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Editorial

Transportation Systems Modeling, Simulation and Analysis with Reference to Energy Supplying

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1. Introduction

Transport plays an important role in the economy of a given country or region. However, at the same time, it is responsible for the high level of energy consumption due to its functioning. The energy demand of transport systems strongly depends on the transport branch under examination and the type of transported cargo. For example, passenger transportation accounts for 50 to 60% of the energy consumption derived from transportation activities, while freight transportation accounts "for only" 40–50% [1]. The dominant transport system is, of course, road transport. It should be noted, however, that in most economies, this mode of transport is responsible for 80% of the national energy consumption [1]. For this reason, for many years, the European Union's transport policy has been promoting more energy-efficient transport systems, such as rail and waterborne transport.

The energy consumption of transport systems has become the subject of numerous studies and publications in recent decades. This is due to the transport policy of the European Union, increasingly limited access to natural energy resources, intensive technological progress and, last year, the energy crisis caused by the armed conflict in Eastern Europe. Therefore, contemporary research aims to ensure that transport systems generate the fewest possible externalities through energy consumption optimization and the consequent operational improvement [2]. Research conducted in this area focuses not only on analyzing the current demand for energy by modern transport systems, but also on modeling future solutions and their optimization using simulation tools. For this reason, the topic of the presented Special Issue responds to the publication needs of scientists representing not only the energy sector, but, above all, the transport sector.

However, it is worth noting that in times of energy crisis, researchers' attention is directed to one more aspect related to the demand for energy reported by a given transport system. In addition to analyses of the energy demands of transport systems, the issue of their resistance to undesirable events, such as disruptions in energy supplies, is also becoming important. For this reason, one of the goals we defined for this Special Issue was to find new approaches to improving the resilience and robustness of transportation systems concerning their power supply. It is worth explaining the necessity of this dual view of the researched issue. As robustness denotes information regarding how the transportation system and its power supply can withstand disruptions and failures, resilience offers information regarding how quickly systems can return to correct operations. From the point of view of transport system management, both pieces of information are critical, as they make it possible to improve transport processes at both the strategic and operational levels.

The purpose of the presented review is to summarize the results published in the Special Issue "Transportation Systems Modeling, Simulation and Analysis with Reference to Energy Supplying". Section 2 will present the essential statistics and describe the published articles. Section 3 will characterize the research areas distinguished by us and

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the publications assigned to them. A summary of the obtained results and the identified areas requiring further development is presented in Section 4.

2. Publication Statistics

Guest editors of this Special Issue invited scientists from around the world to cooperate during the period from 11 August 2021 to 31 December 2022. A total of 11 articles were published in this issue. Figure 1 shows the number of articles that were published during this period. It is worth explaining that articles were accepted for review until the last day of the SI opening; therefore, one of them ended the review process and was published in 2023.

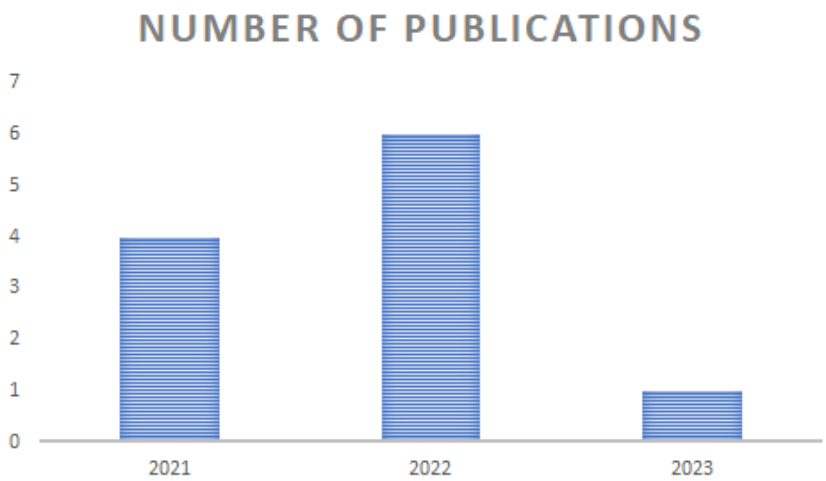

Figure 1. Number of articles accepted for publication during the opening of the Special Issue.

Most of the published articles were prepared by authors from Poland (12 authors), although multi-author teams also came from Russia (3 authors) and China (2 authors). Individual researchers came from Lithuania, Ukraine and Croatia. The countries of origin of the authors are shown in Figure 2.

Figure 2. Authors' countries.

The presented articles were mostly multi-authored; only one was prepared by a single researcher. It is also worth pointing out that in six articles, the authors came from one research center, while in five cases, they represented different research centers. A list of all

publications, with an indication of the number of authors and involved research centers, is presented in Table 1.

Table 1. List of publications with the number of authors and research centers involved in preparing the publication.

Article	Number of Authors	Number of Research Centers
[3]	2	1
[4]	3	2
[5]	3	2
[6]	3	3
[7]	2	1
[8]	3	1
[9]	2	1
[10]	4	3
[11]	2	1
[12]	1	1
[13]	2	2

The analysis of the publication also allowed us to distinguish five thematic areas covered by the presented research results. It is worth pointing out three dominant areas, which include: (1) air transport systems; (2) rail transportation systems; and (3) systems supporting the transport of energy resources. The bibliometric data on the number of publications in each area and their total percentage shares are presented in Figure 3.

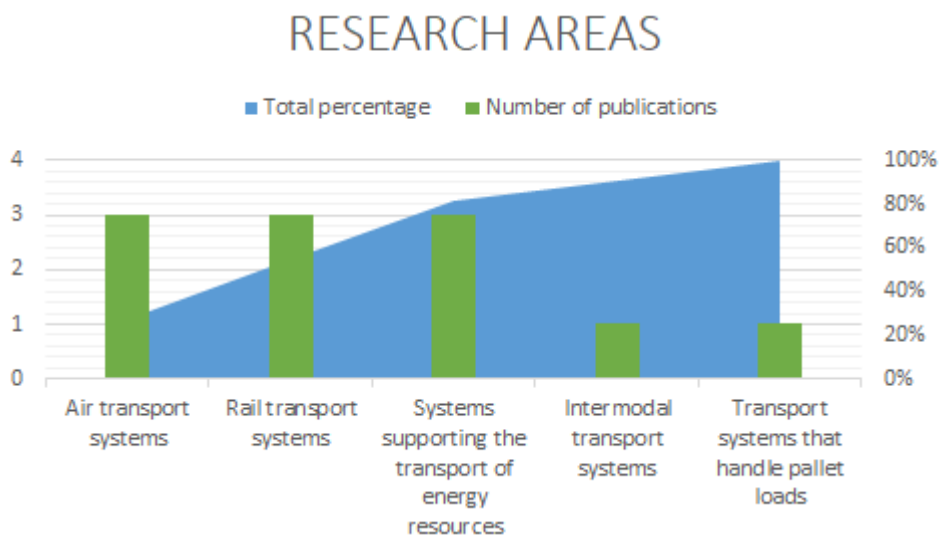

Figure 3. Classification of articles according to accepted thematic areas.

According to the thematic areas highlighted in Figure 3, an analysis of the results presented in the published articles was carried out. The results of this analysis are presented in Section 3.

3. A Short Review of the Contributions in This Issue

The analysis of the publications submitted to this Special Issue allowed us to group them according to the transport branch to which the presented results pertained. In this way, it was possible to distinguish the most numerous groups, including air and rail transport systems. First, the results of the research on air transport will be presented. This group includes the first article which qualified for publication in this Special Issue, namely [3]. This publication aimed to analyze the possibility of reducing contact between operators and passengers in the airport security screening system by process management concerning the

system's power consumption. When analyzing these possibilities, the authors considered the energy consumption of the tested process. A computer simulation was applied to estimate the system's performance and power consumption. Thanks to the conducted analyses, it was possible to identify critical factors affecting the number of contacts between the operator and the passenger while ensuring lower energy consumption by the system. The process of security screening at airports was also an area of research, the results of which are presented in [4]. In this case, however, the authors developed a simulation model that allowed for the simultaneous analysis of airport screening lane performance and power consumption per passenger served. It is worth noting that these two issues have not yet been considered simultaneously in the scientific literature. The paper presents simulation results for three configurations of the tested system. The analysis indicated the possibility of achieving annual savings of up to 4614 kWh, while serving of 2 million passengers, thanks to appropriate system configuration. In the third article on the air transport system [7], the authors focused their attention on the baggage handling process in an airport zone. The authors presented a simulation model to perform an analysis of the sensitivity of the energy consumption of an airport baggage handling system to a change in resource allocation strategy. The research procedure assessed three scenarios relating to different resource allocation strategies. On this basis, the strategy that would bring the most benefits was determined. It is worth noting that the proposed simulation model can be used to optimize both the existing and the designed systems.

The second group of classified articles concerned rail transport systems. One of the analyzed issues was related to timetable planning [5]. According to the authors, an important element affecting the energy consumption of railway traffic is the correct allocation of time reserves when preparing train timetables. For this reason, the authors proposed a simulation model that, based on the probability of failure and its consequences, will allow the acceptable level of robustness to be determined. The probability of no-delay propagation can quantify this level. This model was verified using the example of a selected railway line. The authors also analyzed the energy consumption used during unscheduled train stops depending on the added buffer time. In addition, in the article [9], the authors focused on the possibility of configuring timetables considering energy consumption. They proposed a model for reconfiguring train timetables, considering minimizing the globally consumed energy for traction purposes. A modification of the actual train timetable on the selected route was developed using simulation tools, and a global reduction in the total energy demand by 398 MWh/year was obtained. In the last article from this transport branch [11], the authors defined a research sphere based on a literature review. Their results indicate that the problem of running railway traffic when the capacity of the power supply network is limited (by the size of the permitted currents) and needs to be better studied. For this reason, these researchers proposed a method based on the Markov approach and supplemented by classical theoretical vehicle traffic dynamics to improve the operational robustness of the rail transport system using a DC power supply system. Based on the verification of the method in a real environment, they managed to increase the operational resistance from 0.9454 to 0.9774.

Another distinguished group of publications concerned systems providing transport services for energy resources. The risks associated with the transfer of gas are presented in the article [8]. The presented research results were obtained using the example of the Russian gas transmission network. The article demonstrates the results of simulated attacks on gas pipelines based on the defender–attacker model. The most interconnected sections of the main gas pipelines, the failure of which can cause significant damage to the system in the form of a gas shortage among consumers, were also characterized. The article [10] presents a method for assessing the risk of adverse events according to the logistics of LNG deliveries at a port terminal. The fuzzy logic methodology was used to assess the risk, and the scenarios for the analysis were prepared based on interviews conducted among experts. This method has been verified based on services provided by a selected marine LNG terminal in Poland. In [13], reloading operations in a seaport were also analyzed, but

in this case, the research concerned crude oil transfer. The port operator proposed the crude oil sea–river transshipment scheme in Nantong Port, and the article's authors verified this proposal's feasibility in their research. For the analysis, the authors used the discrete event system modeling and entity relationship diagram method to construct the hierarchical and concept models of the Yangtze River Basin's crude oil sea–river transportation system.

Among the published studies, the issue of combining different means of transport into intermodal transport systems is also discussed. In [12], the factors influencing the real possibility of CO_2 reduction by changing the mode of transport were analyzed. In his research, the author also defined the type of cargo susceptible to changes in the means of transport. A different research topic was presented in [6]. This article's authors focused their attention on issues related to the transport and handling of palletized loads. Many service operations in logistics centers using forklifts are often associated with increased pallet and load damage. The article's authors discussed mechanical damage to loads involving forklifts, load damage test results, anti-slip forklift attachments, computational models of the attachment, prototypes and real-world testing of the attachment on a forklift in a logistics center. Finally, the implementation of the solution in a selected logistics center was described.

4. Conclusions

To summarize the analyzed publications, it is worth emphasizing that the research described in the publications covered all transport branches, but articles on rail and air transport systems dominated. The reported publications lacked results relating to the energy consumption of road transport, which often appears as a research area regarding energy consumption and energy-saving solutions. The second area of research that should be expected in such a Special Issue is using Industry 4.0 solutions to improve the energy demand of processes supported by individual transport systems. This is an important research topic, in particular in the aspect of the digitization of transport processes. Regarding the subject matter of the Special Issue analyzed herein, it is also worth noting that in many publications, digitization is recognized as a system supporting building resilience in technical systems, including transport systems. In connection with the above, it is also notable that the subject of "Transportation Systems Modeling, Simulation and Analysis with Reference to Energy Supplying" should be continued in new editions and supplemented with the aspects indicated in the above conclusions.

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