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SAMPLE STRUCTURAL SOLUTION FOR A CITY TRICYCLE WITH AN ADDITIONAL SOLAR DRIVE

Summary. The everyday use of the bicycle is becoming increasingly common. People noticed the need to take care of both their health and the environment. The geographical location of Poland encourages cycling, which is the reason new kilometres of cycling routes are being built every year. This is associated with the rising interest in buying a bicycle. A conceptual tricycle with an additional electric drive powered by solar panels is presented in this article. The photovoltaic panel is installed on the basket roof. The electric motor may be used during an uphill ride and when the driver has run out of energy for pedalling. In the crank mechanism, there is a sensor which starts the motor when a small foot pressing force on the pedal is detected. The tricycle has an all-purpose structure, owing to which the seat mounted in the basket can be easily replaced with a double seat, a shopping bin or a child's safety seat. The tricycle may be used by both private persons and companies involved in tourist transport. The cost of the structural details of the tricycle suggested in this article does vary considerably from standard electric bikes, however, that solution has several important advantages, which may be decisive in the purchase of this solution.

Keywords: city bike, electric bike, solar drive, cycling infrastructure, active tourism

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1. INTRODUCTION

A growing interest in not only bicycle touring but in everyday cycling as well is observed every year. Usually, a bike becomes an ever-present element of people's lives and is used, for example, as a means of transport for going to work or shops; a fact which follows from the wish to enjoy a healthy lifestyle and for the care of the natural environment. A bike may also be a good alternative to cars, frequently moving around at a low speed due to increasing congestion [7,10].

Many bike models can be found in the market, which makes it easier to choose a bike according to one's needs and preferences. By browsing through bike manufacturers' catalogues, one can find city, trekking and mountain bikes. Traditional human-powered bikes and those equipped with an additional drive are available too. The electric drive is the most used.

Electric bikes are more economical compared to combustion engine vehicles. They have cheaper maintenance cost contrary to using a car. Whereas 100 km of driving costs as much as around PLN 50, covering the same distance by electric bike may cost approximately PLN 1. Given the constant growth of fuel costs, travel by electric bike seems an appropriate alternative for motor vehicles. An electric bike does not need registration or motor insurance, which reduces the vehicle maintenance cost [13].

Besides, current structural solutions make it possible to build small and lightweight motors with a high power/weight ratio. The development of energy storage technology permits the construction of lightweight batteries with big storage capacity, which increases the vehicle range [1].

Keeping an eye on the continuous growth of interest in bicycle touring, local governments allocate funds for the construction of new or the extension of existing cycling paths. This is confirmed by statistical data on cycling path length. Data in [9] show that the length of cycling paths increases every year (Fig. 1). The length of cycling paths in Poland has increased by 8,121.9 km over the last seven years.

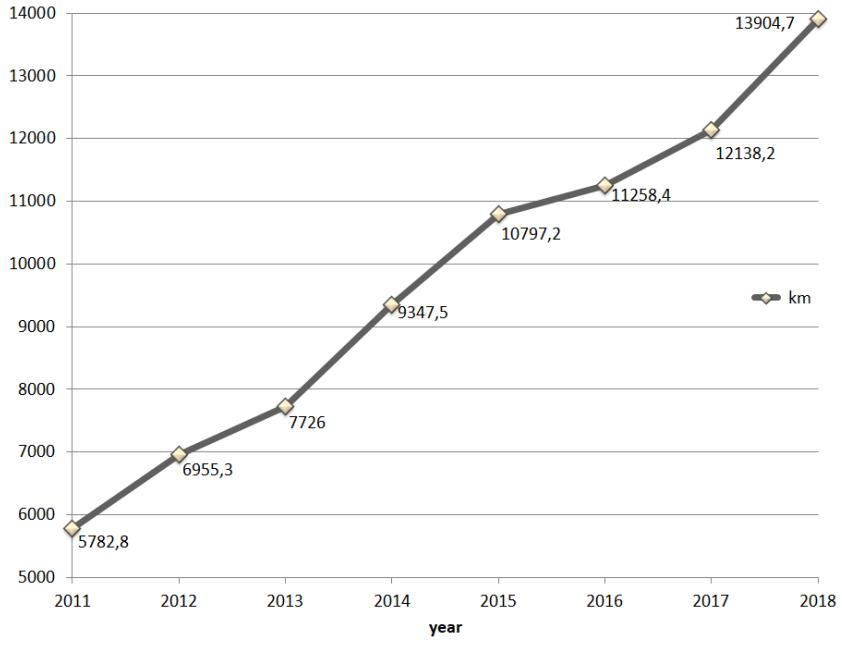

Fig. 1. Length of cycling paths in Poland (on basic [5])

The length of cycling paths by region is shown in Fig. 2. The statistical data from the Central Statistical Office of Poland are from the year 2018. The first one in the league is the Mazowieckie region, where the length of cycling routes is 1,995.6 km, and the Wielkopolskie region comes second with 1,824.4 km. According to statistical data of 2019 from the Polish Tourist Organisation, cycling comes third among the Poles' holiday activities [5].

Approximately, every tenth Pole (9%) declares that he or she has taken part in a trip organised by himself or herself, during which trip a bike was used as a means of transport [5].

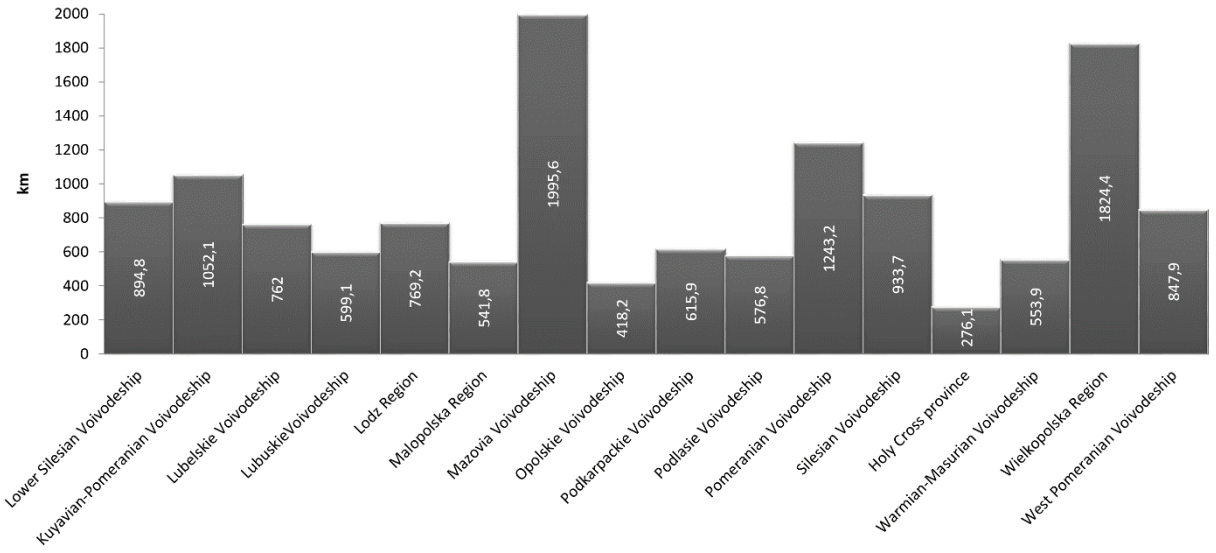

Fig. 2. Length of cycling paths in regions in 2018 (on basic [5])

In addition to investing in new cycling paths, local governments in bigger cities offer city bike rental. Presently, there are several city bike rental services in operation in Poland, including Cracow, Warsaw, Rzeszów, Wrocław, Opole, Poznań, Sopot and Białystok [4]. Bikes at such rental services are usually manufactured upon order from rental companies. The tricycle proposed in this article seems to be an appropriate solution in terms of its functionality described in section 2.

The concept of the creation is the EuroVelo and other similar cycling routes, for example, VeloDunajec, AquaVelo, GreenVelo, VeloNatura, Szlak Stu Jezior or VeloBaltica, is an incentive to participate in bicycle touring. All of these routes run across the regions of Poland and Europe, which are attractive to tourists. The length of each of those routes is significantly longer than one hundred kilometres. An appropriate bike is needed to cover the whole length. An electric tricycle powered by solar energy will permit riding long distances. When the cyclist feels tired, the drive can actuate automatically, without the need to stop and charge batteries, because the solar panels absorb sunlight all the time, thus, keeping the batteries fully ready for use.

Bicycle touring is a form of tourism in which a bike is the main means of transport [8]. Such tourism may be heritage or competitive in nature and is counted as qualified tourism. It is practised both individually and in groups, for example, in bicycle touring clubs. Bicycle touring is of special importance in spatial design in terms of the development of tourist facilities. The development of tourism is taken into consideration at both the local and the regional level [6]. Many forms of bicycle touring may be distinguished depending on the following criteria: the motive (relaxation, exploring, and qualified bicycle touring), landscape type (seaside, lake,

lowland, mountain and city bicycle touring), distance (short- and long-distance bicycle touring), age (touring for children, young persons, adults, families with children and for senior citizens), and the bike type in use (cycling touring, MTB, trekking and city bicycle touring) [11].

2. THE CONCEPT OF A TRICYCLE WITH AN ADDITIONAL DRIVE

The aim of this article is to propose a city tricycle, which will permit the transport of people over considerable distances and make everyday life easier. A tricycle with a basket mounted in its front part will be the best solution. The bicycle concept developed by Ewelina Tokarz is presented in Fig. 3 and presented in the thesis [12]. The proposed tricycle shown in Fig. 3 may be an alternative for motor vehicles. Due to the ever-changing climate, there is a steady decline in rainy and cold days in Poland, with less snowfall in winter as well. This situation presents the incentive to take advantage of an environmentally friendly means of transport. The proposed tricycle will be a good alternative for private persons, who may use it to commute to work or shops, and for companies dealing in passenger transport. The tricycle may become a tourist attraction and be used to carry people who would like to visit the surroundings without a pedalling effort.

a  b 

Fig. 3. Design of the tricycle [12]: a) the overview, b) the solar panel

The underlying idea of the trolley structure is to easily remove the seat installed in the basket and install a double seat, cargo bin or child's safety seat instead.

The tricycle has an additional electric drive powered by the solar system. The photovoltaic panel is installed on the basket roof. The electric motor may be used both during an uphill ride and when the driver has run out of energy for pedalling. In the crank mechanism, there is a sensor, which starts the motor when a small foot pressing force on the pedal is detected. The handlebars have a controller, which permits the adjustment of the capacity at which the motor works. Pressing the brake causes automatic drive disconnection and motor shut down. This is a form of protection, owing to which the cyclist will be sure that the tricycle will not move without his or her knowledge.

Although the time of battery charging from the mains power supply is approximately 3-5 hours, the time of battery charging with the current from the photovoltaic panel is 5-8 hours

and depends on weather conditions. The advantage of the latter solution, however, is that the battery is charged continuously without the need to look for an electric socket. This function is very useful during long trips to undeveloped areas and allows a longer distance to be covered at the same time. The storage battery may also be charged by generally accessible power banks, however, charging time is long and depends on the efficiency of the device. Electric energy recovery by batteries during braking, for example, during a downhill ride, is another form of battery charging. In this case, energy recovery is insignificant and will not permit long distance travel.

Furthermore, an electric drive system installed on the tricycle enables the charging of electronic devices such as a mobile telephone, tablet, etc. through a USB connector.

The diagram of the solar system installed in the planned tricycle is shown in Fig. 4.

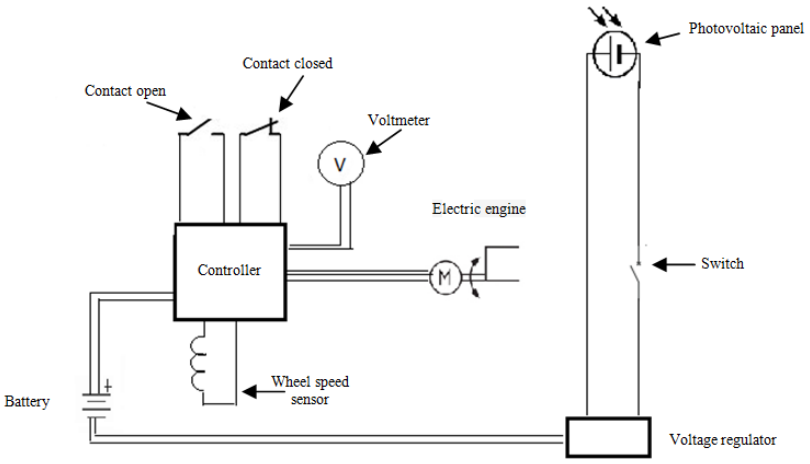

Fig. 4. Diagram of the solar system in the design tricycle [12]

The main tricycle design criteria are as follows:

- The tricycle frame will be made of lightweight materials and painted silver. The frame will be protected against corrosion by painting with anti-corrosion paints. In this type of tricycle, the use of carbon fibres for frame manufacture would be the best solution, but the costs of tricycle production would increase considerably. The objective is for the tricycle to be affordable to all.
- The transmission system will have 7 gears and be fitted in the wheel hub. The main advantage of such a solution is a lower failure frequency of the system. The gears are fully protected from weather conditions, hence, require less service. Shimano shifters will be used.
- V-brakes will be used. In view of their construction, brakes of this type have greater braking power compared to other solutions. They are also more durable, which will permit a greater number of braking cycles.
- Tricycle lighting will be based on LED's owing to which the tricycle will be visible from a considerable distance. The route in front of the tricycle will be well-lit and the driver will enjoy better visibility. Consumption of electric energy will decrease as well. To generate electricity, a magnetic dynamo will be used, which generates power with the use of magnets installed on the spokes. This type of solution does not produce sound and reduces rolling resistance. Standard reflectors will also be used on the pedals, wheels, and the front and back of the tricycle frame.

- Wheels will be fitted by means of bolts, which will enable the installation of the lighting system described above.
- High-quality stainless spokes and aluminium wheel rings will be used.
- The design tricycle dimensions are such that the tricycle fits through all standard doors.
- The height of the driver's seat and handlebars is electronically adjustable.
- A 36 V/250 W brushless electric motor will be installed. Motors of this type are maintenance-free and, practically speaking, failure-free. Small energy consumption is their advantage. Planetary gearing used in the tricycle makes riding without additional resistance possible. After the battery has been isolated, a tricycle with such a drive rides without an additional load [3].
- The tricycle will be equipped with a multi-function electronic LCD with the GPS satellite navigation system. A BOSCH Nyon device may be a suggested solution. The BOSCH Nyon navigation system can display 2D and 3D maps. Text messages can be read and incoming call numbers checked on a 4.3" display unit. The device is fully waterproof and connected with the computer through a micro-USB port [2].
- Easy replacement of the single seat with a double seat, cargo bin or child's safety seat.
- The planned range of the tricycle with a fully-charged battery is from 20 to 50 km.

The basic tricycle dimensions are shown in Fig. 5, and other technical parameters of the tricycle are as follows [12]:

- wheel size: front: 24", back: 26",
- tricycle weight: 28 kg,
- trolley load-bearing capacity: 150 kg,
- maximum saddle height: 852 mm.

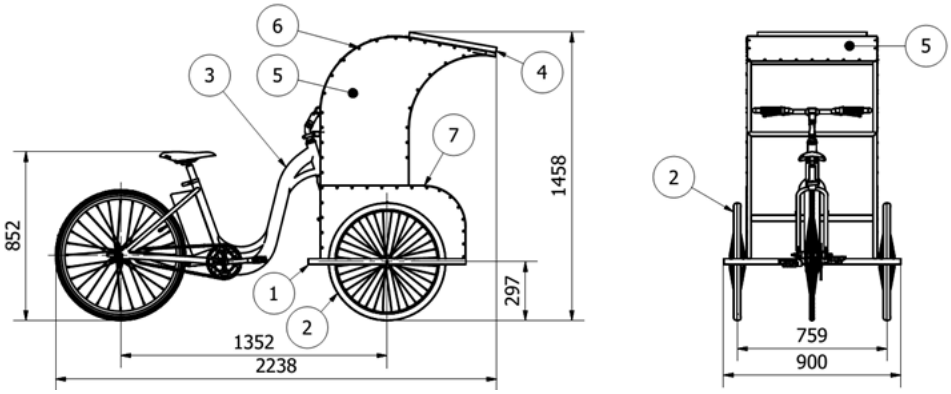

Fig. 5. Basic tricycle dimensions [12]
1 – basket frame, 2 – 26" wheel, 3 – frame, 4 – photovoltaic panel,
5 – guards, 6 – rivet set, 7 – metal guards

Visibility from the driver's level is not limited because all trolley guards will be made of high-quality acrylic glass. During a ride in the rain, guards improve the driver's visibility by protecting his or her hands and face from rain, and raindrops rebound from the aerodynamic guard structure, hence, do not fall on the driver. The driver's visibility will not be impaired by persons sitting in the basket either, as it is designed in such a way that the passenger's head is at the handlebar height. The seat is equipped with a safety belt which protects the passenger from falling out during the ride.

3. CONCLUSION

Statistical data presented in this article show the possibility of dynamic development of both bicycles touring and everyday bike use in the future. The wish to enjoy an active lifestyle and admire nature enhances this situation. Poland's geographic position is conducive to bicycle touring. Cycling routes diversified in terms of the height profile, surroundings, etc., sometimes running across national parks, are of particular interest to foreigners, who come gladly to spend several days riding a bike.

It is, therefore, necessary to reach out to cyclists and take care of appropriate infrastructure, which also includes bikes, by suggesting new structural solutions for mass tourism. Given many types of bikes available in the market, it is not easy to choose an appropriate model.

The cost of the structural details of the tricycle suggested in this article does vary considerably from standard electric bikes, however, this solution has several important advantages, which may be decisive in the purchase of this solution. The first advantage is the possibility of continuous battery charging without the need to use charging stations or plug the bike to electric sockets. Such a solution permits covering long routes without appropriate infrastructure. The second advantage of the tricycle is its dimensions, which are chosen in such a way that the tricycle does not vary considerably from the clearance gauge of standard bikes. Owing to that, the tricycle can be used on all cycling paths and parked at spaces designed for standard bikes. Children, adults as well as persons with motor dysfunctions may be transported in the tricycle, owing to which family tourism may be practised.

References

1. Adamczyk Dominik, Michał Michna. 2010. „Overview and analysis of the drive systems used in electrical bikes”. *Zeszyty Problemowe – Maszyny elektryczne* 88: 63-68.
2. Bosch Nyon Display Performance Line, Aktiva. Available at: https://sklepebike.pl/pl/p/.
3. Brushless motors for electric bicycles. Available at: https://sklepebike.pl/pl/c/SILNIKI/51.
4. City Bike – bicycle rental. Available at: wrower.pl/miasto/rower-miejski-wypozyczalnia-rowerow,2183.html.
5. Demand for cycling tourism. Available at: https://www.pot.gov.pl/attachments/article/1804/Popyt%20na%20turystykę%20rowerową%20-%20analiza%20desk%20research.pdf.
6. Dębowska-Mróz Marzena, Ewa Ferensztain-Galardos, Renata Krajewska, Andrzej Rogowski. 2018. “Bicycle tourism as a form of active tourism on the example of the municipality of Radom”. *Biuletyn KPZK PAN. Komitet Przestrzennego Zagospodarowania Kraju Polskiej Akademii Nauk* 269: 103-128.
7. Dižo Ján, Miroslav Blatnický, Dalibor Barta, Rafał Melnik. 2019. “Application of simulation computations in investigation of vibration properties of a tricycle”. *Diagnostyka* 20(3): 97-104.
8. Jacyna Marianna, Mariusz Wasiak, Klodawski, Michal Klodawski, Piotr Gołębiowski. 2017. “Modelling of bicycle traffic in the cities using VISUM”. In: *10th International Scientific Conference on Transportation Science and Technology (TRANSBALTICA).* Vilnius, Lithuania. May 04-05, 2017. Transportation Science and Technology. *Procedia Engineering* 187: 435-441.
9. Local data bank. Available at: https://bdl.stat.gov.pl/BDL/dane/podgrup/tablica.

10. Lopez-Escolano Carlos, Angel Pueyo Campos, Sergio Valdivielso Pardos, Eva Nedeliakova, Vladimira Stefancova. 2017. "Incorporating bicycles into urban mobility: an opportunity for sustainable development". *Communications – Scientific Letters of the University of Zilina (Komunikacie)* 19(2): 68-73.
11. Rogowski Mateusz, Marcin Nadolski. 2015. „Inhabitant opinion on cycling in the Poznan agglomeration". *Studia Periegetica* 2(14): 137-155.
12. Tokarz Ewelina. 2016. "Bicycle design with additional solar drive". *Engineering diploma thesis.* State Higher Vocational School in Nowy Sącz.
13. Wasik E., P. Czech, T. Figlus, K. Turoń, R. Kałuża. 2018. „An electric bike as the future of eco-transport". *Autobusy* 6: 771-779. ISSN: 1509-5878. DOI: 10.24136/atest.2018.173.

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