



Sustainable transport – development and goals

Konrad Łuczyszyn
West Pomeranian University of Technology
Szczecin, Poland
tluczyszyn2wp.pl@wp.pl

Abstract

Sustainable development is observed worldwide, and one of the most affected fields is the transport sector. Sustainability brings challenges that must be overcome to achieve high safety and comfort and reduce greenhouse gas emissions. By the end of 2030, United Nations members must achieve the assumed sustainability level. This paper investigates whether it is possible to reduce CO₂ emissions completely, especially in the transport sector. The paper focuses on the challenges to obtaining a high sustainability level, as defined by the United Nations. The examples of sustainability in rail and road transport were analysed and described. Results show the benefits, concerns, and problems of the described solutions.

Keywords

Sustainable development, sustainable transport, environment, challenges,

1. Introduction

Nowadays, the dynamic development of transport services requires new solutions. Worldwide awareness has grown, and people have started caring for the planet. There are many ways of taking care, and different sectors require different levels of intervention. Sustainable development has become a priority for sparing the world from poverty, hunger, and pollution. Specifically, sustainable transport development addresses all modes of transportation.

The main goal of sustainable transport is to reduce the emission of greenhouse gases. The constant economic, social and environmental changes require new solutions and quick and accurate decision-making (*United Nations, 2023*).

It should be noted that the number of factors, random variables, and differences influence the pace of changes. This study shows how many challenges are faced during processes, how many factors impact the pace of change, and what benefits and threats are coming from scientific and technical work.

The paper focuses on whether there are any challenges to obtain a high sustainability level defined by the United Nations. What are the benefits, concerns, and problems of the described solutions? What could postpone the high-level sustainability? The second chapter describes the United Nations 2030 Agenda for Sustainable Development. The third chapter describes the role of artificial intelligence. The fourth chapter collects some state-of-the-art examples and case studies. The fifth chapter gives the conclusion.

2. Importance of the 2030 Agenda for Sustainable Development

During the New York summit, all United Nations member states signed the world-changing document, “2030 Agenda for Sustainable Development”. The agenda consists of 17 main goals, which are meant to provide significant changes in people’s lives and surroundings by using specific tools and taking actions to eliminate poverty, inequality, world instability and other harmful and fatal factors (*Rony et al., 2023*). The entire project is one of the most challenging endeavours in history due to the breadth of its assumptions. By signing the document, world leaders have determined a new route. Thus, it must be demonstrated that every country’s government, society and international politics can cooperate and work effectively to fulfil the obligations outlined in the signed document. Also, this project was called a milestone in order to create a beneficial and better world. Since that day, the commitment to its goals has begun.



2.1 Sustainable transport development

Transport is a specific sector of services area that includes all modes of transport. Road transportation, maritime transportation, air transportation, rail transportation, inland shipping, and pipeline transport are also available. If different modes of transport are combined, we speak about intermodal transportation. Goods in different states of matter (solid, liquid, fluid) are transported, and most can transport passengers (excluding pipelines). The main purposes of sustainable transportation are to reduce the emission of CO₂, to improve the infrastructure and to take care of the safety of goods and passengers (Majerova, 2022).

The European Union has expanded the idea of reducing emissions and created a long-term program that assumes that by 2050, the economy will become climate-neutral. Renewable resources must be used, and zero-emission levels must be reached to achieve this aim. It is envisioned that electricity is the future and that carbon dioxide pollution should disappear. Even if there is remaining CO₂, it will be captured, making air clearer (Directorate-General for Climate Action, 2019).

2.2. Challenges

Regarding transport sustainability and its development, it is important to emphasise that the most important factors are the economy, society and environment. The price tags, limits and cost standards should be set. Action that requires high initial costs of introducing and developing sustainable solutions has to be a barrier for companies, governments and people as customers. An analysis should be done to check whether the solution is cost-effective compared to its activity and influence. Sometimes, the traditional options are more attractive. Regions differ geographically, demographically and culturally, so the methods and operations must be standardised accordingly (United Nations, 2023).

Gathering all necessary regional data makes it possible to start planning the strategy and process. However, unforeseen circumstances and fluctuations may arise, and during the planning phase, it is imperative to consider accountability for unforeseen events. Since the regulations require achieving particular results during development, the efficiency level has to be maintained or improved if possible. The solutions which are part of the sustainable development process should not provide worse results than previous ones. This is one of the reasons why society is a part of projects as well. The balance between what is needed and what must be done must be maintained by finding optimal solutions (United Nations, 2023).

Since the Industrial Revolution, civilisation has been overloaded with pollution: gases, dust, and toxic fumes. First, engines were steam-powered, most households were heated with coal and wood, and coal-fired power stations were the main energy providers. The transport industry emits a high percentage of global CO₂. Road transport is at the top of the list, producing approximately 74% of all pollution in this field. The challenge is to convince people to use urban transport and produce electricity-powered vehicles (Mikušová, Torok, Břida, 2018). Unfortunately, many people do not want to change their behaviour. They find urban transportation uncomfortable, crowded, and badly scheduled and resist changing their habits as long as the old ones work appropriately.

Complexity coming from approaching changes may be disadvantageous. Those responsible for development and implementation must be well-prepared, well-trained and flexible. Initially, the new knowledge may seem overwhelming, and unexpected situations undoubtedly arise, but accepting these challenges is the key to success. Complexity during the first stages may cause troubles, and challenges are not foreseen during the planning phase. Thus, every factor has to be analysed meticulously to avoid additional costs and delays.

In 2020, the COVID-19 pandemic caused global chaos. The transport sector was struck and partially paralysed by the pandemic. The new regulations and restrictions changed the capacity of urban transport. People started using their cars again to avoid possible infection. During this period, the number of people using urban transportation dropped. Funds and workforce shortages hindered research (Transformative Urban Mobility Initiative, 2020). The return from that point has still not been finished.

3. Artificial intelligence as a tool in the development of sustainable transport

As the popularity of artificial intelligence tools has grown, people have managed to introduce them to the transport industry. Road and rail transport benefit the most from applying A.I. tools. In rail transport, to achieve highly prioritised safety, efficiency, and improved operational abilities, artificial intelligence tools have created many solutions relevant to system activity, train bodies, and infrastructure (Ficzere, 2023).



One of the most important changes introduced is the ability of the railway system to manage itself autonomously. This solution requires high-level reliability of the artificial intelligence module, which applies new programming to the train's control system. As a consequence, it increases safety levels and optimises operations and schedules. Optimisation of schedules ensures the most efficient way of employee allocation. A.I. also helps with adequate infrastructure network placement and creation. The infrastructure comprises platforms, rails, traffic lights, monitoring systems and sensors. Embedded nodes send information to each other about approaching trains, and the results are shown as changing traffic lights, but can also be shown as flickering diodes built in the platform or closing gates. It moderately enhances safety and security levels (Zöldy *et al.*, 2022). The most important is that those nodes are working under real-time conditions, and delays or breakdowns might happen. Continuous work consumes the capacity and power of parts. It leads to reliability decreasing. Another benefit of A.I. introduction is the ability to predict potential breakdowns and failures in the system, so decreasing reliability will no longer be an issue.

3.1 Benefits and threats coming from artificial intelligence support

As mentioned, benefits are coming from introducing artificial intelligence in rail transport. Most of them relate to enhancing safety and security levels. These technologies can also strengthen decision-making and data analysis. The algorithms use stored data to find optimal solutions, discover patterns, and encounter possible problems and hazardous situations based on patterns. The systems can handle risk assessment and management, so they slightly increase the chances of avoiding problems and hazards in transportation.

However, there are potential threats to the application of A.I. The A.I. technologies are expensive nowadays (2024). Introducing a new AI-based system has to be cost-effective for authorities and companies. Also, the cybersecurity level of technology needs to be enhanced because cyberattacks are becoming more widespread (Ficzere, 2023). People will lose jobs due to highly automated systems, which can be disapproved or even lead to sudden unemployment rate growth. Privacy concerns represent ubiquitous problems. Data registered by sensors and surveillance systems must also be controlled legally and physically. Another problem is that the age of existing infrastructure and systems may make combining and integrating the new technologies with older ones difficult. In the following subchapters, the author collected one example from Budapest in the public transport sector, where A.I. plays an unquestionably important role:

3.2 Metro Line M4 Budapest

For example, the metro line M4 in Budapest provides autonomous service. This service has advantages and disadvantages (Yang *et al.*, 2023).

- Less human interaction means less possibility of human mistakes.
- Surveillance system and sensors – real-time events are registered, and data are stored.
- Self-steering – there is no need for humans to control the train. The control system is under the influence of A.I. programs.
- Voice notifications – people are automatically informed about the schedule, next stops, and hazardous situations (crossing safety line on the platform).
- Increased capacity –trains can be more frequent.

Disadvantages of the autonomous metro service:

- Lower social acceptance, in Budapest there was a fake metro driver for a year
- Higher cost of maintenance due to the more sensors and more sophisticated trains,
- No job for people – there is no need to have a human driving train – the higher unemployment rate.

To sum up, based on this example, there are many more advantages than disadvantages. It is impossible to eliminate all disadvantages because the costs can be optimised but not completely eliminated. The disapproval of autonomous trains is also unavoidable. No workplace and lack of technological knowledge frustrate people. Power supplies are necessary to keep the train going, and blackouts happen due to natural failures of plants, natural disasters, and strong winds, which can stop electricity supply. The comfort and safety level during travel is high. There is enough space for hundreds of people; even during peak hours, wagons are not overcrowded, and the chance of derailment is very low.



4. Examples of sustainability in different modes of transport

This chapter will analyse the two main environmental pollutant subsector of transport. Air transport is the most developing subsector, and road transport is the most significant air polluter.

4.1 Sustainability in air transport

According to statistics, air transport is one of the safest in the world. Between 2013 and 2022, there were 815 accidents, 70 of which were fatal (ICAO, 2023). This mode of transport is also one of the most environmentally friendly modes. It is responsible for the production of 2% of global CO₂ emissions. It is responsible for 12% of CO₂ emissions among the other modes. Almost 80% of emissions are caused by flights longer than 1500 km, so short flights generate approximately 20% of total emissions (Jahanger *et al.*, 2024).

Despite being one of the most environment-friendly transport modes, even here, progress is constant, and a further reduction of CO₂ is aimed at. Current technologies have been under development, and we have outstanding results nowadays. Engines are powered by fuel made out of natural resources. In the USA in 2021, the first fully carbon dioxide-free flight was introduced.

Another resource that has become more significant recently as a fuel is hydrogen. Hydrogen is believed to be a long-term solution, but there are difficulties with the production of aircraft that can be hydrogen-fueled. Hydrogen in liquid form is stored at a negative temperature of -252°C due to its chemical and physical features. This is a challenge during design to create tanks big enough to transport and safe enough to store hydrogen in a liquid form. From the tanks, it is strictly directed to gas turbines, which power aircraft. The other way of using hydrogen is to send it to fuel cells, which convert it to electricity through a chemical reaction. The reaction produces only water vapour. No harmful gases are emitted.

4.2 Sustainability in Road Transport

Road transport is the most popular mode of transport, which is the reason behind high-level carbon dioxide emissions. Passenger cars accounted for 73% of total emissions 2022 (Citaristi, 2022). The dense transport networks, vehicle availability, and production costs make this mode the most popular. Traditional cars are powered by gasoline (naphtha) or gas (petrol), and due to the features and abilities of the engine, they produce CO₂ during combustion. A sustainable approach to road transport might focus on analysing current road networks and systems and determining and selecting the main factors considered in traffic, which could be traffic density, traffic flow, demand for mobility, and emissions.

Sustainability can be achieved by modification of transport networks and infrastructure. Examples of changes are traffic light management, the introduction of velocity limits, the modernisation of current networks and prohibitions relating to an absolute ban on vehicles in particular places. The last solution is used, for example, in Berlin, Germany. The diesel ban was introduced in 2019, and some streets in the city centre require stickers EURO 6. Vehicles powered by diesel can only meet EURO 5 standards, so if these vehicles enter restricted zones, drivers are penalised. Since 2018, five German cities decided to follow this trend, and few others have indicated an interest (Letmathe and Soares, 2020).

Sustainable transport development is not only about vehicles but also about network creation. During construction, the landscapes and huge areas change completely, and heavy machinery generates negative impacts. Decision-makers are responsible for finding optimal solutions. Simulations, modelling, and analysis are usually required to achieve optimal solutions. The entire process assumes that during the modelling phase, it is necessary to map the transport network, determine demand, determine and model traffic flow, measure emissions, identify relations in functionality between determined and measured factors, develop the mathematical method, and implement it. The last step is to simulate the process to determine whether the model will work (Merkisz *et al.*, 2013).

The automotive industry has developed electric cars and hybrid vehicles powered by an electric motor. Hybrid vehicles do not give up on using internal combustion engines. They combine internal combustion engines and electric motors instead. Many cities have charging stations where people can charge their electric vehicles (Fig. 1). Research on new technologies considers current and upcoming regulations. Industries have started to produce cars made of eco-friendly materials from recycling or lightweight metals. Hydrogen cells power fuel cell vehicles and convert hydrogen into electricity (Meelen and Schwanen, 2023).

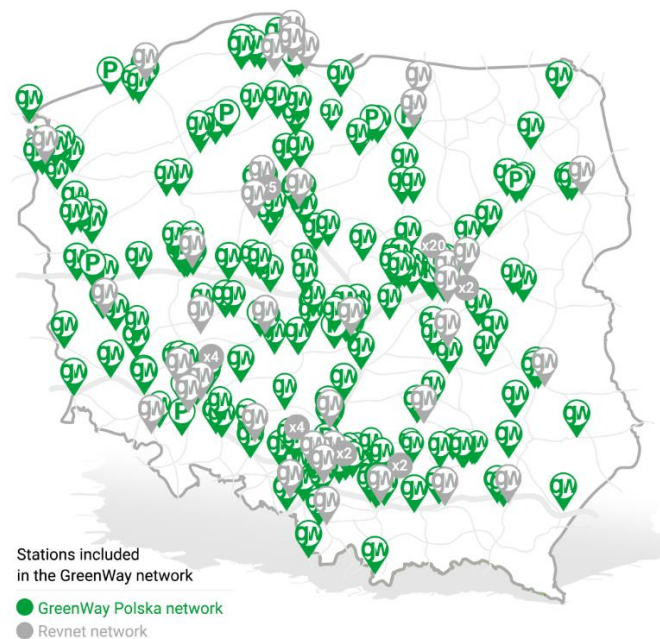


Figure 1. Map of charging stations in Poland
Source: GreenWay Polska (2022)

Unfortunately, the power of electric cars does not allow for long rides, and the charging process is relatively lengthy. Fueling a car with gasoline or petrol (or hydrogen in the future) means faster charging. Hybrid cars are a better option because you can travel much longer distances and change the source.

5. Conclusions

Sustainable transport development is a long-term process with many phases and challenges. Every mode of transport is under development in order to achieve sustainability. World awareness has grown in recent years, resulting in worldwide programs. People responsible for actions and activities take directives and clues into consideration but struggle with economic, social, and environmental challenges. The main task is harmonising every sphere, fulfilling expectations and plans, and finding optimal solutions. Cooperation between government, society and international politics is needed to achieve sustainable transport. Every mode of transportation uses different approaches, but the goal is to achieve climate-neutral transport. In order to reduce carbon emissions, renewable energy resources and gases like hydrogen are promoted to power road vehicles, aeroplanes, and trains. Two main documents were signed based on forecasts, and it was assumed that by 2030 and 2050, the world would fulfil them. However, no one predicted even harder challenges like the outbreak of COVID-19, which delayed the development of sustainable transport. Thus, fulfilling the program by the end of 2030 can be problematic.

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