

# Sustainability of passenger transport as a precondition for fulfilling the 4.0 company concept – analysis of trends in the Czech Republic

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**Abstract.** Strengthening public transport can significantly contribute to transport sustainability, in particular to reducing greenhouse gas emissions. This article primarily aims to analyse the long-term trend in the production of carbon dioxide by individual types of transport throughout the Czech Republic and to compare the performance of public passenger transport and passenger car transport. The analysis concludes that the performance of public passenger transport by land in the Czech Republic has not been increasing over a long period; on the contrary, individual transport has been strengthening. There has been an increasing trend in CO<sub>2</sub> emissions from transport for a long period. Thus, the development of subsidies in the public transport clearly shows that to fund public passenger transport is in the public interest.

**Key words:** Sustainable development, transport, emissions, performance.

## 1 Introduction

Environmental issues, growing urban population and dwindling crude oil reserves are the main reasons why there is more and more talk about transport sustainability. Gumbo and Moyo [1] warn of this problem especially in developing countries. Lefevre, Briand, Pye, et al. [2] state that “the transport sector represents 25% of global CO<sub>2</sub> emissions” and further point to the fact that “while a range of options exist to decarbonize the passenger transport sector, the detailed sequencing of actions and resulting transformations over time remain largely unexplained in political debates”.

The problem of CO<sub>2</sub> emissions is compounded by the decline in organic productive areas, especially in cities and on outskirts. This decline is exacerbated by the lack of capacity to sequester CO<sub>2</sub> on both the microscale and mesoscale, which results in rising temperatures and reduced air quality within urban boundaries [3]. The above-named authors (Lefevre, Briand, Pye, et al.) [2] indicate that the results across countries correspond with the following theses:

- to achieve deep decarbonisation, resolute action for all types of transport is needed, especially for solutions on the demand side;

- deep decarbonisation is compatible with other political priorities, such as meeting the mobility needs at affordable costs; and
- strategies should be adapted to the purpose of mobility, to local contexts and national circumstances, with the framework being adapted to other sectors and further developed in the context of future political processes.

Stefaniec, Hosseini, Xie, et al. [4] propose to introduce a systematic approach to transport evaluation based on the social, economic and environmental dimensions of sustainability in order to support decision makers (in better evaluation of transport sustainability performance). Sultana, Salon and Cuba [5] also admit that there are inherent trade-offs that may hinder win-win-win strategies across this environmental, economic and social domain. Umar, Ji, Kirikkaleli et al. [6] demonstrate that there is an important cointegration equation between CO<sub>2</sub> emissions, innovations, financial development, transport infrastructure and real GDP, on which individual political decisions should be based - for example, to strengthen the performance of public passenger transport and to encourage restrictions on individual transport or to support pooling of drives - more people travel in fewer vehicles [7].

All over the world governments have introduced sustainability programs and policies that lead to a shift from traditional private car-dependent transport systems to the greater use of public transport, cycling and walking [8] or the use of electric three-wheelers [9]. Many research teams [10, 11] offer tools for decision-making of local governments in order to assess the global and local sustainability of transport systems, mostly based on multi-criteria decision making. The trend of transport inclusion into a sophisticated system of life is growing stronger in all aspects - in the offer of equal access to public services and job opportunities, in environmental protection and sustainable use of natural resources [12]. This article aims to create a time series of data on carbon dioxide production by individual types of transport throughout the Czech Republic, to determine a long-term trend between 2000 and 2018 and to describe the trend. Furthermore, based on the comparison of performance of public passenger transport, a conclusion will be drawn as to whether there are really changes or shifts in favour of public passenger transport and how strong these shifts are. A partial aim is to evaluate the transport output, both by the number of transported persons and by kilometres per person. The last aim is to describe the amount of subsidies provided from the state budget of the Czech Republic, on the basis of which it will be possible to state whether funding and supporting public transport as a whole is in the real interest of the state.

To meet the aforementioned aims, statistical data of the Ministry of Transport of the Czech Republic from individual yearbooks (publicly available) and data of the Ministry of the Environment of the Czech Republic are used. Only the data on the land passenger transport are used from the data set on transported persons. Passenger shipping and air travel are excluded from the survey. This procedure is also applied to the analysis of transport output, which will be supplemented by data on the length of lines and roads. MS Excel is used for data processing.

## **2 Sustainability in passenger transport – greenhouse gas emissions**

European countries have undertaken to meet the commitments of the White Paper, which is the so-called Single European Transport Area Plan, i.e. creating a competitive and resource-efficient transport system. Strengthening public transport can significantly contribute to meeting one of the objectives of the White Paper that reads as follows: “To reduce greenhouse gas emissions by at least 60% by 2050 compared to 1990” [13, p.3]. In order to determine the trend in the production of greenhouse gases in the Czech Republic, it is necessary to create a time series of carbon dioxide emissions for individual types of

transport. Data from the Ministry of the Environment are used for a longer time series (Table 1). It is not possible to compile a sufficiently long time series from the data of the Ministry of Transport, where the data for 2019 are also given. This is due to the fact that in 2019 there was a change in the methodology and only the data for the last five-year period were revised retrospectively. If we compare the data from both sources, the total emissions from transport are the same, but there are noticeable deviations between individual categories.

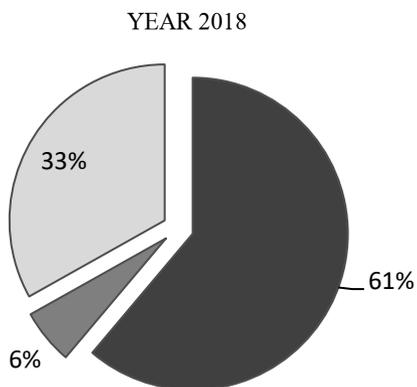
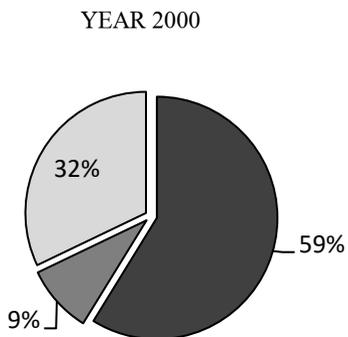
**Table 1.** Carbon dioxide (CO<sub>2</sub>) emissions between 2000 and 2018 (in thousands of tonnes) in the Czech Republic

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Passenger car transport	7,391	7,807	8,295	9,596	9,997	10,579	10,822	11,545	11,365	11,295
Public passenger transport by land	1,143	1,152	1,120	1,128	1,105	1,162	1,169	1,186	1,275	1,271
Other transport	4,031	4,433	4,526	5,176	5,677	6,303	6,475	6,703	6,909	6,543
Transport in total	12,565	13,392	13,940	15,900	16,779	18,044	18,467	19,434	19,550	19,109

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Passenger car transport	10,761	10,887	10,622	10,690	10,978	11,461	12,068	12,420	12,751
Public passenger transport by land	1,277	1,287	1,292	1,219	1,355	1,304	1,293	1,268	1,189
Other transport	6,104	6,004	5,912	5,762	5,997	6,291	6,605	6,811	6,898
Transport in total	18,143	18,178	17,825	17,671	18,330	19,056	19,966	20,499	20,838

Source: Own processing according to the Ministry of the Environment of the CR, 2020.

- Passenger car transport
- Public passenger transport by land
- Other transport



**Fig. 1.** Proportion of carbon dioxide (CO<sub>2</sub>) emissions in the total emissions from transport in % - year 2000

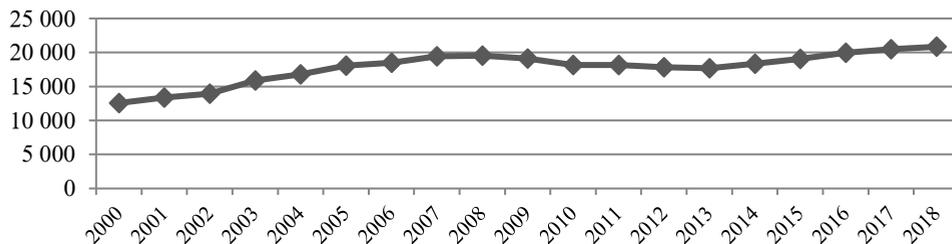
Source: own processing according to the Ministry of the Environment of the CR, 2020

**Fig. 2.** Proportion of carbon dioxide (CO<sub>2</sub>) emissions in the total emissions from transport in % - year 2018

Source: Own processing according to the Ministry of the Environment of the CR, 2020.

Figure 1 and figure 2 clearly show that the individual car transport accounted for 59% of total CO<sub>2</sub> emissions in 2000 and by 2018 this proportion rose to 61%. It is necessary to realize that the minority proportion of emissions includes not only public passenger transport, but also freight transport and air and water transport.

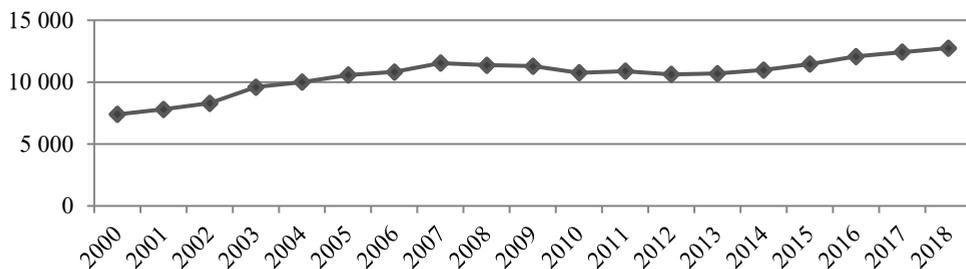
We can derive the trend of emissions in the time series:



**Fig. 3.** Trend in the development of the total carbon dioxide emissions (CO<sub>2</sub>) from transport between 2000 and 2018 (in thousands of tonnes)

Source: Own processing according to the Ministry of the Environment of the CR, 2020.

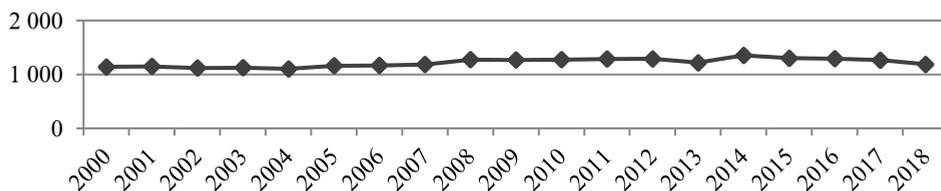
It can be observed from the aforementioned that the total CO<sub>2</sub> emissions have not been reduced yet. The growing trend is confirmed by the fact that between 2000 and 2018 CO<sub>2</sub> emissions from transport increased by 66%. The trend in the development of total emissions from transport (Figure 3) clearly shows that there was a linear growth between 2000 and 2008. Between 2008 and 2013, there was a slight decrease and stagnation in total CO<sub>2</sub> emissions from transport and since 2014 emissions were growing linearly again.



**Fig. 4.** Trend in the development of carbon dioxide emissions (CO<sub>2</sub>) from the passenger car transport between 2000 and 2018 (in thousands of tonnes).

Source: Own processing according to the Ministry of the Environment of the CR, 2020.

CO<sub>2</sub> emissions from the passenger car transport (Figure 4) more or less copy the curve of the total emissions from transport.



**Fig. 5.** Trend in the development of carbon dioxide (CO<sub>2</sub>) emissions from the public passenger transport by land between 2000 and 2018 (in thousands of tonnes)

Source: Own processing according to the Ministry of the Environment of the CR, 2020.

The curve of emissions from the public passenger transport by land (Figure 5) is rather different. There was an evident stagnation throughout the monitoring period. Between 2007 and 2008 there was a certain growth. On the contrary, in 2013 there was a more significant decline, which was followed by a steeper growth, and then the curve had a declining trend

until 2018. It can be stated from the above that it is really necessary to start motivating the inhabitants to reduce the individual car transport and to strengthen the public transport in order to reduce greenhouse gas emissions.

### 3 Transport performance in passenger transport, passengers transported

Passenger transport performance is usually expressed in two ways - on the one hand in the number of transported passengers and on the other hand in kilometres per person. The kilometre per person represents the transport of one person over a distance of one kilometre. It is calculated as the product of the transport performance (i.e. the distance a passenger travels on average) and the number of transported persons. The Ministry of Transport of the Czech Republic regularly collects data from transport companies and summarises them in yearbooks. One set of the data is the transported persons and kilometres per person (according to the data of the Ministry of Transport of the Czech Republic, 2020).

#### 3.1 Evaluation of transport performance by the number of persons transported

First, the development trend in the number of transported persons is described on the basis of comparing the data from the yearbooks of the Ministry of Transport of the Czech Republic:

**Table 2.** Passenger transport (in millions) between 2005 and 2019 in the Czech Republic

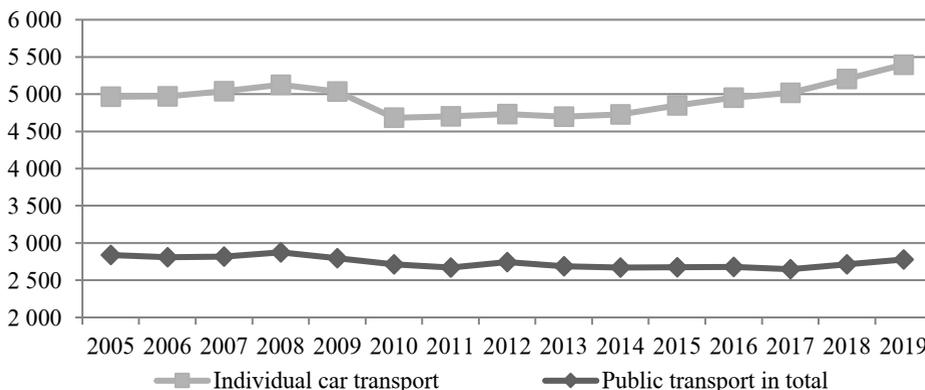
	2005	2006	2007	2008	2009	2010	2011	2012
Roads in total	4,967.42	4,968.74	5,037.65	5,124.62	5,034.57	4,682.10	4,701.00	4,732.02
Railway transport	180.27	183.03	184.23	177.42	164.96	164.80	167.93	172.80
Bus transport	388.26	387.71	375.02	373.40	367.65	372.60	364.62	344.99
Municipal public transport	2,268.89	2,238.01	2,258.39	2,323.80	2,261.96	2,174.70	2,138.46	2,224.23
Public transport in total	2,837.42	2,808.75	2,817.65	2,874.62	2,794.57	2,712.10	2,671.00	2,742.02
Individual car transport	2,130.00	2,160.00	2,220.00	2,250.00	2,240.00	1,970.00	2,030.00	1,990.00

	2013	2014	2015	2016	2017	2018	2019
Roads in total	4,695.72	4,728.50	4,849.20	4,954.10	5,016.70	5,203.40	5,396.30
Railway transport	174.49	176.05	176.60	179.20	183.00	189.50	193.80
Bus transport	337.98	349.52	350.90	332.80	329.70	340.20	354.70
Municipal public transport	2,173.25	2,142.93	2,146.30	2,168.80	2,135.20	2,184.10	2,231.20
Public transport in total	2,685.72	2,668.50	2,673.80	2,680.80	2,647.90	2,713.80	2,779.70
Individual car transport	2,010.00	2,060.00	2,175.40	2,273.30	2,368.80	2,489.60	2,616.60

Source: Own processing according to the Ministry of Transport of the CR, 2020.

There was a decline in the proportion of passengers transported by the land public transport in the total transport (Table 2). In 2005, this percentage was 57% and by 2019 it dropped to 52%. This decrease was caused by a faster growth in the number of persons transported by the individual car transport.

The municipal public transport accounted for the highest percentage in the land public transport, with its stable proportion in public transport remaining at 80%.



**Fig. 6.** The development trend in transported persons (in millions) in the individual car transport and the land public transport between 2005 and 2019

Source: Own processing according to the Ministry of Transport of the CR, 2020.

It is evident from Figure 6 that the development curve of the number of transported persons in the land public transport had a rather stagnant character between 2005 and 2019. There were no significant changes in the development curve, since 2005 there was a slight decrease and only in the last two years a slight increase was recorded. On the contrary, the development curve of transported persons in the individual car transport was significantly growing since 2013. The growth trend of transported persons in the individual car transport had been preceded by a stagnation and significant decline in 2010.

### 3.2 Evaluation of transport performance by kilometres per person

The second way to evaluate the transport performance is the method of describing kilometres per person. Based on the statistical data of the Ministry of Transport of the Czech Republic, the data of registered kilometres per person in the individual types of transport were determined and a time series was created from them:

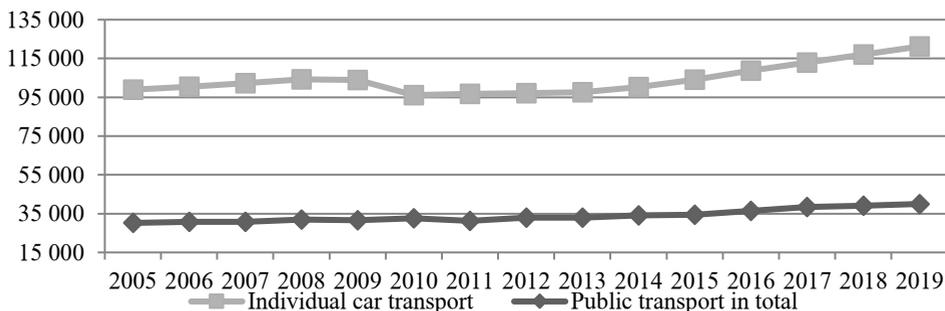
**Table 3.** Transport performance (in millions of kilometres per person) between 2005 and 2019 in the Czech Republic

	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>
Roads in total	98,849.00	100,366.00	102,310.00	104,279.00	103,842.00	96,113.80	96,753.00	97,164.86
Railway transport	6,667.00	6,922.00	6,898.00	6,803.00	6,503.00	6,590.70	6,714.00	7,264.70
Bus transport	8,607.00	9,501.00	9,519.00	9,215.00	9,494.00	10,335.70	9,267.00	9,015.41
Municipal public transport	14,935.00	14,313.00	14,353.00	15,881.00	15,555.00	15,617.40	15,282.00	16,624.75
Public transport in total	30,209.00	30,736.00	30,770.00	31,899.00	31,552.00	32,543.80	31,263.00	32,904.86
Individual car transport	68,640.00	69,630.00	71,540.00	72,380.00	72,290.00	63,570.00	65,490.00	64,260.00

	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>
Roads in total	97,552.36	100,336.89	104,099.00	108,742.60	112,826.60	117,113.50	121,176.80
Railway transport	7,600.60	7,796.50	8,298.10	8,843.40	9,497.60	10,286.00	10,930.60
Bus transport	9,025.57	10,010.20	9,995.90	10,257.10	11,177.80	10,950.40	10,547.00
Municipal public transport	16,276.19	16,270.19	16,100.00	17,387.10	17,824.20	17,906.10	18,520.20
Public transport in total	32,902.36	34,076.89	34,394.00	36,487.60	38,499.60	39,142.50	39,997.80
Individual car transport	64,650.00	66,260.00	69,705.00	72,255.00	74,327.00	77,971.00	81,179.00

Source: Own processing according to the Ministry of Transport of the CR, 2020.

Table 3 gives an overview of the transport performance in kilometres per person. With this evaluation method of the transport performance, there was a slight increase in the proportion of the land public transport, when in 2005 it accounted for 31% which increased to 33% within a year. This was due to the fact that the average transport distance in the public transport increased from 10.6 km in 2005 to 14.4 km in 2019. This phenomenon is positive, it informs us that people started using the public transport more even for longer journeys. This increase in the average transport distance is evident especially in the railway transport, where the average transport distance increased from 37 km to 56 km. On the contrary, there was a slight decrease in the average transport distance in the individual car transport from 32.2 km to 31 km.



**Fig. 7.** The development trend in the transport performance (in millions of kilometres per person) of the individual car transport and the passenger public transport by land between 2005 and 2019  
 Source: Own processing according to the Ministry of Transport of the CR, 2020.

The development trend in the transport performance (Figure 7) clearly shows that there was a slight increase in the public passenger transport throughout the monitoring period. However, there was a relatively steep growth in the performance of passenger car transport since 2013 after a phase of stagnation and decline between 2005 and 2012.

### 3.3 Subsidizing the land public transport from the state budget

The analysis of the public transport use can be supplemented with a time series on the development of subsidies as a state aid. This description provides information on whether it is in the real interest of the state to support public transport as a whole.

**Table 4:** The amount of subsidies in the scheduled public passenger transport (in millions of CZK)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Line bus transport (without municipal public transport)									
Budgets of regional (district) authorities	4,823	4,712	5,054	5,184	5,275	5,251	5,422	6,180	6,642
Municipality budgets	370	368	462	470	550	470	658	632	376
Total	5,193	5,080	5,516	5,654	5,825	5,721	6,080	6,812	7,018
Railway passenger transport									
State budget	4,070	4,074	4,009	4,043	4,233	4,414	4,497	4,645	4,802
Subsidies from regional (district) authorities	8,458	8,672	8,864	9,245	9,290	9,413	9,584	9,794	10,180
Total	12,528	12,746	12,873	13,288	13,523	13,827	14,081	14,439	14,982
Subsidies in total	17,721	17,826	18,389	18,942	19,348	19,548	20,162	21,251	22,000

Source: Own processing according to the Ministry of Transport of the CR, 2020.

Subsidies (Table 4) are listed only for the period up to 2018 (2019 is not available yet) and only for the line bus and railway transport. The table clearly shows that transport subsidies were growing over time. Between 2010 and 2018 there was an increase in subsidies by 24%. The ratio of railway transport subsidies to total subsidies ranges from 68% to 70%.

## 4 Conclusion

At first glance, the analysis clearly shows that the overall performance of the land public transport has not significantly improved since 2005; on the contrary, the use of the individual car transport seems to be strengthening and intensifying. The development trend in the transport performance clearly shows that there was a slight increase in the public passenger transport throughout the monitoring period. However, there was a relatively steep growth in the performance of passenger car transport since 2013 after a phase of stagnation and decline between 2005 and 2012.

The total CO<sub>2</sub> emissions have not been reduced yet. The growing trend is confirmed by the fact that between 2000 and 2018 CO<sub>2</sub> emissions from transport increased by 66%. Given the longer-term efforts and goals to substantially reduce CO<sub>2</sub> emissions (which was illustrated with the increasing trend in provided subsidies), this signal is alarming and it would certainly be appropriate to address this topic in more depth – to conduct more detailed research both at the level of individual regions or at the level of individual transport companies and to look for problematic aspects that prevent the land public transport being stronger pushed through at the expense of the individual road transport. Unfortunately, the current situation in connection with the coronavirus pandemic may, on the contrary, exacerbate the transport crisis and further reduce the use of public transport.

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