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Eco-mobility - new solutions and technologies in urban transport

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Abstract. The article addresses modern technical solutions and technologies in the field of eco-mobility, which help solve problems of public transport in large agglomerations. Based on the example of Szczecin, specific ideas and projects were presented, the implementation of which is the basis for the functioning and development of the city.
Key words: eco-mobility, technology, urban transport.

INTRODUCTION

All urban agglomerations, irrespective of the nationality or geographical location, face similar problems as a result of the large number of people gathered in a relatively small area. This has a negative impact on the development of infrastructure, standard of living, pollution of the environment, it also reduces the possibility of planned management of available human resources and equipment.

There are, of course, many good solutions to these problems but there is no one specific, universal and timeless solution. The most effective seems to be a hybrid combination of two or more ideas that are matched ideally to the needs, possibilities and expectations of local authorities and residents.

Transporting huge numbers of inhabitants from many thousands of 'bedrooms' and suburban residential estates to work, educational institutions or offices, and in the afternoon providing a collision-free and as short as possible time of return is a challenge both for the city authorities and the urban transport.

1. METHODS OF URBAN TRANSPORT REORGANISATION

1.1 Application of new technologies

A very good example is the use of alternative fuels and power systems for urban buses. In order to meet the EU and national regulations and the expectations of the more aware part of the population, the authorities create legislation and regulations that promote such solutions.

a. Hybrid drives

- the bus is equipped with 2 coupled and complementary engines, most often diesel engines and electric one motors. Switching between the drive types is automatic under the specified operating conditions or it can be done by the driver when required.

b. Fully electric drives

- The depot charging system consists of a power supply infrastructure and e-buses that run on designated routes for a maximum of 18 hours a day, covering a distance of 120-200 km with the option of changing drivers, and then the buses must appear in the depot to recharge the battery. The process of charging with the devices with 50 -150 kV voltage is long and necessary after every day of operation. We need to purchase a sufficient number of stations to ensure that we can load all or part of the vehicle fleet at a particular depot at the same time.
- The opportunity charging system is based on a completely different charging system of 300 kV or more and batteries of different construction, chemical composition and capabilities. Thanks to this solution, the bus is charged in 5-12 minutes at a bus terminus or junctional stops where different routes cross. The whole process of charging with the current of very high values is carried out safely and smoothly during the exchange of passengers.

This enables all day long operation, it does not require many stationary charging stations, reduces many hours of downtime and increases the profitability and economy because the vehicles that have a lower unladen weight take 30% more passengers.

c. Electric drives with hydrogen cells

Many companies are working on fuel cells. The supply with hydrogen reduces the refuelling time to 3 minutes and guarantees a range of 700 kilometres (for cars). In Poland (possibly also in Szczecin) the infrastructure is to be built in the coming years. All experts agree that flammable gas is much safer than petrol or LPG. It's because it is 14 times lighter than air. Thus, it flows up quickly and does not pose a threat to passengers or the car. Additional benefits are derived from the possibility of obtaining it in an environmentally friendly manner. In Australia, hydrogen from coal is successfully produced. The gasification method allows to generate clean, liquefied fuel. In countries where coal reserves are very limited, hydrogen can be obtained from water or municipal waste.

The bus is equipped with an electric motor and the main difference is that the energy stored in the hydrogen cell is used to supply it.

In optimal conditions, the wind power plant transforms water from the nearby reservoir into hydrogen and oxygen. By using a special system, the hydrogen is pumped to the nearby filling station dedicated exclusively for this purpose (safety considerations during storage and filling of hydrogen cells suggest this).The bus carries out transport in the designated area of the city without the need for interruptions to recharge the batteries - the hydrogen filling process is similar to the LPG filling but it takes much less time.

Fig. 1.1. Bus of the year 2017 -Solaris Urbino 12 Electric. It has got two systems installed – the depot charging and the opportunity charging [1]

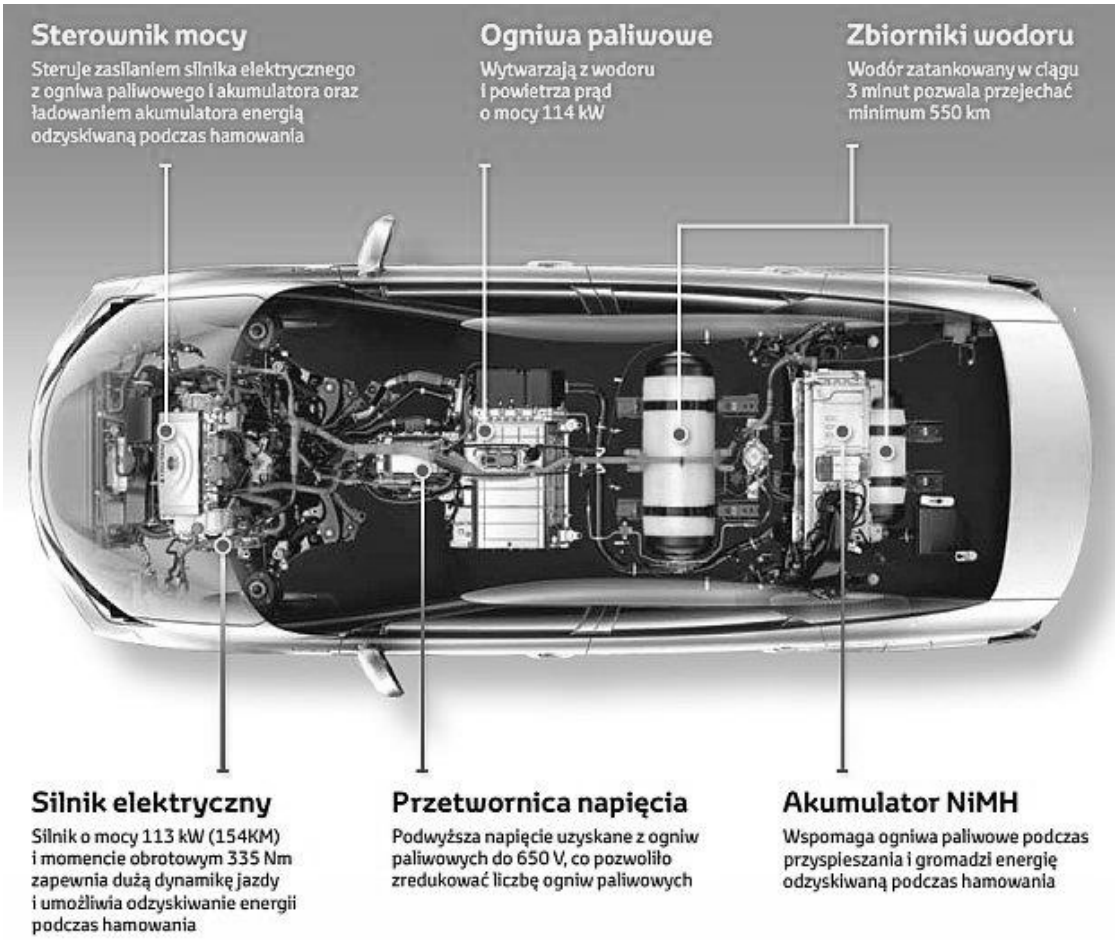

Fig. 1.2. Car with electric motor and hydrogen cell [2]

Key:

Power controller:
It controls the supply of the electric motor from the fuel cell and battery, and the battery charging with energy recovered during braking.

Fuel cells:
They generate 114 kW current of hydrogen and air.

Hydrogen tanks:
Filling with hydrogen within 5 minutes allows the driving range of 550 km

Electric motor:
The motor of 113 kW (154 kW) and the torque of 335 Nm ensures the driving dynamics and energy recovery during braking.

Voltage converter:
It increases the voltage obtained from the fuel cells up to 650V, which allowed to reduce the quantity of fuel cells.

NiMH battery:
It supports the fuel cells during acceleration and stores energy recovered during braking.

d. Other alternative drives

It is possible to use magnetic, air and other drives in buses but they remain mainly in the phase of research experiments or purely theoretical assumptions. They are not used in practice in the transport of people and will probably not be yet used for a long time.

1.2 Reorganisation of existing transport arrangements:

- consolidation of bus and tram lines to achieve a coherent transport system,
- introduction of dedicated solutions on selected lines,
- letting buses to the tracks - independence of traffic jams caused by other vehicles in the street traffic,
- creation of new lines and connections resulting from the dynamic development and growth of selected districts and regions of the metropolis.

1.3 Total replacement of vehicle fleet / way of moving residents:

- modern wheeled and rail vehicles adapted to the requirements and needs of the market,
  which is a long and costly process due to the number of vehicles that need to be replaced / modernised,
- complete abandonment of old vehicle fleet, which does not meet the current standards and customer expectations.

A new approach to the problem and the search for non-standard solutions:

- searching for new solutions based on the change of initial assumptions,
- return to old ideas and such ideas, which for various reasons were not implemented previously - the main topic is the Szczecin bypass, which was planned as early as in the 1930's,
- proper information and promotion of planned projects to achieve broad public acceptance

2. REORGANISATION OF URBAN TRANSPORT BASED ON THE EXAMPLE OF THE SZCZECIN AGGLOMERATION

As mentioned above, the city authorities decided to cooperate closely and create a compact and comprehensive urban transport system based on the Szczecińska Kolej Metropolitarna SKM [*Szczecin Metropolitan Railway*], the Tramwaje Szczecińskie [*Szczecin Trams*] and the Szczecin and Police bus depots associated in the Zarząd Dróg i Transportu Miejskiego ZDTiM [*Road and Urban Transport Authority*].

Fig. 1.3. Testing of the fully electric Linkker bus in the streets of Szczecin – 2017 [3]

2.1 The three pillars of transport

The visualisation presented below shows how engineers and analysts can see how a complex public transport system may look like and function, based on the above-mentioned 3 pillars of the public transport in our city. At present, this project is well advanced, and it will soon be a daily reality and not only a computing vision. Anyone who uses the fast tram, the "Park and Ride" system and other facilities can confirm the validity of these assumptions.

2.2 Reorganisation of infrastructure

a. Reorganisation of existing transport solutions:

- consolidation of bus and tram lines to obtain a coherent transport system - reconstruction of the Arkońska Terminus - connection of bus and tram lines from this route with vehicles transporting people from the centre to the Głębokie Lake,
- introduction of dedicated solutions on selected lines, e.g. fast tram from the Górniczy Basin to the Słoneczne Estate,
- letting buses to the tracks - exit from the city in Wyszyńskiego Street,
- partial use of tracks at the stops of Niepodległości and Żołnierska Streets - independence of traffic jams caused by other vehicles in the street traffic,
- creation of new lines and connections resulting from the dynamic development and growth of selected districts and regions of the metropolis, e.g. the route from the Górniczy Basin to the Słoneczne Estate.

As it can be seen from the list, there is a lack of a sufficient number of modern vehicles adapted to the requirements and needs of the market. Tendering procedures are complex and it is often difficult to select the winner or - as in the case of Szczecin - there is only one bidder who meets the conditions. The purchase has been completed - but whether it is the best offer - time will show.

Fig. 2.1. Visualisation of cooperation of Szczecińska Kolej Metropolitarna SKM [*Szczecin Metropolitan Railway*], the Tramwaje Szczecińskie [*Szczecin Trams*] and buses from the Zarząd Dróg i Transportu Miejskiego ZDTiM [*Road and Urban Transport Authority*] [4]

b. Total replacement of vehicle fleet / way of moving residents

Fig. 2.2. Average age of vehicle fleet of bus companies [own elaboration based on data provided by companies, 2016]

Key:

Średni wiek taboru:	Average age of vehicle fleet
Średni wiek taboru poszczególnych spółek:	Average age of vehicle fleet of particular companies
Spółki:	Companies

As mentioned above, this is a long and costly process due to the number of vehicles that need to be replaced/modernised. The purchase of vehicle fleet is an investment for years - it must be done carefully, taking into account all available information concerning economic and legal conditions but with respect to the opinion of the residents of the region.

Even in this case, the age and usefulness of the vehicle fleet in individual bases varies greatly - which makes the process of consolidation and purchase of determined series of buses very difficult. The process of operation requires vehicles to operate in the same depots - it is about training the drivers and the maintenance services, keeping the warehouses of spare parts and consumables.

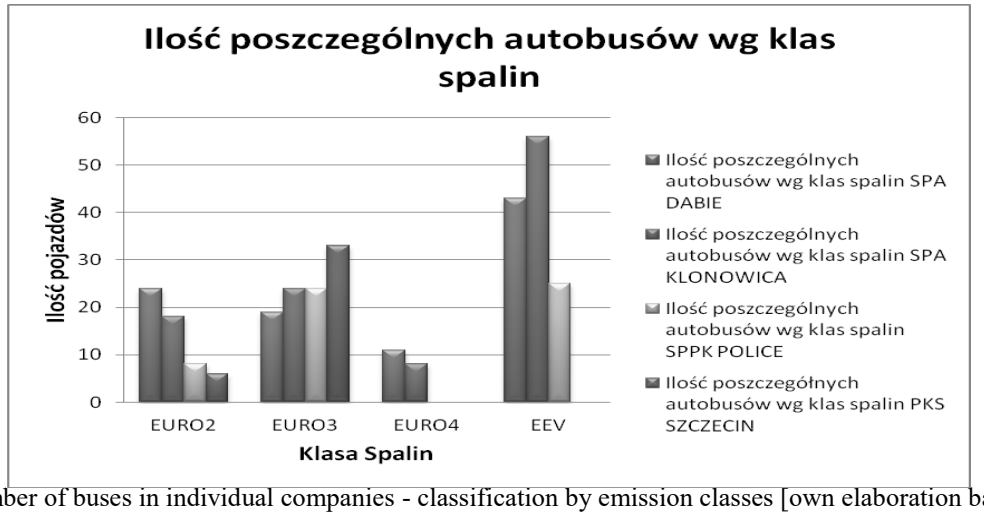

Fig. 2.3. Number of buses in individual companies - classification by emission classes [own elaboration based on data provided by the companies, 2016]

Key:
Ilość pojazdów: Number of vehicles
Ilość poszczególnych autobusów wg klas spalin: Number of particular buses according to emission classes
Klasa spalin: Emission class

c. A new approach to the problem and the search for non-standard solutions

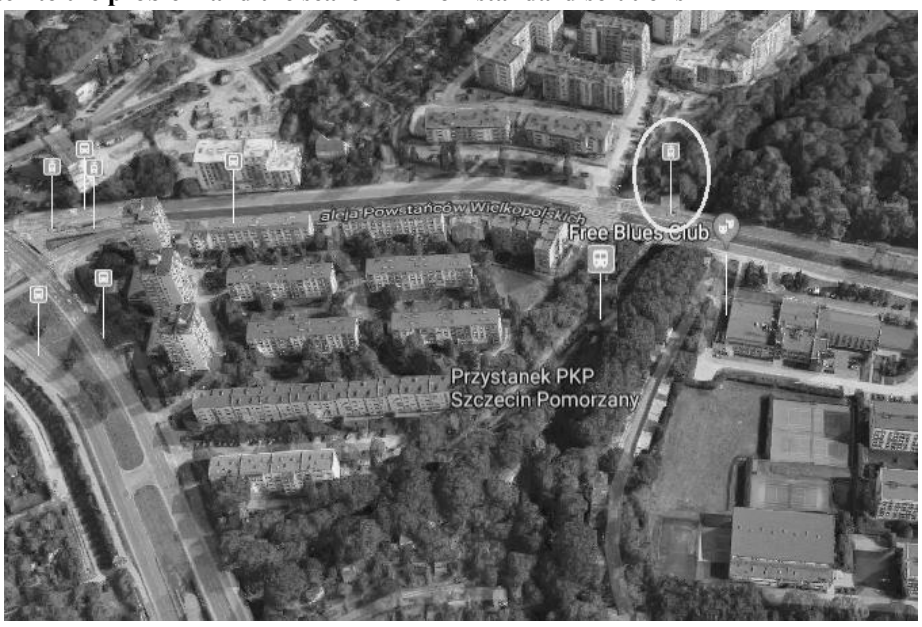

Fig. 2.4. Szczecin Pomorzany stop [own elaboration based on: https://www.google.pl/maps]

Key:
Przystanek PKP Szczecin Pomorzany: Szczecin Pomorzany Railway Stop

In Szczecin, we can clearly see a return to the old ideas and such ideas which, for various reasons, were not implemented previously. One of them is certainly the use and modernisation of the existing railway tracks and the whole infrastructure for the purposes of the Szczecin Metropolitan Railway. For example, one transport node will be located in the Pomorzany district. As shown in Fig. 2.4, the railway stop will be moved closer to the bridge located at the Powstańców Wielkopolskich Avenue. A new tram stop will also be created under the name of Pomorzany SKM [*Szczecin Metropolitan Railway*] (marked in yellow). The following trams will depart from this stop: 4 (Krzekowo - Pomorzany), 11 (Ludowa - Pomorzany), 12 (Niebuszewo Railway Station - Pomorzany) and night buses: 523 (Wiszesława - Cukrowa - Przecław), 524 (Police Jasienica - Police Depot - Pomorzany Dobrzynska), 529 (Głębokie Jaworowa - Krzekowo – Rodła Square).

Fig. 2.5. New hybrid SOLARIS bus (one of 16) in the streets of Szczecin [6]

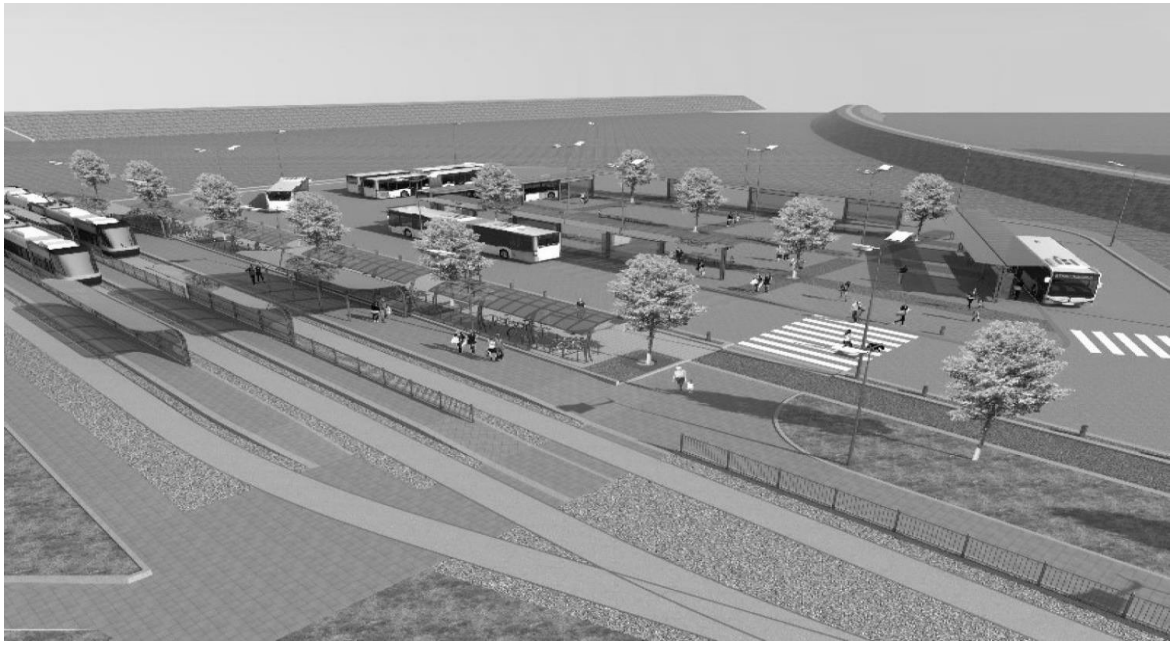

Fig. 2.6. Visualisation of the comprehensive urban transport system in Szczecin [4]

2.3 Purchase of new vehicle fleet adapted to changing situation

The city's latest purchase is 16 SOLARIS hybrid buses (8 single and 8 articulated buses), purchased with government subsidies, which are the link between the old fleet and the fully ecological eco-buses.

The vehicles are already known to the residents and despite their initial objections they have been accepted as a new means of transport in the Szczecin Agglomeration. The diverse composition of this group of buses results from the specificity of the city, the terrain and sometimes completely different transport needs in different districts.

2.4 Implementation of assumptions of the new economic plan

The Słoneczne Estate is the area where the changes made over the last few years are the most visible - it is also a landmark of the city because it is located at the entrance from central Poland and other more distant regions. It is already clear that the direction of the undertaken changes is the right one and that these projects should be continued and that the construction of the infrastructure necessary for the development and expansion of eco-mobility in all its forms should be taken forward.

CONCLUSION

The works on the new urban transport system in Szczecin were approved by the city and governmental authorities, which resulted in appropriate financial support. The gradual modernisation of the vehicle fleet and rolling stock planned for years is under way, along with massive earthworks changing the infrastructure. At the same time, various information campaigns are being carried out to promote selected solutions in the field of eco-mobility.

Taking care to protect the natural environment and the image of Szczecin - the city, in which green areas occupy a significant part of the area - gives the expected long-term effects in the form of new investments and the support of the residents for the changes made.

It is clear that the era of diesel engines is slowly passing and that urban transport will be based on one of the eco-mobility systems. This is apparent from the modern, economical and resident-friendly buses, which are gradually replacing the old, worn out fleet from the previous era and are a very good showcase of our city. This is one of many elements of Szczecin's development strategy, therefore the right decisions of the authorities and their consistent implementation have got a positive reception and acceptance of many of the residents.

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