

CO<sub>2</sub> EMISSION CHANGES IN LITHUANIAN TRANSPORT SECTOR OVER 1996–2007Renata Dagiliute<sup>1</sup>, Inga Ziukelyte<sup>2</sup>

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**Abstract.** Climate change and growing CO<sub>2</sub> emission are widely discussed issue. During transitional economic downturn period (1990–1995) CO<sub>2</sub> emission in Lithuania has decreased significantly. However, CO<sub>2</sub> emission is growing recently in Lithuania and this growth could be attributed to transport which is one of the main sectors contributing to the CO<sub>2</sub> emission. The paper aims to examine the dynamics of CO<sub>2</sub> emission and related indicators in transport sector in Lithuania during the economy growth period 1996–2007. Paper analyses main trends in transport CO<sub>2</sub> emission, gross domestic product (GDP), final energy consumption, and CO<sub>2</sub> intensity in Lithuania. Over 1996–2007 period GDP created in Lithuanian transport sector was on steady increase (17 % annually), followed by final energy consumption growth and respectively increased CO<sub>2</sub> emission. Over the growth period CO<sub>2</sub> emission of transport sector have increased 1.5 times and amounted to 15.9 million tons in 2007. In 2007 transport sector was responsible for 21 % of all CO<sub>2</sub> emission with the biggest share of road transport (95 %) within the sector. Despite growing overall CO<sub>2</sub> emission, amount of CO<sub>2</sub> per unit of GDP (CO<sub>2</sub> intensity) in transport sector was on decreasing trend and since 1996 have decreased 2.3 times. As Lithuanian National Strategy for Sustainable Development aims to increase overall eco-efficiency and to reach EU-15 level of eco-efficiency on average, comparative analysis with EU-15 was conducted. It revealed achieved progress towards foreseen goals. If in 1996 Lithuania CO<sub>2</sub> intensity in transport sector was 30 % higher than EU-15, in 2007 CO<sub>2</sub> intensity of Lithuanian transport converged to that of EU-15 and accounted to 480 CO<sub>2</sub> t/1000 PPS (purchasing power standard). These positive changes were induced by high rate of GDP growth in transport sector, implementation of new technologies and more efficient energy consumption in transport sector.

**Keywords:** climate change, transport sector, carbon dioxide, CO<sub>2</sub> emission, CO<sub>2</sub> intensity.

## 1. Introduction

Great attention to the climate change and related impacts is paid recently. Although in general greenhouse effect is a natural phenomenon, recently human activities, such as fuel burning, cement manufacturing resulted in global warming with all related outcomes: temperature increase, melting ice caps, disappearing glaciers, rising sea level, reduced fresh water and food resources, floods, droughts and heat waves, biodiversity loss, spread of various diseases, which are not specific to one or another region (Gore 2008, Bieška *et al.* 2010).

Up to 60 % of atmospheric CO<sub>2</sub> is retained in the atmosphere, while the rest dissolves in the oceans or is included in the photosynthesis process (Solomon *et al.* 2007). CO<sub>2</sub> in the atmosphere lasts on average from 50 to 200 years and the effect will be felt in subsequent centuries (Štreimikienė *et al.* 2005).

The Intergovernmental Panel on Climate Change has provided evidence that the current climate warming have started mostly due to anthropogenic activities and has recognized that if strict measures to reduce gas emissions are not provided, greenhouse gas levels by the middle of

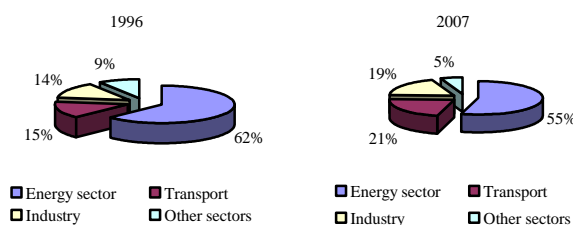
this century will double compared with pre-industrial levels (Baltrėnas 2007, Hofmann *et al.* 2009). This would lead consequently to the negative environmental impacts.

One of the main greenhouse gases (GHG) related to anthropogenic activities is carbon dioxide, accounting to 80 % of all anthropogenic GHG emission. Fossil fuel and coal burning in thermal power plants are one of the main reasons leading to the sharp increase in carbon dioxide concentrations in the atmosphere. Deforestation, wetland drainage and other land-use change-related activities also results in increase of carbon dioxide concentration in the atmosphere.

Despite implementation of various measures CO<sub>2</sub> emissions are not decreasing as it was expected by international commitments. Of special interest is transport sector as CO<sub>2</sub> emissions from transport sector has been increasing globally and is expected to grow further (Uherek *et al.* 2010). Therefore it could be concluded that transport sector contributes significantly to the intensification of the climate change. Land transport is responsible for 1/5 of all carbon emission (in CO<sub>2</sub> equivalents) (Uherek *et al.* 2010), shipping accounts to 2.7 % (Eyring

et al. 2010) and aviation – about 2.5 % (Lee et al. 2010) of all global anthropogenic emission of CO<sub>2</sub>.

In general goal of sustainable transport is to ensure that transport systems meet society's economic, social and environmental needs while reducing their adverse impact on the economy, society and the environment (Council of... 2006). Lithuanian National sustainable development strategy (2009) aims to long-term economic and ecologic efficiency and to decrease air pollution and emissions of GHG, too. One of the mains aims is to achieve that greenhouse gas emissions will increase two times slower than the increase of transport sector itself. In general Lithuanian National Sustainable Development strategy aims to achieve eco-efficiency levels of EU-15 (2003) by the year 2020 (NDVS, 2009). Though during transition period CO<sub>2</sub> emission in Lithuania has decreased significantly and international commitments (Kyoto protocol) regarding GHG are met, contribution of transport sector to the growth of CO<sub>2</sub> emission is growing in Lithuania recently (Fig. 1).



**Fig 1.** Structural changes of CO<sub>2</sub> emission by sector in Lithuania in 1996 and 2007 (Based on: EAA)

Therefore, the aim of this paper is to examine the dynamics of CO<sub>2</sub> emission and related indicators in transport sector in Lithuania during the economy growth period 1996–2007. Paper analyses main trends in transport CO<sub>2</sub> emission, gross domestic product (GDP), final energy consumption, and CO<sub>2</sub> intensity in Lithuania. Paper is structured as follows. First we present some data and methodology issues, and then changes of CO<sub>2</sub> emissions and the analysis of the development of transport sector itself is presented in section 3.1. Further CO<sub>2</sub> intensity in transport sector is analysed and achievements according foreseen goals are discussed, and finally some conclusions are drawn.

## 2. Methods and data issues

To reveal on-going changes in transport sector and related CO<sub>2</sub> emission analysis is focused on:

- Economic indicators:
  - GDP - gross domestic product, mln. PPS. Purchasing power standard is artificial currency, presented at constant prices using purchasing power parity. Purchasing power parity (PPP) - the national currency exchange rates, which eliminate the differences in price levels between countries and allows meaningful comparison.
  - Number of road vehicles.

- Energy indicators:
  - Final energy consumption in 1000 toe (toe - tone of oil equivalent). Final energy - is the primary and secondary energy that is consumed directly to meet human needs.
  - Structure of fuel consumed (%).
- CO<sub>2</sub> emission indicators:
  - CO<sub>2</sub> emission from transport sector in million tons.
  - Share of CO<sub>2</sub> emission from different transport modes.
  - CO<sub>2</sub> intensity (thous.t/thous. PPS). CO<sub>2</sub> intensity is the quantity of CO<sub>2</sub> emissions into the environment per unit of gross domestic product (GDP) created in transport sector.

Study covers 1996–2007 year period, when after transitional decline pronounced growth of transport sector is observed. Data used in the paper is mainly from the European Environment Agency, the Statistical Office of European Communities (Eurostat) and the Lithuanian Department of Statistics under the Lithuanian Government of the Republic.

First, the changes in CO<sub>2</sub> emissions and CO<sub>2</sub> intensity in Lithuanian transport sector during the period of 1996–2007 are analysed and decoupling trends is discussed. Then some comparison analysis between EU-15 and Lithuania is conducted. For the better interpretation of on-going changes 1996 was chosen as the base year and equalled to 100 %.

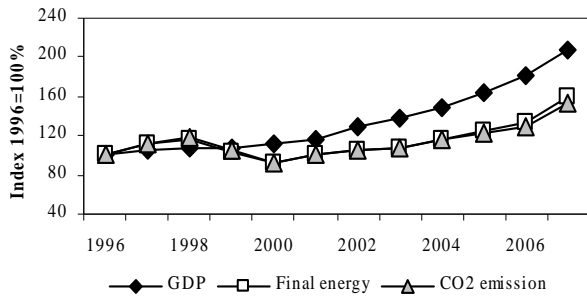
## 3. Results and discussion

### 3.1. GDP, fuel consumption and CO<sub>2</sub> emission trends in transport sector

Development of GDP, final energy consumption and CO<sub>2</sub> emissions in Lithuanian transport sector is presented in Figure 2.

During 1996–2007 GDP created in transport sector increased two times, and this indicates overall importance of transport sector for the whole economy. CO<sub>2</sub> emissions during the period increased 1.5 times. Hence, CO<sub>2</sub> emissions in transport sector have grown much more slowly than the economy. And this trend should be treated positively from the point of sustainability. However, since 2000, then fast economy growth has started, CO<sub>2</sub> emissions also started to increase, but at much higher rate. This relatively significant increase could be associated with a rapid increase in fuel consumption due to increased number of vehicles and increased transportation volumes.

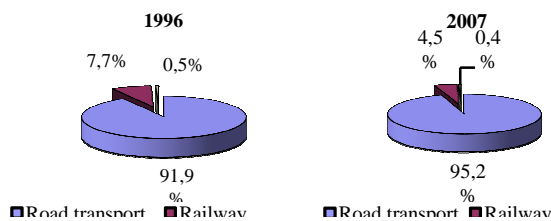
Final energy consumption in the transport sector increased 1.6 times during the period under analysis. Though CO<sub>2</sub> emissions vary gradually with final energy consumption, since 2005 some decoupling of CO<sub>2</sub> emissions from final energy consumption in the transport sector is observed. These positive changes could be explained by “greener” technologies, as well as the changed structure of fuel consumed (the share of biofuels, liquefied petroleum gas has increased (Fig. 5)).



**Fig 2.** GDP, final energy consumption and CO<sub>2</sub> emission in Lithuanian transport sector over 1996 – 2007 period (Based on: Eurostat and Lithuanian Statistics)

In overall terms it can be stated that one of the main challenges of sustainable development to decouple CO<sub>2</sub> emissions from economic growth has been relatively achieved, i.e., CO<sub>2</sub> emission has grown slower than GDP created in transport sector (Juknys 2008; Barysienė 2009).

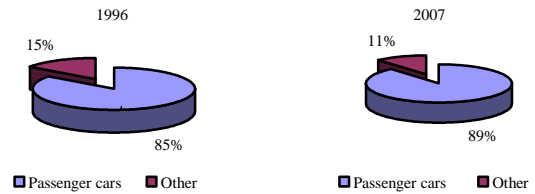
Despite these positive changes road transport remains a problematic from the point of sustainability. As the results show road transport is responsible for the biggest share of all CO<sub>2</sub> emissions from transport sector in Lithuania (Fig. 3). If in 1996 road transport was responsible for 91.9 % of all CO<sub>2</sub> emissions in transport sector, in 2007 this share reached more than 95 %. The share of the railway sector decrease from 7.7 % in 1996 to 4.5 % in 2007. This could be explained by relatively low competitiveness (insufficient infrastructure, relatively slow, inconvenient) of rail compare to the road transport. One of the main sustainable development strategy aims is to develop more environment friendly transport types is not given enough attention and investments, both passenger and freight transport share of rail doesn't increase in the overall volumes. The CO<sub>2</sub> emission from navigation is not very significant compared to road or rail transport and constitute about 0.5% of all CO<sub>2</sub> emission in transport sector in Lithuania.



**Fig 3.** Share of CO<sub>2</sub> emission from different transport modes in 1996 and 2007 in Lithuania (Based on: EAA)

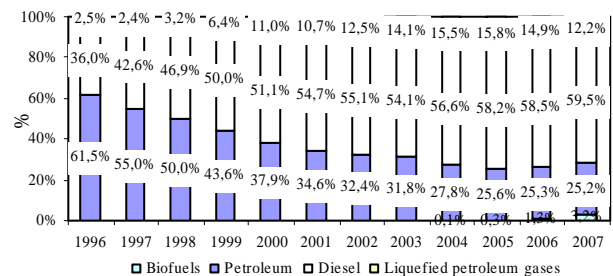
Significant impact of road transport to the CO<sub>2</sub> emission is determined by increasing number of road vehicles. During 1996–2007 period number of road vehicles, mainly personal cars, more than doubled in Lithuania. If in 1996 there were 208 cars per 1000 inhabitants in Lithuania, in 2007 this indicator amounted to 453 cars/1000 inhabitants. Recently passenger cars amount to 89 % of all road vehicles in Lithuania (Fig. 4). Growing number of vehicles outweighed efficiency gains in fuel consumption, fuel quality and structural changes of fuel

consumption (Fig. 5) and overall fuel consumption and CO<sub>2</sub> emission is growing respectively. As Uherek and others (2010) state improvements of efficiency and promotion of biofuels could be not sufficient and more radical changes are needed to manage impact of land transport to climate change.



**Fig 4.** Structure of Lithuanian vehicle fleet in 1996 and 2007 (Based on: Lithuanian Statistics)

Still from the point of sustainability in transport sector increasing consumption of more environmental friendly fuels like biofuels and liquid petroleum gas should be considered as positive changes. Lithuania is committed that biofuels in transport will make 5.75 % in 2010 and in 2020 – 15 %. However, diesel amounts to 60 % of all fuel consumed (Fig. 5) (and this could be associated with a significantly increased volumes of freight transport) and biofuels consisted only 3.2 % and liquid petroleum gas 12.2 % of all fuel consumed in transport sector in 2007.



**Fig. 5.** Structural changes in fuel consumption in Lithuanian transport sector over 1996–2007 (Based on: Statistics of Lithuania)

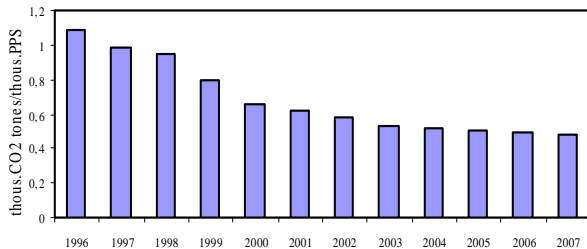
### 3.2. CO<sub>2</sub> intensity in Lithuanian transport sector

Figure 6 presents changes of CO<sub>2</sub> intensity in relation to GDP. Data show that CO<sub>2</sub> emission intensity during the 1996–2007 period had a tendency to decrease. Since 1996 CO<sub>2</sub> intensity decreased 2.3 times and amounted to 0.48 thous.CO<sub>2</sub> tones/thous. PPS in Lithuanian transport sector in 2007.

This trend should be evaluated as a positive one, as it indicates not only improving economic situation, but more efficient use of fuel, use of new technologies and more environment friendly fuel, as it was already discussed (Fig. 5). These changes confirm statement (section 3.1) that at least relative decoupling of CO<sub>2</sub> emission from economy growth is taking place (Fig. 2).

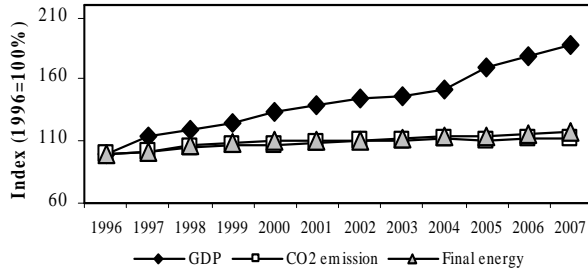
Then comparing development of transport sector in Lithuania and EU Old member states remarkable differ-

ences could be observed regarding decoupling course (Fig. 2 and Fig. 7). All three indexes have trend to grow in EU-15. However, regarding one of the main EU goals of sustainable transport to make the economy grow faster than emissions, EU-15 progresses quite well and much more pronounced relative decoupling of CO<sub>2</sub> emission from transport growth is taking place in EU-15 compare to that of Lithuania.

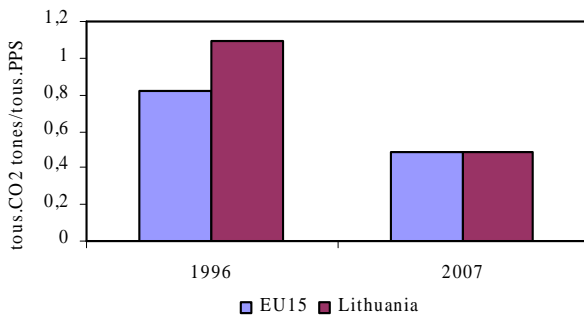


**Fig 6.** CO<sub>2</sub> intensity in transport sector in Lithuania over 1996 – 2007 (Based on: Eurostat and EAA; own calculations)

Another positive feature of EU-15 development is that final energy consumption during the whole period was slightly higher than CO<sub>2</sub> emissions and since 2003 faster decoupling of CO<sub>2</sub> emission from final energy consumption in transport sector has started. Meanwhile in Lithuania, some minor positive changes have started only since 2005 (Fig. 2).



**Fig 7.** GDP, final energy consumption and CO<sub>2</sub> emission trends in transport sector in EU15 over 1996–2007 (Based on: Eurostat and EAA)



**Fig 8.** Comparison of CO<sub>2</sub> intensity in ES-15 and Lithuania in 1996 and 2007 (Based on: Eurostat and EAA; own calculations)

Both in Lithuania and in the EU-15 transport sector's CO<sub>2</sub> intensity was on declining trend. Although in

Lithuania CO<sub>2</sub> intensity was 1.3 times higher than in EU-15 in 1996, in 2007 CO<sub>2</sub> intensity in Lithuanian transport sector have converged with that of the EU15 and recently amounts to 0.48 thous.CO<sub>2</sub> tones/thous.PPS (Fig. 8). One of the Lithuanian targets to reach EU15 efficiency level is fulfilled in the transport sector. But more efforts are needed to mitigate overall CO<sub>2</sub> emission from this sector.

According to EU Sustainable Development Strategy, the EU countries should make major efforts to improve the efficiency of final energy consumption (Council of... 2006). However, as it is already has been mentioned improvements of eco-efficiency of fuel consumption is not sufficient prerequisite regarding CO<sub>2</sub> mitigation (Uherek *et al.* 2010). As transport is the sector which emissions are hardest to cut, to reach significant progress actions in all levels of government will be needed (Marsden and Rye 2010), not neglecting the importance of changes in personal travelling habits and attitudes .

#### 4. Conclusions

1. Transport sector is one of the main sectors of the economy having a significant impact on the main greenhouse gas, CO<sub>2</sub>, emission. During the period of 1996–2007 the transport sector's contribution to CO<sub>2</sub> emission in Lithuania has increased significantly and CO<sub>2</sub> emission from transport sector amounted to 21 % of all CO<sub>2</sub> emission in Lithuania in 2007.
2. It should be viewed positively that in Lithuania the GDP created in transport sector increased twofold over 1996–2007 period, while CO<sub>2</sub> emission in the transport sector grew much more slowly than the GDP and increased only 1.5 times. Since 2005 some relative decoupling of CO<sub>2</sub> emission from the final energy consumption is also observed and this could be linked to modern technologies and the structural changes of the fuel used.
3. In comparison with other transport modes, road transport emits the largest share of transport emission of CO<sub>2</sub> (95 %). In particular, road transport has been developing rapidly recently, the number of road vehicles, passenger and cargo transportation by road increased significantly.
4. CO<sub>2</sub> intensity in Lithuanian transport sector within 1996–2007 tended to decline. During the period this indicator decreased 2.3 times, reaching 0.48 thous.CO<sub>2</sub> tones/thous.PPS. These environmentally friendly developments can be attributed to the rapid growth of transport sector, new technologies and more efficient energy use in transport sector.
5. Both in Lithuania and in the EU-15 transport sector's CO<sub>2</sub> intensity was on declining trend. Although in Lithuania CO<sub>2</sub> intensity was 1.3 times higher than in EU-15 in 1996, in 2007 CO<sub>2</sub> intensity in Lithuanian transport sector have converged with that of the EU15 and recently amounts to 0.48 thous.CO<sub>2</sub> tones/thous.PPS.

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