

# INDICATOR SYSTEMS FOR MEASURING AND MONITORING SUSTAINABILITY OF TRANSPORT

Marie Kubáňková – Jaroslava Hyršlová – Helena Becková

---

## Abstract

Transport has significant and long-lasting economic, social and environmental impacts, and so it is an important factor of sustainability. This paper deals with sustainable transport and it is focused primarily on indicator systems for measuring and monitoring transport sustainability. Sustainable transport indicators are defined as statistical measures that give an indication of the sustainability of social, environmental and economic development. The main objective of the paper is to present and clarify frameworks of sustainable transport indicators as results of international research. The paper also explores practical applications of indicators for measuring and monitoring sustainability of transport. Attention is especially paid to the indicators used in the Czech Republic for assessment of individual objectives and measures of the Czech transport policy. The paper provides a basic overview of indicators that are suggested for monitoring and measuring sustainability in the area of transport in comparison with the indicators of the transport policy recommended by the ASSESS project.

**Key words:** sustainability, sustainable transport, sustainable transport indicators

**JEL Code:** O38, R41

---

## Introduction

The impact of transport has crucial importance for sustainable development (Litman, 2008). The issue has been examined by many researchers; primarily the term sustainable transport itself had to be defined, performance of transport in economic, social and environmental perspectives evaluated and also methods of sustainable transport assessment devised. Interestingly, there is still no single universally accepted definition of “sustainable transport” (Castillo and Pitfield, 2010); the EU defines sustainable transport as an objective of the EU that “ensures that our transport systems meet society’s economic, social, and environmental needs whilst minimizing their undesirable impacts on the economy, society, and the environment” (Pei et al., 2010). Stanley and Lucas (2014) describe collective transport targets in more detail; collective transport a) meets personal travel needs and facilitates strong

communities, b) supports economic development and equitable social participation, c) promotes environmental health, d) has appropriate institutional arrangements and stakeholder involvement (including sufficient sustainable funding) to deliver.

Economic, environmental and social impacts of transport can be assessed through diverse criteria and indicators (Meunier, 2012). The indicators may be perceived as sustainable transport assessment tools (Castillo and Pitfield, 2010). One of the important elements when implementing a sustainability strategy is the framework used to measure progress toward sustainability objectives (Pei et al., 2010). The main objective of this paper is to provide a basic insight into framework of sustainable transport indicators as results of international research. Attention is especially paid to the indicators used in the Czech Republic for assessment of individual objectives and measures of the Czech transport policy.

## **1 Materials and Methods**

Debates about formulation of the European Common Transport Policy and sustainable transport began 30 years ago; several White Papers have been provided and frameworks set for overall objectives and measures (Gudmundsson and Sorensen, 2013). Decision-makers are forced to provide the monitoring and reporting of the sustainable performance of transport systems because it is viewed as essential (Castillo and Pitfield, 2010); over 40% of state departments of transportation in the USA have incorporated some element of sustainability into their vision or mission statements and the UK has developed comprehensive system to improve sustainable performance of the transport system (Pei et al., 2010).

Sustainability indicators are appropriate for both decision-making process (Janssen and van Ittersum, 2007) and external sustainability reporting (Jones, 2010). Indicators have become common elements in transport planning and policy making (Gudmundsson and Sorensen, 2013) as they provide complex perspective and can be broken down into separate units of information at the same time (Castillo and Pitfield, 2010). Indicators for the transport policy objectives in the EU for the period 2010-2020 were suggested by an ASSESS project (De Ceuster et al., 2005) and are summarized in Table 1.

The issue of sustainable development has been addressed also in connection to urban sustainability. One of the most important world database – the UITP “Millennium cities database for sustainable mobility” – deals with sustainable transport in big cities. According to the pillars of sustainable development Haghshenas and Vaziri (2012) divide indicators in three groups: transportation economic impact indicators, transportation social impact

indicators and transportation environmental impact indicators. The Table 2 shows the examples of the indicators assigned to groups.

**Tab. 1: Indicators used in the ASSESS project**

Indicator	Unit
Transport volume	Tonkm, Passenger km
Modal share	% of Passenger km by mode, % of Ton km by mode
Transport intensity	Passenger km/population, Tonkm/ton
Economic growth	Gross Domestic Product
Employment	Working places
Spatial distribution of economic impacts	GDP/capita
Transport growth and decoupling	Passenger km/GDP, Tonkm/GDP
Accessibility	Hours spent traveling
Vehicle stock and ownership	Number of vehicles
Safety	Number of fatalities
Energy consumption	Ktons oil equivalent
Climate change	Greenhouse Gas emissions
Air quality	Nitrogen oxides emissions, Particulate matter emissions, Sulfur dioxide emissions
Noise exposure	% exposed to levels above 55 dB(A)
Land take for transport	km <sup>2</sup> road
Fragmentation of landscapes	km <sup>2</sup> road

Source: according to De Ceuster et al. (2006)

**Tab. 2: Sustainable transport indicators for city comparison**

Sustainable transport component	Indicator	Unit
<b>Transportation economic impact indicators</b>		
Transportation cost for government	Local government expenditures on transportation per GDP	
Direct transportation cost for user	Average daily user cost over GDP per capita	%
Indirect transportation cost for user	Average time spent in traffic	Minute
<b>Transportation social impact indicators</b>		
Transportation safety	Fatality of transportation per capita	Person
Transportation accessibility	Sum of transportation systems for every citizen passenger-km per area	1/m
Transportation variety	Sum of transportation option vehicle per capita divided per maximum of that option vehicle per capita in all cities	-
<b>Transportation environmental impact indicators</b>		
Transportation emission	Emissions of local air pollutants per capita	kg
Transportation energy consumption	Transport energy use per capita	MJ
Transportation land consumption	Land consumption for transportation infrastructure per capita	m <sup>2</sup>

Source: Haghshenas and Vaziri (2012)

Sustainable transport represents the main goal of the transport policy and transport planning; sustainable transport may be perceived as the outcome of sustainable development of the transportation sector. The concept of sustainable development must be reflected in transportation strategies and the set objectives and measures must be observed and evaluated at regular intervals. For this reason, it is important that an appropriate indicator system will be chosen. This paper, therefore, focuses on following fundamental research questions:

- 1) how are the strategic goals in the context of sustainable development formulated within the transportation policy of the Czech Republic;
- 2) which indicators for assessment of individual objectives and measures are part of the transport policy of the Czech Republic and whether they are in accordance with the approach which has been recommended within the ASSESS project for the period 2010-2020;
- 3) which indicators are observed and posted in regular intervals.

To answer the above mentioned research questions the analysis of documents published by the Ministry of Transport of the Czech Republic, the government body responsible for the management of the transport department, was accomplished. The national transport strategy is incorporated in a document called the Transport Policy of the Czech Republic for 2014–2020 with the Prospect of 2050 (hereinafter only TPCR). The Ministry of Transport of the CR also publishes annually the Transport Yearbook (hereinafter only TYCR) which contains the transport indicator system for the observed calendar year. Both documents were subjected to analysis being implemented in the following steps:

- 1) to provide an answer to the first research question the analysis of objectives and priorities stipulated in the TPCR (Ministry of Transport, 2013) has been carried out in accordance with the principles of sustainable development and transport;
- 2) to provide answers to the second and third research question the indicator system worked out in TPCR and TYCR has been analysed and the comparison of the indicators with those recommended within the ASSESS project has been carried out (De Ceuster et al., 2005).

Due to the fact that the concept of sustainable development takes in consideration three basic aspects – economic, environmental and social all indicators are assessed in terms of the three pillars of sustainable development in accordance with the Haghshenas and Vaziri (2012) approach.

## 2 Results of the Research

The TPCR is a strategic document of the Government of the Czech Republic for the transport sector. The Ministry of Transport of the Czech Republic is the institution that is responsible for implementing the transport policy. The TPCR (Ministry of Transport, 2013) identifies major problems of the sector and proposes measures for solving them. Other strategic documents – action plans further elaborating individual transport areas – are follow-ups to the TPCR.

Safety, sustainable development, economy, environment and public health are fundamental principles enshrined in the transport policy. The main goal of the transport policy is *"to create conditions for the development of high-quality transport system based on the utilization of technical, economic and technological properties of individual transport modes, on the principles of competition, having regard to its economic and social impact and the impact on the environment and public health"* (Ministry of Transport, 2013). The following sectoral and cross-sectoral priorities are stemming from the main goal: users (the end user and the satisfaction of his needs for transport is at the centre of the transport policy's focus), traffic and transport safety (the needs are satisfied through traffic, i.e. carriers and service providers; it is necessary to ensure greater transport safety), funds for transport (transport can function only with adequate financial and energy resources), transport infrastructure (providing quality transport infrastructure is a prerequisite for transport), advanced technologies, research, development and innovation, space technologies (transport development is not possible without research, development, introducing modern management systems and control, information systems, Intelligent Transport Systems (ITS), and navigation systems) reducing the impact on public health and the environment (negative impacts on the environment and public health must be minimized), social issues, employment, education and qualification (transport is dependent on a quality workforce and must be accessible to all social classes), other long-term visions (transport policy must focus on long-term issues and must be in line with the European transport policy up to 2050) and subsidiarity and responsibilities of individual levels (it is necessary to ensure coherence between the objectives of national and regional policies).

The results of the analysis of the indicators for assessment of individual objectives and measures of the TPCR and their compliance with the approach recommended by the ASSESS project for the period 2010–2020 summarise the Table 3, Table 4 and Table 5.

**Tab. 3: Economic indicators for measuring sustainability of transport**

Indicators used in the ASSESS project	Indicators for assessment of the individual objectives and measures of the TPCR
<b>Transportation economic impact indicators</b>	
Transport volume	Building of at least one track section in the high-speed mode
Economic growth	Year-on-year fluctuation of investment spending for the transport infrastructure (over two previous years)
Transport growth and decoupling	Number of completed projects (km) of the core TEN-T railway network for passenger transport / road network / freight transport
Employment	-
Spatial distribution of economic impacts	-
Vehicle stock and ownership	-
-	Use of the Cohesion Fund and the national envelope of "cohesion" CEF to finance the transport infrastructure
-	Use of private capital to finance the transport infrastructure
-	Increase of funds for maintenance of the transport infrastructure

Source: authors with the use of the TPCR (Ministry of Transport, 2013)

**Tab. 4: Social indicators for measuring sustainability of transport**

Indicators used in the ASSESS project	Indicators for assessment of the individual objectives and measures of the TPCR
<b>Transportation social impact indicators</b>	
Modal share	Percentage of the volume of railway passenger transport operated on the basis of tenders or in open market mode
Modal share	Performance of combined transport
Transport intensity	Number of km of road and motorway network equipped with dynamic traffic control
Transport intensity	Number of operational rail freight corridors
Transport intensity	Share of the volume of the rail and waterborne transport in the total volume of freight transport over 300 km
Transport intensity	Performance of public passenger transport
Transport intensity	Share of public passenger transport in total passenger transport performance
Transport intensity	Share of the volume of public transport to private car transport in cities over 100 thousand inhab. (separately)
Transport intensity	Number of km of roads with distance based charging
Transport intensity	Number of person-km per one Crown spent from public budgets in line bus transport in public interest
Transport intensity	Number of person-km per one Crown spent from public budgets in public transport / in the railway transport
Accessibility	Connection of all regions to motorway network / rapid high capacity railway
Accessibility	Number of public multimodal terminals
Accessibility	Percentage of Czech population living in municipalities included in one of the transport systems integrating railway and public bus line transport
Accessibility	Number of cities with a valid urban sustainable mobility plan
Accessibility	Completing the restructuring
Safety	Development of accident rate (number of fatalities, seriously wounded)

Source: authors with the use of the TPCR (Ministry of Transport, 2013)

**Tab. 5: Environmental indicators for measuring sustainability of transport**

Indicators used in the ASSESS project	Indicators for assessment of the individual objectives and measures of the TPCR
<b>Transportation environmental impact indicators</b>	
Climate change, Air quality	Emissions of nitrogen oxides, CO2 emissions from transport
Energy consumption	Share of gasoline, diesel and kerosene on total energy consumption
Energy consumption, Air quality	Share of the fleet in road transport using energy not derived from crude oil
Noise exposure	Share of population exposed to excess noise from transport
Land take for transport	-
Fragmentation of landscapes	-

Source: authors with the use of the TPCR (Ministry of Transport, 2013)

The last section of the research is focused on the analysis of indicators which the Ministry of Transport of the Czech Republic observes and posts annually in the TYCR. The aim is to compare the indicators with those used by the ASSESS project. Also within this task the indicators were divided into three groups: transportation economic impact indicators, transportation social impact indicators and transportation environmental impact indicators. The Table 6 summarizes the results.

**Table 6: Sustainable transport indicators observed at national level**

Indicators used in the TYCR	Indicators used in the ASSESS project
<b>Transportation economic impact indicators</b>	
Economic indicators of the development of national economy and the transport sector (development of national economy in the Czech Republic, summary indicators of the transport sector economy, basic economic indicators of legal and natural persons in transport) Transport (passenger transport, transport of goods)  Transport equipment (railway transport, road and urban public transport, inland waterways transport, air transport – civil aircraft register)	Economic growth Spatial distribution of economic impacts Employment  Transport volume Transport growth and decoupling Vehicle stock and ownership
<b>Transportation social impact indicators</b>	
Transport (passenger transport, transport of goods) Transport infrastructure (railway infrastructure, road and urban public transport infrastructure, navigable inland waterways regularly used for transport, air transport infrastructure, pipeline transport infrastructure, combined transport infrastructure) Transport accidents (rail traffic accidents, road traffic accidents resulted in personal injury or death, inland waterways traffic accidents, civil air traffic accidents)	Modal share Transport intensity Accessibility  Safety
<b>Transportation environmental impact indicators</b>	
Transport impact on environment (energy consumption in transport, total transport emission, emissions by mode of transport per inhabitant) - - -	Energy consumption Climate change Air quality Noise exposure Land take for transportation Fragmentation of landscapes

Source: authors with the use of the TYCR (Ministry of Transport, 2014)

## **Conclusion**

The analysis of the goals and priorities of the Transport Policy of the Czech Republic for 2014–2020 shows that the Policy is aimed at the sustainable development of the transport sector. The aim is to optimize infrastructure capacity, use advanced technologies and alternative energy sources, optimize processes, improve research and development activities, promote transfer of knowledge and technologies and ensure their use in practice. All this should be done with regard to the economic and social influences and impacts on the environment.

34 indicators will be used for monitoring the implementation of the objectives and priorities established under the Transport Policy of the Czech Republic for the period up to 2020. The TPCR (Ministry of Transport, 2013) divides the indicators into groups by following priorities: users, resources and transport infrastructure.

This paper evaluates whether the sustainable development indicators are in line with the approach recommended by the ASSESS project. It has been determined that the indicators established under the TPCR for monitoring the implementation of objectives and effectiveness of measures cover all three pillars of the sustainable development. The economic indicators are concentrated on the development of infrastructure, change in expenses for infrastructure investments and the method of their financing. There is a clear attempt to increase operating expenses for the maintenance of transport infrastructure. In accordance with the recommendations of the ASSESS project, following areas are not measured by economic indicators: employment, spatial distribution of economic impacts, vehicle stock and ownership. Regarding the social indicators the greatest attention is paid to transport intensity and transport accessibility, which is in line with the competitive economy of the Czech Republic and the cohesion of its regions. Attention is also focused on monitoring transport safety; the development of the number of accidents is monitored (number of fatalities, seriously wounded). Environmental indicators are set to monitor the most significant environmental impacts of transport: energy consumption, emissions and noise exposure. Land take as a part of transport development is not monitored with the help of the environmental indicators.

The Ministry of Transport of the Czech Republic posts annually fundamental indicators monitoring the development of the transport sector. The indicators cover the three aspects of sustainable development while much space is devoted to economic and social perspectives. The economic and social indicators are in line with the approach recommended



by the ASSESS project. Indicators monitoring major environmental impacts of transport like noise exposure and land take are neither observed nor posted.

The paper has provided a basic overview of indicators that are suggested for monitoring and measuring sustainability in the area of transport in comparison with the indicators of the transport policy recommended by the ASSESS project. The research is focused on basic categories of indicators; a detailed analysis of the indicators should follow. Although indicators are considered supportive for setting strategies and policy implementation, Sébastien and Bauler (2013) recognize associated practical problems with their use. These problems relate more to political and communication role of indicators than to their use in decision-making. They suggest more involvement of NGOs, researchers and social networks to debate and test indicators in longitudinal studies. Furthermore Shiau (2012) presents a process of sustainability compound indicators with stakeholders' involvement where the stakeholders make decisions about evaluation criteria, criteria weights and performance evaluation. The next research in this field should address these problems.

## References

- Castillo, H., & Pitfield, D. E. (2010). ELASTIC – A methodological framework for identifying and selecting sustainable transport indicators. *Transportation Research Part D*, *15*, 179-188.
- De Ceuster, G. et al. (2005). *ASSESS Final Report*. Brussels: DG TREN, European Commission. Retrieved from <http://www.tmlleuven.be/project/assess/>.
- De Ceuster, G., Logghe, S., & Van Herbruggen, B. (2006). Indicator Assessment of the Objectives of the White Paper on Transport. Presentation at European Transport Conference, Strasbourg, 18–20 September 2006.
- Gudmundsson, H., & Sorensen, C. H. (2013). Some use – Little influence? On the roles of indicators in European sustainable transport policy. *Ecological Indicators*, *35*, 43-51.
- Haghshenas, H., & Vaziri, M. (2012). Urban sustainable transportation indicators for global comparison. *Ecological Indicators*, *15*, 115-121.
- Janssen, S., & Ittersum van, M. K. (2007). Assessing farm innovations and responses to policies: A review of bio-economic farm models. *Agricultural Systems*, *94*, 622-636.
- Jones, M. J. (2010). Accounting for the environment: Towards a theoretical perspective for environmental accounting and reporting. *Accounting Forum*, *34*, 123-138.

- Litman, T. (2008). Sustainable Transportation Indicators. Sustainable Transportation Indicators Subcommittee of the Transportation Research Board.
- Meunier, D. (2012). Towards a sustainable development approach in transport assessment. *Procedia – Social and Behavioral Sciences*, 48, 3065-3077.
- Ministry of Transport (2013). The Transport Policy of the Czech Republic for 2014 – 2020 with the Prospect of 2050. Retrieved April 2, 2015, from: [http://www.mdcr.cz/NR/rdonlyres/DB292074-62B4-4B09-9D43-9697A1A86FB0/0/B1300298\\_ministerstvo\\_dopravy\\_2014\\_2020\\_ENG05.pdf](http://www.mdcr.cz/NR/rdonlyres/DB292074-62B4-4B09-9D43-9697A1A86FB0/0/B1300298_ministerstvo_dopravy_2014_2020_ENG05.pdf)
- Ministry of Transport (2014). Transport Yearbook 2013. Retrieved January 26, 2015, from [https://www.sydos.cz/cs/rocenka-2013/yearbook/htm\\_uk/index.html](https://www.sydos.cz/cs/rocenka-2013/yearbook/htm_uk/index.html)
- Pei, Y. L. et al. (2010). Performance measurement frameworks and the development of effective sustainable transport strategies and indicators. *Transportation Research Record: Journal of the Transportation Research Board*, 73-80.
- Sébastien, L., & Bauler, T. (2013). Use and influence of composite indicators for sustainable development at the EU-level. *Ecological Indicators*, 35, 3-12.
- Shiau, T. (2012). Evaluating sustainable transport strategies with incomplete information for Taipei City. *Transportation Research Part D*, 17, 427-432.
- Stanley, J., & Lucas, K. (2014). Workshop 6 Report: Delivering sustainable public transport. *Research in Transportation Economics*, 48, 315-322.

## **Contacts**

Marie Kubáňková

Research Institute for Fodder Crops, Ltd. Troubsko

Zahradní 400/1, 664 41 Troubsko

mariekubankova@gmail.com

Jaroslava Hyršlová

Jan Perner Transport Faculty, University of Pardubice

Studentská 95, 532 10 Pardubice

jaroslava.hyrslava@upce.cz

Helena Becková

Jan Perner Transport Faculty, University of Pardubice

Studentská 95, 532 10 Pardubice

helena.beckova@upce.cz