers. However, with the increasing number of electric cars, they will have to be curtailed and changed to other facilitations, so that the city does not become "clogged" with

electric cars again. Public transport based on green solutions should then play a major role.

Market for other electric vehicles: vans, trucks and buses

The Electromobility and Alternative Fuels Act of 2018[23] obliges local authorities of towns with more than 50,000 inhabitants to introduce into public transport min. 5% of electric buses in 2021, 10% in 2023, 20% in 2025, up to 30% in 2028. In addition to the legal obligation, a good solution would be governmental financial and/or organisational support for poorer municipalities that cannot afford to quickly replace or introduce 'green' public transport fleets. In richer areas that can afford to introduce 'green' public transport solutions, a higher percentage of residents have the opportunity to find a well-paid job and afford to buy an electric car in the future. In poorer municipalities, there are relatively fewer such residents and thus attitudes towards ecology are less friendly. State measures supporting local authorities in the promotion of electromobility could contribute to a slow but steady change in the attitudes of residents, which are shaped, among other things, by observation of their immediate environment. Cities with the largest fleet of urban electric buses currently include Warszawa (162 buses), Kraków (78), Jaworzno (44) and Zielona Góra (43). A total of 638 electric buses are running throughout Poland.[24]

Poland is the largest exporter of electric buses in Europe with a market share of around 45%. The largest factories of finished electric buses are: Solaris in Bolechowo near Poznań, Volvo in Wrocław and MAN Truck & Bus in Starachowice. Scania in Słupsk also has plans to start production in 2022.

There are still relatively few electric vans and trucks registered in Poland – 1657 units at the end of 2021. The relatively short range and power of electric trucks and their high price discourages entrepreneurs from buying and using these vehicles. The impulse to increase demand here should be at national level: subsidies, tax exemptions

[23] Ustawa z dnia 11 stycznia 2018 r. o elektromobilności i paliwach alternatywnych, Dz.U. [Journal of Laws of the Republic of Poland] 2018, item 317.

[24] Figures for 2021.

and investment allowances (including in fast charging stations), faster depreciation. At the local level, facilitation of movement on selected routes and areas and relief from local taxes (e.g. on property used to maintain the infrastructure of electric vehicles – car parks, charging stations). For entrepreneurs, an important incentive would be the possibility to fully deduct the costs of purchasing and operating an electric vehicle also for private purposes. The marketing effect related to corporate social responsibility may also prove important. Companies using electric vehicles should emphasise care for the environment in their public relations messages. This builds a competitive advantage in the environment and influences the company's image, especially in buyer segments sensitive to this element. The latter are increasing in number regardless of the type of products and services sold. In future, enclaves will be created in certain areas or city districts where only electric vehicle transport will be possible. An extreme and specific example in this respect is Zermatt in Switzerland, at the foot of the Alpine Matterhorn mountain. Despite extremely restrictive restrictions, virtually eliminating internal combustion and even excessive electric transport for both private individuals and companies, the town has been visited by tourists from all over the world in increasing numbers in recent years (excluding the period of the COVID-19 pandemic). Most European cities do not have such conditions, including scenic and recreational qualities, as Zermatt, but certain elements of environmental management from Swiss cities can be adapted in virtually any city, although only in selected and limited areas. These could be inner city centres, recreation and communal areas on the attractive tourist fringes of large cities, selected enclaves of specific neighbourhoods. Electric vehicle manufacturers and social institutions should support initiatives to create such areas and use only electric vehicles in them.

Conclusions

The development of the electric vehicle market depends on many factors. Among them, marketing aspects related to the attitudes of potential buyers towards ecology are of great importance. Electric car vendors should primarily target their messages to the group of

marketing innovators and early followers. In these segments, high price plays a less important role and price elasticity of demand is low. This group includes owners of their own homes, where charging their vehicles from their own electricity network is facilitated. This is particularly the case for residents of the suburbs of large cities and surrounding towns, whose residents have relatively high incomes due to their proximity to the labour market of large conurbations. Such customers, a large proportion of whom are highly educated, are more environmentally aware of smog pollution and traffic jams in large cities. Further groups of customers, for whom price is an important barrier to purchasing electrics, will become followers in their purchases. For them, it will be important to support the state and local governments in the purchase and use of electric vehicles. Reliable information about the growing environmental advantage of electric vehicles over combustion vehicles should play a key role in marketing messages. Exaggerating the advantages of electric cars and concealing information about the still relatively large carbon footprint of their manufacture and operation, particularly in economies based on fossil fuels, which include Poland, does not serve to change reluctant attitudes. It may even give rise to false stereotypes about the lack of impact of technological changes on environmental pollution.

The energy crisis associated with the sanctions imposed on Russia after the attack on Ukraine will have a two-way impact on the development of the electric vehicle market. On the one hand, the high prices of raw materials used in vehicle production, including rare metals, will reduce demand for these vehicles, but on the other hand, high fossil fuel prices will accelerate the shift away from internal combustion vehicles. As during the fuel crisis of the 1970s, when intensive work began in the United States to develop more fuel-efficient internal combustion vehicles that use significantly less fuel than earlier models. In turn, users accepted the limitations of the vehicles due to reduced combustion.

The state, local governments and social institutions should provide organisational support and subsidies for the creation of charging infrastructure, create facilities for moving and parking electric cars. Infrastructure conducive to the purchase of 'electrics' should also include repair and service workshops, the lack or scarcity of which is

indicated by potential buyers as a barrier to purchase, as traditional car workshops refuse or are reluctant to provide post-warranty services for electric vehicles. Facilitation and investment relief should also apply to companies providing services to electric cars users in other scopes. Special preferences should apply to transport service companies.

The last but not the least important task for state and local government institutions is to increase the share of electric vehicles in public transport. In addition to the positive impact on the environment, action in this area is causing a change in social attitudes towards accepting and following change. Residents observing changing public transport begin to appreciate the advantages of electromobility, and an additional motivation becomes their desire to keep up with modernity, even if they are not directly convinced by rational arguments or emotional marketing messages.

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Business models in the industry of electric vehicles

Abstract
This paper discusses business models in the industry of electric vehicles, with a special focus on the connection between business models and the lifecycle of technologies. Discussion starts with an insight into the dynamics of the global vehicle fleet in general, and the observation that our civilization produces more and more new vehicles per capita. That general fact, in turn, is interpreted as a pattern in collective energy management. A review of literature regarding business models in the industry of electric vehicles follows, further followed with a short case study of 3 businesses in the industry: Tesla, Rivian, and Lucid Group. The paper continues with the conclusion that the pace of technological change in the industry is closely connected to the cash flows of the businesses involved.
Keywords: business models, electric vehicles, technological change, lifecycle of technology

Introduction: the puzzle of pooled distributed energy storage

As a civilization, we are currently changing our energy base. An overview of main trends which that change entails suggests something like collective experimentation, with collective learning occurring in overlapping cycles of various duration. When we look at the percentage share of renewable sources in the total consumption of energy,[1] a bumpy cycle appears that looks like learning with experimentation. When we narrow down to the share of renewables

[1] *Renewable energy consumption (% of total final energy consumption)*, The World Bank, https://data.worldbank.org/indicator/EG.FEC.RNEW.ZS [accessed: 14.06.2022].

in the total consumption of electricity,[2] a more pronounced upward trend is visible, with an episode of past experimentation. The use of nuclear power to generate electricity[3] looks like a long-run experiment, which now is in its phase of winding down. Energy efficiency, defined as average real output per unit of energy use[4] follows quite unequivocal a trend upwards. Still, when we care to have a look at the coefficient of energy consumed per person per year,[5] a strong trend upwards appears, with some deep bumps in the past. It can be argued that historically, the way we shape our energy base is collectively intelligent learning through experimentation rather than unequivocal a trend of technological progress.

As a civilisation, we seem to be maximizing the real output of goods and services, whilst energy efficiency is just a means to that end.[6] Notwithstanding, human societies do demonstrate the capacity to form local equilibriums between their respective demographic size, the available food base and energy consumption[7].

In the public discourse on energy, the main focus is on the generation thereof, which tends to keep in the shadow the issue of storage. Nevertheless, the latter is of capital importance, especially in the view of remodelling our power systems towards more flexible, resilient networks, with substantial input from non-fossil sources. Energy storage capacity cost and discharge efficiency are the most important

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2 *Renewable electricity output (% of total electricity output)*, The World Bank, https://data.worldbank.org/indicator/EG.ELC.RNEW.ZS [accessed: 14.06.2022].

3 *Electricity production from nuclear sources (% of total)*, The World Bank, https://data.worldbank.org/indicator/EG.ELC.NUCL.ZS [accessed: 14.06.2022].

4 *GDP per unit of energy use (constant 2017 PPP $ per kg of oil equivalent)*, The World Bank, https://data.worldbank.org/indicator/EG.GDP.PUSE.KO.PP.KD [accessed: 14.06.2022].

5 *Energy use (kg of oil equivalent per capita)*, The World Bank, https://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE [accessed: 14.06.2022].

6 K. Waśniewski, *Technological change as intelligent, energy-maximizing adaptation*, "Journal of Economic and Social Thought" 2017, vol. 4 no. 3, pp. 263–276, http://dx.doi.org/10.1453/jest.v4i3.1410; idem, *Energy efficiency as manifestation of collective intelligence in human societies*, "Energy" 2020, vol. 191, 116500, https://doi.org/10.1016/j.energy.2019.116500.

7 Idem, *Settlement by energy – can renewable energies sustain our civilisation?*, "International Journal of Energy and Environmental Research" 2017, vol. 5, no. 3, pp. 1–18.

performance parameters in that respect.[8] It seems that flexibility as regards the time of energy storage plays a crucial role in the development of storage technologies, ranging from short smoothening of supply all the way up to making strategic reserves of capacity in the power system.[9] There is substantial evidence that the current surge in the fleet of electric vehicles plays an important role in optimizing the systems of energy storage, with car batteries working as a dispersed reservoir of energy.[10] Still, whilst being a floating reserve of power, the charging of electric vehicles creates substantial challenges for the stability of the incumbent power systems. It seems that the only viable solution is precisely to use car batteries as both receivers and suppliers of energy in a wide range of applications[11].

Against that theoretical background, the question arises whether we, humans, demonstrate the signs of collectively intelligent adaptation to the imperatives outlined in literature. Data published by the International Organization of Motor Vehicle Manufacturers (OICA), when interpolated with that on the global headcount of population,[12] allows noticing an interesting trend: between 1999 and 2016, at the worldwide scale, there had been more and more new cars produced per each new human being born, as shown in Figure 1.

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8 N.A. Sepulveda *et al.*, *The design space for long-duration energy storage in decarbonized power systems*, "Nature Energy" 2021, vol. 6, pp. 506–516, https://doi.org/10.1038/s41560-021-00796-8.

9 J.A. Dowling, *et al.*, *Role of Long-Duration Energy Storage in Variable Renewable Electricity Systems*, "Joule" 2020, vol. 4, no. 9, pp. 1907–1928, https://doi.org/10.1016/j.joule.2020.07.007.

10 M. Victoria, *et al.*, *The role of storage technologies throughout the decarbonisation of the sector-coupled European energy system*, "Energy Conversion and Management" 2019, vol. 201, 111977, https://doi.org/10.1016/j.enconman.2019.111977.

11 S. Alshahrani, M. Khalid, M. Almuhaini, *Electric Vehicles Beyond Energy Storage and Modern Power Networks: Challenges and Applications*, "IEEE Access" 2019, vol. 7, pp. 99031–99064, https://doi.org/10.1109/ACCESS.2019.2928639; Bo Zeng *et al.*, *Bilevel Robust Optimization of Electric Vehicle Charging Stations With Distributed Energy Resources*, "IEEE Transactions on Industry Applications" 2020, vol. 56, no. 5, pp. 5836–5847, https://doi.org/10.1109/TIA.2020.298474.1.

12 *Population, total*, The World Bank, https://data.worldbank.org/indicator/SP.POP.TOTL [accessed: 14.06.2022].

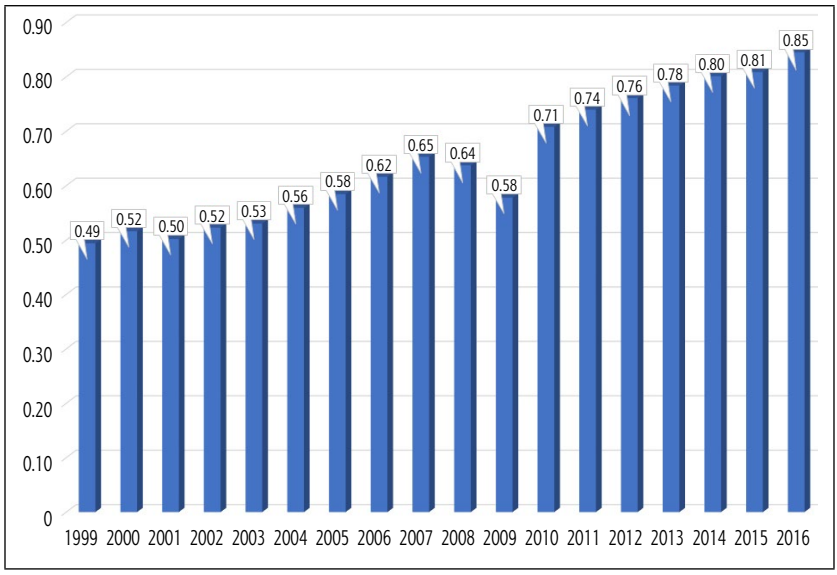


Figure 1. New cars produced per each new human born

Source: author's own work, based on data from OICA and World Bank.

Why do we consistently make more and more physical substance of cars per each new human born? It is tempting to engage into the now classical explanatory path of the Club of Rome, and to perceive the phenomenon as a case of overshot industrial production, driven by capitalistic greed. Still, data from OICA, combined with detailed financial statements provided by automotive companies at the investor-relations sites,[13] suggests something different. Most of the big automotive players seem to be optimizing their operational cashflows by downsizing the volume of output; they make more money by making less cars. The only player who seems to be unequivocally making more operational money out of making more cars is Tesla.

Making more and more cars per each new human means that we are collectively ramping up a special form of energy storage. Each car is a moving reservoir of chemical energy, immediately converted into kinetic energy, which, in turn, has economic utility. Making more cars

[13] *SEC Filings*, General Motors Company, https://investor.gm.com/sec-filings [accessed: 14.06.2022]; *SEC Filings*, Investors Library, Toyota, https://global.toyota/en/ir/library/sec/ [accessed: 14.06.2022]; *SEC Filings*, Tesla Investor Relations, https://ir.tesla.com/sec-filings [accessed: 14.06.2022].

with batteries pays off better than making more cars with combustible fuel in their tanks: a new generation of movable reservoirs in chemical energy is replacing an older generation thereof. Let's hypothesise that this is precisely the point of each new human being coupled with more and more of a new car being made: the point is more chemical energy convertible into kinetic energy. Do we need to move around more, as time passes? Maybe, although with more and more humans being around in a constant space, there is more and more humans per square kilometre, and that incremental growth in the density of population happens mostly in cities. Space available for travelling and needed to be covered, per one each human being, is decreasing. Less space to travel in means less need for means of transportation.

Thus, what are we after, collectively? We might be preparing for having to move around more in the future, or for having to restructure the geography of our settlements. On the other hand, the fact of developing the amount of dispersed, temporarily stored energy (in cars) might be a manifestation of us learning how to build and maintain large, dispersed networks of energy reservoirs in themselves. Isn't it frivolous to hypothesise that we collectively devote resources learning the best ways of developing what we are developing? This is quite a plausible explanation for some puzzling historical facts. Medieval cathedrals were being built over several decades, e.g. Notre Dame in Paris, kept under construction from 1160 to 1245.[14] Yet, in the shadow of cathedrals, the same people would erect quite complex military fortifications at a lightning-fast pace. When building cathedrals, the masters of stone masonry would do something apparently idiotic: they would make, then demolish, and then make again the same portion of the edifice, many times. Why slowing down something we can do quickly? In order to experiment with the process and with the technologies involved. Cathedrals were experimental labs of physics, mathematics and management, long before these scientific disciplines even emerged. The official idea of getting closer to God expressed an entire culture – the medieval Christianity – which was learning how to learn by experimentation. The concept of fulfilling

[14] C. Bruzelius, *The Construction of Notre-Dame in Paris*, "The Art Bulletin" 1987, vol. 69, no. 4, pp. 540–569, https://doi.org/10.1080/00043079.1987.10788458.

God's will through perseverant pursuit, whilst being stoic as regards exogenous risks, was excellent a cultural vehicle to that purpose.

In the 17th century, the cutting edge of technology was to be found in the industry of textile and garments,[15] which, peculiarly in Europe, was subject to quickly changing fashions, geographically idiosyncratic and strongly enforced through social peer pressure. That, in turn, pushed European businesspeople to experiment with the division of labour, the management of supply chains, quick study of subtle shades in customers' tastes and just as quick adaptation thereto. This is how Europeans prepared for the much later introduction of mechanized industry, which, in turn, gave birth to what we are today: a species controlling something like 30% of all energy on the surface of our planet.

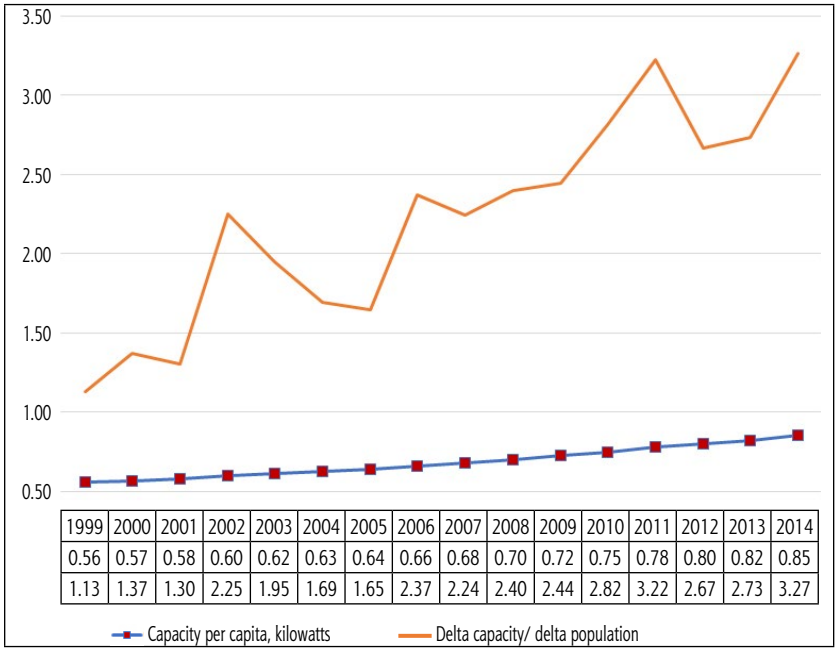
Maybe we are experimenting with dispersed, highly mobile and coordinated networks of small energy reservoirs – the automotive fleet – just for the sake of learning how to develop such networks? Data published by United Nations, as regards the total net installed capacity of electric power plants[16] allows calculating the average capacity per capita, at the global scale. In 2014, that average was 60% higher than in 1999. The process of incremental change in capacity per capita looks even more interesting when observed as the first moment. As ones divides the annual incremental change in aggregate installed capacity on the planet, and divides it by the absolute demographic increment, thus when we compute 'Delta capacity / delta population', that coefficient of elasticity grows even faster than capacity per capita. In 2014, it was almost three times more than in 1999. We, humans, keep developing denser a network of cars, as compared to our population, and, at the same time, we keep increasing the relative power capacity which every human can tap into.

It is somehow tempting to take an intellectual shortcut, once again, and to claim that it is all because we consume more and more energy per capita. We consume more goods per capita, we do more travel for leisure per capita, and, at the end of the day, we need more capacity in power plants and more cars. However, we increase our average annual

[15] F. Braudel, *The wheels of commerce*, University of California Press, Berkeley 1992 (*Civilization and Capitalism, 15th–18th century*, vol. 2).

[16] *UNSD Energy statistics*, UNSTATS, https://unstats.un.org/unsd/energystats/ [accessed: 14.06.2022].

consumption of energy per one human being, and yet this is a very gentle increment: barely 18% from 1999 through 2014 (Figure 2). Nothing to do with the quick accumulation of generative capacity.[17] The author formalized this general observation with two coefficients of elasticity, thus two first moments denominated over the incremental change in the consumption of energy per person per year. Firstly, incremental change in the number of new cars per each new human born has been denominated over the average consumption of energy per capita. In Figure 3, this is the coefficient 'Elasticity of cars per capita to energy per capita'. Between 1999 and 2014, this elasticity had passed from 0.49 to 0.79. We keep accumulating something like an overhead of incremental car fleet, as compared to the amount of energy we consume. Secondly, I formalized the comparison between individual consumption of energy and average power capacity per capita. This is the 'Elasticity of capacity per capita to energy per capita' column shown below. Once again, it is a growing trend.



1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
0.56	0.57	0.58	0.60	0.62	0.63	0.64	0.66	0.68	0.70	0.72	0.75	0.78	0.80	0.82	0.85
1.13	1.37	1.30	2.25	1.95	1.69	1.65	2.37	2.24	2.40	2.44	2.82	3.22	2.67	2.73	3.27

Figure 2. Total net installed capacity of electric power plants per capita, globally
Source: author's own work, based on data from UNSTATS and World Bank.

[17] *Energy use (kg of oil equivalent per capita)*, *op. cit.*

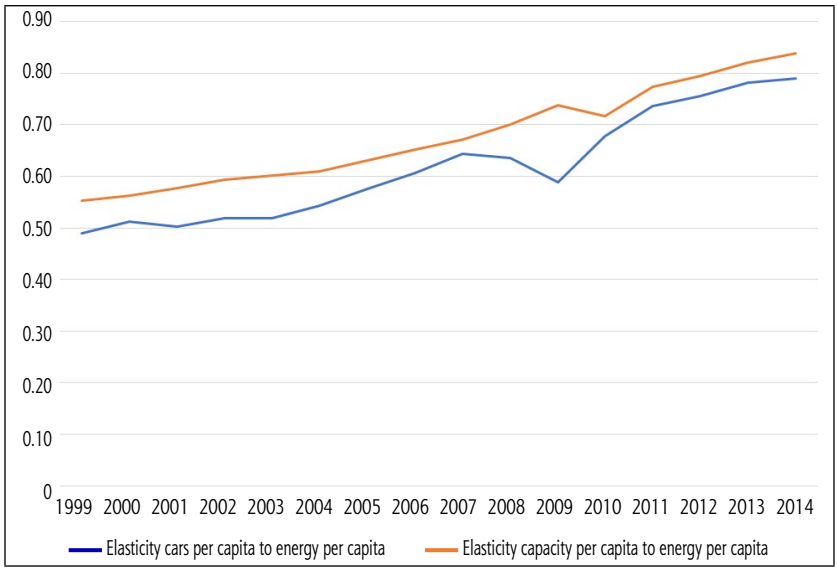


Figure 3. Elasticity of cars per capita to energy per capita and elasticity of capacity per capita to energy per capita
Source: author's own work.

At the worldwide scale, we keep beefing up our collective reserves of energy, and we seriously mean business about dispersing those reserves into networks of small reservoirs, possibly on wheels. Increased propensity to store is a historically known collective response to anticipated shortage. Do we, the human race, collectively and not quite consciously anticipate a shortage of energy? How could that happen? Our biology should suggest it is just the opposite. With the climate change being around, we technically have more energy in the ambient environment, not less. What exact kind of shortage in energy are we collectively anticipating? The previously outlined, collective propensity to develop dispersed networks of storage suggest that we collectively anticipate local shortages rather than a general one.

Why business models matter in the industry of electric vehicles?

The above introduction is the background for the general question: why do business models matter in the industry of electric vehicles? From the lifecycle perspective, the technology of electric vehicles

is in its phase of development. It is past the launching phase, when the main challenge was to convince some first, pioneer consumers, and volumes in the market are growing rapidly.[18]

Business models can be defined at two levels of abstraction. Firstly, business models are institutions that connect people doing business, i.e. investors, lenders, and entrepreneurs.[19] Secondly, in a broader sense, business models are ways of doing business, involving a wide range of stakeholders: governments at local and central levels, consumers, suppliers, functionally connected sectors, etc.[20] The deeper the technological change, the more it requires adaptive change in business models.[21] From yet another perspective, a business model is a replicator: it is, quite simply, what works in a business sufficiently well to make that business replicable across space and over time. Seen under that angle, business models do not necessarily manifest themselves in each business. There can be non-replicable businesses, devoid of any model. The lack of successful business models has been identified in meta-analyses as a barrier to the diffusion of electric vehicles in the market of end-users.[22]

Currently, the industry of electric vehicles provides for 5 basic technological types:[23]

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18 M. Abdelbaky, J.R. Peeters, W. Dewulf, *On the influence of second use, future battery technologies, and battery lifetime on the maximum recycled content of future electric vehicle batteries in Europe*, "Waste Management" 2021, vol. 125, pp. 1–9, https://doi.org/10.1016/j.wasman.2021.02.032.

19 R.G. Hagstrom, *The Warren Buffett Way*, John Wiley & Sons, Hoboken, NJ 2013.

20 R. Amit, Ch. Zott, *Business Model Innovation Strategy: Transformational Concepts and Tools for Entrepreneurial Leaders*, John Wiley & Sons, Hoboken, NJ 2020.

21 J.A. Schumpeter, *Business Cycles [Volume One]: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process*, Martino Fine Books Eastford, CT 2017 [reprint of 1939 first edition]; M.F. Guillén, *2030: How Today's Biggest Trends Will Collide and Reshape the Future of Everything*, St. Martin's Publishing Group, New York 2020.

22 L. Maybury, P. Corcoran, L. Cipcigan, *Mathematical modelling of electric vehicle adoption: A systematic literature review*, "Transportation Research Part D: Transport and Environment", vol. 107, 103278, https://doi.org/10.1016/j.trd.2022.103278.

23 A.G. Abo-Khalil *et al.*, *Electric Vehicle Impact on Energy Industry, Policy, Technical Barriers, and Power Systems*, "International Journal of Thermofluids" 2022, vol. 13, 100134, https://doi.org/10.1016/j.ijft.2022.100134.

1. Battery-based electric vehicles (BEV), which have no internal combustion engine and are powered by battery-based electric motor(s).
2. Hybrid electric vehicles (HEV) carry more than one energy source, in a system of alternative propulsion: a motor powered by electric energy from the battery is combined an internal combustion engine (ICE) that drives a generator that can supply energy to the electric motor or can be connected directly to the HEV traction.
3. Plug-in hybrid electric vehicles (PHEV) are an extension of the HEV; where battery is slightly larger than the HEV battery, and the ICE is lower than the HEV ICE or a common combustion vehicle. PHEVs are commonly charged straight from the power grid, not from the internal generator.
4. Fuel cell electric vehicles (FCEV) source electrical energy from a fuel, usually from hydrogen (although others, such as methanol, natural gas, biogas, urea, biomass in wastewater, waste carbon, etc. are being studied).
5. Extended range electric vehicles (ER-EV) present largely the same characteristics as the battery-electric vehicle but also carries another secondary source – an auxiliary small internal generator – that works as an internal generator to recharge the batteries, thus increasing the range of the vehicle. The combustion engine does not move the vehicle, and it only generates energy to recharge the batteries and thus has greater autonomy for the electric motor.

These 5 technological types are at different stages of their lifecycle. While the HEV technology is at the transition from development to maturity, BEVs, ER-EVs and PHEVs are (interestingly) more or less at the same, quite early a section of the development curve. The FCEVs are still in the very early launching phase, with only concept vehicles being manufactured. Thus, if innovation in business models is assumed to go somehow hand-in-hand with technological change, the former is going and will be going through a telescopic change, superimposing different technologies. Yet, considered as a whole, thus across all those 5 technologies, the industry of electric vehicles is mature enough to be considered as vital for economic growth and job creation. In that sense, business models in the industry are no

more conveying a complete novelty: they more and more go with the stream of economic growth and are stimulated by it.[24]

Business models in the industry of electric vehicles need both to challenge incumbent assumptions, and to adapt to specific local contexts in terms of technological base and economic conditions. In general, business models in transportation systems integrate the industry which makes vehicles as such with another industry that provides the source of energy. Transport based on animal power – horses and oxen – was integrated with farming, for the supply of fodder. Business models in the industry of internal-combustion-powered vehicles are integrated with those in the business of fossil fuels. In their turn, business models specific to the industry of electric vehicles coordinate the sectors of electricity and transport. Still, the issue as such does not come as a complete novelty: with the development of electricity-powered railways, in the second half of the 20th century, the question had to be addressed. Electric vehicles bring an update to that connection between power systems and transportation: the issue of batteries. Batteries are mobile reservoirs of energy. As stated earlier, the deployment of such mobile energy assets, combined with a network of distributed energy resources (charging stations for electric vehicles and gas stations for internal combustion engines) is a marked trait of the human civilization over more than a century.

Vertical integration is the most important current trend of change in the business models prevalent in the industry of electric vehicles, currently. The specificity of electric vehicles in this respect is that vertical integration downstream is at least as important and profitable as that reaching upstream. Battery-as-a-service (BaaS) is a good example of that, including battery swaps. That trend of vertical integration is undergirded by another one, namely by the systematic drop in the manufacturing cost of Li-Ion battery packs. The trend of development in intelligent vehicles, as well as in intelligent fleets thereof, is another important one. The broad business model (i.e. the business model involving stakeholders other than manufacturers and dealers)

[24] A. Gupta, H. Kumar, *Multi-dimensional perspectives on electric vehicles design: A mind map approach*, "Cleaner Engineering and Technology" 2022, vol. 8, 100483, https://doi.org/10.1016/j.clet.2022.100483.

in the industry of electric vehicles engages social stakeholders (governments, NGOs) in an unusual manner and to and unusual degree.[25] The total pool of batteries in the market, in the amount needed for significant deployment of electric vehicles, becomes a new form of massive, man-made structure, and requires new business models to function. The concept of circular economy, where waste can become a resource, finds a salient application in this case. [26]

Networks of charging stations mediate between the fleet of electric cars and the pool of batteries. Charging stations make batteries useful, quite simply. The complete ecosystem of charging services encompasses 3 different, although somehow overlapping business models: the manufacturer of equipment, the operator of charge points, and the provider of mobile services.[27] The deployment of those business models, together with the physical development of the charging infrastructure determine the practical absorption of the relatively novel technologies – BEVs and PEHVs – by the larger market. Both the density of vehicle fleets and that of the power grid are the greatest in cities and here comes an interesting trait of business models in the industry of electric vehicles: they seem to be largely symbiotic with the business models of cities as such.[28] Interestingly, relatively the youngest technology of electric vehicles, namely that of hydrogen-based fuel cells, seems to require a new

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[25] Cao Jidi *et al.*, *Electric vehicle industry sustainable development with a stakeholder engagement system*, "Technology in Society" 2021, vol. 67, 101771, https://doi.org/10.1016/j.techsoc.2021.101771.

[26] S. O'Neill, *Battery Recycling Challenge Looms as Electric Vehicle Business Booms*, "Engineering" 2021, vol. 7, no. 12, pp. 1657–1660, https://doi.org/10.1016/j.eng.2021.11.009; K. Chirumalla, L.G. Reyes, R. Toorajipour, *Mapping a circular business opportunity in electric vehicle battery value chain: A multi-stakeholder framework to create a win–win–win situation*, "Journal of Business Research" 2022, vol. 145, pp. 569–582, https://doi.org/10.1016/j.jbusres.2022.02.070.

[27] A. Goncearuc, *et al.*, *An integrative approach for business modelling: Application to the EV charging market*, "Journal of Business Research" 2022, vol. 143, pp. 184–200, https://doi.org/10.1016/j.jbusres.2021.12.077.

[28] F. Pardo-Bosch *et al.*, *Sustainable deployment of an electric vehicle public charging infrastructure network from a city business model perspective*, "Sustainable Cities and Society" 2021, vol. 71, 102957, https://doi.org/10.1016/j.scs.2021.102957.

approach to business models, as it requires coupling the transportation sector with that of hydrogen production.[29]

As business models in the industry of electric vehicles are still on the make, market actors are still learning what kind of observable empirical data is relevant for the optimization of those models. Technologies interact with driving patterns, as well as with more general patterns of mobility in local communities. Operating cost per kilometer (per unit of distance effectively covered) seems to be a key variable which the consumers' purchasing decisions hinge upon.[30] Some research suggests that total cost of ownership should be taken into account, comprising such variables as: the manufacturer's suggested retail price, the resale value of the vehicle, government subsidies, the retailer's discount, the cost of batteries, maintenance and repair costs, insurance cost, vehicle tax, loan interest cost, and energy consumption cost. Hybrid vehicles (HEV) seem to offer the most advantageous deals in that respect, whilst the technologically younger BEVs and PHEVs are still too early in their technological lifecycle to offer significant cost reductions to end-users.[31]

Exploratory case study of Tesla, Rivian, and Lucid Motors

When looked upon from the strictly financial perspective, business models in the industry of electric vehicles offer an interesting effect of scale. As one compares the financials of Tesla Tesla,[32] Rivian,[33] and Lucid Group,[34] the first is representative for a big,

[29] C.T.C. Trapp, D.K. Kanbach, S. Kraus, *Sector coupling and business models towards sustainability: The case of the hydrogen vehicle industry*, "Sustainable Technology and Entrepreneurship" 2022, vol. 1, no. 2, 100014, https://doi.org/10.1016/j.stae.2022.100014.

[30] K.A. Collett, *et al.*, *Can electric vehicles be good for Sub-Saharan Africa?*, "Energy Strategy Reviews" 2021, vol. 38, 100722, https://doi.org/10.1016/j.esr.2021.100722.

[31] P. Suttakul *et al.*, *Total cost of ownership of internal combustion engine and electric vehicles: A real-world comparison for the case of Thailand*, "Energy Reports" 2022, vol. 8, pp. 545–553, https://doi.org/10.1016/j.egyr.2022.05.213.

[32] *SEC Filings*, Tesla Investor Relations, *op. cit.*

[33] *Investor Relations*, Rivian, https://rivian.com/investors [accessed: 22.06.2022].

[34] *Investor Relations*, Lucid Group, Inc., https://ir.lucidmotors.com/ [accessed: 22.06.2022].

well-established business structure in the EV industry, whilst the two others are younger and smaller. The categorization of these three business models into different classes of maturity can be done on the basis of their cash flow; the gauge of 'owners' earnings' can be applied:[35] net profit plus amortization minus capital expenditures. As for the end of 2021, Tesla showed owners' earnings of $5644 million + $2911 million - $7742 million = $813 million, having delivered 936,222 vehicles. In the case of Lucid Group the corresponding figure was of - $2597,8 million + $62,9 million - $421,2 million = - $2956,1 million. Lucid Group began delivering cars to customers only in October 2021. Rivian reported - $4688 million + $197 million - $1794 million = - $6285 million of owners' earnings in 2021, with a volume of sales at 1011 vehicles.

The balance sheets of these three allow some insight into their respective degree of financial liquidity. At the end of Q1 2022, cash & cash equivalents make 26.5% of assets at Tesla, 72.84% at the Lucid Group, and 81.3% at Rivian. It can be assumed, that the greater that percentage of cash in the overall capital balance, the greater strategic flexibility is desired by the management of the firm. In other words, Tesla is representative for an already established business model, whilst Lucid and Rivian are examples of very fluid business models, still on the make. That, in turn, allows a numerical simulation based on the relative maturity of business models in the whole industry. Should the industry of electric vehicles evolve slowly, the Tesla-type of stable business model would dominate it, and therefore the whole business of electric vehicles would generate a positive stream of owners' earnings. It would be a capital-generating industry. On the other hand, if the industry evolves very quickly – too quickly for any definitive business model to settle down – it is likely to be dominated by Rivian-or-Lucid-types. That, in turn, generates a constant need for capital, in the absence of owners' earnings.

Those two alternative scenarios translate into further expectations from the part of capital providers. Once a business model starts generating positive owners' earnings, investors and lenders are relatively calmer, and more ready to accept relatively longer a return on investment. This, in turn, translates into long-term strategies in

[35] R.G. Hagstrom, *op. cit.*

operations. Conversely, business models which need cash rather than generate it are perceived as highly risky for investors, and that risk needs hedging and insurance, i.e. financial curtailment. In other words, the faster the change in business models, the more financial capital the whole industry requires. With respect to technological types mentioned earlier (i.e. BEV, HEV, PHEV, FC-EV, ER-EV), the importance of their different maturity becomes apparent at the financial level.

It is possible to imagine a financially neutral path of development in the industry of electric vehicles, where owners' earnings generated by the incumbent, well established businesses finance those with more experimental business models. When experimentation slows down, the whole industry generates net owners' earnings, which can be reinvested or distributed to other industries. At the same time, the industry becomes less risky for new investors and lenders. If, conversely, experimentation accelerates (e.g. in the case of rapid transition to hydrogen-based fuel cells), cash-demanding business models prevail over those cash-generating ones. The industry becomes riskier for investors and lenders, whilst remaining in need of abundant external financing.

Conclusions

Transition towards electric vehicles is a powerful, apparently irreversible trend of technological change. Earlier developments, especially the intensive growth of fleet in vehicles based on internal combustion, allow guessing, at the level of our entire technological civilization, a broad push towards growing a pool of distributed, mobile energy resources. Technological change towards electric vehicles seems to have distinct stages. It starts with the development of electrical propulsion systems as such, then it branches out into improvements at the level of batteries and charging stations (thus in the mobile sources of energy), just to transition into technological concepts where charging itself becomes obsolete, as it is the case with hydrogen-based fuel cells. Business models follow that technological thread of progress. Relatively the earliest technologies of electrical propulsion, namely the battery-powered vehicles (BEVs)

and the hybrid ones (HEVs) seem to have served the development of now-well-established business models, able to generate positive cash flows for their capital providers. Once the business structures built around these two technological types had become replicable, younger technologies gained grounds to grow: the plug-in hybrid vehicles (PHEVs), extended-range vehicles (ER-EVs), as well as the fuel-cell vehicles (FCEV).

A cursory look at the annual reports of three businesses in the industry of electric vehicles – Tesla, Rivian, and Lucid Group – allow uncovering a financial logic in the burgeoning of new business models and their possible transition to replicable solutions. New, highly experimental business structures need substantial intake of cash, even to the point of displaying negative equity. When earlier, well-replicable business structures are present in the same industry, they can generate the cash needed, and technological change becomes a dynamic equilibrium between cash-generating business structures on the one hand, and those absorbing cash, on the other hand. A tentative study of Tesla, the only business in in the industry of electric vehicles which went all along that path of transition, allows guessing a cycle of roughly a decade before an experimental business structure becomes a replicable business model.

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The environmental aspect of ECSR in the concept of organisational improvement in the electric vehicles sector

Abstract
The development trends of electric vehicles are presented in the light of the fight against global warming and the desire to improve the living conditions of the population, mainly in cities. Electric vehicle manufacturers as well as service companies in this sector can use the concepts of ECSR and organisational improvement. Their use to date is presented. Both concepts present a strategic approach. Their combined use is proposed, taking into account ecological innovation, particularly in the case of electric vehicle manufacturers. Attention was drawn to the need to respect social aspects and sectoral conditions.
Keywords: ECSR, organisation improvement, electromobility, EFQM, management

Introduction

The fight against global warming and the need to improve living conditions are driving efforts to create green transport. These are related to the implementation of electromobility. It includes the production sphere, implemented by electric vehicle manufacturers, but also the creation of a system of services related to access to charging stations and vehicle servicing. In particular, the actions taken play an important role in connection with urban pollution problems. The electromobility programme means the implementation of the

assumptions of sustainable development,[1] with emphasis on social and environmental aspects. This is reflected in the ECSR (Environmental Corporate Social Responsibility) concept. It elevates ecological aspects to a strategic position, decisive for the construction of the value of companies.[2] This is an approach that goes beyond an understanding of ECSR in tactical terms, in fact based on the implementation of the ISO 14000 series of standards on environmental issues for companies that respect the assumptions of CSR (Corporate Social Responsibility).

Electric vehicles (EVs) manufacturers should therefore follow a strategic ECSR approach as part of their development. It also serves the strategic objectives of organisational excellence (e.g. the EFQM model). Organisational excellence can therefore be achieved using ECSR, with an emphasis on the role of the environmental factor. The presented approach emphasises the innovative attitude of companies, based on increasing the environmental awareness of all stakeholders.

Hypothesis: In the electric vehicle sector, the strategic orientation of companies may involve achieving organisational excellence with a green factor. The creation of this excellence, with a focus on innovation, can be based on the implementation of the strategic orientation of ECSR.

The environmental aspect of electromobility

In the literature, the issues of electric vehicles are considered within the framework of the UN's activities on sustainable development.[3] With regard to the issue of sustainable transport, UN proposals refer to goals related to health and well-being (healthy living),

[1] This concept is described from different points of view, see A. Chodyński, *Kreowanie odpowiedzialnego biznesu*, Oficyna Wydawnicza AFM, Kraków 2016, pp. 29–39.

[2] A. Chodyński, A. Jabłoński, M. Jabłoński, *Environmental Corporate Social Responsibility (ECSR) – koncepcja strategiczna budowy wartości firmy oparta na kryteriach ekologicznych*, "Przegląd Organizacji" 2008, no. 3, pp. 30–32.

[3] In 2015, the UN General Assembly adopted the Sustainable Development Goals (SDGs). They are part of the New 2030 Agenda for Sustainable Development, http://www.csrinfo.org/wp-content/uploads/2016/10/Kamil-Wyszkowski-UN-Global-Compact-w-Polsce-SDGs-2015-30-realizacja-globalnego-planu-rozwoju_Warszawa-25.10.pdf [accessed: 12.02.2022].

sustainable cities and communities, clean energy, climate and sustainable production and consumption. The issue of eco-efficiency in the use of electric vehicles is addressed, noting the variation in different parts of Europe (28 countries were surveyed), taking into account, among other things, the life cycle assessment of vehicles. In considering eco-efficiency, environmental metrics were taken into account (carbon footprint and water and energy consumption). Countries such as Denmark, Germany, Italy, Portugal and Spain have been shown to have a competitive advantage based on eco-efficiency.[4]

The global literature highlights various developments in transport in relation to carbon dioxide emissions and also carbon monoxide. For Pakistan, the future importance of the hydrogen fuelled vehicles market and the move away from hybrid electric vehicles is indicated. E-mobility includes all-electric vehicles, hybrid electric vehicles and hydrogen fuel cell technology.[5] E-mobility interests include small-in-wheel electric vehicles, kick scooters, scooters, motorbikes and delivery robots.[6]

The Nordic countries, as part of the decarbonisation of the transport sector, assume the interconnection of electric energy systems with the electricity market. The electromobility approach to electric vehicles makes use of learning effects from the technological linkages of wind energy projects and the construction of EV charging infrastructure. Research in Denmark, Finland, Norway and Sweden has identified institutional mechanisms regarding joint activities, learning effects or institutional density. Technological mechanisms are related to economies of scale, economic scope and learning effects. Attention is paid to the importance of network externalities or the use of technological interrelatedness. In the description of behavioural

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4 N.C. Onat *et al.*, *How eco-efficient are electric vehicles across Europe? A regionalized life cycle assessment-based eco-efficiency analysis*, "Sustainable Development" 2021, vol. 29, no. 5, pp. 941–956.

5 A.H.K. Babar, Y. Ali, A.U. Khan, *Moving toward green mobility: overview and analysis of electric vehicle selection, Pakistan a case in point*, "Environment, Development & Sustainability" 2021, vol. 23, no. 7, pp. 10994–11011.

6 H. Ohn, *Electro-mechanical traction control for small in-wheel electric mobility*, "IEEE Transactions on Vehicular Technology" 2021, vol. 70, no. 12, pp. 12542–12551.

mechanisms, attention is drawn to habituation, cognitive switching costs and increasing informational returns.[7] In the opinion of the author of this study, the implementation of the described mechanisms will be significantly influenced by the environmental awareness of stakeholders in the EV sector.

Studies on electric vehicles (EVs) in 20 countries highlight the importance of government policies, including financial incentives, traffic regulation in favour of EVs or the creation of charging infrastructures. The results show that buyers are more inclined to purchase battery electric vehicles (BEVs) than plug-in hybrid electric vehicles (PHEVs).[8] The impact of financial as well as non-financial incentives and tax policies on the diffusion of electromobility in relation to BEVs is considered[9].

Consideration is being given to (private) households in terms of electromobility, taking into account the use of electric vehicles but in conjunction with photovoltaic and energy storage systems (battery storages).[10]

In the research on electric cars referring mainly to the Pakistan market, different options were considered: full electric vehicle, hybrid electric vehicle, hydrogen fuel cell, combustion vehicle. The SWOT analysis considered costs and benefits according to internal and external criteria. External benefits relate to pollution control, affordability, future sustainability, efficiency, national benefit. Internal benefits include technological advancements and energy sustainability, and there is a global incentive effect, which has an impact on internal costs.[11]

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7 K. Kotilainen *et al.*, *From path dependence to policy mixes for Nordic electric mobility: Lessons for accelerating future transport transitions*, "Policy Sciences" 2019, vol. 52, no. 4, pp. 573–600.

8 N. Rietmann, T. Lieven, *How policy measures succeeded to promote electric mobility – worldwide review and outlook*, "Journal of Cleaner Production" 2019, vol. 206, pp. 66–75.

9 S. Fluchs, *The diffusion of electric mobility in the European Union and beyond*, "Transportation Research Part D: Transport and Environment" 2020, 102462.

10 K. Laurischkat, D. Jandt, *Techno-economic analysis of sustainable mobility and energy solutions consisting of electric vehicles, photovoltaic systems and battery storages*, "Journal of Cleaner Production" 2018, vol. 179, pp. 642–661.

11 A.H.K. Babar, Y. Ali, A.U. Khan, *op. cit*.

With the main focus on urban applications, new technologies and innovations in mobility based on shared automated electric vehicles (SAEV) solutions for public transport are being considered. SAEV-related mobility studies propose the use of mobility indicators relating, among other things, to environmental impact. In addition, social, economic, governance and technical impacts are considered. SAEV encompasses different vehicles, e.g. robo-taxis and automated shuttles in public transport, taking into account the different forms of vehicle ownership. SAEVs can provide different types of services, e.g. rides on different routes or door-to-door services.[12]

Considerations for transport solutions aimed at reducing environmental and noise pollution include the use of hybrid or electric vehicles equipped with propellers, for densely populated urban centres.[13] A review of the literature indicates that the issue of electric vehicle development is linked to urban development. Reference can therefore be made to the smart city concept, with a clear pro-environmental orientation, including with regard to the role of transport and the provision of mobility.[14] Attention is drawn to the focus on pro-environmental innovation as a basis for the development of the electric vehicle sector.

The ECSR concept

In the proposed concept, highlighting the importance of ecological criteria leads to an increase in the value of the company. Ecological criteria are strategic in nature. Within the sectoral analysis, the ecological factor is treated as a key success factor. Cooperation with stakeholders is emphasised. The concept considers the benefits of building ecological competence, ecological knowledge

[12] E.H. Nemoto, *How to measure the impacts of shared automated electric vehicles on urban mobility*, "Transportation Research Part D: Transport and Environment" 2021, vol. 93, 102766.

[13] F. Afonso *et al.*, *On the design of environmentally sustainable aircraft for urban air mobility*, "Transportation Research Part D: Transport and Environment" 2021, vol. 91, 102688.

[14] A. Chodyński, *Wykorzystanie dorobku nauk o zarządzaniu na rzecz podnoszenia bezpieczeństwa miast. Koncepcja smart*, "Bezpieczeństwo. Teoria i Praktyka" 2019, no. 4, pp. 39–62.

management, the use of intellectual capital. ECSR has an impact on organisational learning. It influences companies' competitive strategies, the creation of business processes and business models. The impact of ECSR also applies to products. In the marketing sphere, it can be associated with the implementation of ecological marketing and ecological benchmarking. The concept assumes its beneficial impact on the realisation of eco-innovation.[15] ECSR is treated as an innovative solution to CSR, emphasising the importance of environmental protection. ECSR initiatives on the part of companies can relate to products, processes, policies and programmes. The role of stakeholders in the implementation of ECSR is emphasised.[16] A review of the literature indicates that ECSR originally arose from the concepts of *environmental management* and CSR. ECSR is considered, inter alia, as a relevant and distinct aspect within CSR.[17]

The ECSR concept, linked to the concept of *sustainability* in corporate business, addressing economic, social and environmental issues for the community was for example considered for a mining company in Indonesia.[18] Its use has also been proposed for a calorific energy company in Poland (highlighting the importance of ISO 14001).[19]

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15 A. Chodyński, A. Jabłoński, M. Jabłoński, *op. cit*.

16 P. Nigam, P.A Chavla, *A conceptual study on environmental corporate social responsibility (ECSR)*, "Quarterly Journal of Management Development" 2018, vol. 49, no. 1, pp. 84–87, https://www.researchgate.net/profile/Parag-Shukla/publication/344672742_Re-Imagining_Retail_The_Key_To_Survive_in_an_Omni_Channel_Retail_Environment/links/5f886f0ba6fdccfd7b653328/Re-Imagining-Retail-The-Key-To-Survive-in-an-Omni-Channel-Retail-Environment.pdf [accessed 1.02.2022].

17 S.-P. Chuang, S.-J. Huang, *The effect of environmental corporate social responsibility on environmental performance and business competitiveness: the mediation of green information technology capital*, "Journal of Business Ethics" 2018, vol. 150, no. 4, pp. 991–1009.

18 I.Z. Rela *et al.*, *Effects of environmental corporate social responsibility on environmental well-being perception and the mediation role of community resilience*, "Corporate Social Responsibility & Environmental Management" 2020, vol. 27, no. 5, pp. 2176–2187.

19 R. Wolniak *et al.*, *Environmental corporate social responsibility activities in heating industry – case study*, "Energies" 2021, vol. 14, no. 7, 1930, https://www.researchgate.net/publication/350533857_Environmental_Corporate_Social_Responsibility_Activities_in_Heating_Industry-Case_Study [accessed 1.02.2022].

Shiley Hu and Xiaohong Wang present the role of ECSR using 162 private large Chinese firms as an example. The proactive investment orientation of the ECSR character is due to the interaction of various factors: institutional embededness (institutions in the formal and informal sense), the strength of family influence (predominant shareholders, family businesses) on firms' strategies, goals and behaviour, and the resource base held. ECSR can be considered as passive (reactive, obligatory) and proactive. The latter is voluntary, non-mandatory and is linked to, among other things, relevant environmental objectives. In addition, public disclosure of its environmental performance, voluntary environmental investment activities, internal and external audits in this area are indicated as objectives. Voluntary investment activities are assessed through the reduction of environmental pollution.[20] Magdalena Suska analyses the implementation of the ECSR assumptions, emphasising the activities for the reduction of environmental pollution by large Polish enterprises of the mining and fuel (liquid and gas fuels) industries. She associates the development of the ECSR concept mainly with the fact of increasing the role of the ecological factor and energy management.[21]

ECSR uses environmental awareness in corporate decision-making to reduce environmental impact. The implementation of ECSR causes economic impacts, is reflected in the stock market, influences international expansion, customer loyalty and the creation of green innovations. The latter affect opportunities to build competitive advantage. When considering ECSR as a carrier (driver) of innovation, eco-innovation is cited as an example. These problems considered for large companies also become relevant for small and medium-sized enterprises.[22] The 'green' innovative aspects of ECSR for small and

[20] S. Hu, X. Wang, *The origin of proactive environmental corporate social responsibility (ECSR) of large firms: institutional embededness-driven, family involvement-promoted, or resource-dependent?*, "Sustainability" 2021, vol. 13, no. 3, 1197, https://www.mdpi.com/2071-1050/13/3/1197/htm [accessed: 1.02.2022].

[21] M. Suska, *Environmental corporate social responsibility (ECSR) on the example of Polish champion oil, gas and mining companies*, "Sustainability" 2021, vol. 13, no. 11, 6179, https://www.mdpi.com/2071-1050/13/11/6179 [accessed: 1.02.2022].

[22] F.J. Forcadell, F. Úbeda, E. Aracil, *The effect of environmental corporate social responsibility on industrial SMEs' innovation*, pp. 1–21, Comillas

medium-sized enterprises based on technological resources are considered.[23] ECSR activities from a marketing point of view are also considered, building on environmental aspects by considering consumer benefits (welfare), consumer inclusion (involvement) and philanthropic activities by companies.[24] ECSR is considered from a technological point of view in terms of, inter alia, reducing carbon emissions.[25]

ECSR and the EFQM model for organisational improvement in manufacturers of electric vehicles

Various models of organisational excellence are described within management concepts and practice. In the USA, the model embodied in the principles of the Malcolm Baldrige National Quality Award is popular, in the UK the British Quality Foundation (BQF) model or Kanji's Business Excellence Model (KBEM) are used. In continental Europe, the EFQM is used. A characteristic feature of these models is their comprehensiveness, covering the most important areas of an organisation's functioning. Its evaluation relates to financial or market performance, but also includes such qualitative achievements as satisfaction of both customers and employees

Pontifical University, https://repositorio.comillas.edu/xmlui/bitstream/handle/11531/45096/paper%20ECSR%20innov%20SME%2002-01-20%20sent%20to%20ACIEK.pdf?sequence=1&isAllowed=y [accessed: 2.02.2022].

[23] Eidem, *Effects of environmental corporate social responsibility on innovativeness of Spanish industrial SMEs*, "Technological Forecasting and Social Change" 2021, vol. 162, 120355, https://www.sciencedirect.com/science/article/abs/pii/S0040162520311811#! [accessed: 2.02.2022].

[24] S. Munerah, S. Thambiah, S. Muthaiyah, *Environmental corporate social responsibility (ECSR) as a predictor of consumer's green behaviour*, "International Journal of Business and Management" 2018, vol. 13, no. 11, pp. 241–249, https://www.researchgate.net/publication/328579354_Environmental_Corporate_Social_Responsibility_ECSR_As_a_Predictor_of_Consumer's_Green_Behavior [accessed: 1.02.2022].

[25] H.-S. Kim, H.J. Jung, Ch.H. Lee, *Motivation for firm ECSR: firm's CO_2 emissions and search for renewable energy technology*, "Academy of Management Proceedings" 2021, https://journals.aom.org/doi/abs/10.5465/AMBPP.2021.14144abstract [accessed: 14.05.2022].

or impact on society. The importance of balance in terms of economic development (profit), social development (people) and environmental development (planet) is emphasised, as are qualitative factors influencing performance, including the role of people and leadership, the impact of partnerships, the importance of strategy and process implementation. The importance of organisational creativity and innovation involving stakeholders is emphasised, leading to continuous improvement.[26]

By analysing the individual elements of the EFQM model, even starting from its initial version,[27] it is possible to point out the benefits of implementing the ECSR assumptions in relation to the individual areas covered by the model for EV manufacturers:

- in the area of leadership, pro-environmental values play an important role, working with stakeholders to reduce the risks associated with global warming or improving living conditions for people in cities, among other things;
- human resource management should be based on shared values and the development of relevant competences, including environmental competences;
- The construction of the strategy should be based on the assumption of the development of companies based on ecological values, creating and using the necessary resources, including the intellectual (intangible) resources of the organisation. It is worth noting that the increase in environmental awareness of stakeholders can be treated as an opportunity. The concepts of an agile enterprise, capable of exploiting opportunities, can therefore be used. Andrzej Olak sees agile as the ability to react quickly and adapt to often surprising and unpredictable market changes.[28] Various aspects of agility can be considered, taking into account the driving

[26] K. Łobos, *Modele doskonałości organizacyjnej*, [in:] idem, *Koncepcje zarządzania*, Wydawnictwo Wyższej Szkoły Bankowej w Poznaniu, Poznań 2021, pp. 113–119, https://www.wydawnictwo.wsb.pl/sites/wydawnictwo.wsb.pl/files/do_pobrania/Lobos_Koncepcje_zarzadzania.pdf [accessed: 16.05.2022].

[27] *Europejska nagroda jakości*, Encyklopedia Zarządzania, https://mfiles.pl/pl/index.php/Europejska_nagroda_jako%C5%9Bci [accessed 28.10.2021].

[28] A. Olak, *Organizacja zwinna – wyznaczniki oraz kierunki strategii prowadzące do zwinności przedsiębiorstwa*, "E-mentor" 2017, no. 1 (68), pp. 48–54.

forces behind agility (including reference to the company's environment), the competences possessed and the transmitters of agility including methods, practices and tools (including agile strategies).[29] The problem of transforming agile behaviour into a sustainable trend for the organisation remains to be solved;

- the area of partnerships and resources should take into account modern concepts of stakeholder management, treating them as a resource for a company focused on innovative solutions in the field of electric vehicles;
- the process area should take into account not only their traditional metrics (time, quality, costs) but should refer to the design and implementation of processes taking into account social and environmental aspects, including processes related to the implementation of cooperation with stakeholders;
- areas of employee and customer satisfaction should take into account employees' identification with the company's environmental goals and professed organisational values in this respect, while customer satisfaction can be built on their growing environmental awareness;
- The relationship with the environment should, on the one hand, be linked to the approach described by corporate social responsibility (CSR) and environmental responsibility (ECSR), paying attention, however, to social acceptance of innovative, environmentally friendly solutions in the form of electric vehicles, involving stakeholders at the various stages of creating these products. The lessons learned from their development and operation can be applied throughout their entire life cycle (ecological cycle assessment). ECSR increases the legitimacy of companies;
- The financial effect should be reflected in the built competitive advantage of companies in the electric vehicle sector, as it results from the assumptions of ECSR. Competitive advantage of companies may also be documented by the increase of their social impact, built on the basis of impact potential. It can be defined as capabilities, which are repetitive patterns of action or competences within

[29] A. Stachowiak, P. Cyplik, *Aspekt dojrzałości do zwinności w definiowaniu strategii zwinności przedsiębiorstwa*, "Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu" 2018, no. 505, pp. 203–215.

the EV sector based on combinations of own internal resources, influencing other actors. In proposing a definition of impact potential,[30] attention was drawn to the role of impacts through catalytic innovation. The author of this study emphasises that the role of this type of innovation, which often changes the way certain communities operate, their expectations and behaviour, can be of particular importance for the development of electric vehicles, meeting the environmental expectations of these communities.

EV manufacturers can build their competitive advantage by leveraging stakeholder environmental awareness and eco-innovation as proposed for building eco-visionary organisations.[31]

Both the EFQM and ECSR concepts emphasise the strategic aspect. This common approach can be manifested in the way in which environmental measures concerning patterns of behaviour (pattern) are implemented in terms of ethical behaviour.[32]

ECSR and EFQM in the light of market and sector conditions

Factors encouraging customers in Poland to purchase electric cars include: appropriate price, tax exemptions on purchases, increasing the number of charging points, solutions concerning parking zones (e.g. free parking) and enabling entry into low-emission zones. The possibility of bus lanes is also mentioned. Another argument is that electric cars are mechanically and structurally uncomplicated (for example, there are far fewer components in BEVs than in conventional cars). This reduces the possibility of breakdowns which lowers operating costs. The extended warranty periods offered by manufacturers for individual car components indicate that these vehicles are not prone to breakdown. The price level for servicing

[30] A. Chodyński, *Uczenie się i wpływ społeczny a bezpieczeństwo na poziomie lokalnym – zarządzanie w sytuacji awarii zagrażającej środowisku naturalnemu*, "Bezpieczeństwo. Teoria i Praktyka" 2021, no. 4, pp. 61–80.

[31] A. Chodyński, *Dynamika przedsiębiorczości i zarządzania innowacjami w firmach. Odpowiedzialność – prospołeczność – ekologia – bezpieczeństwo*, Oficyna Wydawnicza KAAFM, Kraków 2021, pp. 226–229.

[32] W. Yuan, Y. Bao, A. Verbeke, *Integrating CSR initiatives in business: an organizing framework*, "Journal of Business Ethics", 2011, vol. 101, no. 1, pp. 75–92.

an electric car is comparable to combustion vehicles. However, it is worth noting the need for electric car service technicians to be certified.[33]

The process approach, embodied in both ECSR and EFQM, can refer to the implementation of manufacturing processes at an EV manufacturer as well as customer service. Service in process approach can be considered in the case of vehicle charging. In the literature, a process approach is described for the sale of new cars in distribution networks including the *workflow* of the process and the information exchange system. The successive stages of the sale are considered (along with different variants based on the customer's decision): selection of the car by the customer, negotiation of the terms of sale, issuing of the *pro-forma* document, preparation of the car, communication with the customer, payment control and sale.[34]

The ECSR and EFQM models emphasise the innovation and learning aspect. According to the author of this study for electric car manufacturers, innovation and learning should be based on market and sectoral experiences resulting from the role of 'green' values. Innovation and learning is also important in establishing appropriate supply chains. The achievements of companies with an innovation mindset from the pharmaceutical sector can be leveraged. In particular, it is important to build long-term relationships with suppliers that not only take into account pricing aspects, but devote much attention to the creation of added value resulting from the realisation of innovations. In addition to the obvious aspect of pricing, the partnership approach to value creation plays an important role. This

[33] J. Janczewski, *Serwisowanie samochodów w wymiarze elektromobilności*, "Zarządzanie Innowacyjne w Gospodarce i Biznesie" 2018, no. 2 (27), pp. 169–178, https://ziwgib.ahe.lodz.pl/sites/default/files/ZIwGiB_27_2018_e_book.pdf [accessed: 14.02.2022]. The article includes technical details on servicing electric cars, and comparison (including servicing costs) with traditional (combustion) cars.

[34] T. Gospodarek, *Modelowanie w naukach o zarządzaniu oparte na metodzie programów badawczych i formalizmie reprezentatywnym*, Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu, Wrocław 2009, pp. 217–220, https://books.google.pl/books?hl=en&lr=&id=-FM-MHYJJFwC&oi=fnd&pg=PA1&dq=info:IeJOJoAnfIgJ:scholar.google.com&ots=HKfp9PFrNj&sig=aeyvdCIYu8jBBoBPMvQh87kWu3o&redir_esc=y#v=onepage&q&f=false [accessed: 14.02.2022].

should take into account the influence of both business factors related to the industry or one's negotiating position and cultural factors related to long-term strategy (including with regard to how profits are maximised), with emphasis on the role of the human factor, behaviour related to shared values and ethics. The role of the organisation's culture in relations with suppliers is emphasised, including the importance of the behaviour of purchasing divisions as well as the role of trust and the need for continuous learning.[35]

Conclusions

Achieving organisational excellence for both EV manufacturers and service providers, such as for servicing and recharging, can be based on ECSR. This should take advantage of the strategic orientation of both concepts. Implementation of electromobility assumptions, with a strategic pro-environmental attitude, actually results in a clear emphasis on innovation and pro-environmental routines and practices resulting from prioritising the environmental strategic goals of companies in terms of manufacturing, operation and end-of-life disposal of electric vehicles. Social aspects play an important role in the ECSR concept. They are also related to the element referred to as environment in the EFQM model. Consideration of the social aspects of technology using the example of electric vehicles points to the importance of the social embedding process of technological diffusion, taking into account cultural aspects, the context of the users (indicating that other actors besides the users should also be taken into account), the policies applied and the infrastructure.[36]

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[35] P. Buła, K. Pawlak, *Archetyp systemowy "złego rozwiązania – dobrego lekarstwa" w realizacji funkcji zakupowej w przemyśle farmaceutycznym*, "Przedsiębiorczość i Zarządzanie" 2018, vol. 19, no. 6: *Konkurencyjność współczesnych przedsiębiorstw – modele, koncepcje i uwarunkowania*, part 2, pp. 77–90.

[36] L. Kanger, *et al.*, *Technological diffusion as a process of societal embedding: lessons from historical automobile transitions for future electric mobility*, "Transportation Research Part D: Transport and Environment" 2019, vol. 71, pp. 47–66.

The EFQM model emphasises the role of innovation and creativity in an organisation's efforts to create higher added value and continuous improvement. Involving different stakeholder groups in the innovation process is proposed. This is in line with the ECSR concept, and stakeholder support can be based on the environmental values so important in the electric vehicle sector.

According to Małgorzata Z. Wiśniewska, the development of the concept of continuous improvement should take into account the assumptions of organisational resilience.[37] This may be the subject of further research in the electric vehicle sector in conjunction with ECSR. It is assumed that the concept of resilience, also based on the ecological factor, predicts behaviour aimed at the functioning of the company on the market even in the presence of various threats.[38] The company's behaviour is considered in the event of a turbulent environment.[39]

The literature also stresses the need to go beyond the usual considerations of electric vehicles in the urban environment with regard to technical, safety, regulatory and commercial aspects. It is proposed that individual preferences, lifestyles and (as contextual conditions) settlements, endowments and mobility practices should be included in the discussion. The role of attitudes favourable to the dissemination of electromobility assumptions in urban settings is emphasised.[40] These views should be taken into account when improving ECSR-based organisations in the electric vehicle sector. It is worth noting that the impact of environmental awareness on customers'

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[37] M.Z. Wiśniewska, *Kultura organizacyjna oraz kultury wzmacniające doskonalenie podmiotów opieki zdrowotnej*, Instytut Naukowo-Wydawniczy "Spatium", Radom 2021, pp. 257–259, http://inw-spatium.pl/wp-content/uploads/2021/03/Kultura-organizacyjna-oraz-kultury-wzmacniaj%C4%85ce-....pdf [accessed: 19.04.2022].

[38] A. Chodyński, *Dynamika przedsiębiorczości…*, *op. cit.*, pp. 186–203.

[39] Idem, *Kryzys pozaekonomiczny przedsiębiorstwa – ekologiczny aspekt rezyliencji organizacyjnej*, [in:] *Zrównoważony rozwój, systemy informacyjne i zarządzanie bezpieczeństwem w perspektywie długoterminowej przedsiębiorstw,* ed. A. Chodyński, D. Fatuła, M.A. Leśniewski, Oficyna Wydawnicza KAAFM, Kraków 2022, pp. 11–31.

[40] P. Pucci, *Spatial dimensions of electric mobility – scenarios for efficient and fair diffusion of electric vehicles in the Milan Urban Region*, "Cities" 2021, Vol. 110, 103069.

purchasing decisions should be considered in relation to other important factors influencing these decisions, such as price, benefits of electric vehicles and authorities' policies on urban mobility.

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Pro-environmental managerial behaviour in the human resource management system of electric car manufacturing and service companies

Abstract
'Green' human resource management is the starting point in shaping pro-environmental employee behaviour in a group of managers and subordinates. One of the elements of positive influence on the environment are electric cars, which are one of the links of the 'greening' of humanity, the 'greening' of organisations wishing to preserve a clean environment for future generations. The study presents 'green' human resource management with the demonstration of pro-environmental behaviour of managers of electric car companies. The study was based on a literature study.
Keywords: 'green' human resource management, 'green' manager, electric cars

Introduction

The world is currently moving towards sustainable development with concern for the environment, through which humans can live and shape the socio-economic development of the world. The overriding concern for the environment in the strategies of companies (organisations) is becoming a reality. Man must maintain a balance between the society, economy and environment, because its neglect will lead to the gradual annihilation of mankind. Man's response to maintaining the balance is sustainable development

(eco-development), ecology. There are various forms of manifestation of this balance through, among others, 'green' (ecological) management of human resources, pro-environmental behaviour of employees (managers, subordinates) or the production and sale of low-emission, ecological cars seen through the prism of hybrid and electric cars. A common feature of pro-environmental actions is that they have an environmental awareness and an eco-developmental awareness. The former refers to man's positive perception of the environment and the latter refers to man's integral perception of socio-economic development and the environment. Environmental awareness is the substructure of eco-developmental awareness. With these layers of consciousness, development can be built and shaped to maintain the 'tranquillity' of the environment. In order for environmental behaviour to be activated by people in an organisation, these two layers of consciousness have to be active in the minds of managers and subordinates. A physical form of the manifestation of environmental concern in the long term is, for example, in electric cars. Every year, these cars are being purchased by an increasing number of customers and are becoming more technologically advanced. In addition to electric cars, an important environmental issue is the sources of electricity – which can be generated from non-renewable resources such as coal, lignite, oil, and renewable resources such as solar radiation, wind and water. With electric cars, mankind will be able to think more securely about its future and that of future generations. The aim of this study is to present 'green' human resource management in terms of pro-environmental behaviour of managers in the area of electric cars. The paper is based on a literature study and contributes to the discussion on the 'greening' of employees and electric cars in the field of Management and Quality Sciences.

'Green' human resource management. Ecologically-sensitive manager

Human resource management refers to activities that shape developmental attitudes in employees in an organisation and is subject

to permanent change. There are various models in the literature that illustrate the evolution of human resource management (e.g. T. Listwan's model,[1] A. Pocztowski's model,[2] etc.). R. Schuler and S.E. Jackson see a change in the approach to human resource management, which is caused by the organisation's pursuit of sustainability or taking into account the impact of stakeholders on the organisation.[3] The impact of stakeholders on areas of human resource management has been taken into account in the well-known and very popular Harvard model.[4] In his books, M. Armstrong extends the issue of human resource management to include corporate social responsibility or employee well-being.[5]

Environmental issues are manifested in the concept of 'green' human resource management. D.W.S. Renwick, T. Redman and S. Maguire link human resource management processes to the environment, thus placing the issue of sustainability at the centre of people management. Environmental awareness[6] and eco-developmental awareness[7] play a very important role in the concept of 'green' human resource management. Eco-development awareness has its value in the combined view of the three systems, i.e. society – economy – environment in the development of organisations or individual countries.[8] According to D.W.S. Renwick, T. Redman and S. Maguire,

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1 T. Listwan, *Współczesne tendencje w zarządzaniu kadrami organizacji*, "Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu" 2008, no. 31, pp. 23–33.

2 A. Pocztowski, *Zarządzanie zasobami ludzkimi. Strategie – procesy – metody*, Polskie Wydawnictwo Ekonomiczne, Warszawa 2007.

3 R. Schuler, S.E. Jackson, *Human resource management and organizational effectiveness: yesterday and today*, "Journal of Organizational Effectiveness: People and Performance" 2014, vol. 1, no. 1, pp. 35–55.

4 A. Pocztowski, *op. cit.*, p. 25.

5 M. Armstrong, S. Taylor, *Armstrong's Handbook of Human Resource Management Practice*, Kogan Page, London 2014.

6 A. Chodyński, *Odpowiedzialność ekologiczna w proaktywnym rozwoju przedsiębiorstw*, Krakowskie Towarzystwo Edukacyjne sp. z o.o. – Oficyna Wydawnicza AFM, Kraków 2011, p. 155.

7 M.A. Leśniewski *Świadomość ekorozwojowa w konkurencyjności miękkiej przedsiębiorstw*, "Edukacja Ekonomistów i Menedżerów" 2016, no. 2 (40), pp. 151–164.

8 *Ibidem*, p. 151.

it is necessary to contribute to the development of 'green' skills of employees through:[9]

1. recruitment process and training of managers and 'green' leadership,
2. motivating employees to take pro-environmental actions,
3. generating the conditions for employee involvement in environmental protection, using the organisational culture.

The concept of I. Ehnert and W. Harry includes various approaches in the area of human resource management.[10] Based on the literature review, it can be assumed that sustainable human resource management consists of:[11]

1. continuing development of staff competences in a strategic perspective,
2. striving for a work-life balance, in the light of which employees would have time for rest, positive family and social relations, thus creating a good image of the employee in the organisation,
3. health of employees,
4. equal treatment of men and women in terms of pay or career advancement, etc.,
5. shaping a friendly organisational culture within the organisation,
6. involvement of employees in minimising the environmental impact of the organisation.

For managers, their environmental and social activism is implemented in three areas:[12]

1. achieving the company's objectives,
2. performing the actual work,
3. behavioural aspects.

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[9] D.W.S. Renwick, T. Redman, S. Maguire, *Green human resource management: a review and research agenda*, "International Journal of Management Reviews" 2013, vol. 15, no. 1, pp. 1–14.

[10] I. Ehnert, W. Harry, *Recent developments and future prospects on sustainable human resource management: introduction to the special issue*, "Management Revue" 2012, vol. 23, no. 3, p. 231.

[11] A. Zaleśna, B. Wyrzykowska, *Zrównoważone zarządzanie zasobami ludzkimi w praktyce przedsiębiorstw w Polsce*, "Organizacja i Kierowanie" 2017, no. 1 (175), pp. 151–165.

[12] A. Pabian, *Sustainable personnel – pracownicy przedsiębiorstwa przyszłości*, "Zarządzanie Zasobami Ludzkimi" 2011, no. 5, pp. 13–14.

The domain of managers is, first and foremost, the implementation of the company's principled objectives (e.g. strategic, tactical and operational plans). Responsible managers are pro-environment and pro-social. Clean (low-carbon) production is one of the main objectives of their pro-environmental activities. The company's suppliers must also be characterised by a pro-environmental and pro-social attitude. A second important area of activity for sustainable managers is to ensure production mix. These products are made of ecological materials, save electricity and water with which they are supplied, guarantee that the needs of customers are met, can be recycled, and are pro-environmental. The third area of activity of sustainable managers is formed by social activities. Managers recognise the social problems of the world and have the intention to contribute to solving them.

A 'green' manager is a person who is particularly sensitive to environmental protection with various ecological, eco-developmental skills. Such a manager is aware that the company (organisation) has an impact on the environment through its activities. Such a manager should have a developed environmental awareness and eco-developmental consciousness. Building eco-developmental competitiveness should enable the organisation to achieve a competitive advantage.[13] Eco-developmental competitiveness is a big step towards being an eco-developmental enterprise.

Environmental competence of managers

Interactions with the natural environment play an important role in business development. They are important for the long-term management of the enterprise.[14] The shaping of these interactions takes place within the framework of state environmental policy. This translates into multi-directional pro-environmental conditioning

[13] M.A. Leśniewski, *Konkurencyjność ekorozwojowa przedsiębiorstw*, "Ekonomika i Organizacja Przedsiębiorstwa" 2016, no. 3, pp. 3–16.

[14] K. Lisiecka, A. Kubasik, *Środowisko w globalnej orientacji zarządzania przedsiębiorstwem*, Kolegium Zarządzania Akademii Ekonomicznej w Katowicach, Katowice 2001, pp. 229–244.

of entrepreneurial activities.[15] Positive interactions require companies to take their environmental social responsibility obligations seriously. Building and maintaining correct interactions with the environment by enterprises is regarded as a future-oriented source of competitive advantage in the market.[16]

Key competences, as resources, processes and capabilities of a company's competitive advantage, enable access to significant markets, make an important contribution to the perceived benefits of customers, enable cost reductions, make imitation by competitors more difficult, or allow the creation of an appropriate long-term architecture for its management. The company[17] should be able to take care of, identify and create key competences and build development strategies on their foundations.[18] Organisational knowledge plays an important role in the creation of key competences. Key competences form an important part of an organisation's learning system.[19] Ecological competence is the ability to effectively collate ecological resources.[20]

Ecological quality is seen as an active system of quality characteristics of products and manufacturing processes in which ecological parameters and factors will play an important role.[21] This necessitates a combined view of product quality and manufacturing process quality and the perception that the ecological elements relate to both the product characteristics and the ecological characteristics of the

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15 A. Kubasik, *Ekologiczne uwarunkowania działań przedsiębiorczych*, [in:] *Uwarunkowania przedsiębiorczości*, ed. K. Jaremczuk, Państwowa Wyższa Szkoła Zawodowa im. Stefana Tarnowskiego w Tarnobrzegu, Tarnobrzeg 2001, pp. 290–313.

16 J. Wysocki, *Innovative Green Initiatives in the Manufacturing SME Sector in Poland*, "Sustainability" 2021, vol. 13, no. 4, 2386.

17 In the study, the term *company* is used interchangeably with the term *firm* to avoid excessive repetition.

18 M. Bratnicki, *Kompetencje przedsiębiorstwa*, Agencja Wydawnicza Placet, Warszawa 2000, p. 14.

19 J. Rokita, *Organizacja ucząca się*, Wydawnictwo Akademii Ekonomicznej w Katowicach, Katowice 2003, pp. 115–117.

20 K. Zimniewicz, *Współczesne koncepcje i metody zarządzania*, Polskie Wydawnictwo Ekonomiczne, Warszawa 1999, p. 178.

21 A. Chodyński, *Zarządzanie rozwojem firmy. Strategia jakości ekologicznej*, Wyższa Szkoła Zarządzania i Marketingu, Sosnowiec 2002, pp. 74–75.

production technology from obtaining the raw materials to the disposal of the final product. This requires the existence of a system for the formation of product quality and the environment in the chain: raw material suppliers –product manufacturers – product users.

Shaping a company's environmental competence requires the following skills:[22]

1. diagnosing important aspects of the environment,
2. selecting priorities,
3. identifying the ecological profile,
4. following legislative developments,
5. using the so-called good management practices,
6. identifying the product's ecological life cycle,
7. identifying important ecological parameters,
8. reducing environmental risk,
9. applying dynamic approach to environmental risk,
10. identifying and preventing contingent environmental liabilities,
11. determining goodwill for "environmental reasons",
12. creating environmental image of the organisation,
13. cooperating with environmental organisations,
14. using various sources of funding for environmental activities,
15. continuing learning of the staff,
16. drawing on own experience and that of other organisations.

Ecological competence makes it possible to create an ecological quality strategy as a corporate leading strategy. Ecological quality is a dynamic system of quality characteristics of products/services and production processes, where their interrelationships are shaped by ecological factors.[23] Ecological quality refers to the necessity to treat product and process quality holistically as ecological factors relate to product characteristics and ecological characteristics of production technology.

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[22] A. Kubasik, *Obszary kreowania kompetencji ekologicznych przedsiębiorstwa*, "Przegląd Organizacji" 2006, no. 5, p. 29.

[23] *Zarządzanie kompetencjami w organizacji*, ed. E. Masłyk-Musiał, Oficyna Wydawnicza Wyższej Szkoły Menedżerskiej, Warszawa 2005.

Environmental value of the organisation

Corporate values are often listed alongside a company's mission. The mission depicts where the organisation is going, while values define the behavioural aspects that enable the company to achieve its strategic and operational goals. Organisation's values are not only a component of the organisational culture, but are an important factor in company's intangible assets. Research indicates that company's intangible assets account for as much as 80% of the market value valuation of the company.[24] Responsibility for the implementation of corporate values should be placed high up in the company's organisational structure, i.e. in the hands of the managing director, as this implementation should encompass the entire company.[25]

For a widening group of consumers, ecology is an important part of their lifestyle. Ecological ideas (concepts)[26] are already penetrating not only companies, e.g. in the form of manufacturing energy-efficient environmentally friendly products/services, but also those companies that not so long ago were not identified with ecology. Ecological products take different forms, e.g. typical ecological products, products without ecological connotations but trying to touch on ecological issues (e.g. tampons without a plastic applicator), or even non-ecological products (e.g. bottled water) making efforts to escape this perception. Corporate interest in environmentalism should be taken as a good habit.[27]

Companies that intend to implement 'green' measures in their development should start by taking into account the various compositions of corporate values. This shapes the direction of development

[24] A. Stafiej-Bartosik, Ł. Makuch, *Koncentracja na wartościach*, [in:] *Odpowiedzialny biznes 2011. CSR 2.0*, supplement to "Harvard Business Review Polska", July 2011, [as cited in:] M. Hajdas, *Ekologia jako wartość korporacyjna*, "Rocznik Ochrony Środowiska" 2013, vol. 15, p. 2863.

[25] J.M.T. Balmer, E.R. Gray, *Corporate brands: What are they? What of them?*, "European Journal of Marketing" 2003, vol. 37, no. 7/8, pp. 972–997.

[26] Eg the concept of eco-developmental competitiveness or the concept of eco-developmental awareness by Michał Adam Leśniewski.

[27] W. Liu *et al.*, *The organizational collaboration framework of smart logistics ecological chain: a multi-case study in China*, "Industrial Management & Data Systems" 2021, vol. 121, no. 9, pp. 2026–2047.

and creates perspectives for employee action on green initiatives. Corporate Value Index studies show that globally, 18% of companies list the environment among the variety of corporate values. In Polish companies, the percentage is slightly higher at 21%.[28] The generation of the second decade of the 21st century is the first to consider socially responsible business as a basis or hygiene factor rather than a differentiator or added value.[29] In many countries, including Poland, companies that take ecology as one of their corporate values often demand a higher price from consumers for their 'green' efforts. Consumer research conducted in the USA by GfK shows that the percentage of those who are prepared to pay more for 'green' products is declining.[30]

Corporate environmental strategies

In highly developed countries since the 1970s, in Poland since the beginning of the 1990s, environmental protection, mainly product 'greening' and the implementation of pro-ecological production processes, has increasingly become a domain of activity or a strategic goal.[31] Companies aiming at strategic functioning should demonstrate full rationality of ecological strategies and their implementation at a level ensuring meeting the requirements of the market and the changing environment. The 'greening' of a company requires the application of methods and means of operation appropriate to the creation of 'green' products/services.[32] The selection of

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[28] J. Neff, *As more marketers go green, fewer consumers willing to pay for it*, Ad Age, 24.09.2012, https://adage.com/article/news/marketers-green-fewer-consumers-pay/237377 [accessed: 20.06.2023]; M. Hajdas, *op. cit*., p. 2867.

[29] H. Chernoivanova *et al.*, *Efficiency Management of the Enterprises Activity Based on the Principles of Innovative Development*, "International Journal of Computer Science & Network Security" 2021, vol. 21, no. 12, pp. 328–334.

[30] J. Neff, *op. cit.*; M. Hajdas, *op. cit*., p. 2867.

[31] S.U. Rehman *et al.*, *The role of environmental management control systems for ecological sustainability and sustainable performance*, "Management Decision" 2021, vol. 59, no. 9, pp. 2217–2237.

[32] A. Sulich, L. Sołoducho-Pelc, M. Ferasso, *Management Styles and Decision--Making: Pro-Ecological Strategy Approach*, "Sustainability" 2021, vol. 13, no. 4, 1604.

a development and environmental strategy forms the basis of the company's environmental policy, which is the mechanism for implementing and improving the company's holistic environmental management system. It is directed by the company's management and should take into account issues such as:[33]

1. pro-environmental statement by the company's managers,
2. company's environmental priorities,
3. main environmental objectives,
4. ensuring legal requirements in environmental protection,
5. meeting environmental expectations of the local community,
6. a positive attitude on the part of the company towards the environmental requirements of its customers for goods and services,
7. shaping environmental requirements for suppliers of raw materials and materials, directing the reduction of the environmental nuisance of the company and the products/services produced,
8. the way the environmental policy is monitored with other company policies, e.g. product/service quality improvement policy, health and safety policy.

In shaping a company's strategy, it is important to identify and describe current social trends and to analyse the related attitudes, consumer reactions, their needs. Current trends do not appear suddenly, nor do they disappear quickly. Socio-economic changes take shape over the long term and have an impact on social behaviour.

Each organisation shapes its own strategy towards environmental protection. There are four basic types of corporate strategy from an environmental point of view:[34]

1. *Offensive:* which makes use of measures to improve production processes relating to environmental protection. Technical and technological measures are implemented to reduce pressure on the environment,
2. *Innovative:* seeking new technologies adapted to environmental protection over time. This strategy entails activities to create

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[33] A. Wiśniewska, *Strategie proekologiczne w zarządzaniu przedsiębiorstwem*, [in:] *Studia ekologiczno-krajoznawcze w programowaniu rozwoju zrównoważonego. Przegląd polskich doświadczeń u progu integracji z Unią Europejską*, ed. by M. Kistowski, Uniwersytet Gdański, Gdańsk 2004, pp. 93–94.

[34] *Ibidem*.

a secondary use of waste. The measures taken are directed towards a thorough improvement of the company–environment relationship,

3. *Defensive:* the strategy of withdrawing environmentally destructive products/ services from the market and abandoning technologies that do not meet environmental criteria. This strategy is applied until a way, method or means of implementing an offensive or innovative strategy has been found,
4. *Neutral:* complying only with the necessary environmental regulations. Uninterested companies do not attempt to develop an environmental management strategy, understanding that the environmental problem does not concern them.

The environmental strategies shaped by a company can be divided into two basic groups. The first characterises the activities carried out by companies in response to legislated regulations and is referred to as *passive strategy*. The second group includes activities initiated by companies, both affected by the activity of the company's authorities and under the pressure of organisations and social groups, as well as stimuli coming from the market, and is then called *active strategy*.

Passive strategy is the company's primary approach to environmental issues, in which the company limits its environmental activities to the legally required minimum. Meeting the legal aspects requires adequate financial resources and, therefore, environmental protection is treated by companies in terms of costs.

Active strategy demonstrates the great importance companies attach to environmental sustainability, seeing it as a factor that shapes their competitive advantage in the marketplace. Thanks to this strategy, there is an improvement in the image of the company in the attitudes, behaviour of the public and the authorities of the company. The protection of the environment is gradually becoming one of the elements that enable a company to increase its expansion in markets. This strategy is based on a constant search to reduce pressure on the environment.

'Greening' as a determinant of electric vehicles

Over the years, it has become quite popular in the automotive industry to showcase eco-friendly new car models, including electric and hybrid cars, at launches. This may indicate that consumers are definitely more likely to feel responsible for environmental protection and consciously choose more environmentally friendly car models. Car manufacturers are creating so-called "special" models that are directly associated with ecology. An example of this is Toyota Prius, the first mass-produced hybrid car. This model went on sale in 1997 and is still being produced as the next generation. The hybrid powertrain consists of an internal combustion engine and an electric motor. The internal combustion engine is used for basic day-to-day operation and the electric motor is intended to propel the vehicle when we are driving at an easy-going pace and do not have much need for high power. Electricity is generated from mechanical work during braking and is stored in special batteries. The decisive advantages of using this car are lower emissions, reduced fuel consumption and the absence of noise from the combustion engine, as well as the low-emission performance when the car uses only the electric motor. Unlike traditional internal combustion engines, when driving in traffic jams, with relatively frequent stops, the engine automatically switches off and does not need additional power to start up again. It is fashionable to use 'start & stop' systems, which switch off the engine when stationary and restart it when the driver releases the brake and push the accelerator pedal to move the car. In practice, this solution reduces combustion by up to 8%. A major drawback of this Toyota model is the price. The new Prius in the most economic version costs 199,900 PLN gross (as for November 2023). The manufacturer relatively defines the battery life as 5 years or 150,000 km.[35] According to research conducted on the American market by the IntelliChoice company, the cost of purchasing a hybrid car with an average annual mileage of approx. 25,000 km will pay for itself after just 5 years. The study took into

[35] K. Zagajewska, A. Hasiuk, *Aspekty ekologiczne jako stymulatory sprzedaży samochodów*, "Management Systems in Production Engineering" 2011, no. 3, p. 20.

account the loss of value of the car, the purchase of fuel, the cost of maintaining the car, servicing costs, insurance and taxes. It is noteworthy that the research was conducted on the American market, where fuel prices are relatively lower than in Europe, which means that the purchase of a hybrid car should be relatively more attractive for the consumer.[36]

Of the range of internal combustion and hybrid cars, by far the electric car has almost zero contribution to atmospheric pollution and energy consumption can be lower, as electric motors are more efficient than internal combustion engines, can be switched off during stops, and allow a large proportion of kinetic energy to be recovered during deceleration and braking, especially with urban driving included. The main point limiting the mass use of EVs (electric vehicles) is the source of electricity. For economic reasons, the lead acid battery has been the most commonly used to date. The energy stored in this 400 kg battery is equivalent to that provided by 5 litres of fuel. This high mass and low energy efficiency determine that the acceleration speed and range of the EV are low. The lack of a suitable and relatively low-cost source of electricity and the need for combustion engine vehicles to drastically reduce harmful emissions has led manufacturers to strongly consider HEVs[37] (hybrid electric vehicles)[38]. EVs require a continuous energy stream of 40 kWh and this should be provided by the current lithium-ion batteries, which have the highest energy density (Wh/kg). Analysing batteries with the same energy density, the new fourth-generation lithium-ion batteries developed by Hitachi have half the volume and weight of today's highly refined nickel-metal hydride batteries and only 1/3 the volume and weight of today's lead-acid batteries. Hitachi plans to produce 700,000 battery packs for hybrid cars. Battery charging times have reduced to such a level that it is becoming possible to use the batteries to their full potential in vehicles. Today's manufactured lithium-ion batteries can usually be charged to 80% of their capacity in 15 to 60 minutes. It is

[36] *Ibidem*.

[37] The idea of a hybrid vehicle was presented for patenting by Belgian engineer H. Pieper as early as 1905, see: US913846A: Mixed drive for autovehicles, https://patents.google.com/patent/US913846A/en [accessed: 20.06.2023].

[38] K. Polakowski, *Samochody elektryczne pojazdami najbliższej przyszłości?*, "Prace Instytutu Elektrotechniki" 2011, no. 252, p. 24.

noteworthy that a higher charging current results in a faster degradation of the battery and thus in frequent replacement.[39]

Conclusions

The present times force mankind and the employees of organisations (companies) to apply all the principles related to the balance between socio-economic development and the environment in the form of eco-development (sustainable development) or ecology. Any change should start with the individual, the employee of the organisation, who will have an ecological awareness and an eco-developmental awareness, ie types of pro-environmental awareness. Every organisation should manage human resources with a positive attitude towards the environment, i.e. 'green' human resource management. Organisations should have 'green' managers instead of ordinary managers, whose implementation of the management process would be based on environmental values originating from eco-development or ecology. An ecological manager is a profile of a manager who has formed ecological competence, i.e. the ability to see in every aspect of organisational management a concern for the environment. The interweaving of environmental aspects in the decision-making process constitutes the environmental value of an enterprise. Organisation's environmental values should manifest themselves not only through a 'green' personnel process, an environmental strategy, waste sorting or having a hybrid-electric car fleet, but also by offering eco-friendly products/services. 'Green' activities require a company to adopt 'green' strategies, which are to be strategies adopted for years and constantly monitored. One of the manifestations of the 'greening' of an organisation's life, consumers' lifestyles, are electric cars, the purchase and ownership of which is connected, among other things, with the existing global trend or human concern in the form of less harmful impact on the environment. Analysing the level of environmental impact of electric cars, this group of cars has a bright future ahead of it. Electric cars are becoming more and more perfect every year. Electric cars

[39] *Ibidem*, p. 33.

are a certain element that is being incorporated into, among other things, smart homes, smart cities, petrol stations and so on. These cars are environmentally friendly, but attention must be paid to the sources of electricity creation, which not only comes from renewable but also from non-renewable energy sources. Electric cars represent an important positive human response to the environment.

Employees (managers[40] and subordinates) of electric car companies need to have pro-environmental behaviours that enable them to increase the value of ecologically produced electric cars. These behaviours can be considered through the lens of 'green' competences, which can be divided into 'green' behavioural competences and 'green' functional competences. 'Green' behavioural competences (soft competences) manifest themselves in the form of dynamic thinking about innovative changes in the production and operation of electric cars, increasing environmental knowledge of electric cars, thinking permanently about improvements in the use of electric cars, learning to use all goods used in the production of electric cars economically, etc. 'Green' functional competences (hard competences) manifest themselves in the form of waste segregation, reduction of waste generation (e.g. zero waste concept), energy-efficient production of electric cars, creation of rules for economical use of electric cars that are simple to describe to customers, etc.[41]

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[40] Managers in electric car companies need to implement a 'green' staffing process that will enable them to recruit employees with environmental awareness or eco-consciousness, very important for a pro-environmental company.

[41] Ł.J. Kozar, P. Oleksiak, *Organizacje wobec wyzwań zrównoważonego rozwoju – wybrane aspekty,* Wydawnictwo Uniwersytetu Łódzkiego, Łódź 2022, p. 41.

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Process excellence in electric vehicle service companies: environmental aspect

Abstract
Climate warming is the result of human activity. This is a serious problem and challenge for the whole world. Therefore, it is necessary to take measures to inhibit negative changes and the resulting socio-economic consequences (e.g. costs associated with extreme weather events). The most important task is to reduce greenhouse gas emissions into the atmosphere. Gas emissions in some sectors are increasing, which is especially true of transportation. One important part of this task is the transition from fossil fuels to zero-carbon energy sources. This means decarbonizing the transportation sector. The challenge is the development of electromobility (electric vehicles / EV industry). In this case, we can talk about an ecosystem of electric vehicles, in which we are dealing not only with manufacturers of these vehicles, but with suppliers of products and services. The early stage of development of this industry poses challenges in improving and achieving maturity, and ultimately process excellence. It has been pointed out that the achievement of process excellence is associated with the attainment of increasingly higher levels of maturity, the assessment of which requires the use of appropriate tools, the so-called maturity models. The purpose of the article is to evaluate the practical use of the concept of organizational process maturity in EV companies for achieving excellence. The research method used in this study is a critical review of concepts and views found in the contemporary literature on the subject.
Keywords: excellence, process maturity, process maturity models, electric vehicle ecosystem

Introduction

Human activity has a dominant influence on climate warming, which is mainly the result of greenhouse gas emissions.[1] The adoption of the United Nations Framework Convention on Climate Change (UNFCCC), successively the Kyoto Protocol (1997) and the Paris Agreement (2015) have become formal recognition, both of the causes of climate change (as an effect of human activity) and the assumption of responsibilities to counter it and its effects. In December 2019, the European Commission announced the European Green Deal (EGD) as a strategy through which EU climate neutrality can be achieved. EU leaders embraced the initiative and backed the goal of achieving EU climate neutrality by 2050. This followed commitments made in 2015 by the EU and member states in connection with the signing of the Paris Agreement. The EGD is the EU's strategy for achieving the goal of climate neutrality by 2050. The EGD emphasizes the need for a holistic and cross-sectoral approach in which all relevant policy areas contribute to the overarching climate goal. The package includes initiatives in a number of closely related areas, like climate, environment, energy, transport, industry, agriculture and sustainable financing. In the European Climate Law, which is part of the EGD, the EU has set a binding target: to achieve climate neutrality by 2050. This means that greenhouse gas emissions must decrease significantly in the coming decades. An intermediate step toward climate neutrality is to be the more ambitious goal of reducing emissions by a minimum of 55% by 2030. A consistent and faster reduction of emissions in all sectors of the economy is therefore necessary. A new law will be needed in all sectors where CO_2 is emitted today. To this end, the *Fit for 55* package has been created to transform the assumptions of the EGD into concrete regulations, with no exceptions. It includes changes for electricity, buildings, heating, transportation,

[1] See: *Summary for Policymakers*, [in:] *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. V. Masson-Delmotte *et al.*, Cambridge University Press, Cambridge–New York, pp. 3–32, https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf [accessed: 18.06.2022].

industry, agriculture and forestry, and the introduction of tools to mobilize real change in the form of rules, norms and standards (e.g. emissions standards for new cars). For manufacturers, this means incentives to develop pro-environmental product offerings and invest in technologies that reduce CO_2 emissions. From the consumer's perspective, it means that it will be impossible to choose carbon-intensive solutions (standards) or the cost of emissions will be factored into the price.

Greenhouse gases emissions continue to rise in some sectors (including transportation). The element of the EGD in this area is the Sustainable and Smart Mobility Initiative. It is assumed that a net-zero-emissions society and economy will not be possible without a more sustainable and smarter mobility sector. It is estimated that in order to achieve climate neutrality, transportation sector emissions must be reduced by 90% by 2050. To this end, in the *Fit for 55* package, the European Commission has proposed to revise CO_2 regulations for cars and vans. The EU-wide reduction targets for 2030 are to be increased, and the new target for 2035 is to reach 100%. In practice, this means that no more cars or vans with internal combustion engines will be allowed on the EU market from 2035. In June of 2022 the European Parliament voted on a plan to ban the sale of cars with internal combustion engines after 2035. More strict CO_2 standards for cars and vans are expected to help member states meet the increased national targets under the Effort Sharing Regulation, while spurring technological innovation in the sector. Electric vehicles (EVs) are believed to be more environmentally friendly than conventional vehicles and could reduce reliance on diesel fuel, and in addition to reducing harmful emissions, it will be possible to reduce noise.

Reducing emissions is the subject of the Electromobility Development Program, which is one of the key projects of the Polish Strategy for Responsible Development (Pol. Strategia na rzecz Odpowiedzialnego Rozwoju, SOR).[2] This was followed by a regulatory package consisting of planning documents and legal acts:

[2] *Informacje o Strategii na rzecz Odpowiedzialnego Rozwoju*, https://www.gov.pl/web/fundusze-regiony/informacje-o-strategii-na-rzecz-odpowiedzialnego-rozwoju [accessed: 18.06.2022].

- Plan for the Development of Electromobility in Poland "Energy to the Future" (defines the benefits associated with the spread of the use of electric vehicles in our country and identifies the economic and industrial potential of this area and discusses the objectives, including the creation of conditions for the development of electromobility, the development of industry in the area of electromobility, the stabilization of the electricity grid).[3]
- National policy framework for the development of alternative fuel infrastructure (implements European regulations on, among other things, the conditions for building infrastructure for alternative fuels).[4]
- Law on Electromobility and Alternative Fuels (its purpose is to stimulate the development of electromobility and promote the use of other alternative fuels (including LNG and CNG) in the transport sector in Poland).[5]
- The law establishing the Low Emission Transport Fund (LETF), its task is to finance projects related to the development of electromobility and transportation based on alternative fuels. With the funds from the LETF, the goals established in other strategic documents will be implemented.[6]

The plan indicates that one of the prerequisites for the success of electromobility development in Poland is "the establishment of a foundation for the electromobility ecosystem and the coordination of electromobility industry development activities, the stimulation

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[3] *Plan Rozwoju Elektromobilności w Polsce „Energia do przyszłości"*, Ministerstwo Energii, Warszawa 2017, https://www.gov.pl/web/klimat/elektromobilnosc-w-polsce [accessed: 18.06.2022].

[4] *Krajowe ramy polityki rozwoju infrastruktury paliw alternatywnych*, Ministerstwo Energii, Warszawa 2017, https://www.gov.pl/attachment/ff504f84-5cbc-45b1-9c5a-4d089a634a8b [accessed: 18.06.2022].

[5] Ustawa z dnia 11 stycznia 2018 r. o elektromobilności i paliwach alternatywnych, Dz.U. [Journal of Laws of the Republic of Poland] 2018, item 317, https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20180000317 [accessed: 18.06.2022].

[6] Ustawa z dnia 6 czerwca 2018 r. o zmianie ustawy o biokomponentach i biopaliwach ciekłych oraz niektórych innych ustaw, Dz.U. 2018, item 1356, https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20180001356 [accessed: 18.06.2022].

of demand for electric vehicles and the exemplary role of the administration."[7]

Electric vehicles ecosystem (EVE)

Planning documents use the term 'electromobility' or 'electromobility market'.[8] This term can be associated with all issues related to the use of electric vehicles, operation and technical issues related to EVs, such as infrastructure or charging technology. Important formal-legal or socio-economic aspects cannot be overlooked. In the scientific literature, one may encounter the term electric vehicle industry or EV industry. Electric vehicles use one or more electric motors as a source of propulsion, powered either directly from an external power plant, or by an on-board electric generator. Electric vehicles include plug-in electric cars, hybrid cars, hydrogen-powered vehicles, electric trains, electric buses, electric trucks and electric motorcycles/scooters. Given the relatively short existence of this industry, particularly in Poland, it can be said to be an emerging industry.[9] Electric vehicles have the potential to change the nature of the entire vehicle manufacturing industry and the ecosystem surrounding current fuel vehicles.[10] However, the EV industry needs an ecosystem that can provide the necessary technologies, services and processes to facilitate its market penetration. Emerging industries often emerge amid technological and market uncertainty, as well as a weak industrial system.[11] Researchers suggest fostering a business ecosystem around an emerging industry,[12]

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7 *Plan Rozwoju Elektromobilności w Polsce…*, *op. cit.*, p. 12.

8 *Ibidem*.

9 Ch. Lu *et al.*, *Business ecosystem and stakeholders' role transformation: Evidence from Chinese emerging electric vehicle industry*, "Expert Systems with Applications" 2014, vol. 41, no. 10, pp. 4579–4595.

10 Ch. Petrie, *Changing the World*, "IEEE Internet Computing" 2012, vol. 16, no. 1, pp. 87–89.

11 K. Rong, Y. Shi, J. Yu, *Nurturing business ecosystem to deal with industry uncertainties*, "Industrial Management & Data Systems" 2013, vol. 113, no. 3, pp. 385–402.

12 J.F. Moore, *The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems*, Harper Business, New York 1996.

and creating a friendly and healthy network of stakeholders.[13] The concept of a business ecosystem would equip companies with a more comprehensive view of inter-industry cooperation, rather than directly linking supply chain partners.[14]

Within the emerging industry business ecosystem, stakeholders are viewed as agents driving complex behaviour through interactions with other system players (or agents) and the environment.[15] Business ecosystems address business opportunities that require a diverse set of capabilities to meet customer needs that are beyond the capabilities of a single company.[16] A business ecosystem can invest more resources and accept more risk by sharing costs, integrate a broader set of differentiated capabilities and develop a broader set of products.[17] Business ecosystems work to incorporate the next round of innovation by combining the synergies of different companies and public actors towards a common innovation.[18] The competitive and cooperative interactions of actors contribute to the ecosystem by creating new offerings and satisfying customer needs.[19] In this way, actors in a co-evolutionary relationship activate selective pressure on others and influence each other's evolution.[20] In an ideal ecosystem, actors share resources, knowledge and technologies across the eco-

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[13] M. Iansiti, R. Levien, *The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation and Sustainability*, Harvard Business School Press, Boston, MA 2004; M. Kenney, B. Pon, *Structuring the smartphone industry: is the mobile internet OS platform the key?*, "Journal of Industry, Competition and Trade" 2011, vol. 11, pp. 239–261.

[14] K. Rong, Y. Shi, J. Yu, *op. cit*.

[15] Ch. Rammel, S. Stagl, H. Wilfing, *Managing complex adaptive systems – A co-evolutionary perspective on natural resource management*, "Ecological Economics" 2007, vol. 63, no. pp. 9–21.

[16] P. Carbone, *The Emerging Promise of Business EcoSystems*, "Open Source Business Resource", February 2009, Technology Innovation Management Review, https://www.timreview.ca/article/227 [accessed: 12.06.2022].

[17] M. Iansiti, R. Levien, *Strategy as Ecology*, "Harvard Business Review" 2004, vol. 82, no. 3, pp. 68–78.

[18] J.F. Moore, *Predators and Prey: A New Ecology of Competition*, "Harvard Business Review" 1993, vol. 71, no. 3, pp. 75–86.

[19] *Ibidem*.

[20] A. Corallo, *The Business Ecosystem as a Multiple Dynamic Network*, [in:] *The Digital Business Ecosystem*, eds. A. Corallo, G. Passiante, A. Prencipe, Edward Elgar Publishing, Cheltenham 2007, pp. 11–32.

system, providing the basis for holistic value creation through the ecosystem.[21] Each organization adds its distinct aspects of offerings to the value generated by the ecosystem and shares the total value created by the ecosystem.[22] Ecosystem productivity can be measured by the network's ability to consistently reduce costs and introduce new products.

The literature points to various classifications of participants in the business ecosystem.[23] J.F. Moore proposed that member organizations within a business ecosystem include suppliers, leading manufacturers, competitors and other stakeholders such as government, local governments, industry associations, standards bodies, competitors, and business opportunities.[24] In emerging ecosystems such as the EV ecosystem, focal companies typically focus on working with relevant stakeholders such as leading customers, key suppliers and channels to define new customer value propositions based on innovation, determine how to deliver and implement the customer value proposition, and design a business that serves the potential market.[25] The EV ecosystem has been competing with the fuel vehicle ecosystem for some time without significant global success and most likely largely due to the dominance of a key stakeholder, the vehicle manufacturing industry. For the other stakeholders, the market and negotiating power is much less. Thus, the EV ecosystem is not yet providing a good enough business case for the majority of customers

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21 G. Hearn, C.A. Pace, *Value Creating Ecologies: Understanding Next Generation Business Systems*, "Foresight" 2006, vol. 8, no. 1, pp. 55–65.

22 L.M. Camarinha-Matos *et al.*, *Collaborative Networked Organizations – Concepts and Practice in Manufacturing Enterprises*, "Computers & Industrial Engineering" 2009, vol. 57, no. 1, pp. 46–60.

23 B. Iyer, Ch.-H. Lee, N. Venkatraman, *Managing in a small world ecosystem: Some lessons from the software sector*, "California Management Review" 2006, vol. 48, no. 3, pp. 28–47; E. den Hartigh, T. van Asseldonk, *Business ecosystems: A research framework for investigating the relationship between network structure, firm strategy, and the pattern of innovation diffusion*, paper presented at the ECCON 2004 annual meeting "Co-jumping on a trampoline", Driebergen, The Netherlands, 22–23 October 2004; K. Rong, Y. Shi, J. Yu, *op. cit.*; M. Iansiti, R. Levien, *Strategy as Ecology*, *op. cit.*

24 J.F. Moore, *The Death of Competition…*, *op. cit.*

25 Idem, *Predators and Prey…*, *op. cit.*

and consequently cannot realize its market potential.[26] The great challenge for the EV ecosystem in this competition is to change this status quo by creating compelling value propositions for customers that themselves facilitate the emergence and growth of a thriving global business ecosystem. The EV industry is an emerging industry with strong industrialization potential that requires support from all stakeholders in the business ecosystem.[27] The EV industry faces many challenges. Various studies conducted around the world point to aspects such as:

- Consumers' willingness to pay, attitudes and behaviour, awareness and preferences, which appear to be crucial to the introduction of EVs into the market,[28]
- Consumer concerns about the driving range of electric vehicles and their accessibility due to the charging time required[29]; in addition, consumers appear to be uncertain about potential savings on fuel costs, which is one of the obvious arguments in favour of electric vehicles,[30]

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[26] Ch. Petrie, *op. cit*.

[27] K. Rong, Y. Shi, J. Yu, *op. cit.*; K. Rong *et al.*, *Business ecosystem extension: Facilitating the technology substitution*, "International Journal of Technology Management" 2013, vol. 63, no. 3–4, pp. 268–294; K. Rong, *et al.*, *Linking business ecosystem lifecycle with platform strategy: A triple view of technology, application and organization*, "International Journal of Technology Management" 2013, vol. 62, no. 1, pp. 75–94.

[28] M.K. Hidrue, *et al.*, *Willingness to Pay for Electric Vehicles and their Attributes*, "Resource and Energy Economics" 2011, vol. 33, no. 3, pp. 686–705; S. Skippon, M. Garwood, *Responses to Battery Electric Vehicles: UK Consumer Attitudes and Attributes of Symbolic Meaning Following Direct Experience to Reduce Psychological Distance*, "Transportation Research Part D: Transportation and Environment" 2011, vol. 16, no. 7, pp. 525–531; J. Axsen, K.S. Kurani, A. Burke, *Are Batteries Ready for Plug-in Hybrid Buyers?*, "Transport Policy" 2010, vol. 17, no. 3, pp. 173–182; T. Lieven, *et al.*, *Who will Buy Electric Cars? An Empirical Study in Germany*, "Transportation Research Part D: Transport and Environment" 2011, vol. 16, no. 3, pp. 236–243; Y. Zhang, Y. Yu, B. Zou, *Analyzing Public Awareness and Acceptance of Alternative Fuel Vehicles in China: The Case of EV*, "Energy Policy" 2011, vol. 39, no. 11, pp. 7015–7024; Z. Zulkarnain *et al.*, *Electric Vehicles Market Outlook*, "International Journal of Technology" 2012, vol. 3, no. 2, pp. 156–168.

[29] M.K. Hidrue *et al.*, *op. cit*.

[30] S. Skippon, M. Garwood, *op. cit*.

- EV's positive impact on CO_2 emissions,[31]
- EV charging will affect daily and hourly electricity demand, which may require some regulation or at least demand-based pricing to offset peak demand,[32]
- Electric vehicles can be used as distributed electricity storage when not in use, which would require a smart grid,[33]
- Some of the challenges are related to vehicles, charging infrastructure, battery technology and standardization, and are also related to the design of electric vehicles to adequately meet consumer demands. Design is about performance, style, etc., which requires new types of industry value chains compared to the old structure of the automotive industry. According to most experts, even though there are infrastructure challenges, the most profound problem for EVs is the battery. This is mainly due to the cost of the battery. Several issues related to battery technology need to be solved, such as reducing weight, volume, charging time, operating temperature dependence, and the use and disposal of toxic components. The latter will be a problem when disposing of batteries. Eventually, a disposal system must be developed and financed.
- From an environmental point of view, the problem is the manufacturing process, which can emit more CO_2 than the production of fuel-powered vehicles, by up to 70%.[34] This is of particular importance for taking optimization measures in the production process. Of course, it is not possible to eliminate carbon dioxide from

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[31] A. Perujo, B. Ciuffo, *The Introduction of Electric Vehicles in the Private Fleet: Potential Impact on the Electric Supply System and on the Environment; A Case Study for the Province of Milan, Italy*, "Energy Policy" 2010, vol. 38, no. 8, pp. 4549–4561; C. Camus, T. Farias, J. Esteves, *Potential Impacts Assessment of Plug-in Electric Vehicles on the Portuguese Energy Market*, "Energy Policy" 2011, vol. 39, no. 10, pp. 5883–5897.

[32] A. Perujo, B. Ciuffo, *op. cit*.

[33] P.H. Andersen, J.A. Mathews, M. Rask, *Integrating Private Transport into Renewable Energy Policy: The Strategy of Creating Intelligent Recharging Grids for Electric Vehicles*, "Energy Policy" 2009, vol. 37, no. 7, pp. 2481–2486.

[34] According to Volvo research, *Carbon footprint report: Volvo C40 Recharge*, Volvo, 2021, pp. 5, 6, 24, https://www.volvocars.com/images/v/-/media/market-assets/intl/applications/dotcom/pdf/c40/volvo-c40-recharge-lca-report.pdf [accessed: 18.06.2022].

the production process, but it is possible to balance emissions, such as obtaining energy from RES – the sun (e.g. Gigafactory – the roof of the factory covered with solar cells) or wind, cooperation with companies that use RES, such as energy suppliers or suppliers of cells, in effect this can lead to neutrality in the balance of CO_2 emissions.

The EV ecosystem and its participants

The literature identifies participants within the EV ecosystem (EVE). The EV ecosystem consists of both public and private actors, but ex ante it is assumed that private actors are more dominant in the formation of the EV ecosystem. The EV ecosystem model can include the following main actors (Figure 1):

- End users of consumer electronics who use consumer electronics for mobility purposes. They include consumers, corporate customers and the public sector,
- Power utilities and infrastructures (PUI): facilities that enable the operation of electric vehicles, i.e., charging points, grid providers, electricity producers, fuel suppliers (in the case of hybrid electric vehicles),
- EV manufacturers: a key element in EVE that includes EV manufacturers (OEM), EV suppliers, component suppliers and their related service providers (e.g. mobility/telematics service providers and EV rental service providers),
- Battery suppliers: including battery manufacturers, component suppliers and related research and development (R&D). Together with power companies and electrical system manufacturers, they address identified challenges regarding technical aspects,
- Regulators and external actors: policy makers/regulators from every level of government, e.g. intergovernmental bodies, regional bodies, member states, municipalities and local authorities; EV-related industry association, academic players, R&D centres, and environmentalists as "catalysts" for EV policy implementation,
- EV aggregators/integrators: a system integrator to be a key operator for the ecosystem. The integrator can be one of the existing

players, a brand new player, or a combination of both (e.g. a joint venture).

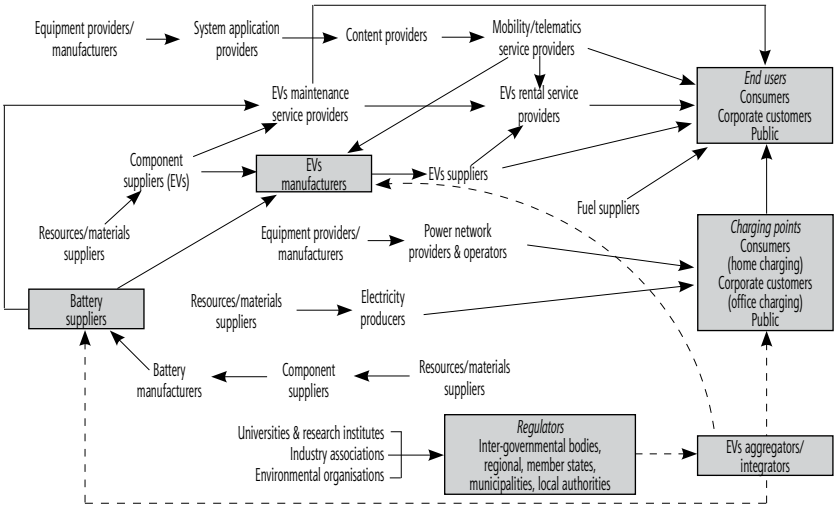

Figure 1. Electric vehicle ecosystem (EVE) model (solid lines – current offerings/ actors, dashed lines – future offerings/actors)

Source: based on Z. Zulkarnain *et al.*, *Electric Vehicles Market Outlook*, "International Journal of Technology" 2012, vol. 3, no. 2, pp. 156–168.

Analysing the EV ecosystem in terms of process implementers, including with regard to ecological aspects, makes it possible to identify problem areas and challenges facing them.

The use of electric vehicles is associated with a range of services of a maintenance nature. This can mean greater use of technology and information systems, for example, in parameter control, which can translate into quick response, greater precision and new service standards. One can point to, for example, the spread of options for remote diagnosis of technical problems in vehicles of various types – cars, trucks or buses. Some of the internal combustion models already offer similar solutions, but it is only in electric vehicles that they are to be used on a large scale. It is not a matter of collecting data and notifying only in the event of an accident or breakdown, but they can be crucial in the process of managing, for example, a fleet of vehicles by the operator and optimize the cost of use, including battery

life, a key element in the environmental aspect. Services from such companies can collect data and send it to manufacturers to optimize future designs and solutions in terms of data collected in "real life" and for real operating conditions.

Concerns are evident on the part of buyers and users, as well as dealerships, but also service centres, which will be servicing and repairing EVs under warranty, as well as after the warranty expires. EV tests and studies conducted in the US, among others, have already proven their low failure rate. However, they seem to be overly optimistic. One of the most serious problems is the inadequate availability of specialists and workshops where they can and will be repaired in the future. Surveys in Poland indicate that the level of preparation of specialists responsible for servicing and repairing EVs is very low and needs to be quickly supplemented. Only 30% of authorized service centres (Pol. *autoryzowana stacja obsługi*, ASO) have had the opportunity to repair electric cars, while just over 35% of service advisors have knowledge of the rules for servicing and maintenance of electric cars.[35] Competency deficiencies among the staff are a necessity to take this aspect into account in the processes responsible for the development of employees in the companies of distributors and dealers of electric cars, but especially ASOs, technical testing stations performing inspections, and above all service establishments, such as car repair shops. This situation affects not only Poland. The problem is also pointed out by the British Institute of the Motor Industry, whose research showed that as many as 97% of mechanics in Britain had neither the knowledge nor the qualifications necessary to service and repair electric cars. The remaining 3%, however, were employed at ASOs of particular brands offering EVs.

The rise of EVs will generate waste in the near future, which will begin to pose an increasingly serious environmental challenge. Used batteries will have to be recycled, but there are solutions that make this possible. The process, by taking this aspect into account already at the design stage, makes it easier to recycle them, in an automated manner using robots. Another aspect is the use of batteries that have

[35] *Elektromobilność w Polsce 2019*, report by Nowe Motywacje, https://nowemotywacje.pl/elektromobilnosc-w-polsce/ [accessed: 18.06.2022].

been replaced for other purposes, hence this could be a potential area for the development of services based on such cells.

The results of IHS Markit's study, *Reinventing the Wheel (RTW): the Future of Cars, Oil, Chemicals, and Electric Power*, may be an important aspect in the analysis of ecosystem players. The study models the penetration of new mobile services and electric systems, including electric vehicles. Three dimensions of competition are identified: type of propulsion (traditional drives will compete with alternative drives – electric, biofuels, hydrogen), type of ownership (car users will choose between owning and using, having the choice of driving on-demand or renting a vehicle (car-sharing)), and level of automation (driver-driven cars will compete with autonomous vehicles). The intersection of these processes is depicted in the form of the mobility cube (Figure 2).[36]

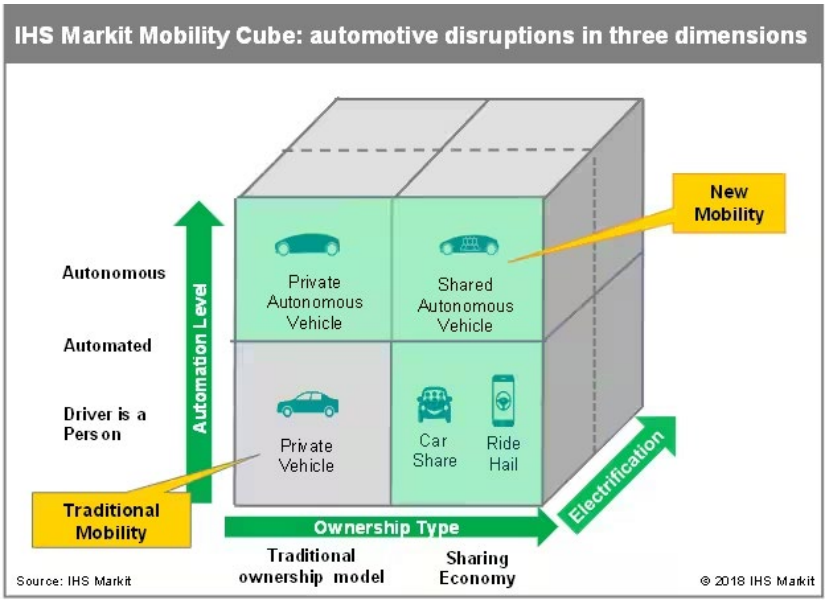

Figure 2. IHS Markit mobility cube

Source: *Multi-dimensional future of mobility means that oil demand outlook is far from clear*, https://ihsmarkit.com/research-analysis/multidimensional-future-mobility-oil-demand-out.html [accessed: 18.06.2022].

[36] *Multi-dimensional future of mobility means that oil demand outlook is far from clear*, https://ihsmarkit.com/research-analysis/multidimensional-future-mobility-oil-demand-out.html [accessed: 18.06.2022].

In the ownership dimension, there is a shift from a model of traditional ownership to a model of on-demand use and sharing of a resource. The autonomy dimension presents the transition from the driver as a person, through the automation of driving, to autonomous cars. The vehicle electrification dimension, on the other hand, refers to the transition from traditional to electric drives. This multidimensional model makes it possible to understand the ongoing, predicted changes in the behaviour of consumer-users of EVs under the influence of dynamic processes taking place in each dimension. The model makes it possible to forecast the growing role of companies implementing services related to electrification and the accompanying changes in the presented dimensions, and thus the need to analyse and improve the processes implemented by these entities.

Excellence vs. process maturity

Today's companies are constantly looking for new solutions and system concepts to improve efficiency in the face of competition in a changing market. Variability forces the emergence of a new type of organization, based on a flat structure, "lean", using the work of teams, constantly adapting their activities to the needs and requirements of customers. Focusing primarily on groups of tasks, activities aimed at satisfying internal and external customers, bringing them value is characteristic of the process approach. S. Nowosielski[37] and P. Grajewski[38] share the view that the Business Process Approach is now one of the key orientations of organization and management, most widely and frequently used in theory and practice. The essence of this approach lies in replacing inflexible functional structures with much more flexible matrix structures. Only those activities through which the organization is able to quickly and efficiently identify, satisfy or even create customer needs and

[37] *Podejście procesowe w organizacjach*, Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu, ed. S. Nowosielski, Wrocław 2009, pp. 125–134.

[38] P. Grajewski, *Procesowe zarządzanie organizacją*, Polskie Wydawnictwo Ekonomiczne, Warszawa 2012, p. 22.

expectations are subject to management.[39] The degree of process implementation in an organization is reflected in the organization's process maturity concept.[40]

The concept of excellence in management was introduced by T.J. Peteres and R.H. Waterman. They pointed out the attributes that characterize an excellent enterprise: inclination, sticking close to the customer, autonomy and entrepreneurship, productivity through people, direct contact with staff, motivation by values, sticking to one's specialty, simple structure and relatively few staff at the corporate headquarters, and the presence of loose and rigid features of the organization.[41] Excellence is associated with the concept of quality, success factors and continuous improvement. Excellence (Latin: *perfectio*) means a flawless, harmonious state.[42] One can also point to synonyms best, exemplary, unsurpassed, excellent, complete. In praxeology, certain characteristics of perfect activity are pointed out: effectiveness, efficiency, cost-effectiveness,[43] while from the essence of management comes the pursuit of perfection. When looking for areas and opportunities for management improvement, attention should be focused on process improvement, as S. Cyfert explicitly points out.[44] Improvement is an approach that, through the continuous introduction of changes, leads to a significant improvement in the quality of processes and products, as well as to an increase in customer satisfaction and an increase in the efficiency of the enterprise.[45]

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[39] Idem, *Koncepcja struktury organizacji procesowej*, TNOiK, Toruń 2003, p. 106.

[40] T.B. Kalinowski, *Dojrzałość procesowa a wyniki organizacji*, Wydawnictwo Uniwersytetu Łódzkiego, Łódź, 2018, p. 7.

[41] A. Skrzypek, *Dojrzałość i doskonalenie organizacji*, TNOiK, Toruń 2019, p. 187.

[42] K. Hys, *Dyfuzja systemu zarządzania jakością i koncepcji społecznej odpowiedzialności organizacji*, Wydawnictwo Politechniki Opolskiej, Opole 2015, p. 47.

[43] M. Juchniewicz, *Koncepcje doskonalenia organizacji – ewolucja, krytyka, perspektywy rozwoju*, "Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu" 2017, no. 463, pp. 35–36.

[44] S. Cyfert, *Strategiczne doskonalenie architektury procesów w zarządzaniu przedsiębiorstwem*, Wydawnictwo Akademii Ekonomicznej w Poznaniu, Poznań 2006 (Prace Habilitacyjne no. 28), p. 25.

[45] M. Juchniewicz, *Koncepcje doskonalenia organizacji…*, *op. cit.*, p. 36.

The goal of the improvement process is to achieve the assumed ideal state, or perfection. Thus, improvement is the way, and excellence is the goal and effect.

The improvement of an organization's operations is carried out mainly through process improvement and the implementation of environmental and safety management systems, management methods and tools for improvement (e.g. Six Sigma, Lean Management, Balanced Scorecard and other global best practices for improvement). Excellence is related to the concept of maturity, i.e. the ability to implement certain activities. Maturity is defined as "a state of full development", "a state of readiness for certain tasks", "full formation". The concept of *organization's maturity* was introduced into management theory by Philip Crosby, an American quality management specialist in the 1970s.[46] M. Juchniewicz points out that the process of achieving maturity is related to the improvement of skills until they are fully achieved in various dimensions: economic, social or biological.[47] Process excellence is associated with varying degrees of maturity of process execution.

The concept of Business Process Maturity is defined in the literature as the degree to which processes are identified, managed, measured, controlled and effective.[48] Process maturity affects the flexibility and effectiveness of processes that are formally defined, managed and measured.[49] M. Rosemann, T. De Bruin and T. Hueffner define process maturity in the dimensions of coverage and proficiency, comparing them to effectiveness and efficiency in relation to processes. Coverage reflects the degree of implementation and execution of process management principles in a company,

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[46] Idem, *Dojrzałość projektowa organizacji*, Wydawnictwo i Firma Poligraficzna Bizarre, Warszawa 2009 (Biblioteka Project Managera), p. 11.

[47] Idem, *Osiąganie doskonałości w realizacji projektów przy wykorzystaniu modeli dojrzałości projektowej*, [in:]: *Zarządzanie projektami – wyzwania i wyniki badań*, eds. M. Trocki, E. Bukłaha, Oficyna Wydawnicza SGH, Warszawa 2016, p. 36.

[48] W.S. Humphrey, *Characterizing the Software Process: A Maturity Framework*, Carnegie-Mellon University, Software Engineering Institute, Pittsburgh 1987, pp. 1–10.

[49] A. Bitkowska, *Ocena dojrzałości procesowej organizacji zgodnie z modelem CMMI*, "Ekonomika i Organizacja Przedsiębiorstwa" 2016, no. 10, pp. 3–12.

while proficiency indicates the quality and effectiveness of process management. Achieving process maturity requires improvement in both coverage and proficiency.[50] T. Grajewski refers process maturity to the extent to which processes are formally defined, managed, flexible, measured and effective.[51] A. Bitkowska defines process maturity as the degree of implementation of process orientation, i.e. a measure of structuring, standardization and optimization.[52] Maturity is strongly related to the state of readiness for certain behaviours. It can signify the achievement of a state of full development and creates opportunities for excellence. The growing interest from the business practice of academia has influenced the emergence of tools for assessing the degree of process maturity, as well as supporting the improvement of aspects of process management in the organization. A process maturity model, according to Software Engineering Institute, is a model that describes the evolutionary path of process improvement in an organization from immature to mature.[53] It can be based on best practices and provides guidance to organizations on how to move from ill-defined and executed processes to implementing stable process practices, which are predictable, optimized and continuously improved.[54] A. Bitkowska defines a design maturity model as a matrix (reference template) that allows process evaluation and improvement. It serves primarily as a tool for describing and analysing the current state and determining the shape of the target state. Based on the analysis of the literature, several components of the process maturity model can be identified synthetically:

- Form: tool; reference standard; collection of elements,

[50] I. De Toro, T. McCabe, *How to stay flexible and elude fads*, "Quality Progress" 1997, vol. 30, no. 3, pp. 55–60.

[51] P. Grajewski, *Uwarunkowania implementacji procesów do organizacji*, "Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu" 2009, no. 52, pp. 381–388.

[52] A. Bitkowska, *Zarządzanie procesowe we współczesnych organizacjach*, Difin, Warszawa 2013, p. 143.

[53] *CMMI for Development*, Version 1.3, Carnegie Mellon University, Software Engineering Institute, Pittsburgh 2010, p. 501.

[54] Ch. Weber, B. Curtis, T. Gardiner, *Business Process Maturity Model (BPMM)*, Version 1.0, Object Management Group, Inc., https://www.omg.org/spec/BPMM/1.0/PDF [accessed: 15.06.2022].

- Purpose: to assess and analyse the level of maturity and determine the desired state; implement best practices aimed at improvement,
- structure: sequential levels of maturity (from immature to mature processes, with a description of how to move between them); evolutionary methodology for implementing process practices (guidance on how to move from poorly performing processes to stable process practices); evolutionary path for process development or improvement.

The definition of a process maturity model, as well as their construction, indicate their gradability.[55] Process maturity models can be divided into two groups: the first refers to the state of individual processes in the organization, the second refers to the process maturity of the organization as a whole, and thus goes beyond the understanding of process maturity sensu stricto (e.g. includes organizational maturity or other types of maturity).[56] An example of a model included in the first group is the CMM/CMMI model (Capability Maturity Model/ Capability Maturity Model Integrated), on which many other process maturity models have been modelled. This model is built from process areas, which form sets of interrelated best practices. Within the process areas, lists of goals (general and specific) and practices are identified. Practices are defined as activities that are important for achieving the goals. The maturity level of processes can be assessed on the basis of scales, called the CMMI representation. This representation can be fixed/staged or continuous. The continuous scale provides an opportunity to assess the state of the organization as a whole, with less focus on the maturity of the processes implemented in it. It is therefore more relevant in developing a standard approach to process improvement within an organization, and can also be used to benchmark processes between organizations. The continuous scale (representation) provides an opportunity to focus on specific processes that are important in terms of the organization's strategic goals. This model was the inspiration for another popular model, BRMM-OMG (Business Process

[55] T.B. Kalinowski, *op. cit.*, p. 70.

[56] M. Röglinger, J. Pöppelbuß, J. Becker, *Maturity models in business process management*, "Business Process Management Journal" 2012, vol. 18, no. 2, pp. 333–338.

Maturity Model – Object Management Group).[57] A number of other models are also described in the literature, such as PEMM (Process and Enterprise Maturity Model) by M. Hammer or MMM/BPOMM (McCormack Maturity Model / Business Process Orientation Maturity Model).[58]

Linking maturity models to various concepts commonly used in management involves a combination of continuous improvement and benchmarking, so that processes and organizations can be improved based on comparison and the adoption of best practices.

Conclusions

The development of electromobility means an increase in GDP, noticeable benefits for the environment, especially reducing the problem of smog in cities. The electrification of transportation itself will also create new jobs. Electromobility is not only the production of components for vehicles, the vehicles themselves and the infrastructure for charging them, but also the growing impact on other entities, including the development of services and many other areas of daily life, and above all the emergence of new business models in the service sector for the EV industry, such as those using digital technologies. Tools such as process maturity models will be helpful in assessing how prepared companies are to provide quality services.

Maturity indicates how and to what degree one is prepared to perform certain tasks. At the same time, it should be noted that achieving even the highest level of maturity, is not the same as achieving excellence, which requires continuous improvement. Assuming that maturity means organizational capabilities, then excellence defines the achievement and maintenance of the highest level of performance, satisfying all stakeholders of the enterprise. This approach allows us to conclude that maturity refers to the way an organization is organized, while excellence focuses on organizational performance. The basic premise of maturity models is the growth of organizational

[57] *About the Business Process Maturity Model Specification Version 1.0*, https://www.omg.org/spec/BPMM/ [accessed: 15.06.2022].

[58] T.B. Kalinowski, *op. cit.*, pp. 53–86.

capabilities to implement strategies and achieve organizational goals. With the maturity level analysis capabilities provided by process maturity models, companies are stimulated to improve and build new organizational capabilities, and a more efficient way of organizing activities is necessary to achieve the set results.[59]

The next step could be a study of excellence and process maturity at companies in the emerging EV market.

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[59] J. Martusewicz, W. Szumowski, *Modele dojrzałości a modele doskonałości. Niezależność czy współzależność na drodze do rozwoju organizacji*, "Organizacja i Kierowanie" 2018, no. 1, pp. 63–78.

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Production and services in the electric vehicle sector in the context of increasing energy security and environmental safety: current situation and overview of key development guidelines

Abstract
Russia's aggression against Ukraine at the beginning of 2022 triggered a price spike in the global natural gas and oil markets, among others. This situation provides a good example of the legitimacy of the European Union's (EU) zero-carbon policy. Diversification and independence may thus translate into increased efficiency in the sector due to the increasing mobility of the population in terms of individual and collective transport, as a consequence of the development of national economies, industry, urban expansion, etc. The production and services of the electric vehicle sector is therefore an important pillar of energy security and environmental safety, not only for the whole EU, but also for individual member states, like Poland, with its CO_2 emissions still not meeting EU standards and the renewable energy sources (RES) sector still facing many problems. Electric vehicles can therefore become the basis for developing smart cities and creating safe living in urban areas. In addition, independence from oil and gas supplies is being built.
Keywords: energy security, environmental safety, EU, Poland, electric cars

Introduction

The war in Ukraine has shown that the corporate environment is volatile, turbulent. Entrepreneurs had not forgotten the effects of

the COVID-19 pandemic, and they had to face further changes coming up. In the case of the energy market, raw materials very quickly started to become more expensive. Initially, there was a debate about the legitimacy of the EU's low-carbon policy and the costs that this transition would require. Entities and organisations in the European forum were declaring abandoning of fossil fuels. International Energy Agency published a plan to reduce oil consumption, with electric propulsion suggested as a solution. Expensive fuel is affecting both individual and collective means of transport, resulting in products and services becoming more expensive.

This analysis is aimed at presenting the electric vehicle sector (in terms of production and services) in both the EU and Poland. A question appears to be relevant: what is the situation now and what are the perspectives? What strategy is promoted by the EU as regards electric vehicles? For the needs of this work, the hypothesis has been stated that the development of the electric vehicle sector increases the energy security and environmental safety of the state.

The article is divided into two parts. The first describes energy security and environmental safety as well as electric vehicle production and services in the EU, the second focuses on electromobility in Poland. Introduction and summary with final conclusions supplement the text.

The character of the article is mixed. On the one hand, the author presents political decisions at the EU level and their impact on the policy of the Polish government as regards the electric vehicle sector. On the other hand, the article analyses the effect of production and services of the solution on the energy security and environmental safety policy.

This article uses the method of analysis of content of press release documents or websites. Empirical methods, i.e. observation and description, as well as general logic methods, i.e. analysis, synthesis, induction and deduction have been used. Primary sources have been used in this article: monographs, articles, and publications on websites of relevant ministries, organisations, entities, etc.

Energy security and environmental safety and the issue of electric vehicle production and services in the EU

Since 1990, the European Union's (EU) strategy has been referring to CO_2 reduction, which is apparent in various industries. The problem persists in a sector such as transport. The mobility of population in particular countries is systematically increasing, which results in increasing transport intensity, including road transport (by more than 50% compared to 1990). Road transport, including cars and trucks, is a major source of pollution. Electric cars could therefore be a solution.[1] However, the discussion revolves around the storage and disposal of batteries. The amendments adopted by the European Parliament (EP) on 10 March 2022 highlight the significant role of batteries in the development of the electric car sector, as well as their negative effect on the environment. Demand is expected to increase, raising strategic and competitive issues between particular manufacturers and consumers. It is therefore important to develop a common framework to define the shape of these relationships and the so-called product life cycle. In addition, the problem of waste battery management arises with the simultaneous zero-carbon policy of the EU. It is therefore important to develop a policy that would promote the protection of the environment and human health. What is required is the cooperation of various communities in the scope of energy, climate, transport, and strategic policies within the EU countries. Support is also required for research or cooperation of various entities within hydrogen valleys or energy clusters.[2]

The 2020 Communication of the Commission indicates that the EU is actively implementing zero-emission solutions. Manufacturers

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1 *CO_2 emissions from cars: facts and figures (infographics)*, European Parliament, News, https://www.europarl.europa.eu/news/en/headlines/society/20190313STO31218/co2-emissions-from-cars-facts-and-figures-infographics [accessed: 12.05.2022].

2 Amendments adopted by the European Parliament on 10 March 2022 on the proposal for a regulation of the European Parliament and of the Council concerning batteries and waste batteries, repealing Directive 2006/66/EC and amending Regulation (EU) 2019/1020 (COM(2020)0798 – C9-0400/2020 – 2020/0353(COD)).

have focused on battery drive systems in their projects, which is evident not only in cars and vans, but also in urban transport (buses). In addition, manufacturers are opting for hydrogen-based solutions, the so-called hydrogen fuel cells. Emission-free solutions are also to be applied in the so-called on-demand passenger transport, like taxis or rental cars. These solutions should meet public expectations and ensure safety in the local area. Adapting policy tools will therefore be important: micromobility or procurement support in the case of zero-emission buses. Including information that will allow participants to familiarise themselves with the proposed solution will also be crucial: special labels, low-emission zones, etc.[3] As regards the type of propulsion, the electric car market in Europe can be divided into: hybrid vehicles, battery electric vehicles, and fuel cell electric vehicles. All are designed for either private or commercial use.

In July 2021, the *Fit for 55* document was published. There are 13 proposals in it that need to be approved by the European Parliament and the member states. An important objective is to limit the registration of internal combustion vehicles in 2035 (within the EU down by 100%). This means a complete phase-out of vans and cars with combustion engines. Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 has also been repealed, replacing Alternative Fuels Infrastructure Directive (AFID) with a regulation (AFIR). The main objective is to promote zero-emission vehicles. This entails the construction of the infrastructure suitable for charging them. By 2030, a hydrogen charging infrastructure is to be in place as part of the Trans-European Transport Network (TEN-T). Such solutions require legal regulations, e.g. regarding payments, information on charging costs, terminal or contactless card payments. It should be emphasised that about 1 million charging points across the EU is to be in use by 2025, with 3 million by 2030.[4] In addition, the requirement to increase charging capacity

[3] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Sustainable and Smart Mobility Strategy – putting European transport on track for the future, 9.12.2020, COM/2020/789 final.

[4] *Fit for 55*, European Council, Council of the EU, https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/ [accessed: 7.04.2022].

should be proportional to the volume of sales of zero-emission units. *Fit for 55* proposes the mandatory installation of the charging points for electric cars at regular intervals on motorways. It also emphasises the importance of extending the EU Emissions Trading Scheme (ETS) to road transport.

It should be noted that the EU passenger car fleet increased in 2020 by 1.2% compared to 2019, with 246.3 million cars in use. The highest increase was reported in Romania and Slovakia (by more than 5%). There are more than 30 million trucks in use in the EU, more than half of which are in France, Italy, and Spain. There are over 700,000 buses registered, mainly in Poland, Italy, and France. Despite major interest in alternative-powered vehicles, they still only account for 5.3% of the total EU fleet (electric hybrids: 1.2%). More than 90% of trucks in the EU use diesel fuel. Less than 1% of trucks have emission-free powertrains. About 94% of buses have a diesel engine, 0.9% have electric batteries, and 1.4% have hybrid powertrains. An example of modern solutions is set by the Netherlands, with more than 10% of electric buses in the total fleet.[5] These data show the potential of electric cars when member states implement the EU guidelines for a zero-emission economy. The data for Q1 2022 confirm this, with the increased market share of hybrid electric vehicles up to 25.1% of total passenger car sales in the European Union (from 20.9% in Q1 2021).[6]

European market players are therefore following the trend and adapt their production and services for the efficient implementation of electric vehicles and related solutions. A solution for energy storage facilities for used batteries from electric cars proposed by the energy holding, RWE, is an example here. The facility is located in Herdecke near Dortmund. It gives a second life to lithium-ion batteries from Audi's electric cars, extending their service life by a further 10 years. Interestingly, the initiators declare that this solution is cheaper than the new cells, and it may provide power supply for stationary energy

[5] *Vehicle in use. Europe 2022*, ACEA, January 2022, https://www.acea.auto/files/ACEA-report-vehicles-in-use-europe-2022.pdf [accessed: 13.05.2022].

[6] *Fuel types of new cars: battery electric 10.0%, hybrid 25.1% and petrol 36.0% market share in Q1 2022*, ACEA, 5.05.2022, https://www.acea.auto/fuel-pc/fuel-types-of-new-cars-battery-electric-10-0-hybrid-25-1-and-petrol-36-0-market-share-in-q1-2022/ [accessed: 12.05.2022].

storage systems. This is a pilot project at this time, but the intentions are far-reaching, for example for renting out such storage facilities.[7]

In 2020, the British "Autocar" weekly ranked the top 10 electric cars: Kia e-Niro, Volkswagen ID.3, Peugeot e-208, Hyundai Kona Electric, Mini Cooper SE, Nissan Leaf, and Opel Corsa-e. The analysis covered three main parameters: price, range, and functionality of the cars. Kia Niro, in hybrid and plug-in hybrid versions, is popular in Europe. On a single charge, its range is from 485 km to 615 km (WLTP standard). It has a 64 kWh battery pack and a number of solutions to reduce energy consumption, for example when braking. In addition, the navigation system suggests routes to choose for optimal energy consumption (e.g. accounting for terrain profiles). Kia e-Niro can reach a speed of 130 km/h. Nissan Leaf is an interesting competitor, with a range from 250 km to 415 km, and a price of about 130,000 zł, or Volkswagen ID.3 in a similar price range.[8]

The key players in the European electric car market are: AB Volvo, BMW Group, BYD Company Ltd., Daimler AG, Ford Motor Company, General Motors Company, Honda Motor Co. Ltd., Hyundai Motor Company, Nissan Motor Co. Ltd., Mitsubishi Motors Corporation Tesla Inc., Volkswagen AG, Toyota Motor Company, and Groupe Renault.[9] When it comes to the share of electric cars in new passenger car registrations in Europe, Norway is ranked first at 64.5%, with Germany second at 13.6%. According to the International Energy Agency (IEA), the US, China, and Europe account for about 90% of global electric car sales.[10]

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7 *Audi tworzy magazyny energii z zużytych baterii aut elektrycznych! Rewolucja w transformacji energetycznej?*, Świat OZE, 20.01.2022, https://swiatoze.pl/audi-tworzy-magazyny-energii-z-zuzytych-baterii-aut-elektrycznych-rewolucja-w-transformacji-energetycznej/ [accessed: 13.05.2022].

8 *Najpopularniejsze auta elektryczne w Europie*, EFL, 30.03.2021, https://efl.pl/pl/biznes-i-ty/artykuly/samochody-elektryczne-w-europie [accessed: 12.05.2022].

9 *European Electric Car Market Forecast Report 2021–2028: Rising Trend of Shared Mobility & Growing Adoption of Autonomous Driving Vehicles*, Globe Newswire, 18.02.2022, https://www.globenewswire.com/news-release/2022/02/18/2387771/28124/en/European-Electric-Car-Market-Forecast-Report-2021-2028-Rising-Trend-of-Shared-Mobility-Growing-Adoption-of-Autonomous-Driving-Vehicles.html [accessed: 12.05.2022].

10 *Power sector accelerating e-mobility: Can utilities turn EVs into a grid asset?*, EY, Eurelectric, 2022, https://assets.ey.com/content/dam/ey-sites/ey-

EY and Eurelectric's report *Can utilities turn EVs into a grid asset?* emphasises the problem of the infrastructure. The electromobility evolution is forcing a surge in sales of zero-emission vehicles and, consequently, increased energy consumption. By 2035, 60% of charging points will be in the UK, Germany, France, Italy, the Netherlands, and Spain, and 10% in Poland, Sweden, Portugal, and Denmark. About 65 million charging points will be needed in 2035, 9 million of which will be public charging stations. The authors of the report predict an increase in energy consumption at approximately 30% per year, until it reaches 200 TWh. Only increased consumption is addressed, and the question arises whether there will be enough charging stations in particular countries.[11]

In the EU, low carbon emissions continue to be the priority. Electric vehicles nicely fit the EU guidelines, being a response to the diversification of energy directions and sources, particularly with regard to relations with Russia. At present, this market is characterised by high dynamism and disproportion in terms of particular member states. However, potential can be seen in both production and services, which only requires regulatory support from the government. Educating the public and informing about the possibilities and future effects of the chosen direction for environmental protection is an additional element.

Electromobility in Poland

In 2016, within the plan for development of electromobility in Poland, the Ministry of Energy presented a document indicating the importance of electric vehicles in creating energy security and environmental safety for this country in the long term. Firstly, they will improve air quality, and secondly, this solution will correspond

com/en_gl/topics/power-and-utilities/power-and-utilities-pdf/power-sector-accelerating-e-mobility-2022-ey-and-eurelectric-report.pdf [accessed: 13.05.2022].

[11] *Raport EY: do 2035 roku liczba pojazdów elektrycznych w Europie wzrośnie z 5 do 130 milionów. Co zrobić by sieć elektroenergetyczna to wytrzymała?*, EY Polska, 23.02.2022, https://www.ey.com/pl_pl/news/2022/02/ey-eurelectric-ev-grid [accessed: 22.05.2022].

with the dominant market trends. Although it requires the development of an appropriate process for the management and planning of as well as response to consumption needs, it offers manufacturing opportunities. The expected solution is to come in the form of, for example, domestic manufacturing of electric cars.[12]

On 16 March 2017, the *Electromobility Development Plan* was adopted in Poland, broken down into three stages. In the first one, by 2018, the focus will be on regulations and preparation of the market for new solutions. In the second stage (2019–2020), building the charging infrastructure for electric vehicles will be the central aspect. In the third stage (2020–2025), the development of various forms of government support for the electric vehicle sector in Poland is assumed.[13]

In 2018, privileges were granted to users of electric cars in Poland as provided for in the legal act: exemption from excise, which should translate into lower prices (similarly to hydrogen cars), a higher depreciation limit, which will allow higher tax deductions, busway entry (which comes in handy during heavy traffic on the roads, valid through January 2026), and exemption from zone parking fees in the city.[14]

Since 2021, the possibility of the subsidies for electric cars has been activated under the *Mój elektryk* (Polish for 'My electric car') programme (National Fund for Environmental Protection and Water Management). Support has been granted to natural persons, entrepreneurs, local governments, and institutions, applicable for purchase, leasing, or long-term rental. Profits under the programme have also been offered to holders of the Large Family Card, with the amount of support rising from (example) PLN 18,000 to

[12] *Plan Rozwoju Elektromobilności w Polsce „Energia do przyszłości"*, Ministerstwo Energii, Warszawa 2017, https://www.gov.pl/web/klimat/elektromobilnosc-w-polsce [accessed: 12.05.2022].

[13] *Rząd przyjął Plan Rozwoju Elektromobilności w Polsce*, Ministerstwo Aktywów Państwowych, 20.03.2017, https://www.gov.pl/web/aktywa-panstwowe/rzad-przyjal-plan-rozwoju-elektromobilnosci-w-polsce-3 [accessed: 12.05.2022].

[14] Ustawa z dnia 11 stycznia 2018 r. o elektromobilności i paliwach alternatywnych, Dz.U. [Journal of Laws of the Republic of Poland] 2018, item 317, https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20180000317/T/D20180317L.pdf [accessed: 12.05.2022].

PLN 27,000. Interestingly, the support may be applied to more than one vehicle.[15]

At the end of 2021, Andrzej Duda, the President of Poland, signed an amendment to the act on electromobility and alternative fuels. The objective for Poland is to implement EU legislation to comply with EU requirements and advance the development of electromobility in Poland. The amendment took into account (among others) Directive 2019/1161 of 20 June 2019 on the promotion of clean and energy-efficient road transport vehicles, and Directive 2019/944 of 5 June 2019 on common rules for the internal market in electricity. Among other things, the act introduced provisions on clean transport zones, defined rules for the installation of charging points in multi-family buildings, and extended the authority of inspectors of Urząd Dozoru Technicznego (UDT, Office of Technical Inspection) and Transportowy Dozór Techniczny (TDT, Transport Technical Inspection) to carry out more extensive inspections, and made it mandatory for operators, suppliers of charging stations to use unique codes. The time limit for the implementation of these changes has been set at 2028.[16]

A 2018 survey by Frost & Sullivan in Poland found negative attitudes towards the development of electromobility. The question can be asked: why? One answer lies in habits (stereotypes), the operation of the market based on existing solutions: manufacturing automotive parts for conventionally powered cars. Interestingly, 44% of those surveyed recognised threat, while 37% believed that nothing would change.[17] In 2021, according to QSense, electric cars accounted for 0.05% of all vehicles registered in Poland.[18]

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[15] *Elektromobilność*, *Mój elektryk*, *O programie*, GOV.pl – Serwis Rzeczypospolitej Polskiej, https://www.gov.pl/web/elektromobilnosc/o-programie [accessed: 13.05.2022].

[16] Ustawa z dnia 2 grudnia 2021 r. o zmianie ustawy o elektromobilności i paliwach alternatywnych oraz niektórych innych ustaw, Dz.U. 2021, item 2269, https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20210002269 [accessed: 12.05.2022].

[17] M. Korolec, K. Bolesta, J. Stenning, *REVolucja za kulisami. Jak elektromobilność zmieni rynek dostawców sektora samochodowego*, Warszawa 2018, https://fppe.pl/wp-content/uploads/2021/06/E-mobility-PL.pdf [accessed: 14.05.2022], p. 25.

[18] *Rynek samochodów elektrycznych – czy jesteśmy gotowi na elektromobilność?*, Swidnica24.pl, 18.12.2021, https://swidnica24.pl/2021/12/rynek-

According to the 'electromobility meter' – a project by the Polskie Stowarzyszenie Paliw Alternatywnych (Polish Alternative Fuels Association) and the Polski Związek Przemysłu Motoryzacyjnego (Polish Automotive Industry Association) – there were about 33,000 electric passenger cars in Poland in 2021. Fully electric BEV (battery electric vehicles) accounted for 48% (approximately 16,000), PHEV (plug-in hybrid electric vehicles) accounted for 52% (approximately 17,000).[19] According to the Fundacja Promocji Pojazdów Elektrycznych (Foundation for the Promotion of Electric Vehicles) and Cambridge Econometrics, the electric car industry will result in the creation of about 50,000 new jobs in Poland in the perspective of about 10 years, which will improve economic growth up to 0.3% (1.1% by 2050).[20]

The electromobility market in Poland includes a number of initiatives that deserve attention. One example is Impact Clear Power Technology, the company which produces the battery storage facilities in Poland, mostly for export (with a capacity of about 1 MWh of energy per day). The company sees a demand for batteries for, among others, buses, and foresees an increased interest in the product (batteries) in the perspective of 3 to 5 years. Using lithium in the recycling process of used cells is to be a solution in line with EU guidelines.[21]

Another example is to be the production of a Polish electric car. ElectroMobility Poland SA was established in October 2016 on the initiative of energy concerns: PGE Polska Grupa Energetyczna SA, Energa SA, Enea SA, and Tauron Polska Energia SA (25% of the share capital each). The potential of the Łukasiewicz Research

samochodow-elektrycznych-czy-jestesmy-gotowi-na-elektromobilnosc/ [accessed: 12.05.2022].

[19] *Licznik elektromobilności: wzrost rejestracji samochodów elektrycznych mimo niedoboru półprzewodników*, PSPA, 16.11.2021, https://pspa.com.pl/2021/informacja/licznik-elektromobilnosci-wzrost-rejestracji-samochodow-elektrycznych-mimo-niedoboru-polprzewodnikow/ [accessed: 12.05.2022].

[20] *Samochody elektryczne – główny kierunek rozwoju motoryzacji*, AmperGo, https://ampergo.pl/baza-wiedzy/samochody-elektryczne-glowny-kierunek-rozwoju-motoryzacji [accessed: 12.05.2022].

[21] P. Myszor, *Baterie, jakie znamy, znikną. Rewolucja jest coraz bliżej*, 12.05.2022, https://www.wnp.pl/motoryzacja/baterie-jakie-znamy-znikna-rewolucja-jest-coraz-blizej,578411.html [accessed: 14.05.2022].

Network is to provide support. 33 institutes are engaged in research in, among other things, means of transport, storage, energy conversion (e.g. fuel cells, batteries). The institutes also conduct a number of studies on electromobility and environmentally friendly solutions. In September 2023, ElectroMobility Poland won the tender and will become the owner of a plot of 117 ha for the construction of a new plant – a car factory in Jaworzno. The project will involve managers known in the market, such as Wojciech Szyszko, former CEO of Kia Motors Poland, or Romuald Rytwiński, associated with General Motors in Europe and worldwide, also responsible for the construction of the Opel plant in Gliwice. The creation of a model strategy for the new product and a proper sales strategy will be the key to achieve efficiency.[22]

BMW i3, Renault Zoe, Skoda Citigo-e iV, Tesla 3, and Tesla S were the the most popular electric cars in Poland in 2021, purchased mostly in Warszawa, Kraków, and Wrocław.[23] Purchasing models can be thought to result from the privileges of buying an electric car and the intention to have a cheaper and faster means of transport. The aspect of entering exclusion zones for combustion vehicles will also be an important argument in the future.

PGE Nowa Energia was to be the pillar for the creation of electric vehicle charging infrastructure in Poland. During the 2018 forum in Krynica, it encouraged local governments to join the "e-Mobility" project. The company's website provided information on ongoing projects as well as registration and charging on www.pgedoladujauto.pl. In 2020, it was reported that the company would abandon its lease for developments near the A1, A2 and A4 motorways. Opinions were published at that time in the press that electromobility would no longer be a priority for PGE Nowa Energia. This was confirmed on 31 March 2022 with the decision to

[22] *Kiedy ruszy produkcja samochodu elektrycznego w Polsce? Jest termin*, Money.pl, 14.12.2021, https://www.money.pl/gospodarka/kiedy-ruszy-produkcja-samochodu-elektrycznego-w-polsce-jest-termin-6715345821047648a.html [accessed: 14.05.2022].

[23] M. Karaś, *Jakie samochody elektryczne wybierali Polacy w 2021 roku?*, Motoklub, 16.03.2022, https://motoklub.pl/jakie-samochody-elektryczne-wybierali-polacy-w-2021-roku [accessed: 12.05.2022].

liquidate the company.[24] PGE is not the only investor on the Polish market: PowerDot promises as many as 1,250 stations (2,500 charging points) to be completed by the end of 2025. The projects are to be located close to the so-called everyday places frequented by the public, such as cinemas, shops, clinics, etc. The first projects are already in place in Kraków or Szczecin. Registration on the website to enable charging is not necessary. The user has only to select one of the suggested options: QR code, payment with a payment card, Google Pay, Apple Pay.[25] It should be noted that 2,166 publicly available electric vehicle charging stations (4,217 points) were in Poland at the end of March 2022. 29% of them were fast direct current (DC) charging stations and 71% were slow alternating current (AC) chargers with a capacity of up to 22 kW.[26]

The *Atlas elektromobilności* (Polish for 'Electromobility atlas') is an interesting source of information about the electric vehicle market in Poland. In offers information about such entities as electric vehicle manufacturers, manufacturers of parts and components for electric vehicles, manufacturers of charging stations, distributors of electric vehicles, distributors of parts and components for electric vehicles, distributors of charging stations, distributors of parts and components for charging stations, electric vehicle charging services, services for electric vehicles, and more.[27]

The idea of creating a market for electric vehicles in Poland is part of the EU's low-emission guidelines. In addition, as a result of the growing costs of transport, the instability of the oil and gas market and, consequently, the search for new directions and sources of diversification of raw material supplies, support for this area seems well substantiated. The question is still to be answered, however, whether the idea will not only be accepted by particular investor companies, but will also receive effective support from the ruling parties in the long term.

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[24] *Profil działalności*, PGE Nowa Energia, https://pgene.pl/profil-dzialalnosci [accessed: 12.05.2022].

[25] *O nas*, PowerDot, https://powerdot.pl/o-nas/ [accessed: 12.05.2022].

[26] *Map of charging stations*, Elektromobilni.pl, https://elektromobilni.pl/stacje-ladowania/ [accessed: 12.05.2022].

[27] *Atlas elektromobilności*, Elektromobilni.pl, https://narzedzia.elektromobilni.pl/kampania/atlas-elektromobilnosci [accessed: 15.05.2022].

Conclusions

The following aspects are important for the summary of the above discussion of the electric vehicle market and its impact on increasing Poland's energy security and environmental safety:

- The war in Ukraine has shown that diversification of energy procurement routes and sources should become a permanent part of corporate policy and management, given the dynamic volatility of the environment in which it operates;
- Poland is not an energy self-sufficient country, which increases the risk of importing energy resources, especially in the face of reduced supplies from Russia;
- The electric vehicle market is the inevitable direction of automotive development, not only for environmental reasons, but also for economic ones, especially as the EU's low-carbon policy is forcing change on the Community's member states;
- At the moment, the Polish electric vehicle market requires intensified activities, convincing the prospective customer that this product is cheaper to maintain than a combustion engine car, that such a choice has priorities not only for the environment, but also for human health, and requires increased investment in infrastructure: charging stations (they are still not very common, e.g. in places of residence, near apartment buildings);
- The question of the storage of batteries from electric vehicles and their negative impact on the natural environment remains open, a discussion which recurs constantly, not only in the EU forum, but also in speeches and discussions by Polish politicians and representatives of the electric vehicle sector, pointing out that approximately 200 kg of carbon dioxide may be emitted during the production of a battery with a capacity of 1 kWh – with the additional issues of extraction of copper, nickel or, for example, cobalt.

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Distance learning for raising environmental awareness in electric vehicle purchasing decisions

Abstract
The chapter presents, among other things, the various forms of distance learning. The differences between them are shown, and for what purpose each is used. This is the first, theoretical part of an ongoing study on the use of distance learning to raise environmental awareness in purchasing decisions for electric vehicles. On the basis of the discussed forms of distance learning, suggestions will be given as to which of them are most relevant to the topic of pro-environmental education in the field of electromobility.
Keywords: distance learning management, purchasing decisions, environmental awareness, electric vehicles

Introduction

Distance learning is one form of education for children, young people and adults alike and can therefore be used in schools, universities and also businesses. In the case of the latter, it can be used both to improve employees' knowledge in the form of internal training, but can also serve as part of a corporate social responsibility strategy.

Distance learning has both supporters and opponents. Whether one prefers this form of knowledge transfer depends largely on one's previous experience with widespread courses using the internet. In the case of positive experiences, recipients and creators of e-learning courses are able to perceive their effectiveness and the convenience of use in the form of independence of time and place

for receiving knowledge. In the case of bad experiences, e-learning will be perceived as unnecessary extra work and activity that does not produce the right results.

The proper preparation of courses that allow the transfer of knowledge at a distance depends on many factors. First and foremost are the decision-makers in companies, who see e-learning as a tool to reach different audiences with knowledge, at different times, without the need for training and other fixed events. Another element is well-trained employees creating the courses/training. It is also important to choose the right format, as well as the tool that will support their work. Next comes the choice of delivery method; it is worth considering whether it will be a course delivered via a special platform, a phone app or simply a course that can be used directly on the company's website. No less important is the content and methodological preparation, as well as the planning of activating and motivating elements in the course. Well-designed courses should contain elements to consolidate knowledge, improve learning, and build social ties between the participants in the teaching group. An interesting way of engaging the audience's attention is to construct the course in a form that gives the user the impression that he or she is not the recipient of a course in which he or she learns, gets tired and has to do something he or she does not feel like doing. Such a way is to involve the user in an educational game. The use of game mechanisms in courses is based on creating a feeling of satisfaction in the user, of the kind that people feel as a result of, for example, overcoming difficulties, winning prizes, but also as a result of competition or cooperation.

The benefits that can be gained by using distance learning depend on many factors. Are automotive companies exploiting this potential? Are the opportunities offered by distance learning in promoting and spreading knowledge of, for example, electric cars recognised by companies involved in the production and sale of electric cars? What could be most beneficial for companies in the automotive industry in promoting knowledge about electric cars: e-learning, d-learning, gamification or micro-learning? Is education through distance learning in the form of e-learning, m-learning or including gamification elements used as part of a corporate social responsibility strategy? In order to find answers to these questions, the study will be divided

into three parts. The first part described in this chapter is the first stage of the research. At this stage, the various forms and methods of distance learning will be defined and the proposed directions of the educational activities undertaken will be determined. The next stage will consist of an analysis of the available educational information on electric cars based on what a potential internet user is able to search for, using similar phrases when searching, changing only the names of the subsequent car brands. Each individual brand's website will then be analysed for educational information on electric cars to see if this content is easy to access from a web user unfamiliar with the company's website. This will provide information on whether a potential audience who would be interested in buying or learning more about electric cars is able to access the right educational information. The final part of the study, also described in subsequent publications, will be to check the same thing but from the companies' side, i.e. how companies are implementing distance learning as part of electric car education. This will allow us to see if this is a significant part of their responsible business strategy, or if the information provided on the website in the form of questions and answers is just something that has little relevance to their environmental strategies, and is only the result of promoting their own brand and wanting to boast about the performance of a new car model.

The issue of electric vehicles includes not only cars, but also various other means of personal or collective transport. It seems that in terms of the impact of environmental awareness on purchasing decisions for these vehicles made by both individual customers, but also companies and institutions, some general assumptions can be made in the distance learning described in this paper. Due to the growing sales dynamics of electric cars, it is this topic – with regard to distance learning – that I have devoted the most attention to.

What is distance learning

Learning is a universal experience – the main force that allows both humans and animals to survive and function in their environment.[1]

[1] C.N. Quinn, *Engaging Learning: Designing e-Learning Simulation Games*, John Wiley & Sons, San Francisco 2005.

Knowledge can be transmitted in a variety of ways, in both traditional and remote forms, but in either case the technical possibilities for presenting educational content are becoming more varied as technology develops.

The development of distance education and the formation of its various forms was linked to technical developments. In the first stages it was correspondence education using letters, later radio, television. Nowadays, with the internet, it is possible to transmit knowledge to practically any place and to any person in the world equipped with an internet-enabled device. The ways in which materials are developed have also changed. Undeniably, the internet, through its communication capabilities, enables distance content creators to improve their methods and techniques of distance learning. "For most of this time, it was seen as a substitute for traditional teaching, in which the teacher was replaced by various types of textbooks and materials. It was only in the computer age that learning content began to be seen as information, that is, a material thing that can be processed, transferred and transmitted. In teaching-learning processes, the issue of information transfer has become particularly interesting."[2] Moreover, factors that are not always positive – such as a pandemic or war – have shown that in some situations distance learning and the now common use of video conferencing tools for educational purposes are not only a possibility, but sometimes a necessity.

The origins of distance learning date back to the nineteenth century, and teaching materials were provided to learners in the form of printed scripts, notes. The development of mass media, in turn, allowed the use of radio, audio-video technology and later also television (in the form of tele-education). Advances in computer technology have made it possible to produce teaching materials in multimedia form, which has made education more attractive. The development of the internet, in turn, made it possible to transmit teaching content to users using e-learning platforms. The following

[2] Z. Meger, *Podstawy e-learningu. Od Shannona do konstruktywizmu*, "E-mentor" 2006, no. 4, pp. 35–42.

stages in the development of distance learning are distinguished in the literature as successive generations.[3]

With the development of technical possibilities, the definitions of distance education have also been modified. According to one of them: "Distance teaching is a method of conducting the didactic process in conditions where teachers and students (pupils) are distant from each other (sometimes considerably) and are not in the same place, using for the transmission of information – in addition to the traditional ways of communication – also contemporary, very modern telecommunication technologies, sending: voice, video images, computer data and printed materials. Today's technologies also allow direct, real-time contact between teacher and student via audio or video conferencing, regardless of the distance separating them."[4]

Differences between d-learning, e-learning, and m-learning

E-learning and distance learning are two names which, although they do not mean the same thing, are often used interchangeably.[5] The definition of distance learning (d-learning) states that it is learning at a distance, i.e. communication between a person transmitting knowledge and a person who is the recipient of this transmission, without the necessity of being at the same place. One literature source states that d-learning can be understood as: "[…] distance learning in which direct, personal contact between student and teacher is replaced by communication based on modern technologies or traditional mail; examples of d-learning are: correspondence courses, educational television programmes, e-learning."[6] Another source states that d-learning "[…] involves

[3] D. Korzan, *Ewolucja kształcenia zdalnego*, http://www.korzan.edu.pl/pdf/zdalne.pdf [accessed: 20.05.2022]; Z. Meger, *Szósta generacja nauczania zdalnego*, http://e-edukacja.fundacja.edu.pl/czwarta/_referaty/sesja_IIb/14_e-edukacja.pdf [accessed: 20.05.2022].

[4] M.J. Kubiak, *Szkoła, Internet, Intranet: Wirtualna edukacja*, MIKOM, Warszawa 2000, p. 12.

[5] B. Berg, *The Differences Between eLearning* And *Distance Learning*, eLearning Industry, 3.01.2018, https://elearningindustry.com/differences-between-elearning-and-distance-learning [accessed: 11.06.2022].

[6] *D-learning, e-learning, m-learning… Czym są? Co je łączy i różni?*, Globalnet, 5.10.2015, http://www.globalnet.com.pl/news/detail/13 [accessed: 12.05.2022].

separating the learner from the teacher. […] This type of learning is particularly useful when one student cannot be physically present due to illness or distance."[7] The most common definition is the one given by Miroslaw J. Kubiak: "Distance teaching is a method of conducting the didactic process in conditions when teachers and students (pupils) are distant from each other (sometimes considerably) and are not in the same place, using to transmit information – in addition to traditional ways of communication – also contemporary, very modern telecommunication technologies, sending: voice, video images, computer data and printed materials. Today's technologies also allow for direct, real-time contact between teacher and student by means of audio- or video-conferencing, regardless of the distance that separates them."[8]

In contrast, the term e-learning[9], according to the literature, means "any type of learning that involves technology to assist the learner. This can include videos, touch screen technology, online tools or any other medium. […] The term refers only to the tools used"[10], or "learning using computer networks and the internet, a type of distance education used in so-called flexible learning; e-learning is often combined with traditional learning (blended learning)."[11] E-learning is also defined as "a didactic process taking place in a non-school space (originating from the concept of distance learning/distance education), which in order to create a new quality of learning uses modern multimedia ICT solutions."[12]

The rapid development in the market of mobile devices has contributed to the emergence of another type of learning, namely

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7 *The differences between elearning and distance learning*, Your Training Edge, http://www.yourtrainingedge.com/the-differences-between-elearning-and-distance-learning/ [accessed: 18.05.2022].

8 M.J. Kubiak, *op. cit.*

9 In Polish, the term 'e-learning' is being translated as: elektroniczna edukacja, zdalna edukacja, zdalne kształcenie, e-nauczanie, see A. Clarke, *e-Learning: Nauka na odległość*, transl. by M. Klebanowski, Wydawnictwa Komunikacji i Łączności, Warszawa 2007.

10 *The differences between elearning and distance learning*, Your Training Edge, *op. cit.*

11 *D-learning, e-learning, m-learning…*, *op. cit*.

12 K. Kuźmicz. *Kultura studiowania w przestrzeni sieci*, Gdańskie Wydawnictwo Psychologiczne, Sopot 2015.

m-learning (mobile-learning). This type, in turn, is defined in the literature as "distance learning using portable wireless equipment (smartphones, PDAs, tablets) with permanent internet access."[13] The use of m-learning in addition to technology also includes the ability to learn anywhere, anytime, with the possibility of eliminating a permanent connection to cable networks.[14]

Analysing the above definitions, it can be concluded that d-learning is the broadest definition and the others, namely m-learning and e-learning, are included in it. With 'e-learning' meaning distance learning using digital media and 'm-learning' indicating that the use of mobile devices is added to it. However, there are situations where training is delivered in a hybrid way, partly stationary and partly using distance learning, in which case we are dealing with b-learning.

In each of the above cases, learning material can be made available via e-learning platforms. An unquestionable advantage of e-learning platforms is the possibility to manage the learning process within a group of users, which works well in companies for staff training. In the case of training/courses for external users, it is possible to use open educational resources and the possibility for both registered and unregistered persons to participate.

A different approach to the learning process is used when applying gamification elements.[15] According to the definition, gamification is the application of techniques used in role-playing games to model the behaviour of participants in a given process, situation, which in turn is not a game.[16] Based on another author of a publication on the subject, "gamification involves the use of game mechanics that mobilise action, increase engagement or simply make boring, repetitive

[13] *D-learning, e-learning, m-learning…*, *op. cit*.

[14] T.S. Georgiev, E. Georgieva, A. Smrikarov, *M-learning – a new stage of e-learning*, International Conference on Computer Systems and Technologies *CompSysTech*, 2004, https://www.researchgate.net/publication/262367952 [accessed: 16.05.2022].

[15] The term 'gamification' is also encountered in Polish literature as 'gryfikacja' or 'grywalizacja' (compound of Polish 'gra' (game) and 'rywalizacja' (competition)), see P. Tkaczyk, *Grywalizacja. Jak zastosować mechanizmy gier w działaniach marketingowych*, Helion, Gliwice 2012.

[16] G. Zichermann, C. Cunningham, *Gamification by Design: Implementing Game Mechanics In Web and Mobile Apps*, O'Reilly Media, Sebastopol, CA 2011, p. 14.

and monotonous activities more enjoyable. It allows us to voluntarily undertake tasks that we usually can't bring ourselves to do. What we love about games is friends, feedback and fun."[17] This type of impact can be found in business, where the concept of games together with loyalty programmes in line with the assumptions of behavioural economics is used to build the motivation of people involved in business processes.[18]

A different approach to the transfer of knowledge at a distance is related to micro-learning. Micro-learning consists of creating short tutorials. "The prepared content should be oriented towards the performance of an activity, the assimilation of a specific piece of knowledge, but should always lead to the intended learning outcome. Micro-learning is implemented in the form of, for example, knowledge pills."[19] Knowledge pills should be created in such a way as to convey knowledge about one selected issue within a few minutes, in an attractive and easy-to-remember form. They can be in the form of videos, animations, texts, diagrams, sounds. When creating knowledge pills, it is important to remember that the possibility of reading them on mobile devices increases the number of recipients and the frequency with which they will reach for further content. This creates an effect where users access the information they need exactly when they need it most. The recipients of such content themselves need brief but specific information on the topic they are looking for, so knowledge pills should not exceed the 3–5 minutes needed to absorb their content. When creating them, it should be remembered that the

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[17] A. Bilska, *Gamifikacja w edukacji*, [as cited in:] D. Elsner, *Gamifikacja jako metoda nauczania* [interview with Iwona Müller], Wolters Kluwer, 15.05.2019, https://www.wolterskluwer.com/pl-pl/news/gamifikacja-jako-metoda-nauczania-danuta-elsner [accessed: 5.05.2022].

[18] G. Zichermann, J. Linder, *The Gamification Revolution: How Leaders Leverage Game Mechanics to Crush the Competition*, McGraw Hill Education, New York, 2013, p. 12.

[19] M. Woźniak-Zapór *et al.*, *Knowledge pills, gamification, e-learning courses – knowledge management in the aspect of the university*, [in:] *Social importance of information systems in management*, ed. T. Grabiński, Towarzystwo Naukowe "Societas Vistulana, Kraków 2020, https://repozytorium.ka.edu.pl/bitstream/handle/11315/30641/GRABINSKI_Social_importance_of_information_systems_In_management_2020.pdf [accessed:15.05.2022], p. 102.

pill should provide the most important knowledge on a given topic without unnecessary digressions and in as short a form as possible. This is so that it is possible to assimilate its content the first time.[20] "Information delivered in such small and accessible forms is characteristic of informal learning. However, with dynamic socio-economic development, these elements should be introduced into formal education. Training organisations and project initiatives are taking the first steps in this direction. Internet services that allow users to post very short information via microblogs such as Twitter ([…] very short messages of up to 140 characters[21]) are becoming increasingly popular. The interest in this form of communication may be an interesting alternative in making contact for educational purposes."[22]

Electric cars – how to pass the knowledge on

Electric cars are an increasingly popular means of transport. It is chosen by people who are pro-environmental and active, as well as by those who choose it because of the current global situation, inflation and rising fuel prices. However, there are still many doubts surrounding the purchase of an electric car for potential car showroom customers. The most common of these are the higher cost of an electric car compared to the same model proposed in the petrol version, the fear of not being able to charge the car if there are long distances between charging stations or any other place without electricity where the user could be, the fear of long charging times, which in the worst cases can last up to 12 hours. Further information likely to sow doubt in people interested in electric cars appears on various forums and social media, as well as on motoring websites and pages. In the listed disadvantages of such cars, the maintenance costs of the car are mentioned, such as the expensive cost of

[20] A. Laśkiewicz, *Pigułka wiedzy: krótko, ciekawie, na temat*, iPro, https://iproelearning.com/html/partners/tech/pigulka_wiedzy_krotko.html [accessed: 22.06.2022].

[21] The original limit was later expanded to 280 characters.

[22] D. Dżega, *Metodyka przygotowywania kursów e-learningowych z uwzględnieniem pigułek wiedzy*, http://e-edukacja.fundacja.edu.pl/dziewiata/referaty/Sesja_2a_2.pdf [accessed: 06.06.2022].

replacing the lithium-ion battery, the higher energy consumption when using additional operating elements such as radio or heating, and when increasing speed.[23]

Electric cars also have advantages, including access to areas with limited traffic, the possibility to drive in bus lanes. According to EV manufacturers, advantages also include reduced maintenance costs, greater driving comfort due to low noise levels, among others.[24]

Given the many doubts and sometimes contradictory information from various sources, education is necessary. Short forms, answering specific questions and doubts, seem to be the most appropriate for this topic. Thus, knowledge pills would work well in this case. They would make it possible to quickly provide detailed knowledge on a given topic of electric cars and their impact on the environment, as well as their proper operation. In addition to knowledge pills, a good practice would be a longer, detailed course allowing to deepen the knowledge for those who are particularly interested in the electric cars, an example of which is the educational film published in January 2020 by the Polish Electromobility Association[25]. The recipients of the film are intended to be primary school pupils, i.e. the target group that will choose their cars with an awareness of environmentally friendly measures acquired from an early age. For the purposes of the film, one of the car companies has made its cars available, which may demonstrate its commitment to education about electric cars.

Conclusions

Of the forms of distance learning presented, knowledge pills can play an interesting role in the process of environmental education. E-learning courses are extensive, allow the inclusion of many references to source texts and explore issues in more detail. Knowledge

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[23] *Auto elektryczne – plusy i minusy*, Motocontroler, 15.03.2021, https://motocontroler.com/auto-elektryczne-plusy-i-minusy/ [accessed: 25.06.2022].

[24] *Ibidem*.

[25] *Film edukacyjny dla szkół podstawowych z zakresu elektromobilności*, Polskie Stowarzyszenie Elektromobilności, https://www.youtube.com/watch?v=FvnBtLOYbHI [accessed: 25.06.2022].

pills, as short tutorials, will work well as elements that present selected issues, but in a complete manner. Extended courses are also a good option for those who are interested in electromobility and would like to spend more time exploring the topic. The solutions proposed will form the basis for analysing the websites of companies in the automotive industry, as well as other organisations involved in motoring, with a view to applying distance learning methods and techniques to pro-electric-car education.

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The possibility of applying the Cost Deployment method in enterprises producing electric vehicles (cars), operating in world-class production systems

Abstract
The Cost Deployment method is a cost analysis method used in companies operating in world-class manufacturing systems. World Class Manufacturing (WCM), i.e. the World Class Manufacturing System, is an integrated management system for a manufacturing company. The main objective of WCM is to maximize the results achieved by the production system, while maintaining quality standards, leading to the improvement of the company's competitiveness. The purpose of this study is to present this method through the prism of cost analysis needs that may occur in a company producing electric vehicles, regardless of whether it is a company applying the WCM principles or with a lower degree of organization of the production process.
Keywords: Cost Deployment, World Class Manufacturing (WCM), Lean Management, Agile

Introduction

Tesla was not the first electric car, appeared on the market. Some of them appeared on the market for the first time like 100 years before Tesla did. Electric car was driven already by one of the Presidents of USA – Woodrow Wilson, president in years 1913–1921.[1] Electric cars were one of the first vehicles used by people to travel. The first electric carriage was created in the first half of the 19th century. The

[1] *Samochody elektryczne – co powinieneś wiedzieć?*, Optimalenergy.pl, https://optimalenergy.pl/samochody-elektryczne/ [accessed: 19.07.2022].

way for the development of electric cars was paved by the invention of the battery and commutator, with which it was possible to drive the motor with direct current.

With regard to climate change and air quality, electric cars seems to be a better solution than petrol or diesel cars.[2]

Nevertheless, "the Swedish brand at the COP26 climate summit signed an agreement according to which by 2035 it will end the sale of combustion-powered cars, and only emission-free vehicles will be offered. At the same time, Volvo also presented a report that compares the carbon dioxide emissions of the same cars differing only in the powertrain. These include the petrol-powered XC40 and the electric XC40 Recharge and C40 Recharge (coupe variant). These cars share a lot of components, so they were ideal for a comparative study."[3]

"These studies show that in the case of production of two of the same models with a conventional drive and an electric drive, the latter causes 70% higher emissions. Ecology, however, starts from the moment it leaves the factory."[4] So, in the case of the production process itself, is it possible to maintain cost discipline and apply the principles of rationality of incurred costs? Principles that are successfully applied in automotive manufacturing companies operating in world-class manufacturing systems?

This seems to be the future, Volvo plans to sell only electric cars by 2030 at the latest, completely withdrawing combustion-powered vehicles from its global portfolio, including hybrid cars. In the case of BMW, by then electric vehicles will account for about half of total sales, while from 2025 all new Mercedes-Benz car models will be purely electric.

It might be asked how Poland is doing on the European electric car's market? Data reported by Strefa Inwestorów doesn't leave any understatements. "In 2022, the number of registered electric

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[2] European Environment Agency, *Electric vehicles: a smart choice for the environment*, 17.12.2018, https://www.eea.europa.eu/articles/electric-vehicles-a-smart [accessed: 7.07.2023].

[3] M. Pokorzyński, *Elektryki nieekologiczne podczas produkcji. Dopiero później są eko*, Auto Świat, 15.11.2021, https://www.auto-swiat.pl/ev/wiadomosci/auta-elektryczne-nieekologiczne-podczas-produkcji-dopiero-pozniej-sa-eko/5w1xpqg [accessed: 15.07.2022].

[4] *Ibidem*.

passenger cars (BEV) in the European Union countries was approximately 3.2 million. This is an increase of 1.1 million units compared to the previous year and 180% more than in 2020. Among the EU countries, Germany recorded the highest number of new registrations, with 1 million registered cars. They are followed by France, with 0.69 million registered BEVs, and the Netherlands, with 0.33 million. The growth rate of electrician registrations between 2021 and 2022 in Europe was particularly high in Bulgaria, Hungary, Lithuania and Poland."[5] European classification is reported on the Figure 1. As shown on the Figure 2, the number of electric passenger cars registered in Poland exceeded 50,000 back in 2021.

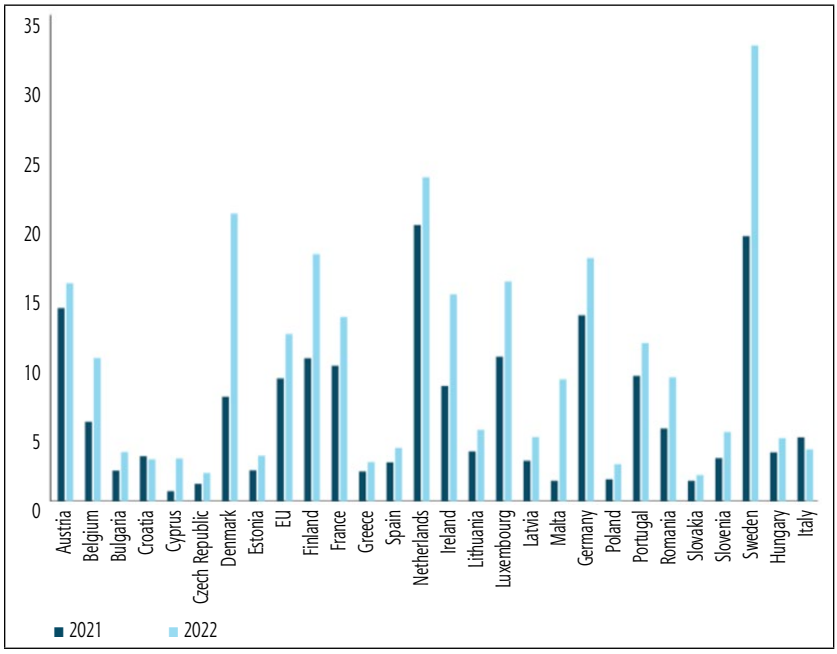

Figure 1. Percentage of newly registered BEV electric passenger cars in all newly registered passenger cars

Source: A. Kiwacka, *Polska w czołówce państw UE z największa dynamiką sprzedaży samochodów elektrycznych*, Strefainwestorow.pl, 4.04.2023, https://strefainwestorow.pl/w-zielonej-strefie/elektromobilnosc/sprzedaz-elektrykow-polska [accessed: 23.09.2023].

[5] A. Kiwacka, *Polska w czołówce państw UE z największa dynamiką sprzedaży samochodów elektrycznych*, Strefainwestorow.pl, 4.04.2023, https://strefainwestorow.pl/w-zielonej-strefie/elektromobilnosc/sprzedaz-elektrykow-polska [accessed: 23.09.2023].

The increase in interest is certainly due to both the subsidy program existing on the Polish market, which is the 'My Electrician' subsidy system and the increasing awareness of consumers. Not without significance is the fact that there are more and more models available on the market, and their range is still growing. As many as 190 electric models were available at the end of 2021. The question is whether new manufacturers may appear in the electric car sector. The willingness to adapt and implement innovative solutions in the automotive sector is very high. This is due to the fact that car manufacturing companies are companies with implemented Lean Management procedures and they are agile companies.

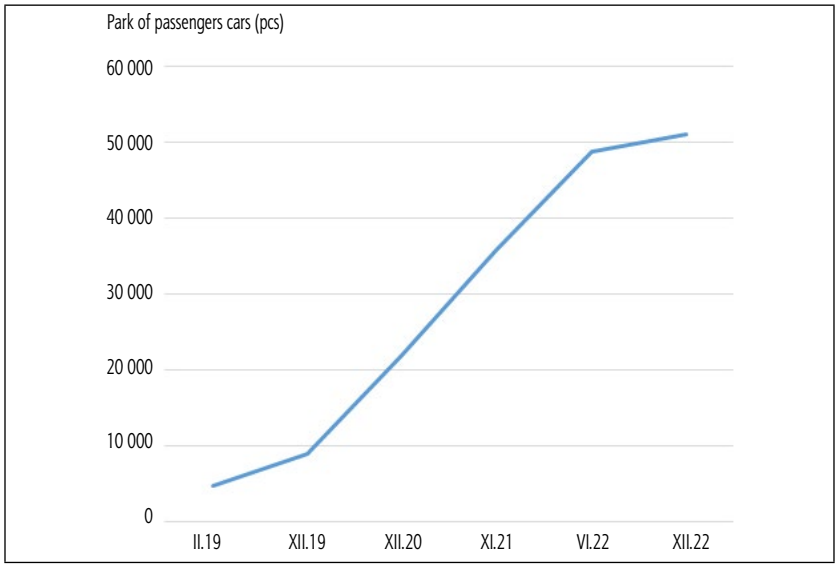

Figure 2. Electric passenger cars (pcs)

Source: own figure based on: Polskie Stowarzyszenie Paliw Alternatywnych, *Licznik Elektromobilności: liczba samochodów z napędem elektrycznym w Polsce przekroczyła 50 tys.*, 12.07.2022, https://pspa.com.pl/2022/informacja/licznik-elektromobilnosci-liczba-samochodow-z-napedem-elektrycznym-w-polsce-przekroczyla-50-tys/ [accessed: 22.07.2022].

The goal of every company acting in Lean or World Class Manufacturing (WCM) environment is to achieve global competitiveness by adhering to the following principles, i.e. no waste, no inventory, no breakdowns, no defects, continuous improvement of the processes used, increased productivity, better safety, etc. The production

costs incurred are also significant, and each company seeking a competitive cost advantage will try to achieve the ideal cost of production. In the case of automotive concerns, we have a situation of mass production, when the cost of production is not counted in millions but in thousands of zlotys due to, for example, a extremely effective production process or the effect of scale. In the case of electric cars, the production process is significantly different from the production process of internal combustion cars. It is not enough to make changes to already existing combustion car designs and subsequently introduce changes in the assembly process itself. Project of an electric car requires the preparation of a practically new project.

Nevertheless, Tesla is a perfect example that, despite the widespread belief that there are high barriers to entry of a new player to the car market, this rule does not apply to the electric car segment. Tesla, as a start-up with no experience in the production of electric vehicles, has become a world leader in this field. In order to build an electric vehicle, in practice, you have to start from scratch, solve completely different problems in the project, and then organize a new assembly line. The electric vehicle segment is a new segment, open to competition, although the recognition of brands holding by existing car concerns and the trust that their customers place in them, gives them a competitive advantage over start-ups without any experience in the production of electric vehicles.

The main difference in the assembly process between combustion and electric vehicles is the introduction of an electric motor, the assembly of which is easier to automate. On the other hand, there is more electronics in the electric motor, which implies the introduction of a very high culture of production process and product quality, for which, in turn, companies producing in the Lean Manufacturing culture or even those producing in the WCM system are already very well prepared. The main goal of WCM is to maximize the results achieved by the production system, while maintaining standards and quality, leading to the improvement of the company's competitiveness. This allows us to achieve the highest level of excellence in world production. For each company, regardless of whether it is a car concern that has been on the market for years and is improving its processes, or a start-up, the leading indicator is the profitability of the

business, and thus the pursuit of an ideal production cost achieved through successive elimination of waste throughout the supply chain.

Striving to achieve the ideal cost of production

WCM assumes the improvement of the company's organizational system in order to achieve a global level of competitiveness.

Companies from the automotive sector that use WCM participate in the evolution of the production system by introducing changes, aimed at strengthening competitiveness. The changes that have taken place over the years have resulted in the division of production systems into the so-called generation evolution classes.[6] The most popular classes include[7]:

- Mass Manufacturing (MP),
- Lean Manufacturing (LM),
- Agile Manufacturing (AM),
- Real Agile Manufacturing (RAM).

It is thanks to the agile approach that the automotive sector is characterized by such high innovativeness of processes, where innovation can be defined according to Radosław Repetowski: "innovations are the result of technical, social, economic, legal, cultural and organizational processes that can be shaped. Currently, the concept of innovation is understood as a certain complex of processes and phenomena covering not only the emergence and implementation of innovation, but also its economic and social effectiveness."[8]

Enterprises, in particular those with the status of WCM, in order to achieve a cost advantage, strive to eliminate all unnecessary operating costs that do not bring added value, i.e. losses.

A characteristic approach is striving to achieve a world-class level in the conditions of setting these ambitious goals in the area of[9]:

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6 M. Dudek, *Struktura organizacji wytwarzania w systemach klasy światowej. Paradoks szczupłości i elastyczności operacyjnej*, Wydawnictwa AGH, Kraków 2019.

7 *Ibidem*, p. 26.

8 R. Repetowski, *Rola innowacji w funkcjonowaniu przedsiębiorstw przemysłowych*, "Prace Komisji Geografii Przemysłu" 2008, nr 10, p. 174.

9 P. Poor, M. Kocisko, R. Krhel, *World class manufacturing (WCM) model as*

– quality,
– costs,
– deliveries.

The use of appropriate procedures is intended to lead the company from the current cost of production to the ideal cost of production, along with the ongoing elimination of activities without added value. Process of such a path is illustrated Figure 3. In the process of striving to achieve the ideal cost of the product, a Cost Deployment analysis is performed, the purpose of which is to indicate and identify the losses arising in the production process.

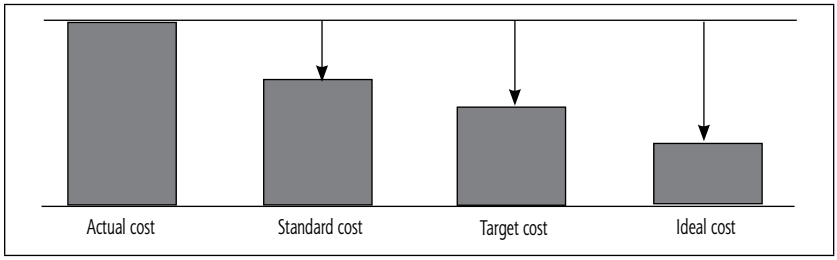

Figure 3. The process of achieving the ideal cost

Source: Own figure based on training materials of companies from the automotive sector (2019).

The uniqueness of the Cost Deployment method lies primarily in the indication of the cause-and-effect relationship of the resulting loss and its quantification. Indication of the cause of the resulting losses allows not only to indicate the source of the loss and its quantification, but also to appropriately select the most technically and economically effective method of elimination, preventing or limiting the probability of this loss in the future, that is shown in Table 1.

Cost Deployment is a method that allows to analyse the current cost of production. This method is also used in companies from the automotive, however mainly used in companies participating in the WCM process. Preliminary research shows, however, that it can be used in those units that intend to introduce at least the core principles of Lean Management in the company, and think about meeting

a tool for company management, [in:] *Proceedings of the 27th DAAAM International Symposium*, ed. B. Katalinic, DAAAM International, Vienna 2016, p. 0387, https://doi.org/10.2507/27th.daaam.proceedings.057.

the needs of customers through continuous improvement and elimination of waste.[10] Therefore, it seems reasonable to say that they can be used in all enterprises producing electric vehicles (cars), provided that they will operate in a world-class production system. The term "world class" was coined by Robert H. Hayes and Steven C. Wheelwright[11] to describe the opportunities that Japanese and German companies developed, as well as American companies that competed on an equal footing with Japanese and German companies. The term "world-class manufacturing" was coined because these manufacturing companies (mainly automotive) achieved outstanding results in their sectors at the global level, i.e. global competition. The previously indicated good practices that make up the WCM are the pillars of the WCM at the same time, which are presented in Table 2.

Table 1. Cost Deployment possible choice of the most technically and economically effective method

Classification	Expected losses	Cost Deployment within the organization	Cost Deployment through benchmarking
The origin of the losses	Losses are generated by non-compliance with applicable processes (standards)	Losses are generated by the deviation of the current process in relation to the target	Losses are indicated by comparing the current situation with the benchmark

Source: Own figure based on training materials of companies from the automotive sector (2019).

By using the Cost Deployment method, it might be possible to identify wastes and losses in the analysed area of electric vehicle production. Losses are successively quantified, assessed and the possibility of their elimination is analysed.

[10] R.S. Kaplan, *Measuring Manufacturing Performance: A New Challenge for Managerial Accounting research*, "The Accounting Review" 1983, vol. LVIII, no. 4, pp. 686–705; L.P. Grasso, *Are ABC and RCA Accounting Systems Compatible with Lean Management?*, "Management Accounting Quarterly" 2005, vol. 7, no. 1, pp. 12–27.

[11] R.H. Hayes, S.C. Wheelwright, *Restoring Our Competitive Edge: Competing through Manufacturing*, John Wiley & Sons, New York 1984.

Table 2. Technical and management pillars in world-class production systems

Technical pillars	Management pillars
• Cost analysis, cost breakdown: Cost Deployment • Autonomous maintenance and organization of the workplace • Professional maintenance • Quality control of products • Logistics and customer service • Early device management and product management • Early product management • Staff development • Security • Environment management	• Management commitment – clarity and definition of objectives in the form of KPIs • The road to a world-class production system, creating an overall project implementation plan • Allocation of highly qualified employees, allocation of human resources • Involvement of the organization, the entire staff • Ability to solve problems, competencies of organization, directing the staff to achieve improvement • Time and budget, setting deadlines and budget, managing resources • Level of detail • Motivating operators

Source: own figure based on: A. Piasecka-Głuszak, *Implementacja World Class Manufacturing w przedsiębiorstwie produkcyjnym na rynku polskim*, Uniwersytet Ekonomiczny in Wrocław 2017, "Ekonomia XXI Wieku" 2017, nr 4, pp. 52–65, https://doi.org/10.15611/e21.2017.4.04.

With the use and implementation of the Cost Deployment method, companies from the electric vehicle sector can strive to achieve a lower production cost than the competition, and thus gain a competitive cost advantage.

Cost Deployment implementation to the company allows to:

1. Indication of relationships between cost factors and processes that generate these costs and indication of types of generated losses in the production process at the same time.
2. Finding the relationship between waste and its reduction and it's monetary quantification.
3. Verification whether there is know-how in the company that contributes to reducing the level of generated waste.
4. Classification of turnaround projects and plans based on cost/benefit analysis.
5. Understanding of the overall value of loss and waste in the plant especially by employees.
6. Creation of a program enabling the implementation of turnaround projects and plans and generating savings.

Goals and grounds of implementing and using of Cost Deployment in an enterprise

The Cost Deployment method enables to achieve cost efficiency also operating in the electric vehicle sector, while maintaining a certain flexibility of the process, agility and appropriate maintaining pretty high level of reactivity on emerging customer needs.

All manufacturing companies, especially those in automotive sector are focused on maintain the lowest cost level possible while satisfying customers and maintaining competitive advantage. This might be some kind of "braking neck" strategy, nevertheless the Cost Deployment method can successfully be a kind of path that can be followed by an enterprise in search of the ideal production cost. To implement Cost Deployment system of cost analysis requires a lot of manufacturing data available. The basic task of modern methods of measurement and evaluation is not to control, but to communicate about the current situation and the goals set to be implemented in line with the strategic goals of the company. There is a need to search for modern enterprise management tools to improve the efficiency and effectiveness of management[12] and Cost Deployment seems to be one of them.

Cost Deployment method offers unique methodology to indicate the cause and effect relationship together with resulting loss and its quantification. This information allows to select the most effective way of loss and waste elimination, both from technical and economical point of view. The change of attitude and perception of ongoing processes is based on four pillars, as show on Figure 4.

Cost Deployment, since it is a method that supports operations of different profile companies, dealing with VUCA world (volatility, uncertainty, complexity, and ambiguity), is a response to traditional cost accounting systems. Cost Deployment aim is to provide information to the decision-making process in the enterprise.

Cost Deployment is a method combining traditional cost accounting, Lean Accounting and management controlling.

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[12] J. Nesterak, *Ewolucja controllingu w Polsce i na świecie*, "Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie" 2013, nr 905, pp. 37–54; *idem*, *Controlling zarządczy. Projektowanie i wdrażanie*, Wolters Kluwer, Warszawa 2015.

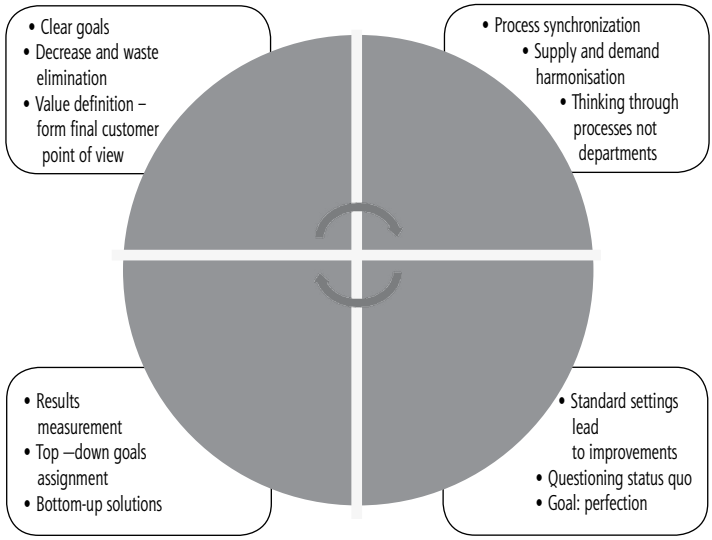

Figure 4. Principles of synchronization of process in the enterprise

Source: J. Nesterak, A. Wodecka-Hyjek, E. Bąchor, *The Cost Deployment Concept – Methodological Outline*, [in:] *Knowledge – economy – society. Business development in digital economy and COVID-19 crisis*, eds. J. Nesterak, B. Ziębicki, Institute of Economics. Polish Academy of Science, Warsaw 2021, p. 226.

Characteristics of the Cost Deployment research procedure

Implementing WCM rules in a company requires introduction and implementation of different pillars – technical and managerial. The Cost Deployment meth is a basic, technical pillar. It might be said, that everything starts from here. Having data to analyse, it means to have knowledge and capacity to measure single cost substance of existent production steps. It is almost mandatory to accept and face constant revision of data and continuous analysis of the production process, and on the first place questioning *status quo*. The Cost Deployment process itself leads to the identification of links between the identification of losses and the determination of their economic value.[13] Whole process is undertaken through matrices

[13] L.C.S. Silva, J.L. Kovaleski, S. Gaia, M. Garcia, P.P. de Andrade Júnior, *Cost Deployment Tool for Technological Innovation of World Class Manufacturing*, "Journal of Transportation Technologies" 2013, vol. 3, no. 1, pp. 19–23, http://dx.doi.org/10.4236/jtts.2013.31002.

use. All matrices represents basic rules of visual management, not only through colour – importance matching rule but also by schematic representation of the processes taking place, making it possible to indicate the relationships between individual departments and processes. Using Cost Deployment method it is possible to indicate which of them are the causes of losses and which losses are the result of other actions.[14] The seven steps that make up the whole process are individual stages that follow each other, and each subsequent one is a detail of the previous one and at the same time an indication of actions that should be taken as a result of their analysis (Figure 5).

The result of the individual stages are matrices that clearly and unambiguously indicate the areas of greatest interest.

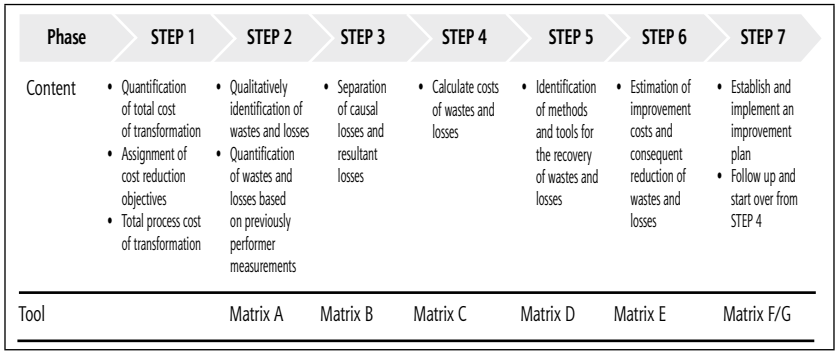

Figure 5. Cost Deployment process

Source: *Ibidem*, p. 228.

Analysis of the transformation process and Matrix A

The initial phase allows for understanding and thorough analysis of the entire production process. The costs, the transformation process, the nature of the costs, where they arise are subject to a detailed analysis. The use of Visual Management techniques allows

[14] A. Petrillo, D. De Felice, F. Zomparelli, *Performance Measurement for World-Class Manufacturing: A Model for the Italian Automotive Industry*, "Total Quality Management & Business Excellence", 2019, vol. 30, issue 7–8, pp. 908–935, https://doi.org/10.1080/14783363.2017.1408402.

you to immediately direct attention to the areas that require the most attention. Locating the losses in individual cost centres (Matrix A) is the starting point for further analyses.[15]

Indication of sources of generated losses – Matrix B

Classification of generated losses within the production process allows you to move to the next stage and create the Matrix B. Martix B allows to indicate the interdependencies between individual loss items and cost centres, while taking into account the nature of the loss, namely whether it is a resultant or causal loss. Ability to indicate the nature of the loss (consequential/causal) enables a direct impact and actions on the generated consequential losses and avoiding their occurrence in the future. In addition, the elimination or reduction of causal losses automatically affects the resulting ones, without the need to take direct action on them.

Very often the resulting loss is also the cause of the next one, which is why it is important to be able to identify the original loss.

Valorisation – Matrix C

The most relevant from purely financial point of view step is the transformation of losses into monetary values. This is done by calculating the costs incurred in individual activities that make up the indicated loss. Losses, which are expressed in technical values, are converted into monetary values, by applying e.g. hourly rates, the cost of renting per m2 of warehouse space, etc. The data contained in Matrix C are of great importance and are analysed from three sides: cost, process phase and loss unit. Determining the significance of losses is often done by applying the Pareto method between the phase of the production process and the type and amount of losses.

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[15] J. Nesterak, A. Wodecka-Hyjek, E. Bąchor, *The cost deployment concept – a methodological outline*, [in:] *Knowledge – economy – society. Business development in digital economy and COVID-19 crisis*, eds. J. Nesterak, B. Ziębicki, Institute of Economics. Polish Academy of Science. Warsaw 2021, pp. 223–236.

Methods of reducing the resulting losses and the cost of their elimination. Costs/benefits analysis – turnaround/repair projects. Matrix D/E

Result of the Matrix C allows for the subsequent stratification of the loss components, which is fundamental for identifying the main cause – the "root" of the occurring losses. Knowledge and awareness of the "true" cause of the losses allows to select the most appropriate repairing tool and determine the appropriate approach to the planned repair projects. This gives the opportunity to rank your losses by loss category and cost centre. Estimated losses needs to be assigned to technical pillars together with methods and tools to be applied. In fact, Matrix D is used for this purpose. Matrix E instead, is a statement of the relationship between the cost generated by a given loss and the cost to be incurred to eliminate it or reduce its size. All proposed actions are selected and evaluated according to three factors: impact, cost and ease of implementation. This so-called ICE analysis (impact/cost/effectiveness) allows you to determine an indicator that clearly shows to what extent it is possible to reduce a given loss. The impact factor determines the value of the identified loss. The cost factor determines the value of the cost of introducing improvement actions for the indicated loss. The last of the three indicators, i.e. the indicator of the ease of implementing the proposed improvements, illustrates the value of their implementation included in the values of time and resources necessary to carry them out. The highest indicator obtained indicated the "best" corrective actions to undertake.

Settlement of actions taken

It is unreasonable to introduce all agreed corrective actions at the same time. Their planning in time is aimed at achieving maximum benefits from their implementation. The sequence of individual projects is based on the results of the ICE analysis, taking into account management suggestions and decisions. Individual repair projects are analysed from the financial point of view and investment efficiency assessment by analysing the indicators, i.e. PBP (payback period), NPV (net present value) and IRR (internal rate

of return) of the analysed projects. Cost is a resultant element, and the reason for its creation is waste. The selection of methods and the effects of their application are subject to evaluation. Matrices F and G are the final matrices in a given Cost Deployment cycle. The Cost Deployment method allows you to establish a cost reduction program in a rational and systematic way. An extremely important aspect here is the connection and joint action, as well as the analysis between the production departments and controlling. Also in this matter, the factor of the globally applied approach is visible, that activities should be extended not to selected departments, but to all departments involved in the production process.

An important aspect in the application of the Cost Deployment method itself is also the use of auxiliary tools. What are IT tools or VSM (value stream mapping). The use of IT tools, both databases and properly parameterized reports, allows obtaining information necessary for the periodically repeated Cost Deployment process. The availability of data enables and supports the enterprise in achieving a certain level of agility, as a combination of the efficiency of Lean Manufacturing with the operational flexibility of modules, providing customized solutions.[16] The use of IT tools primarily enables the efficient and effective implementation of the Cost Deployment process. Supporting tools in the implementation of Cost Deployment are not only IT tools based on data analysis, but also techniques for and supporting the WCM implementation process in the enterprise.[17] A commonly used tool in Lean Manufacturing is VSM. It is a comprehensive analysis and visualization tool for illustrating the main processes and their operations, along with execution times, buffers and information flows.[18]

[16] M. Sajdak, *Zwinność w odpowiedzi współczesnych przedsiębiorstw na nowe wyzwania otoczenia*, "Studia Oeconomica Posnaniensa" 2014, vol. 2, nr 11, pp. 154–168; M. Dudek, *op. cit*.; M. Walczak, A. Wodecka-Hyjek, *Business Model Attributes of a Mass Customization-oriented Company*, [in:] *Knowledge, Economy, Society: Reorientation and Transformations of Economy and Organization Management Concepts*, eds. B. Mikuła, T. Rojek, Foundation of the Cracow University of Economics, Cracow 2018, pp. 103–112.

[17] G.K. DeBusk, *Use Lean Accounting to Add Value to the Organization*, "The Journal of Corporate Accounting & Finance" 2012, vol. 23, issue 3, p. 35, https://doi.org/10.1002/jcaf.21751.

[18] M. Rother, J. Shook, *Learning to see: Value-Stream Mapping to Create Value and Eliminate Muda*, foreword by J. Womack, D. Jones, Lean Enterprise Institute, Cambridge, MA 2003.

Summary

The use of the Cost Deployment method is justified basically in every manufacturing company. Manufacturers dedicate a lot of resources to make sure they prevent waste and financial loss within the business and contribute to maximizing the company's profits. These philosophies bring new, innovative strategies that improve the production process. The dominant philosophy is World Class Manufacturing, within which there is a method of cost analysis, which is Cost Deployment. Because the Cost Deployment method is based on sequential seven steps that must be taken in order to fully understand the places where losses and wastes arise, their causes and what actions to take to eliminate as much of them as possible. In the modern electric vehicle sector, one of the goals of existing companies is to generate profits and added value for shareholders. To be able to achieve this, you need to get a better granularity of cost management. For this purpose, appropriate matrices are used in order to be able to locate the resulting losses and wastes in the entire production process and to better understand the costs attributed to various aspects of the production process. The method of cost analysis, which is Cost Deployment, can be largely used in a company that cannot boast of the implemented WCM, but can certainly strive to obtain it and thus strive to achieve world-class production.

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Impact of the cost of buying and using an electric car on the household budget in Poland

Abstract
Electric cars are being promoted as a clean alternative to internal combustion engine cars. In larger cities, drivers driving electric vehicles have more privileges than those driving combustion cars, as an incentive to buy them. Urban zones are being planned, which will ultimately only be accessible by electric car. Every year, more and more car companies are offering electric cars to their customers. The electric engine does not generate toxic compounds and is therefore not a cause of air quality degradation. But potential customers have many concerns about buying an electric car. They wonder whether the number of charging points at motorways or car parks is sufficient or whether the burden on the home electricity network and the cost of electricity will be too high. The aim of the study is to compare the burden on the household budget caused by purchasing an electric car and an internal combustion engine car.
Keywords: electric car, purchase financing, household budget

Introduction

Electric vehicles are the next stage in the development of human civilisation in the progress of individual transport. It should be noted that the first references to electrically powered vehicles date back to the early 19th century. Unfortunately, the level of development of electrical engineering at the time and the significant development of internal combustion engines (ICE) made electric propulsion forgotten about for years. Nowadays, a great deal of attention is being paid to ecology in the world. Both companies and households are

introducing new solutions to take care of the Earth's environment. One of these is the introduction of electric cars. In larger cities, drivers driving electric vehicles have more privileges than those driving combustion cars, as an incentive to buy them. Urban zones are being planned, which will ultimately only be accessible by electric car. Every year, more and more car companies are offering to buy electric cars for their customers. However, the price of these cars and their use is not a cheap solution, at least that is what most drivers think, and therefore not a solution for all households. The aim of the study is to compare the burden on the household budget caused by purchasing an electric car and an internal combustion engine car.

Advantages and disadvantages of using an electric car

Electric cars are promoted as a clean alternative to combustion cars. The eco-friendly electric engine does not generate toxic compounds and is therefore not a cause of air quality deterioration. Potential customers have many concerns about buying an electric car. They wonder whether the number of charging points at motorways or car parks is sufficient, or whether the burden on home electric networks and the cost of electricity will not be too high. Currently, there are relatively few electric cars on Polish roads. There are some cities where there are more of them than in others, but in total this is a few per cent of new electric cars on a European scale. With the increase in the number of cars being charged from the electric network, it is necessary to develop the infrastructure. The number of publicly available charging stations has been increasing rapidly in recent times. As for the energy bills, yes, the bills will be higher, but it costs less to operate an electric car than an internal combustion engine car and over time this offsets the high purchase price of an electric car, as will be shown in the next section of this paper.

In recent years, the European Union has allocated many billions of euros to research related to the expansion of electric cars and the development of alternative fuel infrastructures including electric vehicle chargers, particularly on the main European transit

corridors. The Community is also focusing on relocating the production of electric batteries to Europe; currently, the majority of production takes place in Japan, China and South Korea. The post-pandemic experience makes it clear that, in order to avoid further disrupted supply chains, Europe should take care of production at home.

The benefits of owning an electric car are divided into those improving comfort, making it easier to get around a large city on a daily basis, activating social responsibility for the environment around us or, finally, bringing a tangible financial benefit to the owner. Driving an electric car is more comfortable. You do not feel the mechanical vibrations inside the vehicle, which is a daily occurrence in combustion cars. The ride is smooth, starting is dynamic and there is no noise while driving. The advantages of driving an electric car are particularly accentuated in urban conditions and traffic jams.[1]

In many cities, the rule of thumb is that the closer you get to the centre, the more difficult it is to get around by car due to the large number of restrictions. However, these restrictions mostly do not apply to electric vehicles. Drivers of electrics can enter clean transport zones that are closed to internal combustion cars, which of course reduces the time it takes to reach, for example, a business meeting scheduled in the centre. Often urban users of electric cars can count on specially designated parking spaces where chargers are set up for free charging. This solution also reduces the time required to find a parking space. Another privilege of the electric car is the ability to drive in lanes designated for public transport and emergency vehicles. This is again a time-saver when navigating the congested city streets.

An electric car is a green car. In Poland, over 90% of electricity comes from burning fossil fuels, mainly coal. Regardless of which source of electricity is used, it is an undeniable fact that the process of converting electricity into mechanical energy in electric vehicles is 100% emission-free and environmentally friendly. Another

[1] S. Gawron, J. Bernatt, *Doświadczenia z eksploatacji samochodów elektrycznych w działalności gospodarczej*, "Maszyny Elektryczne: Zeszyty Problemowe" 2017, no. 2, p. 232.

ecological aspect in the use of an electric vehicle is the considerably longer intervals between servicing, e.g. of the braking system and replacement of discs and pads, no oil changes and other fluids.[2]

In recent years, several surveys have been carried out on respondents' opinions on the advantages and disadvantages of owning and using electric vehicles for individuals. Innogy Poland commissioned a study in 2017 on the interest of Poles in the electric car. The Innogy Group is one of the important corporations in the energy market with its own comprehensive electric vehicle charging systems. The commissioned research was conducted on a group of 700 Polish residents aged 18 and over. As a result of the research, the main reasons delaying the dynamics of electromobility development in Poland were defined.[3]

Table 1. Barriers slowing down the dynamics of electromobility development in Poland

Most frequently identified barriers	
Lack of a publicly accessible network of fast charging stations	41%
Too high a purchase price for an electric vehicle	35%
No possibility of charging the electric vehicle at home and/or at work	33%
Lack of knowledge about electric cars	21%
Short travel range of electrically powered vehicles	20%
Lack of tax incentives and subsidy schemes for purchasing electric vehicles	20%
No privileges for electric vehicle users	7%

Source: D. Zaniewska-Zielińska, *Problemy rozwoju elektromobilności w Polsce*, "Europa Regionum" 2018, vol. 35, no. 2, p. 73.

A survey was conducted among electric car users in 2020–2021[4], in which a questionnaire was carried out asking questions about the advantages, disadvantages and general issues of using electric cars. Almost all (97.7%) of those surveyed expressed complete satisfaction

[2] *Ibidem*.

[3] D. Zaniewska-Zielińska, *Problemy rozwoju elektromobilności w Polsce*, "Europa Regionum" 2018, vol. 35, no. 2, pp. 72–73.

[4] K. Dereń, W. Owczarek, *Elektromobilność w Europie – perspektywy jej wdrożenia w Polsce*, "Zeszyty Naukowe Politechniki Poznańskiej. Organizacja i Zarządzanie" 2021, no. 84, pp. 19–30.

with their car and would not want to return to a combustion car. More than 88% of respondents rated the convenience of an electric car as good or very good. Drivers cited acceleration and dynamics and driving comfort as the biggest surprises, as well as low failure rates. Table 2 shows the advantages and disadvantages most frequently mentioned by electric car drivers surveyed. Compared to the 2017 survey, three disadvantages (barriers) recurred: cost of purchase, poor availability of charging points, need for detailed planning of longer routes.

Table 2. Advantages and disadvantages of electric vehicles

Advantages	Disadvantages
Very low operating costs	Cost of purchase
Low failure rate	Poor availability of charging points
Convenience and amenities	The need for detailed planning of longer routes

Source: K. Dereń, W. Owczarek, *Elektromobilność w Europie – perspektywy jej wdrożenia w Polsce*, "Zeszyty Naukowe Politechniki Poznańskiej. Organizacja i Zarządzanie" 2021, no. 84, p. 23.

The availability of charging points is increasing and continues to increase month by month. The cost of purchase can indeed be an insurmountable barrier for some users however, the running costs of electric cars are very low as will be shown in the last section of this paper.

Financial support: *Mój Elektryk* programme

In July 2021, the Polish National Fund for Environmental Protection and Water Management (Pol. Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej, NFOŚiGW) launched the *Mój elektryk* (Polish for 'My electric car') programme. The aim of the programme is to avoid air pollutant emissions by co-financing projects to reduce the consumption of emission fuels in transport through support for the purchase or leasing of zero-emission cars (including electric cars) by both business entities and individuals. The total amount of non-refundable forms of co-financing is PLN 500,000,000, which should be spent no later than by 30.06.2026. However, in order to receive funding for the purchase or leasing

of an electric car, several conditions must be met (Table 3). In the case of an individual without a Large Family Card (Pol. Karta Dużej Rodziny, KDR), the price of a zero-emission vehicle cannot exceed PLN 225,000; for a KDR holder, there is no limit on the purchase price of the vehicle. In both the first and second situation, there is no limit on the average annual mileage. The amount of the subsidy for an individual without the KDR is PLN 18,750, while for a holder of the Card it is PLN 27,000.

Table 3. Level of subsidy for an individual in the Mój Elektryk programme

Vehicle category	Maximum vehicle price	Average annual mileage (km)	Amount of funding
M1 (passenger cars for max. 8 persons)	Consumer PLN 225,000	Consumer – no limit	PLN 18,750
M1 (passenger cars for max. 8 persons)	Consumer with a Large Family Card (KDR) – no limit	Consumer – no limit	PLN 27,000

Source: own work based on: *Elektromobilność – Mój elektryk*, GOV.pl, https://www.gov.pl/web/elektromobilnosc/program-moj-elektryk [accessed: 31.05.2022].

The partner of the NFOŚiGW in subsidising the purchase or leasing of an electric car for individuals is Bank Ochrony Środowiska (BOŚ). Other commercial banks and leasing companies can cooperate with BOŚ and credit or lease electric carss with state subsidies. According to Annex 1: Priority programme entitled "Mój Elektryk" with the Guidelines on eligible costs, the conditions for the subsidy that must be met are as follows:[5]

1. funding will not be given to projects whose costs have been co-financed by national or foreign public funds, in particular from the European Union budget;
2. the zero-emission vehicle purchased/leased must be new;
3. the zero-emission vehicle purchased/leased must be labelled during its lifetime;
4. the durability period is 2 years from the date of completion of the project (purchase of a vehicle), where in the case of leasing,

[5] Załącznik nr 1: Program Priorytetowy pod nazwą „Mój elektryk" wraz z Wytycznymi w zakresie kosztów kwalifikowalnych, GOV.pl, https://www.gov.pl/web/elektromobilnosc/nabor-dla-bankow-sciezka-leasing [accessed: 31.05.2022].

this should be understood as the date on which the new vehicle is handed over to the beneficiary (Lessee) for use or use and collection of benefits on the basis of a protocol on the handover of the vehicle;

5. the zero-emission vehicle which is the subject of the grant will be registered in the territory of the Republic of Poland for at least 2 years from the date of completion of the project;
6. the registration of the zero-emission vehicle must be made in the name of the owner of the vehicle, who is the beneficiary of the grant under this scheme (in the case of leasing, the vehicle may be registered in the name of the beneficiary or the leasing company with which the leasing contract is bound);
7. the zero-emission vehicle covered by the grant must be insured against damage, destruction and loss due to collision, damage by third parties and theft, including third-party liability and AC insurance (motor hull insurance), at least for the durability period;
8. in the event of failure to comply with the obligations referred to in points 5 to 7, the grant, together with any interest due, shall be reimbursed in accordance with the conditions laid down in the grant agreement; the agreement may, in particular, specify the proportionality of the reimbursement and the cases where reimbursement may be waived;
9. payment of the grant may be conditional on the provision of a repayment security;
10. funding may be granted for a project which has been completed before the date of submission of the application, subject to point 13;
11. the subsidy will be paid only in the form of a refund after the purchase of the vehicle or in the form of a surcharge on the charges laid down in the leasing contracts (initial charge and transfer charge) after the signing of the vehicle handover protocol;
12. where the subsidy relates to a zero-emission vehicle of category M2 or M3 and constitutes public aid, the provisions of the Regulation of the Minister of the Environment of 21 December 2015 on detailed conditions for granting horizontal public aid for environmental protection purposes,[6] concerning aid for invest-

[6] Rozporządzenie Ministra Środowiska z dnia 21 grudnia 2015 r. w sprawie

ments enabling the reduction of pollutant emissions, when EU environmental protection standards have not been established, apply to it;
13. a project consisting in the purchase/leasing of an M2 or M3 vehicle may not have started before the date of submission of the grant application. The start of the project is understood to be the conclusion of the contract for the purchase/leasing of the vehicle;
14. where the applicant is a non-business natural person, he/she may receive one grant covering one zero-emission vehicle;
15. subsidies intended to subsidise the initial payment and the transfer charge indicated in the lease contract for a zero-emission vehicle may be granted if the leased object has not previously been subsidised under the scheme in question.

Cost of ownership and use of electric cars for the household

Electric cars are mainly associated with environmental friendliness due to their significantly reduced carbon dioxide emissions into the atmosphere compared to combustion vehicles.[7] However, it is worth noting that they are also economical vehicles, as their running costs are significantly lower than those of combustion cars. To benchmark the cost-effectiveness of an electric vehicle against an internal combustion vehicle, it is important to consider not only the purchase cost, but also the total cost of ownership (TCO) of the vehicle, which includes: purchase cost, fuel (energy) cost, insurance, maintenance, repairs, taxes and surcharges. In the current situation, the purchase price of an electric is higher than that of a conventionally powered vehicle of the same class. The difference in TCO at the time of purchase is reducible over the lifetime of the vehicle, due to the lower operating and maintenance costs of electric cars.

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szczegółowych warunków udzielania horyzontalnej pomocy publicznej na cele z zakresu ochrony środowiska, Dz.U. [Journal of Laws of the Republic of Poland] 2015, item 2250.

7 K. Polakowski, *Kierunki rozwoju rynku pojazdów elektrycznych*, [in:] *E-mobilność: wizje i scenariusze rozwoju*, eds. J. Gajewski, W. Paprocki, J. Pieriegud, Fundacja Centrum Myśli Strategicznych, Sopot 2017, p. 147.

In this study, an attempt was made to compare the costs of purchasing and maintaining an electric and combustion car by a household with a KDR as well as for a household that does not have this Card. Due to the rapid change in fuel prices as well as the change in car prices, all data for the analysis was set as at 31.05.2022. The following car models were selected for comparison:

- Citroën C4, automatic, petrol 1.2 PureTech 130 hp Shine – ICE car;
- Citroën e-C4 EV136 Shine – electric car.

Two financing options were analysed: subscription purchase and cash purchase.

A new way of financing has been introduced relatively recently – the subscription purchase of a new car for an individual customer. This modern financing scheme combines the benefits of low monthly instalments with the possibility of replacing the car every 3 or 4 years. With this form of financing, there is no need to buy a vehicle outright. The customer only pays off the physical depreciation of the vehicle over the course of the vehicle's life and can then exchange it for a new one without committing his or her capital. The data used for the analysis are presented in Table 4.

Table 4. Data used to calculate the cost of owning and operating an internal combustion engine car and electric car (subscription purchase)

	Internal combustion engine car	Electric car (without KDR)	Electric car (with KDR)
Purchase price	PLN 123,950	PLN 171,322	PLN 171,322
Funding period	48 months		
Own contribution	10% (PLN 12,395)	10% (PLN 17,132)	10% (PLN 17,132)
Subsidy	no	PLN 18,750	PLN 27,000
Motor insurance	PLN 3,279	PLN 4,220	PLN 4,220
Maintenance/service (Premium Package)	PLN 9,540	PLN 5,150	PLN 5,150
Parking subscription	PLN 400	no	no
Annual mileage	20,000 km		
Gross monthly instalment	PLN 1,760	PLN 1,899	PLN 1,682.52
Fuel/energy consumption WLTP	7.5 L/100 km	15 kWh/100 km	15 kWh/100 km
Fuel price per 1 L / energy price per 1 kWh	PLN 7.10/L	PLN 0.52/kWh	PLN0.52/kWh

Source: Author's own work based on data from Citroën (www.citroen.pl) and current average fuel and energy prices (as of 31.05.2022).

One of the utility cost items is the cost of service. For the purposes of the calculation, the premium version of the Service Package was adopted. The package includes: 24-hour Citroën Assistance service available 7 days a week; mobility services (replacement vehicle, continuation of journey or return to home, hotel; warranty extension (repair of mechanical, electrical or electrotechnical defects including parts and labour); periodic inspections (covering the costs of servicing during inspections in accordance with the manufacturer's recommendations – original spare parts, labour, approved oils, fluids and lubricants); consumables (covering the costs of replacing consumable parts (brake pads, brake discs, clutches, shock absorbers – including the cost of these parts).

Electric cars have much more freedom to get around in large cities. As previously mentioned, parking in the inner city of large cities is charged, which is not the case for electric cars. For this cost analysis when using a car with an internal combustion engine, a monthly parking subscription in the City of Kraków was assumed (PLN 400); this is not shown for the cost of using an electric car.

Table 5. TCO of internal combustion engine car vs. electric car (subscription purchase)

	Internal combustion engine	Electric car (without KDR)	Electric car (with KDR)
Gross monthly instalment	PLN 1,760	PLN 1,899	PLN 1,682.52
Monthly maintenance	PLN 198.75	PLN 107.29	PLN 107.29
Monthly exploitation	PLN 888.39	PLN 130.13	PLN 130.13
Parking subscription	PLN 400	–	–
TCO – total monthly cost of ownership and use	PLN 3,247.14	PLN 2,136.42	PLN 1,919.94

Source: Author's own work based on data from Citroën (www.citroen.pl) and current average fuel and energy prices (as of 31.05.2022).

The results of calculating the costs of purchasing and using an electric and a combustion engine car (with subscription purchase) are presented in Table 5. The calculations clearly show that the monthly cost of using an electric car is significantly lower than for a car with an internal combustion engine and amounts to PLN 2,136.42 (without KDR) or PLN 1,919.94 (with KDR) per month for an electric car and PLN 3,247.14 for a combustion engine car, respectively.

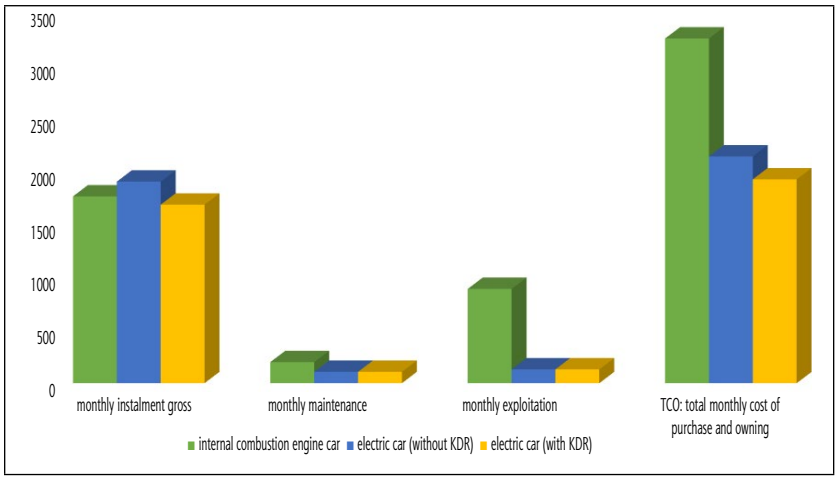

Chart 1. TCO of internal combustion engine car vs. electric car (subscription purchase)

Source: Author's own work based on cost analysis.

Overall – still taking into account the value of the user's own contribution – the monthly costs are as follows:

Internal combustion engine car:

own contribution (10% of purchase price) = PLN 12,395

PLN 12,395 / 48 months of use =PLN 258.23

So the cost of purchase and use is:

PLN 3,247.14 +258.23 = PLN 3,505.37

Electric car (without KDR):

own contribution (10% of purchase price) = PLN 17,132

PLN 17,132 / 48 months of use = PLN 356.92

So the cost of purchase and use is:

PLN 2,136.42 + 356.92 = PLN 2,493.34

Electric car (with KDR):

own contribution (10% of purchase price) = PLN 17,132

PLN 17,132 / 48 months of use = PLN 356.92

So the cost of purchase and use is:

PLN 1,919.94 + 356.92 = PLN 2,276.86

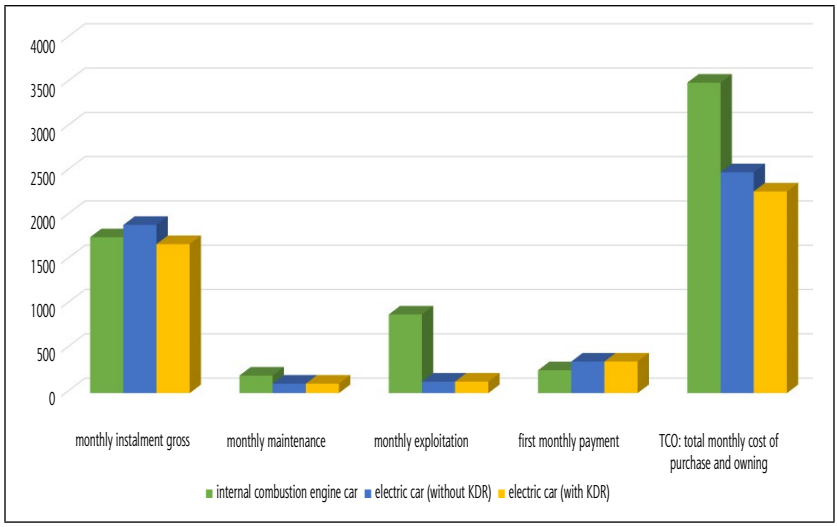

Chart 2. TCO of internal combustion engine car vs. electric car – taking into account the first payment of 10% (subscription purchase)

Source: Author's own work based on cost analysis.

Difference in purchase price (without KDR) = electric car – ICE car

PLN 171,322 –18,750 – 123,950 = PLN 28,622

TCO difference (without KDR) = ICE car – electric car

PLN 3,505.37 – 2,493.34 = PLN 1,012.03 × 48 months = PLN 48,577.44

PLN 48,577.44 – 28,622 = PLN 19,955.44

Difference in purchase price (with KDR) = electric car – ICE car

PLN 171,322 – 27,000 – 123,950 = PLN 20,372

TCO difference (from KDR) = ICE car – electric car

PLN 3,505.37 – 2,276.86 = PLN 1,228.51 × 48 months = PLN 58,968.48

PLN 58,968.48 – 20,372 = PLN 38,596.48

To sum up, the difference in purchase price is offset by the lower TCO of an electric car, so the purchase and TCO of an electric car,

for a period of 4 years, is lower than that of an internal combustion engine car. Taking into account the difference in purchase price and TCO, it is clear that a household without a KDR buying an electric car gains PLN 19,955.44, and one with a KDR gains PLN 38,596.48.

The next section presents a comparative analysis of the costs of purchasing, maintaining and using a combustion engine car and an electric car when buying cash. Of course, in order to be able to compare with the calculation values for a subscription purchase, a useful life of 4 years was assumed as in the calculation above, a subsidy for a household without the KDR as well as with the possession of this Card, and Premium Service Package.

Table 6 shows the data included in the calculation of the cost of owning and maintaining an electric and a combustion car.

Table 6. Data used to calculate the cost of owning and operating an internal combustion engine car and electric car (cash purchase)

	Internal combustion engine car	Electric car (without KDR)	Electric car (with KDR)
Purchase price	PLN 123,950	PLN 171,322	PLN 171,322
Subsidy	no	PLN 18,750	PLN 27,000
Motor insurance	PLN 3,279	PLN 4,220	PLN 4,220
Maintenance/service (Premium Package)	PLN 9,540	PLN 5,150	PLN 5,150
Parking subscription	PLN 400/month	no	no
Annual mileage	20,000 km		
Fuel/energy consumption	7.5 L/100 km	15 kWh/100 km	15 kWh/100 km
Fuel price per 1 L / energy price per 1 kWh	PLN 7.10/L	PLN 0.52/kWh	PLN 0.52/kWh

Source: Author's own work based on data from Citroën (www.citroen.pl) and current average fuel and energy prices (as of 31.05.2022).

Based on the data in Table 6, the costs of use, maintenance and purchase were calculated. It should be noted that the initial value of the car is reduced due to use. It was determined on the basis of the Eurotax tables,[8] that for the models selected for this analysis, the value after 4 years of use will decrease to 51% for a car with a combustion engine and 48% for a car with an electric motor. The results of the calculations are shown in Table 7.

[8] Eurotax, www.eurotax.pl [accessed: 31.05.2022].

Table 7. TCO of internal combustion engine car vs. electric car (cash purchase)

	Internal combustion engine car	Electric car (without KDR)	Electric car (with KDR)
Real monthly decrease in value / 48 months	PLN 1,265.33	PLN 1,464.36	PLN 1,293.49
Monthly maintenance	PLN 198.75	PLN 107.29	PLN 107.29
Monthly exploitation	PLN 888.39	PLN 130.13	PLN 130.13
Parking subscription	PLN 400	–	–
TCO – total monthly cost of ownership and use	PLN 2,752.47	PLN 1,701.78	PLN 1,530.91

Source: Author's own compilation based on data from Citroën (www.citroen.pl) and current average fuel and energy prices (as of 31.05.2022).

Summarising the full lifetime assumed for the calculation, it is clear that the electric car has a significantly lower TCO at each subsidy level. For a family with fewer than 3 children, an electric car is cheaper by more than PLN 1,000 and for a large family by more than PLN 1,200 per month.

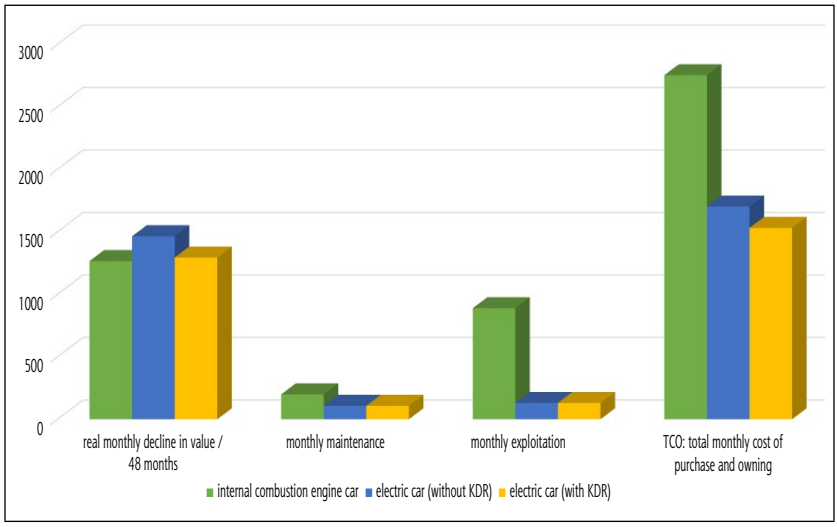

Chart 3. TCO of internal combustion engine car vs. electric car (cash purchase)

Source: Author's own work based on cost analysis.

Table 8 compares the TCO for subscription and cash purchase. The monthly and annual difference was calculated and then the percentage of the annual difference in TCO to the initial value of the vehicle was determined. Analysing the results obtained, it can be

concluded that it is not worthwhile to buy a car with cash. The percentage of the difference in cost established is lower than the current interest rate on deposits in the bank (5% on average). Therefore, instead of getting rid of cash when buying a car, it is possible to make this transaction on a subscription basis, use the car, hold the cash and cover the additional subscription costs with interest from bank deposits.

Table 8. Difference in TCO of subscription and cash vehicle purchase – internal combustion engine car vs. electric car

	Internal combustion engine	Electric car (without KDR)	Electric car (with KDR)
Purchase price	PLN 123,950	PLN 171,322	PLN 171,322
TCO – total monthly cost of ownership and use (subscription purchase)	PLN 3,247.14	PLN 2,136.42	PLN 1,919.94
TCO – total monthly cost of ownership and use (cash purchase)	PLN 2,752.47	PLN 1,701.78	PLN 1,530.91
Monthly difference in TCO (PLN)	PLN 494.67	PLN 434.64	PLN 389.03
Annual difference in TCO (PLN)	PLN 5,936.04	PLN 5,215.68	PLN 4,668.36
Share of annual TCO difference to initial purchase value	4.8%	3%	2%

Source: Author's own compilation based on data from Citroën (www.citroen.pl), Eurotax (www.eurotax.pl) and current average fuel and energy prices (as of 31.05.2022).

Conclusions

Reducing emissions and improving the environment is an important aspect because it affects the quality and safety of life. Lower operating costs as well as safety are the most important arguments for any electric car owner. Unfortunately, there are also disadvantages, which still include the insufficient number of charging points, but this problem is getting smaller every day as the number of charging points is steadily increasing. Scientists are also conducting research into increasing the range for electric cars. There are many arguments that appeal and convince potential buyers of electric cars. The rationales include: comparable purchase costs with an internal combustion vehicle (subsidies for EVs), as outlined above in this paper, measurable savings (fuel vs. electricity costs), lower

maintenance costs, free entry into city centres (free parking), social responsibility for the environment, reduction of CO_2 emissions. On an emotional level, the following are in favour of EVs: convenience and ease of use – fast and intuitive charging, mobility, no noise or vibration, no local CO_2 emissions, no exhaust fumes.

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Media image of electromobility in the Polish regional and national press

Abstract
In the Polish media environment electromobility emerged at the end of the first decade of this century. In the last three years, however, this topic has appeared more and more often, mainly due to changes in law (public co-financing, the government's Electromobility Development Plan), the dynamic development of the electric public transport sector, as well as the announcement of the production of a Polish electric car Izera and EU plans to eliminate the production of internal combustion cars.

This article presents an image of electromobility in selected media sources. Its subjects are articles in some national and local papers (online versions), as well as on specialised websites. The main aim of the article is to assess the quality of the message regarding the overall electromobility policy in the country, as well as the attitude of the media to its development on the local market (based on the example of Kraków).
Keywords: electromobility, electric cars, local media, online newspapers

Introduction

"Electromobility is the totality of issues related to the production and operation of electric vehicles […]. The term refers to both the technical and functional aspects of electric vehicles, charging infrastructure, energy and environmental areas, as well as the social, economic and legal issues related to the production, acquisition and use of EVs."[1]

[1] Quote from the website of the first Polish social campaign supporting the development of the electric car market, Elektromobilni.pl, https://elektro-

The above quote can be seen as the quintessence of the term 'electromobility', which combines issues from the automotive field – in which it has been a leading trend for years – as well as economics, ecology, social behaviour and politics. It encompasses both private investment (sales of electric cars, state support) and public investment (urban transport, charging stations). In our media space, the issue of domestic electromobility appeared in 2009, with the launch of the first electric car charging station in Warsaw.[2]

Media coverage of electromobility policy and directions of its development depended on the current political and social trend, as well as the type of medium. They covered energy issues related to the electrification of public rolling stock in the most important Polish cities, investment issues, including the production of the first Polish electric car – Izera, but also issues of infrastructure management or care for the environment.

The article will discuss the resonance of the media on the development of eco-transport in Poland, from the government's announcements and plans to the issue of the proposed ban on the registration of new cars with internal combustion engines in European Union countries, which is to take effect from 2035. It uses mainly articles from specialised websites dealing with energy and eco-transport issues (e.g. Inzynieria.com, WysokieNapiecie.pl), as well as content from selected media outlets: wPolityce.pl (the online back office of the weekly "Sieci"), Rzeczpospolita online (RP.pl, a daily owned by Gremi Media, hereinafter: "Rz"), regional titles – "Dziennik Polski", "Gazeta Krakowska"[3] (hereinafter: "DP", "GK"), or local online portals.

The aim of the article is first and foremost to assess the quality of the coverage of electromobility in the indicated media. The source material consists of the websites of the mentioned press titles and industry portals. Their analysis was based, inter alia, on the frequency

mobilni.pl/elektromobilnosc/dlaczego-elektromobilnosc#efekt-cieplarniany [accessed: 01.06.2022].

[2] *Pierwsza stacja ładowania samochodów elektrycznych*, Inzynieria.com, 18.11.2009, https://inzynieria.com/energetyka/wiadomosci/15554,pierwsza-stacja-ladowania-samochodow-elektrycznych [accessed: 01.06.2022].

[3] Regional dailies of Polska Press Group, owned from April 2021 by PKN Orlen.

of occurrence of key phrases for the topic such as 'electromobility' and 'electric cars'.

Electromobility in selected Polish media (decade 2011–2021)

An article published in 2009 on Inzynieria.com about the first electric car charging station was also the first on this site with the tag 'electric cars'. The next was only information from 2011, about the launch of the first such station in Wrocław. In the same year, "Rz"[4] assessed that "electromobility – electric-powered vehicles – is gaining in importance. Although the issue is neglected in Poland, the largest German energy companies already have every county covered with their stations". In 2014, the industry portal WysokieNapiecie.pl introduced a tab on e-mobility, where it posted articles on the development of this field in Poland.[5] In the first commentary, the editors only pointed out the unaffordability of electric cars, and the need for a state policy to come out in favour of manufacturers – including preferential tax rates.[6] In the same period, the first juxtapositions with other countries appeared on portals, texts on difficulties in charging batteries of eco-cars, and possible facilities and privileges, such as possibilities of free parking.[7]

In 2016, the first articles on electromobility appeared in portals belonging to the Fratria publishing house (wPolityce.pl, wGospodarce.pl, "Gazeta Bankowa"). This was prompted by the announcement of the government's Strategy for Responsible Development, which

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4 *Samochody rządzą miastami?*, RP.pl, 07.05.2011, https://www.rp.pl/plus-minus/art14545011-samochody-rzadza-miastami [accessed: 02.06.2022].

5 By the end of June 2022, WysokieNapiecie.pl had published 322 articles, reading of which gives a good picture of the development of Polish electromobility.

6 For more on legal considerations: A. Mercik, *Elektromobilność w autobusowym transporcie publicznym organizowanym przez Górnośląsko-Zagłębiowską Metropolię jako narzędzie realizacji idei zrównoważonej mobilności*, "Prace Komisji Geografii Komunikacji PTG" 2020, vol. 23, no. 5, pp. 18–33.

7 A. Sumara, *Elektryczne samochody popularne, ale nie w Polsce*, Inzynieria.com, 7.04.2014, https://inzynieria.com/energetyka/analizy_i_komentarze/37092,elektryczne-samochody-popularne-ale-nie-w-polsce [accessed: 02.06.2022].

naturally became a politically important media topic. Among its assumptions were components of an electromobility development plan (electric cars and buses), and the "Electromobility Development Programme" itself assumed the creation of a 'new industry', or 'E-bus' programme, aimed at creating a Polish electric bus.[8] In the pages of a "Rz" automotive tab moto.rp.pl, the possibility of the success of the government project – one million electric cars by 2025 – was analysed at the time. The conclusion coincided with general feelings about the feasibility of this revolution in the Polish market, i.e. the issue of purchase cost, infrastructure, but also the habits of Poles. In October 2016, "Rz" noted the creation of ElectroMobility, a company founded by four energy companies of the State Treasury: Energa, Enea, Tauron and PGE.

A clear increase in the topic of electromobility has been observed since 2017 – for example, in "Rz", the number of articles during the year increased from a few to more than 70. The daily reported on Poland's backwardness, Lotos' preparations for the electromobility revolution (including the construction of charging points between the Tri-City and Warsaw);[9] it also zoomed in on the list of institutions that opposed the mandatory electrification of 50% of the fleet in state institutions by 2025.[10] The bill supporting electromobility was summed up as follows: "Nobody will buy an electric car if there is no network of chargers. But if there is no money to be made from the poles [chargers], there may be few willing to put them up." The last theme was also repeated on the Fratria (Energa Group investments) portals, besides writing about the plans of the Lublin-based Ursus, in the context of the Programme announced by the government.[11]

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[8] *Rząd stawia na rozwój. Morawiecki: Tysiące nowych miejsc pracy i 32 mld zł inwestycji w Strategii Rozwoju*, wPolityce.pl, 27.06.2016, https://wpolityce.pl/gospodarka/298406-rzad-stawia-na-rozwoj-morawiecki-tysiace-nowych-miejsc-pracy-i-32-mld-zl-inwestycji-w-strategii-rozwoju?strona=2 [accessed: 02.06.2022].

[9] T. Furman, *Lotos inwestuje punkty ładowania aut na prąd*, RP.pl, 6.09.2017, https://energia.rp.pl/elektromobilnosc/art18000471-lotos-inwestuje-punkty-ladowania-aut-na-prad [accessed: 03.06.2022].

[10] A. Wieczerzak-Krusińska, *Ministerstwa nie chcą pojazdów elektrycznych*, 01.06.2017, https://moto.rp.pl/ekologia/art17121801-ministerstwa-nie-chca-pojazdow-elektrycznych [accessed: 03.06.2022].

[11] It quoted then Deputy Prime Minister Jarosław Gowin: "In the next two or

In June 2017, "Gazeta Bankowa" identified the challenges of Polish electromobility,[12] and it was one of the few authorial contributions. Its author warned that "there will be no electromobility in Poland without gigantic investments in infrastructure", as "one million electric cars represent 1 GW of additional power demand in Poland in 2025." In a slightly different vein, another journalist from the magazine, Mariusz Kądziołka, has written: "The government's 'Electromobility Development Plan', which assumes that in 10 years there will be one million electric cars on Polish roads, is not at all – contrary to sceptical opinions – a pipe dream."[13] It is worth noting the apparent politicisation of the message here, exemplified by selected statements by Prime Minister Mateusz Morawiecki. They hit critics of the government programme ("A year ago the vision of electric buses and cars in Poland was laughed at"; "The electromobility we initiated aroused looks of pity from our adversaries, but now everyone admits that we were right"), or they fit into political promises ("there is a good chance that a factory of electric buses, and maybe cars, will be built in Poland").

In 2018, "Rz" mentioned electromobility more than 130 times, and these were analytical materials, including on the future of eco-vehicles, with a clear predominance of the issue of charging.[14] Writing about the poor development of Polish electromobility, journalists pointed out that in sales of electric cars "we are beaten even by the Czechs, Hungarians and… Romanians". "The fact that we are at the tail end of European electromobility should not come as

three years, hundreds of electric buses may appear on the streets of Polish cities, and then thousands", *Elektryczność przyszłością komunikacji miejskiej. Gowin: Pojawią się setki autobusów z napędem elektrycznym*, wPolityce.pl, 29.03.2017, https://wpolityce.pl/gospodarka/333525-elektrycznosc-przyszloscia-komunikacji-miejskiej-gowin-pojawia-sie-setki-autobusow-z-napedem-elektrycznym [accessed: 02.06.2022].

12 M. Siudaj, *Potrzebne kable i prąd, czyli elektromobilność po polsku*, Gazeta Bankowa, 12.06.2017, https://www.gb.pl/gazeta-bankowa-potrzebne-kable-i-prad-czyli-elektromobilnosc-po-polsku-pnews-1068.html [accessed: 02.06.2022].

13 "Gazeta Bankowa" 2016, no. 10 (1186).

14 E.g. A. Wieczerzak-Krusińska, *Czy będą specjalne taryfy dla ładowarek*, RP.pl, 23.07.2018, https://moto.rp.pl/od-kuchni/art17173201-czy-beda-specjalne-taryfy-dla-ladowarek [accessed: 04.06.2022].

a surprise […] Poland is one of the three – next to Bulgaria and Estonia – European countries where there are no incentives at all to increase demand for electric cars, such as government subsidies or tax exemptions."[15] The government's electromobility plan was described in an interview by Paweł Rożyński as "too ambitious and overestimated".[16] Importantly, "Rz" also referred the plan to the transformation of public transport, writing: "The legislator's lack of support for rail vehicles in public transport justifies the question of what the real objectives of the electromobility programme are."[17] According to the journalists, cities, through the development of low-emission public transport, limiting the entry of combustion vehicles into city centres or preferring e-cars in paid parking zones and on bus lanes – will become the actual initiators of the electric revolution on Polish roads.[18]

On Fratria's portals, information on the plans of state-owned companies took the form of announcements from institutional bulletins: *Energa is interested in electromobility* (24.01.2018), *PKN Orlen wants to develop electromobility* (27.04.2018), *The State Forests focus on electromobility* (08.05.2018), *Tauron focuses on electromobility* (21.05.2019). The articles were built on statements made by the presidents of the companies, the construction of most of them was

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[15] A. Woźniak, *Prąd wciąż nie kusi kierowców*, RP.pl, https://moto.rp.pl/tu-i-teraz/art17187801-prad-wciaz-nie-kusi-kierowcow; D. Walewska, *Miliardy na elektryfikację aut, ale do rewolucji daleko*, RP.pl, 05.02.2018, https://moto.rp.pl/archiwum/art17144591-miliardy-na-elektryfikacje-aut-ale-do-rewolucja-daleko [accessed: 05.06.2022].

[16] *Jana Pieriegud: Jesteśmy na początku długiej drogi do elektromobilności*, RP.pl, 1.10.2018, https://www.rp.pl/transport/art1718351-rzeczobiznesie-jana-pieriegud-jestesmy-na-poczatku-dlugiej-drogi-do-elektromobilnosci. "Puls Biznesu", among others, also wrote in a similar vein: M. Bołtryk, *Elektromobilność wygląda dobrze tylko na papierze*, 14.11.2018, https://www.pb.pl/elektromobilnosc-wyglada-dobrze-tylko-na-papierze-945578 [accessed: 05.06.2022].

[17] *Elektromobilność i komunikacja miejska – nie do końca dobrana para*, RP.pl, 20.11.2018, https://www.rp.pl/inne/art9552271-elektromobilnosc-i-komunikacja-miejska-nie-do-konca-dobrana-para [accessed: 05.06.2022].

[18] *Elektromobilność bez samorządów nie zaiskrzy*, RP.pl, 18.02.2018, https://regiony.rp.pl/regiony/art2111401-elektromobilnosc-bez-samorzadow-nie-zaiskrzy [accessed: 05.06.2022].

in fact similar.[19] An interesting thread was President Andrzej Duda's assertion that electromobility in our country will be based on indigenous energy resources.[20]

Carsharing, i.e. the development of electric car rentals, became an important topic in 2019. The issue of subsidies for the purchase of eco-cars was already a regular feature of the articles, while public transport and ecology were marginal. "Rz" focused rather on Western markets, while in Poland it looked at the impact of economic proposals on the boom in electromobility, e.g. the freezing of electricity prices. The support strategies for individuals were questioned (*The government does not believe in electricity*[21]), and the lagging development of infrastructure was once again pointed out.[22] The newspaper also addressed the financial problems of Ursus, whose "dire situation […] will delay the implementation of the government's electromobility programme in public transport."[23]

At the time, an editorial on wGospodarce.pl admitted that "electromobility is slowing down a bit", and there will certainly not be a million cars on Polish roads ("this is influenced by two factors – infrastructure and the offer"[24]). There was also an ecological counter-argument: "So far, however, no studies have been conducted to prove that electromobility is a cleaner solution compared to traditional

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[19] The articles: *Jak ruszyć elektromobilność?*, *Elektromobilność odporna na pandemię* and *Elektromobilność będzie tylko rosła!* were based only on material from PAP or external news agencies.

[20] *Prezydent: Elektromobilność zapewni czyste powietrze. Będzie opierać się na rodzimych zasobach energetycznych*, wPolityce.pl, 17.01.2018, https://wpolityce.pl/polityka/376998-prezydent-elektromobilnosc-zapewni-czyste-powietrze-bedzie-opierac-sie-na-rodzimych-zasobach-energetycznych-galeria [accessed: 05.06.2022].

[21] *Rząd nie wierzy w prąd*, RP.pl, 16.07.2019, https://www.rp.pl/opinie-ekonomiczne/art1228061-rzad-nie-wierzy-w-prad [accessed: 05.06.2022].

[22] A. Woźniak, *Ładowarek w Polsce ciągle mało*, RP.pl, 25.03.2019, https://moto.rp.pl/tu-i-teraz/art17208721-ladowarek-w-polsce-ciagle-za-malo [accessed: 06.06.2022].

[23] Idem, *Ursus zatapiany przez elektryczne autobusy*, RP.pl, 30.05.2019, https://moto.rp.pl/tu-i-teraz/art17223351-ursus-zatapiany-przez-elektryczne-autobusy [accessed: 06.06.2022].

[24] *Elektromobilność nieco zwalnia*, wGospodarce.pl, 7.05.2019, https://wgospodarce.pl/informacje/63256-elektromobilnosc-nieco-zwalnia [accessed: 05.06.2022].

motoring. On the other hand, there are no conclusive statements to the contrary." It also reached for an anti-German narrative by titling one of the articles *Electromobility: Germany wants to be like Poland*.[25] Why – is not clear; the text only describes plans to launch one million electric vehicle charging points in Germany by 2030.

In 2020, one of the leading topics was the subsidy programme announced by the Climate Ministry in December 2019. The general tone of the articles in "Rz" was far from optimistic, as shown by the titles: *Electroclimate. Electricity price hikes will kill electromobility*; *Electromobility feels the crisis particularly hard*; *The e-car market has grown, but is already decelerating*. Similarly in the portals wGospodarce.pl and wPolityce.pl, which still assured at the end of the year that electromobility was "immune to the pandemic"[26], even if earlier "mess in fees" were pointed out.[27] "Rz" drew attention to a report by the Supreme Audit Office (Pol. Najwyższa Izba Kontroli, NIK), stressing that "electromobility in Poland is still in its infancy, despite four years since the vision for its development was presented."[28]

Fratria's portals entered 2021 with an optimistic title: *Electromobility will only grow!*, although the situation was not clear – in February, the only electric car rental company withdrew from Poland. The message was dominated by the EU's plans to introduce the *Fit for 55* legislative package, hence the titles: *Got a car? The EU may want to take it away!*; *What's stopping electromobility?*; *Is electromobility the future or a puff piece for the rich?*. The wGospodarce.pl team asked

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[25] *Elektromobilność: Niemcy chcą być jak Polska*, wGospodarce.pl, 4.11.2019, https://wgospodarce.pl/informacje/70560-elektromobilnosc-niemcy-chca-byc-jak-polska [accessed: 06.06.2022].

[26] *Elektromobilność odporna na pandemię*, wGospodarce.pl, 27.12.2020, https://wgospodarce.pl/informacje/89840-elektromobilnosc-odporna-na-pandemie [accessed: 07.06.2022].

[27] *Elektromobilność i galimatias w opłatach*, 8.09.2020, wGospodarce.pl, https://wgospodarce.pl/informacje/84975-elektromobilnosc-i-galimatias-w-oplatach [accessed: 07.06.2022].

[28] A. Wozniak, *NIK potwierdza: sypie się rządowy program rozwoju elektromobilności*, RP.pl, 06.11.2020, https://moto.rp.pl/tu-i-teraz/art17354701-nik-potwierdza-sypie-sie-rzadowy-program-rozwoju-elektromobilnosci [accessed: 07.06.2022].

Without tax breaks, will e-cars fail to catch on?,[29] which referred to the declaration signed at the COP26 climate summit in Glasgow to ban the registration of new combustion cars from 2035.

In "Rz", the number of articles on electromobility once again reached almost 170, with most space devoted to subsidies (*Subsidies for company EVs*; *Subsidies increase appetite for e-cars*), public transport (*The state will subsidize electric buses*; *Fleets of electric buses are growing faster and faster in cities*) and the *Fit for 55* programme (*Fit for 55 will drive electromobility*).

Summarising the range of topics and the quality of information on electromobility in the media analysed, several important points should be noted.

The message on Fratria's web portals focused on presenting the activities and plans of state-owned companies – Enea, Energa, Tauron, The State Forests[30] or National Fund for Environmental Protection and Water Management. It was constructed mainly on the basis of statements by politicians from the ruling coalition. This is not surprising if we look at the revenues from advertisements placed there: in the first half of 2020, 47% of the advertising budgets of the largest State Treasury companies were directed to the Fratria,[31] so this message can be linked to the promotional strategy of state-owned entities. The articles, prepared by the 'team', were not based on original content, but mainly on ready-made agency materials. In many cases it is difficult not to get the impression that they were sponsored or commissioned articles.[32]

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[29] *Bez ulg podatkowch e-auta się nie przyjmą*?, wGospodarce.pl, 28.11.2021, https://wgospodarce.pl/informacje/104384-bez-ulg-podatkowch-e-auta-sie-nie-przyjma [accessed: 06.06.2022].

[30] *Lasy otwierają się na samochody. Elektryczne*, 27.01.2018, wGospodarce.pl, https://wgospodarce.pl/informacje/45669-lasy-otwieraja-sie-na-samochody-elektryczne [accessed: 05.06.2022].

[31] *"Sieci" pełne dzięki państwowym spółkom*, Press.pl, 30.10.2020, https://www.press.pl/tresc/63761,_sieci_-prosza-o-wsparcie_-choc-sa-liderem-w-pozyskiwaniu-zlecen-z-panstwowych-spolek [accessed: 05.06.2022].

[32] An interview with Prime Minister Morawiecki, signed 'wfd', promoted the Strategy for Responsible Development. In individual cases, texts were labelled as sponsored, e.g.: *Elektromobilna przyszłość*, wPolityce.pl, 24.10.2017, https://wpolityce.pl/gospodarka/363817-elektromobilna-przyszlosc [accessed: 07.06.2022].

The articles published on the pages of "Rz" were of a different nature – their authors provided factual and comprehensive descriptions of the topics covered, and in this respect "Rz" proved itself to be a professional economic journal. Articles were often critical in tone, and clearly structured commentary. The newspaper relied on authoritative material and a broad spectrum of topics related to electromobility.

Electric public transport of Kraków in the regional media

The first electric bus hit the streets of Kraków on 3 January 2013. At the time, Kraków's Municipal Transport Company (Miejskie Przedsiębiorstwo Komunikacyjne SA, MPK) leased it from Solaris, the route was set for route no. 537: from Dworzec Główny Wschód to Witkowice.[33] Information about this event was usually limited to an official MPK announcement. "GK" reported: "An electric bus is already carrying passengers around Kraków", basing the material on photos and a short agency note.[34] RMF treated the subject more extensively, highlighting its eco-friendliness and quiet operation, and that it "takes passengers on board who stand on a lawn-like floor and see a blue sky with clouds on the ceiling."[35] The first articles still weakly raised the environmental impact, focusing instead on the past activities of MPK itself, which back in 2012 submitted a project to purchase 10 electric vehicles. And although the topic was important for transport in the capital of Małopolska, the Kraków media took an unenthusiastic approach to it, which was surprising.

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[33] D. Dukała, *Pierwszy autobus elektryczny w Krakowie*, Inzynieria.com, 04.01.2013, https://inzynieria.com/energetyka/wiadomosci/32515,pierwszy-autobus-elektryczny-w-Krakowie [accessed: 02.06.2022].

[34] M. Stuch, *Elektryczny autobus już wozi pasażerów po Krakowie*, 03.01.2013, Gazeta Krakowska, https://gazetakrakowska.pl/elektryczny-autobus-juz-wozi-pasazerow-po-Krakowie-zdjecia/ar/731941 [accessed: 08.06.2022].

[35] *Cichy, nowoczesny, ekologiczny. Zobacz niezwykły autobus, który jeździ po Krakowie*, RMF24.pl, 3.01.2013, https://www.rmf24.pl/fakty/polska/news-cichy-nowoczesny-ekologiczny-zobacz-niezwykly-autobus-ktory-,nId,767183#crp_state=1 [accessed: 08.06.2022].

In 2013, industry portals reported on the activities of Kraków's MPK (plans to purchase electric buses), in the following year they pointed out, among other things, the delays of other cities in relation to Kraków: "While Warsaw is waiting for the outcome of the dispute over the results of the tender for electric buses, Kraków has today quietly launched the first electric bus line in Poland."[36] Various development strategies were highlighted, such as the leasing of vehicles and a diversified fleet, while criticising that "not everything has played out."

In August 2017, MPK reported on the purchase of twenty more low-floor electric buses with EU funds.[37] The topic was reported by all regional media, but it is difficult to establish the authorship of the news, as they reproduced the same content, and only "GK" signed the article with the name of the journalist, Piotr Rąpalski. Each text, of course, had a different title: *Kraków has 20 new eco-buses* (GK, Kraków Nasze Miasto); *Kraków is the leader in ecological public transport* (Kraków.pl); *Kraków enriched with new buses* (Onet.pl); *Kraków: 20 Solaris electrobuses enter traffic. And the first articulated bus* (transport-publiczny.pl); *From today Kraków has 20 new electric buses. The most in Poland!* (krknews.pl). The PAP communiqué was entitled *20 electric buses from Solaris hit the streets of Kraków*[38].

In 2017, 26 electric-powered public transport vehicles[39] were running in Kraków. Kraków was the first Polish city to launch a regular

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[36] *W Krakowie uruchomiono pierwszą linię autobusów elektrycznych*, Samochodyelektryczne.org, 29.04.2014, http://samochodyelektryczne.org/w_Krakowie_uruchomiono_pierwsza_linie_autobusow_elektrycznych.htm [accessed: 08.06.2022].

[37] *20 niskopodłogowych autobusów elektrycznych dla mieszkańców Krakowa*, MPK S.A. w Krakowie, 09.08.2017, https://www.mpk.krakow.pl/pl/aktualnosci/news,5454,20-niskopodlogowych-autobusow-elektrycznych-dla-mieszkancow-Krakowa.html [accessed: 01.06.2022].

[38] *Na ulice Krakowa wyjechalo 20 autobusow elektrycznych od Solarisa*, PAP, 09.08.2017, https://www.pap.pl/aktualnosci/news%2C1040989%2Cna-ulice-Krakowa-wyjechalo-20-autobusow-elektrycznych-od-solarisa.html [accessed: 06.06.2022].

[39] Solaris Urbino 12 electric – buses awarded the "Bus of the Year" title in the 2017 competition organised by the Association of Commercial Vehicle Editors.

line served only by such buses, also having the first electric articulated bus[40] and the first station for charging buses via pantograph.

However, it was an undoubted success that Kraków was one of the first large cities to comply with the obligations imposed by the Act on Electromobility and Alternative Fuels. These obligations included replacing the fleet of cars at the disposal of the magistrate's office and city institutions, to a level of 10% zero-emission vehicles from 2022. At the end of 2019, the fleet included 47 such cars, as well as 39 internal charging stations. The acquisition of electric cars for municipal institutions was also part of the Municipality's air protection policy.[41] Earlier, in March 2019, during the training course on "Electromobility in practice", the Municipality of Kraków was certified as an "Electromobility-friendly city" and Krakowski Holding Komunalny SA was certified as an "Electromobility-friendly company".[42] This information, however, did not penetrate the Kraków media, and was only noted by the awarded entities and the Kraków.pl website. At the end of the year, the first 17 electric cars were leased and delivered to the Kraków local government[43] – the issue of the three-year lease became the starting point for sceptical in tone articles in "DP" and "GK".

"DP" noted[44]: "City officials have assumed that by the end of 2019 there will be 156 charging points for electric cars in Kraków. But they themselves do not fully believe that the plan will be realised." The

[40] In Warsaw, the first such vehicle only appeared in November, see *Pierwszy przegubowy elektryk w stolicy*, Warszawski Transport Publiczny, 23.11.2017, https://www.wtp.waw.pl/newsy/2017/11/23/pierwszy-przegubowy-elektryk-w-stolicy/ [accessed: 06.06.2022].

[41] *Kraków dobrze oceniony za elektromobilność*, Krakow.pl, 17.12.2020, https://www.krakow.pl/213212,1962,244775,powietrze,krakow_dobrze_oceniony_za_elektromobilnosc.html [accessed: 07.06.2022].

[42] *Kraków – miasto przyjazne elektromobilności*, Krakowski Holding Komunalny, 20.03.2019, https://khk.krakow.pl/pl/aktualnosci/krakow-miasto-przyjazne-elektromobilnosci/ [accessed: 06.06.2022].

[43] *Pierwsze samochody elektryczne dla krakowskich instytucji miejskich już są*, Inzynieria.com, 03.11.2019, https://inzynieria.com/energetyka/wiadomosci/56970,pierwsze-samochody-elektryczne-dla-krakowskich-instytucji-miejskich-juz-sa [accessed: 02.06.2022].

[44] B. Dybała, *Kraków. Mało stacji dla "elektryków". Kiedy pojawią się kolejne?*, Dziennik Polski, 10.04.2019, https://dziennikpolski24.pl/krakow-malo-stacji-dla-elektrykow-kiedy-pojawia-sie-kolejne/ar/c1-14034589 [accessed: 02.06.2022].

newspaper's journalist reported on agreements signed by the city to build charging stations with Smart City Polska and Go+EAuto, and in November he pointed out[45]: "Kraków is still weak in developing a network of publicly accessible charging stations for 'electrics' for residents", "it is still laborious for officials to develop a network of publicly accessible charging stations […]." In mid-2020, the city had 8 publicly accessible charging points for electric vehicles belonging to the Municipality of Kraków, located at four stations.[46]

The articles on electric cars in the "DP" and "GK" tended to have a critical tone, and not only with regard to the activities in Kraków. This is indicated by the headlines: *One million electric cars is still nothing more than wool-gathering*[47]; *We'll conquer the world with something that doesn't exist*; *Charging with electricity more expensive than… refuelling. Dark clouds over electromobility*[48]. In the case of Kraków: *The city will take care of electromobility, but there are still*

[45] B. Dybala, *Urzędnicy przesiedli się do "elektryków", a stacji ładowania aut dla mieszkańców wciąż jest mało*, Dziennik Polski, 4.11.2019, https://dziennikpolski24.pl/urzednicy-przesiedli-sie-do-elektrykow-a-stacji-ladowania-aut-dla-mieszkancow-wciaz-jest-malo/ga/c4-14552285/zd/39791331 [accessed: 02.06.2022].

[46] J. Blikowska, *Zagęści się sieć stacji dla e-pojazdów*, RP.pl, 20.12.2019, https://regiony.rp.pl/innowcje/art17660611-zagesci-sie-siec-stacji-dla-e-pojazdow [accessed: 03.06.2022].

[47] Z. Bartuś, *Milion samochodów na prąd to wciąż bujanie w obłokach*, Dziennik Polski, 24.11.2017, https://dziennikpolski24.pl/milion-samochodow-na-prad-to-wciaz-bujanie-w-oblokach/ar/12704050; idem, *Podbijemy świat czymś, czego nie ma*, Dziennik Polski, 24.11.2017, https://dziennikpolski24.pl/podbijemy-swiat-czyms-czego-nie-ma/ar/12704628 [accessed: 07.06.2022]. Among other things, the author criticised the actions of Law and Justice MEPs: "The European Commission wants to make it compulsory to install chargers for electric cars in new non-residential buildings soon. Although the aim of this coincides with the Law and Justice government's electromobility programme, the party's MEPs voted in Brussels… against it. They explained that they 'do not want the EU to impose anything on Poland on this issue.'"

[48] J. Michalczak, *Ładowanie prądem droższe niż… tankowanie. Ciemne chmury nad elektromobilnością*, Dziennik Polski, 23.01.2020, https://dziennikpolski24.pl/ladowanie-pradem-drozsze-niz-tankowanie-ciemne-chmury-nad-elektromobilnoscia/ar/c3-14733998 [accessed: 01.06.2022].

neither cars nor charging stations[49]; *Officials will rent electric cars for themselves, spend fortune*. "Dziennik Polski", however, also reported on positive, pro-social aspects, such as the creation of the first charging stations in Kraków (2018) and Zielonki (2019). In July 2018, it described planned changes to getting around Kraków's Kazimierz.

In the media, Kraków's electromobility was also presented in relation to smog problems – the reasons included the large amount of car traffic generated by, among others, commuters from surrounding towns and cities, and the need to improve the quality of public transport by, among other things, introducing fleets that reduce emissions of harmful substances.

In the case of incentives to change the transport habits of drivers, the media raised the issue of often controversial "privileges" provided for owners of electric vehicles, related to: the possibility of driving in specific zones, making bus lanes available to them, the right to free parking in Paid Parking Zones, cheaper parking subscription for owners of such vehicles, as well as plug-in hybrids.[50] For some time in the capital city of Małopolska, owners of electric cars could additionally enter the limited traffic zones and the now-defunct Clean Transport Zone (on Kraków's Kazimierz district). The regulations that had been in force there for two months were modified by the decision of Kraków councillors, and in practice abolished. In part, this decision was the result of a protest by restaurateurs, who estimated the losses from the introduction of the zone (and thus the restriction of combustion vehicle traffic), at around 30%.[51]

It is worth noting that the dynamic activities of the Kraków authorities over a certain period of time, directed towards the electrification of the public rolling stock, have not been intensively followed

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[49] P. Ogórek, *Miasto zadba o elektromobilność, ale wciąż nie ma ani samochodów, ani stacji ładowania*, Dziennik Polski, 9.01.2018, https://dziennikpolski24.pl/miasto-zadba-o-elektromobilnosc-ale-wciaz-nie-ma-ani-samochodow-ani-stacji-ladowania/ar/c3-12831752 [accessed: 01.06.2022].

[50] *Jakie przywileje dla pojazdów elektrycznych?*, Kraków.pl, 1.08.2019, https://www.krakow.pl/aktualnosci/231847,29,komunikat,jakie_przywileje_dla_pojazdow_elektrycznych.html [accessed: 02.06.2022].

[51] *Koniec strefy czystego transportu w Krakowie*, WysokieNapiecie.pl, 07.03.2019, https://wysokienapiecie.pl/17607-koniec-strefy-czystego-transportu-w-Krakowie/ [accessed: 06.06.2022].

and commented on in the regional press and on its websites. At the end of June 2022, a search for the phrase "electric cars" returns only 34 results from 2016–2022 on the "Dziennik Polski" website, including 3 news items, and 13 directly related to Kraków. The "Gazeta Krakowska" website published a total of 44 articles with this phrase during this period.

Electromobility development in Poland: summary

When writing about the media image of domestic electromobility – here I will also refer to the media sources already cited – it is impossible not to start with the announced production of the first Polish electric car, Izera. Information about plans to produce a Polish e-car appeared in the media in 2016, with the establishment of ElectroMobility Poland. On 28 July 2020, the car's logo, brand and two prototypes were officially unveiled.[52]

The wPolityce.pl and wGospodarce.pl portals are dominated by agency messages, based on statements by politicians or the President of ElectroMobility Poland. The form of the articles resembles tabloids (And yet! Izera drives) or is a combination of texts from other media (*The State Treasury invests in Izera! We would very much like Poland to have a car brand that we can be proud of*). At the end of 2020, the portal reported that *Izera has taken to the roads. For now demonstratively*, and *Polish electric car from Jaworzno! Izera factory starts in 2024*. In April 2021, the anti-German narrative returned here too: *Izera bothers them? German media attack the Polish project*, which was a reference to the article *The national electric car project… halted the development of electromobility in Poland* from the "Auto Świat" portal,[53] owned by the Swiss-German Ringier Axel Springer group. Gradually, however, the editors of wPolityce.pl themselves toned down their earlier optimism, asking: *When will it be and what's*

[52] A. Woźniak, *Polskie e-auto to Izera*, RP.pl, 28.07.2020, https://moto.rp.pl/parking/art17334881-polskie-e-auto-to-izera [accessed: 01.06.2022].

[53] M. Brzezinski of "Auto Świat" also asked: *Riding Izera – a propaganda hoax on the S2 road?*, 27.11.2020, https://www.auto-swiat.pl/wiadomosci/aktualnosci/jezdzaca-izera-propagandowy-fejk-na-drodze-s2/zn7r1g8 [accessed: 08.06.2022].

next for Izera? New declarations, and *Izera is nowhere. What's happening to the Polish 'electrician'?*

A more blunt assessment of Izera case was given by "Rz", which reported on the cover of issue 176 of the newspaper, dated 29.07.2020: *Izera is to enter production in 2023*. In later months, the journalists of the daily newspaper described every move regarding the investment – the already mentioned test drive or the problems with the construction of the factory (*Factory instead of trees. President signed Lex Izera*). Today, the journal perversely asks: *Izera, or the second keel? 69 million has already been spent on a Polish electrician*, pointing out elsewhere: *The chances of building a Polish electrician are melting away. Izera is stuck*[54].

According to the Electromobility counter, launched in 2019 jointly by the Alternative Fuels Association and the Polish Automotive Industry Association, in May 2022 there were 46,676 electrically powered cars in Poland, including 22,476 fully electric cars (BEVs[55]). The number of charging stations began to approach 2,200, of which 1,561 were direct current (DC) and 629 were alternating current (AC).[56] In Q1 2022, sales of electric cars increased by 140% compared to the previous period. The market share of electric cars almost tripled.

Globally, in terms of new electric car sales, 2021 was a record year. A report by the International Energy Agency – *Global EV Outlook 2022* – shows that their sales doubled, compared to 2020,

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[54] A. Woźniak, *Izera, czyli druga stępka? Na polski elektryk wydano już 69 mln*, RP.pl, 20.06.2022, https://www.rp.pl/transport/art36539821-izera-czyli-druga-stepka-na-polski-elektryk-wydano-juz-69-mln; idem, *Topnieją szanse budowy polskiego elektryka. Izera utknęła w miejscu*, RP.pl, 20.06.2022, https://www.rp.pl/transport/art36539511-topnieja-szanse-budowy-polskiego-elektryka-izera-utknela-w-miejscu [accessed: 25.06.2022]. The "keel" is a reference to the Polish government "Batory" programme for building three ferries. The programme started in 2017 with significant media coverage. As of the end of 2023, none of the ferries is fully built.

[55] PHEVs are so-called plug-in hybrids, i.e. hybrid cars with the possibility of charging from an external source, more: J. Brdulak, P. Pawlak, *Elektromobilność czynnikiem zmian jakościowych polskiego transportu samochodowego*, "Kwartalnik Nauk o Przedsiębiorstwie" 2021, vol. 58, no. 1, pp. 31–42.

[56] Licznik elektromobilności, PSPA, https://pspa.com.pl/research/licznik-elektromobilnosci/ [accessed: 25.06.2022].

to 16.5 million (as of the end of 2021) worldwide.[57] In 2021 alone, a record 6.6 million electric cars were sold, including more than 4.6 million BEVs. As recently as 2018, the global passenger electric car market exceeded 5 million units, of which around 45% were cars in China, while the share of Europe and the US reached – respectively – 24% and 22%. Considering the percentage of electric cars (full or hybrid) in the country's total number of vehicles, Norway dominated, with a share of 10%, while the second, Iceland, had only 3.3%. In Poland, the NIK noted, we had 4134 passenger electric cars (0.2% of the total number) at the end of 2018.

It is difficult to expect that the situation in Poland will be improved, and the transition to electric cars accelerated, by the European Parliament's decision on zero-emission for cars sold in the EU after 2035, i.e. a de facto ban on the sale of new combustion cars in the territory after that date.[58] Following the EU decision, "Rz" reminds us of the disparities in the development of electric car markets and the still poor charging infrastructure. Illustrating this, Adam Woźniak writes about the "gap in Europe" and "Poland lagging behind", pointing out that "half of all charging points in the EU are concentrated in just two countries – the Netherlands (90,000 chargers) and Germany (60,000). Against this background, Romania, for example, one of the countries with the fastest growth in electric car sales, has 0.4% of charging points in the EU, while Poland, with a 2.2% share of electric cars in new passenger vehicle registrations, is among the least 'electrified' countries in Europe.[59]

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[57] *Global EV Outlook 2022*, IEA.org, May 2022, https://www.iea.org/reports/global-ev-outlook-2022 [accessed: 25.06.2022].

[58] M. Brzezinski, *Samochody spalinowe zakazane od 2035 roku*, Auto Świat, 8.06.2022, https://www.auto-swiat.pl/wiadomosci/aktualnosci/samochody-spalinowe-zakazane-od-2035-r-parlament-europejski-zaglosowal/whhqtj2 [accessed: 25.06.2022].

[59] A. Woźniak, *Cała Unia Europejska nie zdoła przełączyć aut na prąd do 2035 roku*, RP.pl, 22.06.2022, https://www.rp.pl/biznes/art36555861-cala-unia-europejska-nie-zdola-przelaczyc-aut-na-prad-do-2035-roku [accessed: 25.06.2022].

Conclusions

The issue of electromobility has various faces in the Polish media. On the one hand, a reader looking for information will find in-depth articles, a number of market analyses and commentaries by specialists, on the other hand, however, he/she may find only superficial, general content, which will be closer to ordered promotional or political materials. The journalistic material analysed over the period 2011–2021 concerning the electric vehicle market, both at the national and regional level, shows disproportions in the scope and quality of information. This applies both to legislation and the existing rules of the whole market, plans for its expansion and modernisation, reliable analysis of the presented prospects and governmental solutions.

The common denominator of all the messages turned out to be the barriers to the development of the electric car market in Poland, related to the launch and management of charging stations, i.e. the preparation of infrastructure suitable for the development of electromobility – both commercial and state-owned. This is a challenge which, according to journalists and market analysts, is still the most important premise for the rapid development of the car eco-market, which must be able to cope with the growing supply and stimulated, for example through a system of subsidies, concessions and tax solutions, demand.

The analysed articles make it possible to assess their content, and consequently – which was the aim – the value, for the reader, of the message about the state and prospects of Polish electromobility. It was interesting to note the avoidance of in-depth, analytical journalistic material that would act as a guide for those wishing to buy low- or zero-emission cars, in favour of general agency messages. What should also puzzle is the inadequate distribution of emphasis on the development of the regional market for electric cars, as can be seen from the content of articles from the "Dziennik Polski" and "Gazeta Krakowska". It can be said that in this respect they do not fulfil their role as newspapers which can stimulate a change in the behaviour and habits of the local community. At the other extreme are the specialist portals, whose materials mainly provide extensive statistical

data on the contemporary market for vehicles powered by alternative energy sources. The last link in the media coverage are portals such as wPolityce.pl and wGspodarce.pl, whose articles are developed by the "editorial staff" and are based entirely on external materials.

The inadequacy and poor pace of development of charging infrastructure proved to be the most important problem and, in the opinion of journalists, even a brake on Polish electromobility. This topic even crowded out in the media the issues of limitations resulting from high prices of electric cars, which started to be more widely commented on after the announcement of the state subsidy programme. In this context, environmental pollution issues also received less attention.

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The role of electric cars in the city's parking policy: Legal aspects of urban planning

Abstract
Sustainability, which is the basis of spatial planning, is a capacious concept and is therefore in danger of being too generalised in the actual spatial planning process. Therefore, the value, in public management, of which spatial planning is a manifestation, is to reveal or design concrete mechanisms for the implementation of the sustainability criterion. One of these mechanisms is to methodically link the spatial planning element of road infrastructure, related to transport intensity, with measures such as the city's parking policy, taking into account the requirements of electromobility. The chapter presents a number of issues related to this process and the relationship between electromobility requirements, spatial planning and the city's parking policy. It presents the issue of taking into account in land-use planning, the shift in transport modes, including from combustion cars to electric cars and from cars to public transport and personal transport facilities.
Keywords: electromobility, road infrastructure, spatial planning, urban space, urban transport, public governance

Introduction

The aim of the discussion is to demonstrate that since sustainable mobility is an element of sustainable development and sustainable development is the basis for spatial planning, a city parking policy that takes into account the assumptions of electromobility is consequently a necessary element of spatial planning. Mobility is linked to issues of air quality protection and energy saving,

which are reflected in the regulation of the Act on Electromobility and Alternative Fuels.[1] This translates into the consideration in spatial planning of the modal shift design, including from combustion cars to electric cars and from passenger cars to public transport and personal transport equipment (Pol. *urządzenia transportu indywidualnego*, hereinafter: UTO). This is because the mode of transport needs to be combined with road infrastructure and the operation of different modes of transport, and road infrastructure is one of the key elements of spatial planning. In this respect, attention should also be paid to the issue of transport accessibility and the fact that sustainable development must be non-exclusive for different groups of city users.

Demonstrating the thesis requires discussion of several issues. Firstly, the issue of local development plans in the context of electromobility. Secondly, the question of the advantages and disadvantages of planning parking spaces in the context of providing a certain amount of them. Thirdly, the question of alternatives to parking space planning.

Consequently, the result of these considerations is to verify the thesis that regulation, whether statutory or at the local authority level, in the form of relevant resolutions on the share of electric passenger car transport in urban transport, must be closely linked to urban planning, including the associated parking policy of the city.

Sustainable mobility as part of sustainable development

Planning for mobility development, including electric mobility, is part of sustainable development,[2] i.e. also part of spatial

[1] Act on Electromobility and Alternative Fuels of 11.01.2018 (Ustawa o elektromobilności i paliwach alternatywnych, consolidated text of 23.05.2022: Dz.U. 2022, item 1083, hereinafter: the Electromobility Act).

[2] Pursuant to Article 3 point 50 of the Environmental Protection Law of 27.04.2001 (Prawo ochrony środowiska, Dz.U. [Journal of Laws of the Republic of Poland] 2021, items 1973, 2127 and 2269), to which the definition is referred by Article 2 point 2 of the Act on Planning and Spatial Development (Ustawa o planowaniu i zagospodarowaniu przestrzennym) of 27.03.2003 (consolidated text of 2022.03.02: Dz.U. 2022, item 503, hereinafter: APS), sustainable development is understood as such social and eco-

planning. At the same time the functioning of electric cars,[3] raises concerns.[4]

The first concern is the price of the car. It also affects urban planning, because sustainable development is also inclusive, i.e. non-exclusive.[5] The city's access privileges for such vehicles (parking fee exemptions) may mean that the availability of urban space for owners of cheaper vehicles is reduced,[6] if no adequate alternative to car transport is envisaged. Therefore, planning for electromobility is determined by the fact that sustainable mobility includes several components: energy-efficient public transport systems, a friendly

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nomic development in which the process of integrating political, economic and social activities takes place while maintaining the balance of nature and sustainability of basic natural processes in order to ensure the possibility of satisfying the basic needs of particular communities or citizens of both the present and future generations. In the National Urban Policy, one of the issues counted among the most important is the consistent pursuit of sustainable mobility in urban areas; see National Urban Policy until 2023 (Krajowa Polityka Miejska 2023, Resolution no. 198 of the Council of Ministers of 20.10.2015 on the adoption of the National Urban Policy, Monitor Polski 2015, item 1235).

3 The operation of electric cars is part of mobility economics. Mobility economics, which is a sub-discipline of economic research, is located within the discipline of economics and finance, and urban logistics within the discipline of management and quality sciences, although it is impossible to deny these areas of scientific research their interdisciplinarity; cf. B. Kos, G. Krawczyk, R. Tomanek, *Inkluzywna mobilność w metropoliach*, Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach, Katowice 2020, pp. 7 and 8. The scientific objective discussed in this publication was to investigate the relationship between sustainability and inclusiveness of mobility and to assess the impact of these processes on urban development. The empirical objective, on the other hand, was to assess the risk of exclusivity of urban mobility balancing instruments applied in transport policy. The law deals with this issue insofar as it is supposed to regulate the rights and obligations of administrative bodies and city users. I use the term "city users" as an umbrella term for residents, businesses, tourists, students, senior citizens and other categories of actors using the city.

4 See the research discussed in the article by R. Klamut, *Postawy wobec samochodów elektrycznych: Badania na grupie studentów uczelni technicznej*, "Zeszyty Naukowe Instytutu Gospodarki Surowcami Mineralnymi i Energią Polskiej Akademii Nauk" 2018, no. 107, pp. 105–118.

5 B. Kos, G. Krawczyk, R. Tomanek, *Inkluzywna mobilność…*, p. 7.

6 *Ibidem*, p. 83.

environment for other modes of transport such as bicycles or other personal transport devices, easy access to all neighbourhoods by foot, bicycle, UTO or public transport.[7] If the share of, for example, bicycles in handling urban transport needs does not exceed a few percent, one reason may be spatial factors that constitute a "glass ceiling" for increasing this rate.[8]

The second concern with electric cars is the travel range, which depends on a network of charging stations. This issue is to be taken care of by the Electromobility Act. At the same time, its requirements are of a general nature, by providing for quantitative indicators and technical and legal requirements. Therefore, spatial planning, bearing in mind the criteria indicated in the Act on Planning and Spatial Development (APS), must confront these indicators with the spatial needs and possibilities of the municipality and with planning criteria, i.e. transport intensity and determination of the number of parking spaces, taking into account the diversification of infrastructure for all available modes of transport.

Local development plan in the context of electromobility

Since planning the development of mobility, including electric mobility, is an element of sustainable development, it is also an element of spatial planning. This follows from the fact that the APS sets out the principles for shaping spatial policy, taking spatial order and sustainable development as the basis.[9] Sustainable development is also the starting point for determining the scope and manner of proceedings in matters of allocating land for specific purposes and establishing the principles of its development and construction.[10]

The expansion of urbanised areas and the concomitant separation of urban functions is increasing the mobility of city dwellers and the

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7 *Ibidem*, p. 34.

8 *Ibidem*, p. 86 and cited therein: M. Sutton, *33 Key Cities Where Cycling Is Growing Its Modal Share*, "Cycling Industry News" 2019, no. 3, https://cyclingindustry.news/five-key-cities-where-cycling-is-taking-modal-share-from-cars [accessed: 22.03.2023].

9 Article 1(1) of APS.

10 *Ibidem*.

average distance travelled.[11] The urban population could account for up to 68% of the population by 2050.[12] Cities must therefore strive to reduce the rate of private motorisation, make better use of public space and save infrastructure.[13] For this reason, urban planning should assume that urban electromobility is based on public transport and, within the framework of electromobility, not only cars, but also scooters, electric bicycles, electric UTOs,[14] and thus infrastructure for non-motorised transport and vehicle charging.[15]

The planning must take into account set out in the APS and the indicators set out in the Electromobility Act (table 1).

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[11] B. Kos, G. Krawczyk, R. Tomanek, *Inkluzywna mobilność…*, p. 47.

[12] *W mieście jeden pojazd carsharingowy może zastąpić aż 7–11 aut prywatnych: rozmowa z Adamem Jedrzejewskim, założycielem i prezesem Stowarzyszenia Mobilne Miasto*, "Logistyka" 2021, no. 2, pp. 10–11; A. Mężyk, S. Zamkowska, *Problemy transportowe miast: Stan i kierunki rozwiązań*, Warszawa 2019, p. 61.

[13] *W mieście jeden pojazd carsharingowy…*, *op. cit*.

[14] B. Kos, G. Krawczyk, R. Tomanek, *Inkluzywna mobilność…*, p. 79.

[15] *Ibidem*, pp. 54–55 and cited therein: K. Nosal, W. Starowicz, *Wybrane zagadnienia zarządzania mobilnością*, "Transport Miejski i Regionalny" 2010, no. 3, pp. 26–31; D.H. Ungemah, C.M. Dusza, *Transportation Demand Management Benchmark: Results from 2008 TDM Program Survey*, "Transportation Research Record" 2009, vol. 2118, no. 1, pp. 55–66; G. Murray, D. Koffman, C. Chambers, *Strategies to Assist Local Transportation Agencies in Becoming Mobility Managers*, Transport Research Board, National Academy Press, Washington D.C. 1997; Concept of Spatial Management of the Country 2030 (Koncepcja Przestrzennego Zagospodarowania Kraju 2030), Resolution No. 239 of the Council of Ministers of 13.12.2011 on adoption of the Concept of Spatial Management of the Country 2030, Monitor Polski 2012, item 252; White Paper, Roadmap to a Single European Transport Area - Towards a competitive and resource-efficient transport system, 2011. White Paper 2011: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, Brussels 2011, COM(2011) 144 final, https://ec.europa.eu/transport/sites/transport/files/themes/strategies/doc/2011_white_paper/white-paperillustrated-brochure_en.pdf [accessed: 22.03.2023]. In addition, it should be taken into account that bicycles and UTOs are increasingly being offered in a so-called 'collaborative consumption' (sharing economy) formula considered as an important instrument for sustainable development, see B. Kos, G. Krawczyk, R. Tomanek, *Inkluzywna mobilność…*, p. 83. Shared mobility is one of the main tools to achieve more sustainable urban transport systems, see *W mieście jeden pojazd carsharingowy…*, *op. cit*.

Table 1. The planning criteria of the Act on Planning and Spatial Development and the indicators set out in the Electromobility Act

Residential buildings		Non-residential buildings	
Single-family	Multi-family	All[1)]	Public use
	located in municipalities with more than 50,000 inhabitants and the associated indoor and outdoor parking areas, shall be designed and built with a connection capacity to equip these areas with a charging point of not less than 3.7 kW[2)]		located in municipalities with more than 50,000 inhabitants and the associated indoor and outdoor parking areas, shall be designed and built with a connection capacity to equip these areas with a charging point of not less than 3.7 kW[3)]
to which more than 10 parking spaces are associated, shall be designed and constructed so as to ensure the installation of ducts for electrical wires and cables at all parking spaces, allowing the installation of charging points at each parking space, if those parking spaces: 1) are located inside a building or 2) are adjacent to a building		to which more than 10 parking spaces are associated, shall be designed and built to ensure the installation of at least one charging point and ducts for electrical wires and cables allowing the installation of at least one charging point per five parking spaces, if those parking spaces: 1) are located inside a building or 2) are adjacent to a building. Adjacent to a building, is understood to mean that a car park is associated with that building, in terms of ownership or use under another legal title, which: 1) directly adjacent to that building or 2) not directly adjacent to that building[4)]	

[1)] It does not apply to buildings owned by small and medium-sized entrepreneurs referred to in the Entrepreneurs' Law of 06.03.2018 (Prawo przedsiębiorców, Dz.U. 2021, item 162, 2105); [2)] Pursuant to Article 12(2) of the Electromobility Act, the minister responsible for energy will determine, by means of a regulation, the method of determining the minimum connection power, guided by the need to ensure in buildings connection power allowing the installation of charging points and the need to gradually increase the number of charging points and taking into account the need to meet the current demand for electricity resulting from the use of these buildings. On 14.05.2021, a decree by the Minister of Climate and Environment also appeared, indicating how the minimum connection power for multi-family residential buildings and public buildings should be determined; [3)] Ditto; [4)] Pursuant to Article 12a(1)(1)–(2) and (2)(1)–(2) and (3)(1)–(2) and (4)(1)–(2) of the Electromobility Act. Article 12a added by Article 1 item 6 of the Act of 2 December 2021 (Ustawa o zmianie ustawy o elektromobilności i paliwach alternatywnych oraz niektórych innych ustaw, Dz.U. 2021, item 2269) amending the Electromobility Act as of 24 December 2021.

Source: Author's own elaboration.

These requirements also apply in the case of buildings undergoing conversion or renovation where the cost of the work carried out on the building envelope or technical systems of the building is more than 25% of the value of the building, not including the value of the land on which the building and the car park are located, and where the cost of installing charging points and duct infrastructure does not exceed 7% of the total cost of the conversion or renovation, if the parking spaces: 1) are located inside the building and the conversion or renovation includes parking or electrical infrastructure of the building, or 2) are adjacent to the building and the conversion or renovation includes parking or electrical infrastructure of the car park. This does not apply to non-residential buildings owned by small and medium-sized enterprises.

The provisions of the Electromobility Act formulate a number of requirements which are interpreted as difficulties of a technical and legal nature.[16] At the same time, however, they are unavoidable

[16] The technical and legal requirements include the following: in the case of buildings which are immovable monuments within the meaning of Article 3(2) of the Act on the Protection and Care of Monuments of 23.07.2003 (Ustawa o ochronie zabytków i opiece nad zabytkami, Dz.U. 2021, item 710, 954), entered in the register of monuments or in the communal register of monuments, the installation of a charging point and ducts for electric wires and cables requires the consent of the provincial conservator of monuments competent for the location of that monument, granted by way of a decision, pursuant to Article 12a(5) and Article 12b(12) of the Act on Electromobility. In multi-family residential buildings where the number of independent residential units is greater than three, the charging point shall be installed and operated after obtaining the consent of the management board of the community or cooperative or the person in charge of the management of the property, issued upon the application of the person holding the legal title to the premises in that building and the parking position for exclusive use, pursuant to Article 12b(1) of the Electromobility Act. It is necessary to draw up an expert opinion on the permissibility of the installation of charging points, except in the case of buildings where the electrical installation intended to supply the charging points has been designed and constructed. In this case, the installation of the charging point shall take into account the solutions adopted for the electrical installation, in particular its technical parameters and the safety measures applied, pursuant to Article 12b(4) and (6) of the Electromobility Act. Permission to install and operate a charging point shall be refused if: it results from the expert report that the installation of the charging point is not possible. When the expert report

in the situation of the need to incorporate the new installation infrastructure into the city's buildings, including the already existing ones. Since the architectural and construction administration body (hereinafter: AAB authority) only applies the regulations, including the provisions of the Electromobility Act,[17] and local spatial development plans (hereinafter: LSDP), it is up to the local government bodies responsible for spatial planning to take all the requirements into account when creating the LSDP.

The APS refers directly to parking spaces only in one place. Namely, it indicates that the LSDP obligatorily specifies the minimum number of parking spaces[18] and the manner of their implementation.[19] The designated number of parking spaces should allow the intended function to be realised taking into account the requirements of the Electromobility Act or as an option below the quantitative thresholds provided for therein. This last sentence sounds like an exhortation to circumvent the Electromobility Act. Nothing could

shows that the installation of the charging point covered by the application is only possible after a change in the contract for the connection of the building to the electricity grid or the execution of a new or reconstruction of the existing electrical installation, permission for the installation and operation of the charging point may only be granted if the applicant undertakes to cover all costs of these activities, pursuant to Article 12b(8)(1) and (9) of the Electromobility Act. If a charging point has been installed at a parking space to which the applicant has exclusive use rights, the electricity distribution system operator shall install a metering and billing system to measure the electricity consumed by the charging point, after concluding the agreement referred to in Article 5(1) of the Energy Law of 10 April 1997, pursuant to Article 12b(10) of the Electromobility Act.

17 Article 12(1) of the Electromobility Act. Electromobility Development Programme (Program Rozwoju Elektromobilności, previously referred to as the Clean Transport Package – Pakiet na rzecz Czystego Transportu) is the result of the adoption of Directive 2014/94/EU of the European Parliament and of the Council on the development of alternative fuel infrastructure in October 2014. According to the cited directive, EU Member States are obliged to deploy alternative fuel infrastructure within set deadlines. In the context of the development of sustainable urban mobility, alternative fuel infrastructure is understood as natural gas refuelling points and electric vehicle charging points.

18 Including spaces for parking vehicles provided with a parking card.

19 Pursuant to Article 15(2)(6) of APS.

be further from the truth. As well as referring directly to the number of parking spaces, the APS refers to a criterion that is much more important from the point of view of sustainability and (electro)mobility. It is about transport intensity.

Pursuant to this criterion, the Act provides that in the case of siting new developments, the requirements of spatial order, effective space management and the economic values of space shall be taken into account by shaping spatial structures while striving to minimise the transport-intensiveness of the spatial system; locating new residential developments in a manner allowing the inhabitants to make maximum use of public mass transport as the primary means of transport; and on other areas only in a situation of a lack of a sufficient number of areas allocated for a given type of development located in the abovementioned areas; in the first place on the areas prepared for development to the highest degree, which means the areas characterised by the best access to the communication network, adequate for the new planned development.[20]

As regards the content of the decision on development conditions (Pol. *decyzja o warunkach zabudowy*, hereinafter: WZ decision), there is no provision in force that would require the number of parking spaces to be specified in this decision. In the opinion of the Supreme Administrative Court, this should take place only at the stage of creating the construction design, which will be approved by the AAB authority and assessed from the point of view of ensuring an appropriate number of parking spaces for the investment.[21] At the stage of obtaining a building permit, the technical conditions apply in this respect. According to them, when developing a building plot, it is necessary to arrange, in accordance with its purpose and manner of development, parking spaces for cars of permanent and periodically staying users, including parking spaces for cars used by disabled persons. The number of parking

[20] Pursuant to Article 1(4)(1), 1(4)(2), 1(4)(4a) and 1(4)(4b) of APS.

[21] Judgment of the NSA (Naczelny Sąd Administracyjny, Supreme Administrative Court) of 5.05.2015, II OSK 2399/13; judgment of the NSA of 7.02.2014, II OSK 2151/12 and II OSK 2640/12; judgment of the NSA of 11.06.2014, II OSK 95/13; judgment of the NSA of 18.06.2014, II OSK 128/13; to the contrary: judgment of the NSA of 12.10.2012, II OSK 812/11.

spaces and the manner of arranging the parking spaces shall be adjusted to the requirements established in the LSDP or the WZ decision, taking into account the necessary number of spaces used by disabled persons.[22] There is no inconsistency in such a reference to the LSDP or WZ decision, as the provision does not refer to the number of parking spaces indicated in the LSDP or WZ decision, but to any requirements of the LSDP or WZ decision that may affect the determination of the needed number of such spaces. In particular, the AAB authorities should take into account, when assessing the number of parking spaces for a development, in the light of the technical conditions, the transport-intensity reduction intentions specified in the local masterplan. In the absence of their determination, or in the case when the basis for granting the building permit is the WZ decision, the criteria from the APS apply directly. As a result of this analysis, it may turn out, for example, that the development in the city centre, in the form of the so-called "plomb", does not require the observance of the ratio of one parking space per flat, if the investor demonstrates that the investment is located in an area served to a high degree by public transport, and will change some parking spaces into spaces intended for bicycles or electric scooters, with the possibility of charging them.

Speaking of service, to a high degree, by public transport, one can go back, for example, to the idea of the 15-minute city,[23] which envisages that 15 minutes from one's place of residence it will be possible to meet the needs of work, commerce, health, education and entertainment, without using a car.

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[22] Decree of the Minister of Infrastructure on the technical conditions to be met by buildings and their location of 12 April 2002 (Rozporządzenie Ministra Infrastruktury w sprawie warunków technicznych, jakim powinny odpowiadać budynki i ich usytuowanie, consolidated text of 2019.06.07: Dz.U. 2019, item 1065, § 18(1) and 18(2)).

[23] The concept of the fifteen-minute city developed by Carlos Moreno, a professor at the Paris-Sorbonne University. Everything needed for basic needs would be within a commute of a quarter of an hour in order to avoid using the car or even public transport, see *W mieście jeden pojazd carsharingowy…*, *op. cit*., p. 13.

An example of a city that has set out to realise this idea is Paris.[24] Stockholm goes further, it wants to be a 1-minute city. The key to the realisation of this idea is the street, which has to be arranged like a day room where no car is parked. The new street quality is to be built at the expense of parking spaces.[25] Sweden's 1-minute cities seem to have developed the idea of parklets,[26] i.e. urban furniture made at the expense of parking spaces. Vienna has moved in a similar direction, proving that the street can be a great place for a neighbourhood dinner, for example. Social spaces at the expense of parking spaces are being created in Vienna as part of the Neighbourhood Oasis programme.[27]

On the one hand, it is risky not to include in the LSDP any of the obligatory arrangements, as this failure may result in the invalidation of the LSDP on the basis of the allegation of violation of Article 28 of the APS, if it would lead to disruption of the spatial order in the area covered by the plan.[28] This justifies the view that it is necessary to specify in the LSDP the minimum number of parking spaces (providing indicators allowing to establish it).[29] At the same time, it may emerge from the specific circumstances of the facts that such spaces will not be determined.[30] Special circumstances

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[24] Paris has decided to implement this idea while assuming the removal of 70,000 parking spaces. Such closures can take place in the context of renovations, revitalisation and other planned, gradual transformation of space. In Kraków, this is what happened in Świętego Ducha Square, where a car park was removed and turned into a space with a different character. Before 2008, Mały Rynek and Szczepański Square served as car parks, today they are venues for cultural events.

[25] M. Domagała, *Na zachodzie Europy likwidują miejsca parkingowe i robią na nich miejsca spotkań*, Wyborcza.pl, 29.12.2021, https://wyborcza.pl/7,177851,27951080,na-zachodzie-europy-likwiduja-miejsca-parkingowe-i-robia-miejsca.html [accessed: 22.03.2023].

[26] E.g. on Krupnicza Street in Kraków.

[27] The programme is not only being implemented in the city centre, but also in other neighbourhoods.

[28] Judgment of the WSA (Wojewódzki Sąd Administracyjny, Voivodship Administrative Court) in Poznań of 27.02.2013, IV SA/Po 577/12.

[29] Judgment of the NSA of 24.07.2018, II OSK 477/18; the minimum number of parking spaces referred to in Article 15(2)(6) of APS refers to residential and service development.

[30] Judgment of the WSA in Białystok of 9.01.2020, II SA/Br 812/19.

may be the identification of alternatives for parking spaces, due to the diversification of transport modes in the area.

Advantages and disadvantages of planning parking spaces in terms of their quantity

The obligation to build parking spaces has a number of disadvantages, from a spatial planning point of view. The first is that it prevents the density of development, which is one of the objectives of spatial planning. This concerns areas where the construction of parking spaces is impossible or economically unjustified, while the National Urban Policy until 2023 mentions among its specific recommendations the creation of dense and compact development with a multifunctional structure, which can be an element shaping a lifestyle based on local services with minimal transport needs.[31]

Another disadvantage is that the generation of parking spaces generates road capacity needs. A congestion arises, i.e. sustained traffic volumes of transport modes that are higher than the infrastructure capacity.

The third disadvantage is that increasing the number of parking spaces stands in the way of promoting public transport, which is part of balancing mobility. Spatial policy should take steps to reduce the desire to use the car and encourage the use of public transport.

Wrocław, for example, formulated explicitly that its aim was to improve public transport while limiting "the convenience of using private cars for short distances."[32] It has opted to adapt the city centre to function with limited car traffic and to introduce numerous pedestrian zones,[33] including exclusive public transport access to selected streets. The means to this end is to favour the expansion

[31] Mężyk A., Zamkowska S., *op. cit.*, pp. 57–58.

[32] *Strategia – Wrocław 2000 Plus*, document adopted by the City Council of Wrocław by Resolution no. LII/765/98 of 4.06.1998, p. 28.

[33] R. Galar, G. Roman, J. Waszkiewicz, *Strategia "Wrocław w perspektywie 2020 plus"*, document adopted by the City Council of Wrocław by Resolution no. LIV/3250/06 of 6.07.2006.

of public transport and cycling and pedestrian infrastructure over that for individual car transport.[34]

Alternative to planning for parking spaces

The basic principle of traffic organisation is that the more lanes, the more cars. As long as planners keep widening roads and building new ones, drivers will not have a good choice of alternative modes of transport.[35] By increasing the supply of roads, traffic will not be relieved, but more people will be able to drive.[36] When planners measure how an investment will affect road capacity, they assume that once a new road or lane is built, it will be used by roughly the same number of drivers. Meanwhile, demand stimulation is taking place. It is assumed that the extra lane will absorb the cars, without considering that it will generate more traffic.[37] Instead of building roads, urban planners should focus on creating conditions for the use of other modes of transport. The number of cars depends on how people choose to move around the city.[38]

Mobility management is presented as a targeted effort to reduce the fulfilment of transport needs by cars.[39] In such a situation, it is

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[34] *Wrocławska Polityka Mobilności*, Annex to Resolution no. XLVIII/1169/13 of the City Council of Wrocław of 19.09.2013, p. 5, http://wrosystem.um.wroc.pl/beta_4/webdisk/163701/1169ru06z.pdf [accessed: 22.03.2023].

[35] J. Sadik-Khan, S. Solomonow, *Walka o ulice. Jak odzyskać miasto dla ludzi*, Wysoki Zamek, Kraków 2017, p. 79.

[36] *Ibidem*, p. 94. This does not only apply to roads. If a person has some available space, a plate, a suitcase, a box, etc., then he or she has inclinations to fill them all up (unless quantity determines price, for example). Just observe the dinner served as a buffet on holiday. Even if the number of helpings is unlimited, people tend to fill the plate in its entirety, regardless of its size.

[37] *Ibidem*, p. 95. Statement by urban planner Jeff Speck, who has seen this assumption work in practice and believes it is a sign of reluctance to accept that the environment influences behaviour.

[38] J. Sadik-Khan, S. Solomonow, *op. cit*., pp. 96 and 97.

[39] K. Nosal, *Wpływ wybranych instrumentów zarządzania mobilnością na podział zadań przewozowych*, PhD thesis, Cracow University of Technology, Faculty of Civil Engineering, 2015; B. Kos, G. Krawczyk, R. Tomanek, *Modelowanie mobilności w miastach*, Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach, Katowice 2018, p. 23.

essential to plan the city's development in terms of balancing mobility – including enabling mobility needs to be met by socially efficient transport systems. A key factor is the continuous cooperation with the stakeholders of the mobility plan.[40] In a survey conducted by IBRiS in 2015, more than 55% of respondents were in favour of restricting car traffic in the city centre and 66% of respondents were in favour of prioritising public transport even at the expense of car traffic.[41] In September of the same year, in a local referendum, 67.5% of the inhabitants of Wrocław who took part in the vote were in favour of gradually reducing car traffic in the city centre.[42] This is all the more important as sustainable mobility is decisively influenced by transport needs, including transport preferences and behaviour.[43]

The fears of entrepreneurs and some residents of restricting car traffic are channelled into slogans such as "Kazimierz[44]: an exclusion zone", after the introduction of the limited traffic zone in

[40] Sustainable Urban Mobility Plans (SUMPs) are a mobility management methodology favoured by the European Commission that seeks to improve the quality of life and functioning of cities through integrated planning addressing all modes of transport and transport behaviour. SUMPs are developed with the participation of stakeholders – an important element of the concept is the participatory approach throughout the planning process, see *ibidem*, pp. 24 and 40–45.

[41] M. Kokoszkiewicz, *Magistrat przeprowadził sondaż. Chcemy mniej aut w centrum*, Wrocław.wyborcza.pl, 13.05.2015, https://wroclaw.wyborcza.pl/wroclaw/1,35754,17907372,Magistrat_przeprowadzil_sondaz__Chcemy_mniej_aut_w.html [accessed: 22.03.2023].

[42] Local referendum results: Biuletyn Informacji Publicznej Urzędu Miejskiego Wrocławia, Referendum lokalne 2015, https://bip.um.wroc.pl/artykul/716/18992/referendum-lokalne-2015 [accessed: 22.03.2023]. Traffic between districts should be routed via inner city ring roads, M. Koczan, *Polityka mobilności Wrocławia jako przejaw działań w zakresie bezpieczeństwa ekologicznego*, "Bezpieczeństwo. Teoria i Praktyka" 2021, no. 4, p. 91, https://repozytorium.ka.edu.pl/server/api/core/bitstreams/5fe35f2d-051d-477b-8730-b00be97c0759/content [accessed: 22.03.2023].

[43] B. Kos, G. Krawczyk, R. Tomanek, *Modelowanie mobilności…*, *op. cit.*, p. 16 and cited therein: *Planning and Design for Sustainable Urban Mobility: Global Report on Human Settlements 2013*, UN-Habitat, 2013, https://unhabitat.org/planning-and-design-for-sustainable-urban-mobility-global-report-on-human-settlements-2013 [accessed: 22.03.2023].

[44] Part of Kraków's Stare Miasto (Old Town) district.

Kraków.[45] From the entrepreneurs' point of view, there is a fear of an outflow of customers. At the same time, studies show that these fears are unfounded. In Madrid, for example, consumer traffic was studied and was highest in the area covered by the low emission zone. Spending by residents there increased by 8.6% compared to 3.3% in the rest of the city.[46] In London, where pedestrians and cyclists were prioritised, vacancy rates in retail premises were 17% lower than in areas where car traffic was not restricted. The same was true in Altrincham near Manchester, which was labelled a "ghost town" in 2010 (the vacancy rate was almost 30%). After infrastructure improvements, pedestrian traffic increased by 11.4% and the vacancy rate decreased by 7%. Studies from car-restricted zones in Copenhagen, London or Berlin show that shoppers who reach shops and restaurants on foot or by bicycle are more frequent visitors than those who arrive by car, and consequently spend more money in them. In the German capital, where car parks have been converted into bicycle parking spaces, customers using them spent € 7,500 compared to € 6,625 spent by car drivers.[47]

Conclusions

The role of electric cars in a city's parking policy does not mean simply replacing traditional parking spaces with spaces for electric cars with the appropriate infrastructure. This is taken care of by the Electromobility Act. Urban planning has to deal with weighing the planned number of parking spaces dedicated to electric cars, exclusively or interchangeable with traditionally powered cars, to the total number of planned parking spaces. The challenge is to plan for competition between electric public transport and cars,

[45] Such posters appeared in February 2019, one month after the Clean Transport Zone was established in Kraków. At the same time, Low Emission Zones are already in force in more than 250 cities in 14 European countries.

[46] It is true that the Madrid zone was abolished by the Supreme Court, but the Spanish want to return to this solution.

[47] M. Waluś, *Przedsiębiorcy stracą na powstaniu Strefy Czystego Transportu w Krakowie? Doświadczenia Madrytu czy Londynu temu przeczą*, 30.12.2021, Krakow.wyborcza.pl [accessed: 22.03.2023].

including electric cars, aimed at encouraging the use of such transport or discouraging the use of individual transport. This is done through infrastructure planning geared to favouring certain modes of transport as well as reducing parking space requirements in favour of requirements to accommodate alternative modes of transport.[48] The provisions of the APS are demanding in this respect, as they create criteria rather than indicators. At the same time, however, this nature of the regulations allows for flexibility and taking into account the conditions of a specific area.

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[48] This kind of planning should not be shifted to the investor, who, using the technical conditions, can himself present an appropriate project to provide the investment with adequate communication, because, although such individual planning is possible and effective on a micro scale, it should be supported or replaced by planning on a local authority scale, i.e. in this context on a macro scale.

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