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PLATFORM TO SUPPORT THE IMPLEMENTATION OF ELECTROMOBILITY IN SMART CITIES BASED ON ICT APPLICATIONS - CONCEPT FOR AN ELECTRIC TRAVELLING PROJECT

Summary. The concept of an innovative tool for supporting electromobility development is presented in this paper. The main aim is intended to ease the implementation and further development of electromobility in urban and suburban areas. The final outcome of the research is a tool, which includes integrated modules related to travel and charging point location planning and simulation.

Keywords: electromobility; sustainable transport; ICT; urban planning.

1. INTRODUCTION

Dynamic changes, either enforced by law or resulting from the current situation in the centres of large cities, make it difficult to predict the real future shape of transport systems in urban areas. Guidelines or recommendations regarding directions for developing EU transport systems were included in consecutive white papers and communications [16].

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A comprehensive approach is needed using a variety of measures, including the integration of planning, organization, policy and law. To promote change in the modal split, people who travel need to be incentivized and, from a long-term perspective, realize change in their travel behaviour [7]. The second area of initiatives includes technologies enabling a reduction in noise, emissions into the environment and the use of non-renewable resources. One of the important documents defining the European strategy for the use of alternative fuels, from 24 January 2013 [3], draws attention to threats related to the high oil dependence in Europe (in relation to mobility and transport). Electricity was listed among the alternative fuel sources listed in the document. In the white paper, "Roadmap to a Single European Transport Area White Paper COM (2011) 144 final", the EU has set a target to "halve the use of 'conventionally-fuelled' cars in urban transport by 2030 and phase them out in cities by 2050".

In 2016, another competition was announced as part of the ERANET programme. Known as the Electric Mobility Europe Call, the expected outcomes are likely to include the following [4]:

- intensified uptake of electromobility in urban and suburban areas
- improved connectivity between electric vehicles and the existing infrastructure
- increased choice for customers or consumers seeking to reduce the environmental impact of their travel

The paper deals with the concept of an innovative tool related to the project "Electric Travelling - Platform to Support the Implementation of Electromobility in Smart Cities Based on ICT Applications" project (hereafter "ET project"), which started in 2018. The following chapters include the identification of the main aim of the project and the proposed structure of the innovative tool, as well as the expected impacts for citizens and urban areas.

2. MAIN AIM OF THE ELECTRIC TRAVELLING PROJECT

When defining sustainable development [1,9,11,21], it is necessary to have complete knowledge of current transport systems, but also actual travel needs. Meanwhile, sustainable transport includes technologies that enable a reduction in noise, emissions into the environment and the use of non-renewable resources.

There is still a lack of universal tools to solve more than one or two problems at the same time. Analyses of existing travel planners show that these tools mostly use only time and distance criteria, with only a few using environmental criteria [2,6,12]. It is important to prepare more complex solutions as integrated systems, which will have directly and indirectly impact on travel behaviours, especially those related to electromobility. The ET project, due to its complexity, is the answer to both needs by developing a complex ICT system known as ETSys On the one hand, it is directly addressed at travellers, while, on the other side, the system's final functions and routing processes are related to parameters, which will be set by local authorities. Moreover, some modules of the proposed ETSys will have an indirect impact in changing current travelling behaviour because they will suggest to local authorities the measures to be implemented in order to achieve the correct changes [5].

ETSys aims to strongly support the implementation of electromobility based on two innovative points or general added values (a step beyond the current state-of-the-art situation) [5, 23-25]:

- From a micro perspective, the extension of current routing algorithms and travel planning tools with a focus on electromobility, which will include the possibility to prioritize areas of electromobility using a heuristic approach in relation to the road network of the city and a daily activity chain optimization algorithm, which will be open to independent ITS input information. These two elements will result in ETPlanner, which will be friendlier for electric vehicle (EV) users and, from a long-term perspective, see a rapid growth in the number of EV users in the city.
- From a macro perspective, the final integrated ETSys will include modules that will allow for the optimal allocation of charging stations (based on many input parameters), the analysis of emissions in detail and the comparison of scenarios. ETSys will become a powerful tool to support decision-making in local authorities (infrastructure managers, public administrations etc.). The implemented functions (among others, big data to understand daily travel patterns and their day-to-day fluctuations, and an LCA tool, which includes EV and multi-agent simulation and scenario comparison) will provide a guide for the development of a proper strategy in the design and implementation of the charging infrastructure.

Both elements are intrinsically related, embodied in the concept of the future traveller and aligned with the objective of developing new knowledge about different aspects of travelling to support electromobility patterns.

Given its interdisciplinary character, the ET project has required a diverse research team. Thus, an international consortium was established under the leadership of Saitec. The team consists of researchers and scientists representing companies and scientific institutions from four European countries: Saitec, Factor CO2 and DeustoTech (Spain), Silesian University of Technology (Poland), Budapest University of Technology and Economics (Hungary), and the Delft University of Technology and Over Morgen (the Netherlands).

3. ETSYS ARCHITECTURE

The ET project is intended to ease the implementation and further development of electromobility in urban and suburban areas. The project results will provide adequate ICT tools to identify smart electromobility solutions adapted to specific urban or suburban areas, which will facilitate the introduction of EVs and the required charging stations in the existing transport infrastructure.

ETSys provides a set of modules in one integrated system, which will give local authorities powerful tools to analyse and find the best solutions to foster electromobility. It will offer simulations of current and user-defined what-if scenarios, where the optimization algorithms will allocate charging stations and evaluate the impact of the solution. City authorities can use this system to allow travellers to plan their trips, but in accordance with some prioritized criteria.

As the final outcome of the ET project, ETSys will include the following integrated modules (Figure 1) [5]:

- ETPlanner - A door-to-door travel planner with a routing optimizer (including greener criteria to minimize environmental impact) ready for EVs and directed at promoting this travel mode. This includes a daily travel chain optimization method and an advanced heuristic approach to allow local authorities to prioritize

areas of electromobility in the city. The multimodal travel planner will allow data to be collected from users' queries.

- ETCharge - This includes an optimal multicriteria allocation algorithm for charging stations. This module will support charging infrastructure planning in cities by estimating the current demand and forecasting future demand for charging stations.
- ETSim - This is a multi-agent simulator, which will simulate people travelling in a selected area (based on routes estimated by ETPlanner). Simulation results will be compared for different scenarios (current state, new charging point location from ETCharge and several incentives).
- ETReport - This reports on the module addresses for local authorities and presents the simulation results. It can serve as a guide as to how to develop the transport system to achieve faster progress with the introduction of EVs in the city or in increasing their number.

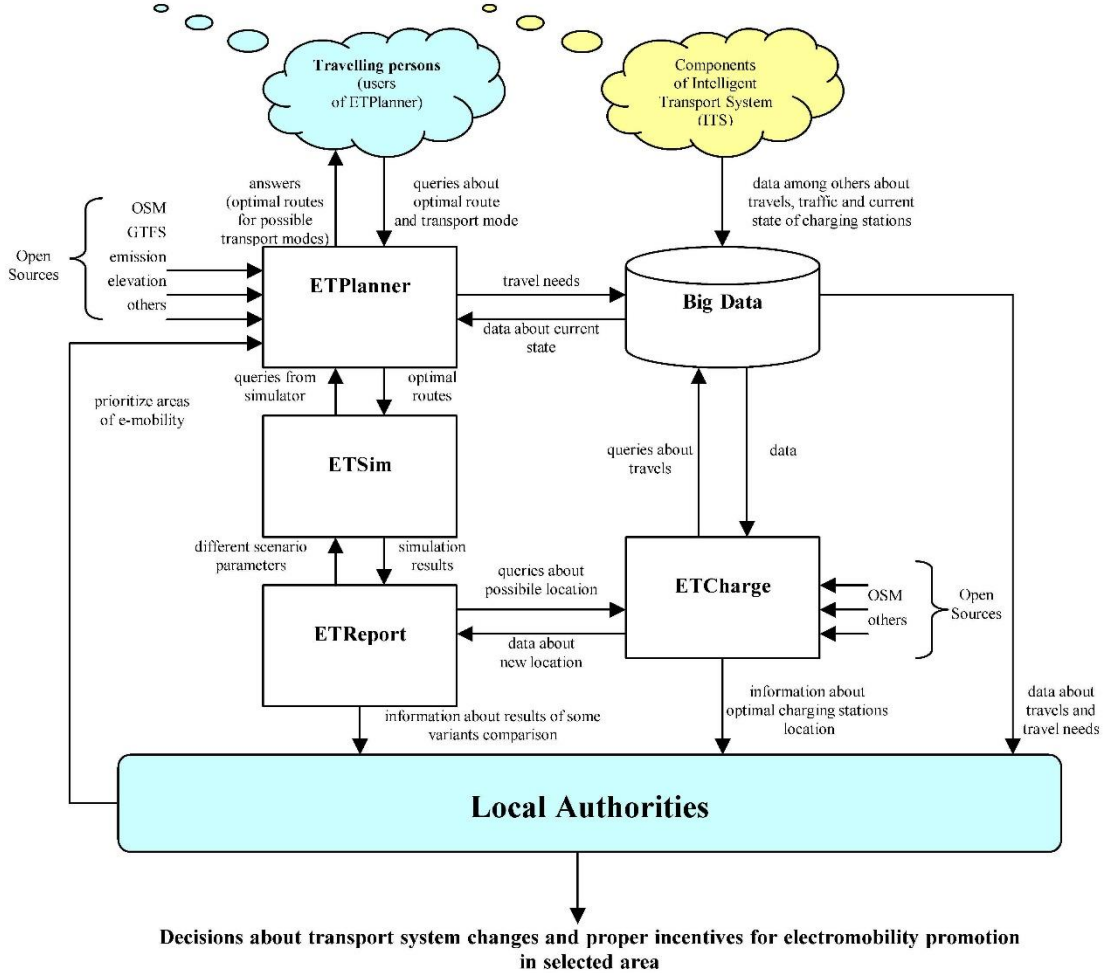


Fig. 1. Proposed modules of the ETSys platform with two kinds of user
Source: own research

Furthermore, the proposed system will be open so that it can be connected to other existing ITS components, by using specified protocols for data exchange. ETSys, as the final outcome of the ET project, will facilitate the introduction of EV-friendly transport policies in cities, while, at the same time, more quickly change the travel behaviour of citizens.

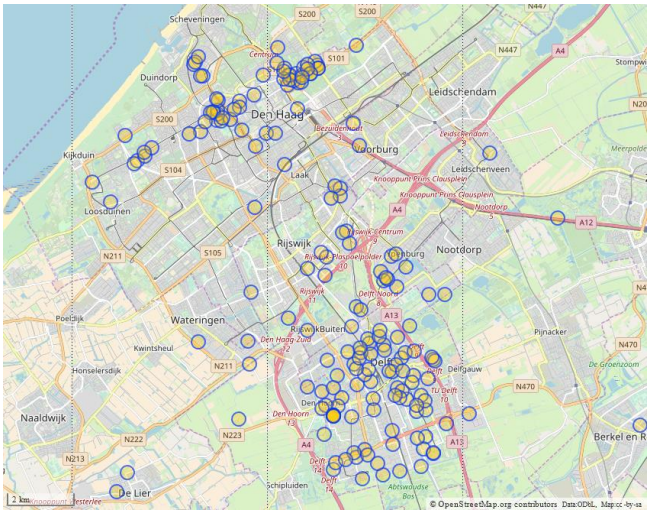
4. RESEARCH AREAS AND EXPECTED IMPACT

Three cities were selected as research areas: The Hague, Sosnowiec and Zalaegerszeg, from the Netherlands, Poland and Hungary, respectively. The selected cities are open to electromobility trends and represent different levels of electromobility development. From the list, The Hague is a leader based on the number of existing charging points, while the other cities have only a few (Figure 2). It is important, when carrying out comprehensive tests and validation of the project's product, that the optimized integration of electromobility into the transport system of the cities is supported.

The expected impacts, from a long-term perspective, and the related steps in the ET project are as follows [5]:

- Increasing number of charging points in urban and suburban areas, which will move electromobility into the transport mainstream. This can be one of the results of simplifying decision-making with regard to proper charging station locations.
- Increasing the number of EV users, as a result of improved connectivity between EVs and the existing infrastructure, will tackle barriers such as people's perceptions about EVs in terms of limited range, poor infrastructure etc.
- Increasing the number of people with knowledge of the environmental impact of transport and more pro-ecological solutions (improved public acceptance for electromobility) by using the final product of the project, both directly and indirectly, so as to change travel behaviour.
- Including EVs in the current modal split of traffic, as well as raising the importance in the literature of EVs in traffic, to bring about changes in travel behaviour. Currently, the modal split in traffic models often neglects personal electrics cars as a separate group of means of transport. EVs have different characteristics in terms of parameters and should be analysed separately.
- Pollution and noise reduction in urban areas, thereby reducing Europe's carbon emissions, improving air quality, decreasing noise pollution and supporting economic growth by increasing the percentage of EVs used for travel.
- Improving current transport systems according to the real needs of travellers based on big data collected from system users (this depends on the number of final ETSys users).
- Greater integration of existing transport systems in cities. ETSys is a complex solution, which can be connected to others currently existing in the cities.
- Accelerating electromobility development in Europe. ETSys will be universal and related to some input data, which can be collected from different parts of Europe as well. This means that ETSys may be implemented in other cities.

a)



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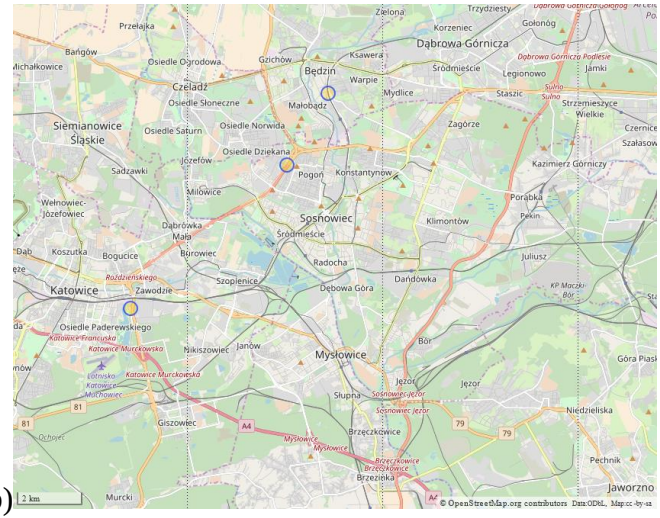

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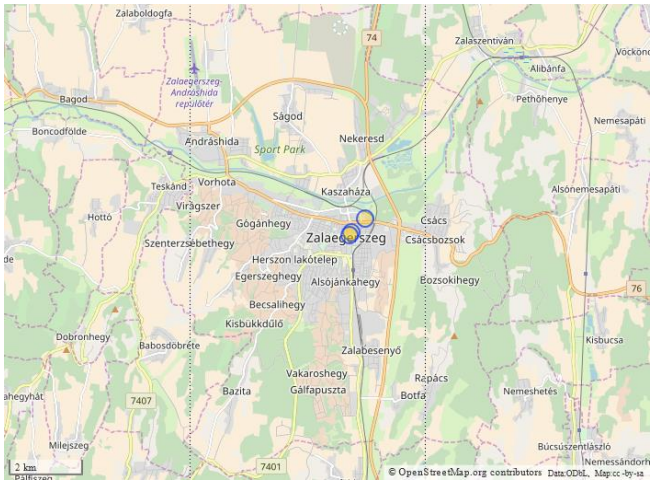

Fig. 2. Research areas with existing charging points: a) The Hague, b) Sosnowiec and c) Zalaegerszeg
Source: own research based on [8,10]

5. CONCLUSION

The described ET project offers new possibilities for changing travel behaviour by expanding the functionalities of travel planners and drawing special attention to electromobility. The project will assist travellers in choosing the travel mode (includes EVs) and route (by using ICT applications), as well as support local authorities in the definition of appropriate directions for the development of electromobility.

In the future, it will be possible to think about using artificial intelligence methods, which are already used today in many areas of life [17-20,22].

Decarbonizing the transportation sector is one of the main challenges facing the whole world [14,15]. A change in the way of thinking is necessary to promote electromobility or other new, clean and sustainable technology for vehicles [13]. For instance, EVs are more efficient from an energy point of view, more economic in terms of consumption and more environmentally friendly compared to internal combustion engine vehicles. To highlight the benefits of EV technology for ETSys users, it will always show a comparison between the journeys by the selected means of transport and an EV. People must obtain full knowledge of the impacts that each means of transport involve in order to make the proper travel decisions. Local authorities, throughout ETSys, will receive a powerful tool to help with decision-making problems about the development of transport infrastructure related to electromobility.

Interdisciplinary and international cooperation on the project provides an opportunity for implementing innovative solutions and more importantly universal ones, which are independent from the area in which they are applied. According to European guidelines and plans for the near future, it is possible that initiatives such as the ET project may have an important influence on transport systems in cities.

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References

1. Banister David. 2008. "The sustainable mobility paradigm". *Transport Policy* 15: 73-80.

2. Borkowski Przemysław. 2017. "Towards an optimal multimodal travel planner-lessons from the European experience". In Sierpiński G. (ed.) *Intelligent Transport Systems and Travel Behavior*: 163-174. Cham: Advances in Intelligent Systems and Computing 505, Springer.
3. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Clean Power for Transport: A European Alternative Fuels Strategy, COM (2013), 17, Brussels 24 January 2013.
4. *Electric Mobility Europe Call 2016. Guide for Applicants*.
5. Electric Travelling - Platform to Support the Implementation of Electromobility in Smart Cities Based on ICT Applications - Project Proposal Under Emeurope Programme, 2016.
6. Esztergár-Kiss Domokos, Csaba Csiszár. 2015. "Evaluation of multimodal journey planners and definition of service levels". *International Journal of Intelligent Transportation Systems Research*, 13: 154-165.
7. Hebel K. 2013. *Zachowania transportowe mieszkańców w kształtowaniu transportu miejskiego*. [In Polish: *Transport Behaviour of Residents in Shaping Urban Transport*.] Gdańsk: Wydawnictwo Uniwersytetu Gdańskiego.
8. "OpenStreetMap service". Available at: https://www.openstreetmap.org/.
9. *Our Common Future. Report of the World Commission on Environment and Development.* 1987.
10. "Overpass service". Accessed: 30 April 2018. Available at: http://overpass-turbo.eu/.
11. Pawłowska Barbara. 2013. *Zrównoważony rozwój transportu na tle współczesnych procesów społeczno-gospodarczych*. [In Polish: *Sustainable Transport Development Against the Background of Contemporary Socio-economic Processes*.] Gdańsk: Wydawnictwo Uniwersytetu Gdańskiego.
12. Pijoan Ander, Oihane Kamara-Esteban, Ainhoa Alonso-Vicario, Cruz E. Borges. 2018. "Transport choice modeling for the evaluation of new transport policies". *Sustainability*, 10: 1230. DOI: 10.3390/su10041230.
13. Ministerstwo Energii. 2016. *Plan rozwoju elektromobilności w Polsce. Energia do przyszłości.* [In Polish: Ministry of Energy. 2016. *Plan for the Development of Electromobility in Poland. Energy for the Future*.]
14. Santos Georgina. 2017. "Road transport and CO2 emissions: what are the challenges?". *Transport Policy* 59: 71-74. DOI: 10.1016/j.tranpol.2017.06.007.
15. Van der Zwaan Bob, Ilkka Keppo, Filip Johnsson. 2013. "How to decarbonizes the transport sector?". *Energy Policy* 61: 562-573. DOI: 10.1016/j.enpol.2013.05.118.
16. *White Paper: Roadmap to a Single European Transport Area - Towards a Competitive and Resource Efficient Transport System*. COM (2011) 144.
17. Ogiela Lidia, Ryszard Tadeusiewicz, Marek Ogiela. 2006. "Cognitive analysis in diagnostic DSS-type IT systems". In *Eighth International Conference on Artificial Intelligence and Soft Computing (ICAISC 2006)*. Zakopane, Poland. 25-29 June 2006. *Artificial Intelligence and Soft Computing - ICAISC 2006*: 962-971. Book series: *Lecture Notes in Computer Science* 4029.
18. Ogiela Lidia, Ryszard Tadeusiewicz, Marek Ogiela. 2006. "Cognitive computing in intelligent medical pattern recognition systems". In Huang D.S., Li K., Irwin G.W. (eds.) *International Conference on Intelligent Computing (ICIC)*. Kunming, P.R. China. 16-19 August 2006. *Intelligent Control and Automation*: 851-856. Book series: *Lecture Notes in Control and Information Sciences* 344.

19. Ogiela Marek, Ryszard Tadeusiewicz, Lidia Ogiela. 2005. "Intelligent semantic information retrieval in medical pattern cognitive analysis". In Gervasi O., Gavrilova M.L., Kumar V. et al. (eds.) *International Conference on Computational Science and Its Applications (ICCSA 2005)*. Singapore. 9-12 May 2005. *Computational Science and Its Applications - ICCSA 2005* Vol. 4: 852-857. Book series: *Lecture Notes in Computer Science* 3483.
20. Tadeusiewicz Ryszard, Lidia Ogiela, Marek Ogiela. 2008. "The automatic understanding approach to systems analysis and design". *International Journal of Information Management* 28(1): 38-48.
21. Jacyna M., M. Wasiak, K. Lewczuk, M. Kłodawski. 2014. "Simulation model of transport system of Poland as a tool for developing sustainable transport". *Archives of Transport* 31(3): 23-35.
22. Celiński I. 2017. "Mobile diagnostics of vehicles as a means to examine and define speed limits in a road". *Diagnostyka* 18(1): 67-72.
23. Jacyna M., K. Lewczuk, E. Szczepanski, P. Golebiowski, R. Jachimowski, M. Klodawski, D. Pyza, O. Sivets, M. Wasiak, J. Zak, I. Jacyna-Golda. 2015. "Effectiveness of national transport system according to costs of emission of pollutants". In Nowakowski T., Mlynczak M., Jodejko-Pietruczuk A., Werbinska-Wojciechowska S. (eds.) *Safety and Reliability: Methodology and Applications. Proceedings of the European Safety and Reliability Conference (ESREL)*: 559-567. Wroclaw, Poland. 14-18 September 2014. Boca Raton, FL: CRC Press-Taylor & Francis Group. ISBN: 978-1-315-73697-6, 978-1-138-02681-0.
24. Lubos Kucera, Tomas Gajdosik, Igor Gajdac, Martin Mruzek, Maria Tomasikova2017. "Simulation of real driving cycles of electric cars in laboratory conditions". *Komunikacie* 2017(2a).
25. Anjum Naweed, Ganesh Balakrishnan, Matthew J. W. Thomas 2014. "Challenges facing simulator use in transportation research: lessons from a road safety case study". *Road & Transport Research: A Journal of Australian and New Zealand Research and Practice* 23(2). ISSN: 1037-5783 June 2014.

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