

## **MEASURES AND INDICATORS OF SUSTAINABLE TRANSPORT**

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**Abstract:** Quick and greatly aggravating the natural environment for development of transport taking place in recent decades, and occurring at the turn of the century imbalance in the field of human activity gave rise to the concept of sustainable development relate also to the forms and methods of mobility of people and goods. The continuous increase in the number of motor vehicles and their operation cause limitation of natural resources, especially crude oil, and pollution from the burning of fossil fuels in motor vehicles contribute to the destruction of the ecosystem and threaten human health on a global level and local level. The aim of this paper is to provide metrics and indicators in charge of sustainable development in terms of transportation. Analysis of appropriate indicators are set that correspond to an appropriate degree for transport as are used to identify trends and to carry out the evolution of specific legislation and environmental.

**Keywords:** sustainable development, measures and indicators of transport

### **1. Introduction**

Environmental aspects are becoming more visible in everyday life as well as in business enterprises. Waste segregation, their re-use, production in environmentally friendly circumstances, producing and buying organic products are examples of projects that are becoming more and more popular. Access to information about environment protection is greater year by year. Doubtlessly also the issue of sustainable development is one of more often discussed topics. The view that sustainable development as a matter of fact is further stage of environmental protection is becoming more common in literature

Sustainable development of transport is one of the individual solutions for all sustainability. For its understanding it's necessary to start the considerations from the concept of sustainable development. The term is synonymous with the term sustainability, although sometimes there are trials to diversify it. Certainly it can be said that the concept of sustainability is a bit older but today those two terms are used interchangeably. Often, we can also meet the definition of permanent development, which results from a more literal translation of the original name of this concept- sustainable development. All of these terms refer to the same, in Polish legislation was adopted a form of sustainable development.

### **2. Sustainable development indicators**

Indicators of sustainability in transport plays important role as they are used to identify trends and to predict the transport problems. They are also helpful in setting goals to achieve and necessary to carry out the evaluation of specific legislation. However there is a problem of measuring the indicator, it comes from the fact that in the literature and many documents of international and domestic organizations is introduced diversity approach to

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measuring the features of sustainable development. Thus, the analysis concerning that balance are dependent to a large extent, from the indicators which were used to carry it out. Specific policy can be effective only if it is verified by one set of indicators. Otherwise, it will be inappropriate or even harmful. EUROSTAT indicators database is a particular reference for the Polish indicators of sustainable transport. In that base indicators of sustainable development are divided into 10 topics. Sustainable transport is the seventh theme and includes 13 different indicators of which not all are described, also concerning them database is not developed or is under review as shown in Table 1.

Table 1

*Indicators of sustainable transport*

<b>TRANSPORT</b>		
<b>Level 1</b>	<b>Level 2</b>	<b>Level 3</b>
<b>1. Transport energy consumption with division for means of transport</b>	<b>Transport and mobility</b>	
	2. Modal division of passenger transport	4. Quantity of freight transport
		5. Quantity of passenger transport
	3. Modal division of freight transport	6. Energy consumption by means of transport
		7. Investments in transport and infrastructure by means of transport
	<b>Social and environmental impacts of transport</b>	
	8. Greenhouse gas emissions by means of transport	10. Compounds emissions – precursors of ozone transport
	9. Victims of fatal road accidents	11. Emissions of suspended particulates from transport
		12. Average carbon dioxide emissions per km from new passenger cars
	The context indicator: Fuel prices in road transport	

*Source: Own elaboration based on EUROSTAT*

*Transport energy consumption with division for means of transport* – This indicator is defined as the ratio of energy in transport to the size of GDP. It includes the energy consumption of all modes of transport (road, rail, navigation within the land, air) used in individual, commercial and public transport, excluding shipping and pipelines. There is prospect of development of this indicator, so that it will be possible to compare the volume of traffic to the size of GDP. Under the present circumstances full and consistent statistics on traffic are not available. Improving the availability of the data may contribute to the development and growth of this indicator in future [11].

*Modal split of passenger transport* – this indicator is defined as the percentage of each mode of transport in total inland transport, expressed in passenger-kilometres (pkm) – one passenger traveling a distance of one kilometre. It based on the transport of cars, buses, coaches and trains (underground, tram and train). All data should be based on movements on national territory, regardless of the nationality of the vehicle, but the data collection methodology is not harmonized at EU level. This indicator reflects the preferences of the passengers on the chosen means of transport and can be helpful in assessing the effectiveness of the policy, which should aim to promote environmentally friendly passenger transport. Currently indicator does not include maritime and air transport, even though the last one is growing in importance, it has a significant proportion of energy consumption and also has a significant impact on the environment. Expansion rate of missing means of transport will determine the full picture of modal split. This indicator could also be expressed in a different unit of measurement - in kilometres per vehicle. This change can be completed when the data traffic will be available for all types of land transport. Necessary for that unit of measurement is to correct her load factor that is the average number of passengers per vehicle [11].

*Modal split of passenger transport* – this indicator is defined as the percentage of each mean of transport in total inland transport, expressed in passenger-kilometres (pkm) – one passenger traveling a distance of one kilometre. Road transport is based on the movement of vehicles registered in the reporting country. Rail and inland waterways is usually based on movements in the territory of the country, regardless of the origin of the vehicle or vessel, although there are differences in the definition of this indicator depending on the country. The desired trend of this indicator is the declining share of road transport in total transport because it is the least energy-saving mode and causes more greenhouse gas emissions per tonne-kilometre than rail or inland waterway transport. It also has the highest rate of accidents and major impact on the economy. The EU and Member States are obliged to take steps to shift from road transport to rail, water and public passenger transport. A limitation of that indicator, which may lead to restrictions in its reporting, is that it does not include sea and air transport. Indicator has two different test principle: the principle of nationality (road) and the principle of territoriality (rail and inland waterways), there from the number of certain types of vehicles is dependent on the size of the country and consequently, the comparison of countries with large territorial disparities does not give effective results and reduces the importance of this indicator [11].

*Freight volume* – the indicator is defined as the ratio of freight transport (road, rail, inland waterway), measured in tonne-kilometres of Gross Domestic Product at constant volumes. Rail and river transport refers to movement within the country, regardless of the nationality of the vehicle or vessel. Road transport embrace all movements of the vehicles registered in reporting country. The policy aim is to divide the economic growth from the demand for transport in order to reduce the impact on the environment. Statistics on aviation and shipping are not included because of the difficulty in dealing with relation to land transport. Pipeline transport is also not taken into account. To allow further analysis of the impact on the environment (for example, emissions) and measure the progress of this influence, the rate should be supplemented with a measure expressed in kilometres per vehicle type. Aviation and maritime transport should be taken into account. Eurostat makes efforts to improve the consistency of collation of means of transport and is looking for a solution in methodological problems in calculation of this indicator [11].

*Volume of passenger transport* – indicator is expressed as the ratio between the volume of passenger transport, measured in passenger-kilometres (pkm) and the size of GDP. The

indicator includes transport across the country by car, bus, coach and train. The priority of transport policy is to provide users mobility service through a comprehensive system of public passenger transport. The quality of these services and their price supposed to has the effect of moving the number of passengers using private transport towards public passenger transport. In order to change travel habits in urban areas cycling, walking and public transport are promoted and efforts are made to increase the environmental awareness of citizens. The aim is to combine cycling with public transport stops and parking spaces for motor vehicles. To allow further analysis of the impact of transport on the environment indicator should be complemented with measures of passenger kilometers for a given mean of transport. This indicator can be used in the future for integrated analysis of transport and employment, use of energy, emissions etc., based on data on the vehicles used by the economic subjects [11].

*Energy consumption by means of transport* – indicator includes the energy consumption in all means of transport (road, rail, domestic aviation, international aviation, inland waterways), with the exception of maritime and pipelines. Energy demand is closely linked to the demand for transport, and energy consumption is dependent on the type of transport. The EU aims are to propose a modernization and decarbonization of the transport sector, contributing to increased competitiveness. The means for this supposed to be the early implementation of the infrastructure for electric mobility, intelligent traffic management systems, promoting new technologies including electric and hybrid cars, along with the support for the research and standardization. The prospect of improving this ratio would be to compare the volume of traffic with GDP, but the statistical data on the volume is still not available in full and consistent form [11].

*Investment in transport and infrastructure by means of transport* – this is a new indicator, not described yet. Statistical data is also not available.

*Greenhouse gas emissions from transport* – this indicator shows trends in emissions of greenhouse gases emitted by means of transport (road, rail, inland waterways, volatile domestic). In the context of the transport only three gases are significant – carbon dioxide, methane and nitrogen oxide. They were adequately aggregative to their relative potential contributing to global warming. United Nations Framework Convention on Climate Change has the object to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent human interference with the climate system. The level should be achieved within a sufficient period to allow ecosystems to adapt naturally to climate change. Countries are required to maintain the level of greenhouse gas emissions, which does not exceed the allocated amount, calculated in accordance with the bill reducing those emissions by 5% compared to 1990. The indicator does not include changes resulting from absorption of greenhouse gases for example by forestry. Removing gases from the atmosphere is one of the most controversial issue to the extent of climate change research [11].

*Victims of fatal road accidents* – an indicator presents the annual number of road accident victims, including motorists and passengers of motorized vehicles, bicycles, and pedestrians who died within 30 days since the accident. For countries that do not apply this definition adjustment factors are introduced. Statistics data of the total number of fatalities and the number of deaths per million inhabitants is available as shown in Table 2.

This indicator reflects the quality of available infrastructure, vehicle safety standards, legal framework, enforcement agencies and driver behaviours. The European Commission has adopted plans to reduce the number of road fatalities by half over the next 10 years. One of the proposed initiatives is to improve vehicle safety standards and increased

enforcement of traffic laws. Currently, works are undertaken to determine the adjustable indexes that are more accurate, and thus the indicator will increase in value. This indicator can be used for integrated analysis, e.g. in combination with a modal passenger transport division to acquire assessment of the impact of increased use of road transport. You can also analyse the indicator of the data for other causes of death and to evaluate its impact on life expectancy [11].

Table 2

*Fatalities on the road, broken down by country (per million inhabitants)*

Member State	Number of fatalities per million inhabitants		Changing the number of fatalities	
	2001	2012	2009–2012	2001–2012
<b>Latvia</b>	236	97	–14%	–61%
<b>Spain</b>	136	54	–9%	–55%
<b>France</b>	134	62	–7%	–51%
<b>Portugal</b>	163	79	1%	–49%
<b>Germany</b>	85	45	–12%	–48%
<b>Poland</b>	145	102	–15%	–29%
<b>Czech Republic</b>	130	76	–11%	–40%
<b>UE</b>	112	62	–11%	–43%

*Source: Own elaboration based on EUROSTAD*

*Emissions trade* – transport of ozone precursors – this indicator is defined as the aggregate potential emissions from transport compounds (i.e. oxides of nitrogen, carbon monoxide, methane, volatile organic compounds), which affect the ozone layer. Statistic data is currently under review and is not available [11].

*Emissions of suspended particulates from transport* – this indicator is defined as the aggregate potential of creation from suspended particulates from transport of nitrogen oxides, sulphur dioxide and ammonia. Statistic data is currently under review and is not available [10].

*Average carbon dioxide emissions per km from new passenger cars* – this indicator is defined as the average carbon dioxide emissions per kilometre for new passenger cars registered in the under review year. This average is not reduced as expected, despite the tendency of transition to diesel fuel, producing less CO<sub>2</sub> and efforts of car manufactures which are being made about improving fuel efficiency. The reasons must therefore be seen in consumer preferences in terms of comfort and safety of those functions (and thus increasing the weight of the vehicle), increased engine power and 4-wheel drives [12]

*Prices for fuel in road transport* – this indicator is based on the harmonized indices of consumer prices (HICP), which is calculated by all Member States of the EU harmonized methodology [13].

From the attached Table III. we can come to conclusion that not all measures provide us with information about the status of sustainable development in all its spheres. It should also be noted that while some indicators seem to broadly describe all of the spheres, their value stay only an estimate. Work on the creation of a homogenous indicator are held, the value of which will not be subject to manipulations, and allows for unambiguous assessment of sustainable development. The measure of social quality of life, used by UNDP [4] is the human development index HDI [3]. It represents the non-economic data,

which are important in the assessment of sustainable development. HDI is a measure of the average rates of the three basic areas of life: health, education and income. In the area of health the indicator of life expectancy rate is assess in the field of education, literacy rate and enrolment, and in GDP per capital income [2] HDI is based on a scale of 1 to 100, which is interpreted as follows [7]

- less than 50 points – countries with low human development,
- 50–70 points – countries with medium human development,
- over 80 points – countries with high human development.
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Table 3

*Meters and the objectives of sustainable development*

<b>Meter</b>	<b>Economic development</b>	<b>Social development</b>	<b>Environment protection</b>
Traditional economic measures (GNP, GDP)	+	+/-	-
Green measures of GDP	+	+/-	+
HDI, HPI, GDI	+	+	-
The ecological footprint	-	-	+
Cross measure (P-S-R, D-P-S-I-R)	+	+	+

*Source: B. Jaros: Mierniki rozwoju zrównoważonego i trwałego*

Complementing the HDI is a poor indicator of social HPI [6], and the rate of social relations between men and women GDI [10]. HPI is calculated differently in third world countries and other developed countries. In the third world poverty determinants are: the percentage of residents who do not live to 40 years of age, the proportion of people without access to health care and clean water, the proportion of people who can't write and read and the percentage of children to age 5 with underweight. In developed countries such determinants are: the percentage of people who will live to 60 years of age, the proportion of adult men who cannot adequately use the written word, the number of people reaching the income level of less than 50% of the average incomes in a particular country. Also it is taken into account the proportion of people remain out of work for over a year [1]. On the basis of the same data rate GDI is calculated to show the difference between the rate of social development of men and women in the particular country. The higher the difference, the lower the coefficient of GDI compared to HDI. GDI also shows the extent to which women take an active part in economic and political life of the country. It is calculated their percentage share, compared with that of men, among parliamentarians, professionals and technical staff, senior management and the production of national income [5].

There are also cross-cutting indicators based on the P-S-R scheme: pressure – state – response. They are, for example, short-term environmental indicators OECD [8] or

environmental sustainable development indicators of the ONZ. This scheme is based on the consideration of consecutive events. Indicators of environmental pressures on the human activities concerns those form of human activity which reduce the quality and quantity of environmental resources. There are direct indicators of pressures that are in the category of emissions and consumption of natural resources and the intermediate pressure indicators, which describe the harmful activities leading to exert direct pressure [8]. Indicators of the environment concern the environment and its resources. They also refers indirectly to the ultimate goal of environmental protection policy. They should be used for evaluation of the review of the environment and the changes that took place during the time [14]. Indicators of social response to environmental changes show the extent to which the public is interested in the response to these changes and what is being done to solve problems [9].

### 3. Summary

At the turn of the century transportation shows a certain lack of balance. The constant increase in the number of vehicles and their exploitation is a huge burden for availability of natural resources, primarily oil. Emissions from the combustion of fuels for motor vehicles contribute to the destruction of the ecosystem and human health at a global and local rank. Other problems associated with the use of motorized transport is road accidents, harmful to human health noise, land use patterns that interfere with the patterns of settlement and migration and the integrality of ecosystem. The purpose of environmentally sustainable transport development is to contribute to action which meets these trends and introduce the sustainable transport.

The concept of sustainable development is absolutely right idea, but still not very well received in practice, at least in Poland. The most common reason to deny ecology is a translation of the need to incur higher costs, but with a little creativity, thanks to through environmental efforts these costs can be reduced. In the Western countries acts with accordance to the concept of sustainable development and corporate social responsibility are becoming more and more popular. Meters and sustainable development indicators allows to identify appropriate assumptions for transport. Determine them allows for broader understanding of the terms of the European Union.

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