A thesis submitted to the Department of Environmental Sciences and Policy of Central European University in part fulfillment of the Degree of Master of Science

Implication of Transport Modal Shifts for Transport Energy Intensity: An International Comparison on CEE Countries during the Transition Years

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May, 2008

Budapest

Erasmus Mundus Masters Course in Environmental Sciences, Policy and Management

MESPOM

This thesis is submitted in fulfillment of the Master of Science degree awarded as a result of successful completion of the Erasmus Mundus Masters course in Environmental Sciences, Policy and Management (MESPOM) jointly operated by the University of the Aegean (Greece), Central European University (Hungary), Lund University (Sweden) and the University of Manchester (United Kingdom).

Supported by the European Commission's Erasmus Mundus Programme

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Nyamjav, E. 2008. *Implication of Transport Modal Shifts for Transport Energy Intensity: an International Comparison on CEE Countries during the Transition Years*. Master of Science thesis, Department of Environmental Sciences and Policy, Central European University, Budapest.

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ABSTRACT OF THESIS submitted by:
Erdenesaikhan NYAMJAV for the degree of Master of Science and entitled: Implication of Transport Modal Shifts for Transport Energy Intensity: an International Comparison on CEE Countries during the Transition Years.

Month and Year of submission: May, 2008.

Transport energy intensity largely depends on the modal split of transport activities and contributes significantly to the GHG emissions from transport energy consumption. To examine the role of modal split in transport energy intensity, this thesis investigates the changes in transport trends in the CEE countries during the transition years. The findings clearly indicate that a larger share of energy efficient transport modes results in a reduction of the transport energy intensity, but many CEE countries show the pattern of growing energy intensity, to levels similar with EU-15. Still there exists, for the CEE countries, a door of opportunity to achieve a substantial share of energy efficient transport modes, even though this cannot be as high as envisaged during the pre-transition period. If the transport modal split is managed effectively, the CEE transport energy intensity can possibly drop below the energy intensive levels; this apparently can assist CEE countries towards mitigating potential GHG emissions from the transport. As the research examines general transport trends and analyzes overall transport energy intensity ratios, relevant future research methods can be improved on the basis of this work.

Keywords: transport energy intensity, modal shift, CEE, transport energy efficiency in transition economies

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Acknowledgements

Foremost I would like to thank my research supervisors Dr Diana Ürge-Vorsatz, Central European University for her academic guidance and precious supports, and Dr Dias Haralambopoulos, the University of the Aegean for his invaluable advice. Especially I would like to acknowledge my gratitude to Dr Eszter Timar for her continuous facilitation and instruction on my academic writing.

I am always thankful for MESPOM consortium for their academic efforts and financial funds for my graduate studies. All MESPOM course modules were instructive for my research and helpful to construct my ideas.

Further my thanks go to my friends and colleagues who enriched me throughout my studies and this research. I would like to thank my family the Nyamjav's and my sister Oyuntuya Nyamjav for their encouragement during this research.

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Abbreviations

Country

CZ	Czech Republic
EE	Estonia
HU	Hungary
LT	Lithuania
LU	Luxembourg
LV	Latvia
PL	Poland
SI	Slovenia
SK	Slovak Republic
BG	Bulgaria
RO	Romania
USA	United States of America
JP	Japan
EU-15	"Old" EU Member States: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, Sweden, United Kingdom

Units

Tkm tonne kilometre

Pkm passenger kilometre

Mio (pkm/tkm) – millions of transport activity

Mtoe millions of tonne oil equivalent

Toe tonne of oil equivalent

GHG greenhouse gases

CO_2 Carbon Dioxide
N_2O Nitrous Oxide
MtCO2-eq Millions of tonne of Carbon Dioxide equivalent

Organization

COMECOM	Council for Mutual Economic Assistance Area
EC	European Commission
EC DG TREN	European Commission, Directorate-General for Energy and Transport
ECMT	European Conference of Ministries of Transport
EEA	European Environment Agency
ERDB	European Regional Development Bank
EU	European Union
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
OECD	Organization for Economic Cooperation and Development
UITP	International Association of Public Transport
UNECE	United Nations Economic Commission for Europe
USAID	United States Agency for International Development
USDE	United States Department of Energy

Introduction

As defined by the Organization Economic Co-operation and Development (OECD), the word '*transport*' is used "*to refer to the means of movement and is also preferred for the adjective form, as in transport activity*" (1996). The European Conference of Ministers of Transport (ECMT 1997) recognized that the transport activity releases the major anthropogenic pollutants of greenhouse gases (GHG) into the environment. The Intergovernmental Panel on Climate Change(IPCC 2007) estimates the contribution of transport to total GHG emissions was about 23%, with emissions of CO_2 and N_2O amounting to about 6300–6400 MtCO2-eq in 2004. Acknowledging the fact that much of transport GHG emissions are due to transport energy consumption, the International Energy Agency (2006) identifies the factors influencing energy use in the transport sector:

- **Transport activity** (the level of mobility demand and transport of goods)
- **Modal mix** (choice of mix of transport modes like cars, buses, planes, ship etc)
- **Energy intensity** (final energy per unit of transportation activity)
- **Fuel mix** (the types and the mix of fuel used in each transport mode)

These factors are closely dependent on regional development. Remarkable changes in the transport energy factors are apparent for the Central and Eastern European (CEE) countries over the transition years from the centrally planned periods to the market oriented economies. Due to data limitation, the thesis analyzes only three factors for the CEE countries: transport activities, modal split, and energy intensity. Thus, the fuel mix is not discussed in this research. Before the transition to market economy, the CEE transport sector had lower energy intensity than the Western European countries, North America and Japan (Vorsatz *et al* 2006). A foundation for that success was the effective management of transport modes. Studies prove that the CEE countries had a high share of organized trips, including public transport and rail passenger and freight transport during the centrally planned periods (Vorsatz 1997;

Vorsatz *et al* 2006). In line with that, other reasons were the policy restriction over private car ownership and the poor infrastructure as well. This situation has changed dramatically after the transition; a new picture appears as post-transition transport development has facilitated an exponential growth of car ownership, increases of road freight, reductions of public transport and the fall of rail transport activities. The post-transition transport trend reversely increases energy consumption, hence boosts GHG emissions. In other words, the regional trend follows that of Western Europe (CEE Bankwatch Network 2004).

During the transport development, the accession of CEE countries to the European Union (EU) brings a balance: the artificially controlled low level of mobility and car ownership has changed to the levels regulated by affordability, culture and the state of transport infrastructure (Boza-Kiss 2005). This balance has still preserved some of the positive legacies of centrally planned economies, resulting in a relatively higher use of public transport and rail freight transport for the CEE countries than the Western Europe. However, other reasons such as lack of infrastructure development, declining services, financing problems are gradually eroding the importance of energy efficient transport modes in the CEE countries.

The EU enlargement opens a range of transport development opportunities for the CEE countries. Nevertheless, studies prove that the majority of investment and funds have been dominantly used to support road transport infrastructure. Following this trend, a divergence of transport modes appears in the region: passenger car mobility and road freight shipping take up the major roles; and the share of public transport, rail passenger and rail freight transports have been diminished remarkably. If this tendency continues without reversing it, further increases of energy intensive transport movement will have detrimental impacts on transport-related GHG emissions in the CEE countries. The further expected modal split, growth in individual mobility and volume of road freight, will push transport-related emissions up more dynamically to catch up with the EU-15. These increases pose a high risk to other major efforts to curb transport related GHG emissions.

What promises in the CEE countries is an existing door of opportunity to re-achieve lower transport energy intensity without restraining market and societal trends of free mobility. The post-transition transport trends in the CEE show a direct impact on transport energy intensity. The calculation in this thesis and the European Union scenario study on transport and energy found that the passenger and freight transportation had an increase of energy intensity when road modes make up larger portions compared to the other modes. Interestingly, some CEE countries still maintain remarkably high shares of public transport and rail transportation; hence they result in the decline of transport energy intensity below the mid-1990s levels in recent years. In line with EU legacies and strong commitments to curb GHG emissions, the newly EU member CEE countries can seek an option of policy leapfrogging to bring back the old advantage of energy efficiency through effective regulation of transport modes.

How to design such smart policy may require empirical evidence to review historical records to determine their correlation with energy intensity in the region. To contribute some analyses, this thesis examines recent and past transport energy trends in the CEE countries and compares their situation with the EU-15 countries and world indicators where possible.

Aim

Therefore, the current aim of the thesis is to investigate how changes in transport modal split link to energy intensity in the CEE countries during the transition years.

Objectives

In order to achieve this aim of research, the current thesis explores the following objectives:

- Discuss the CEE transport landscape during the transition periods from the centrally planned economies to the EU membership to emphasize on road and rail sectors.

- Examine the CEE transport activity trends, and compare with the average EU-15 and other world indicators where possible
- Estimate the energy intensity trends of transport modes for the CEE region
- Identify the positive and negative transport changes that contribute significantly to transport energy situation in the CEE countries, and compare the results with the EU-15 to highlight the differences where possible.
- Outline policy considerations for the energy efficient transport modes in the region.

Thesis structure

The thesis consists of the following main parts. After this introduction, Chapter 1, Methodology and Data reviews the relevant literature on transport energy in European context and filters the possible contribution of this thesis for research discussions. This chapter further outlines the scope of thesis and describes the methods used and obtained data in this research. To provide the basis of transport situation in the CEE countries, Chapter 2 deals with the transport development issues in the region for three major periods: the pre-transition, the post-transition, and the EU enlargement. Analyzing the statistical data, Chapter 3 explores the CEE transport activity trends and modal split by road and rail transport modes. Then, Chapter 4 examines the CEE transport energy trends by two main transport sectors. Chapter 5 analyzes the CEE transport energy intensity with both calculation in this thesis and the scenario results from the EU study. Combining the transport activity and energy trends, Chapter 6 discusses the correlation between the two analyses and suggests relevant assumptions for the CEE transport energy intensity and modal split. Based on the literature review and empirical evidence, the Conclusion summarizes the main findings from the thesis research and recommends relevant transport and transport related policy considerations for CEE decision makers. Finally, the thesis includes the References and Appendices of data.

Chapter 1. Methodology and data

To achieve the aim and supporting objectives, this study employs the relevant research methods. Analyses and discussions in this research contain a number of approaches: analyses of transport energy intensity, data collection from first hand statistical sources, and assessment on existing empirical research materials. Along with the points from the bibliographical survey, these methods help to set the originality and the contribution of this research for scientific literature on the CEE transport energy studies in specific and environmental sciences in broad extent.

1.1. Bibliographical survey

This research reviews possible empirical works focusing on the CEE transport in regard to the transition and the EU accession periods. Although the next chapters make use of previous studies and documents for respective arguments, this section particularly deals with existing research on transport energy of the CEE. Surveying the key literature on the topic allows pinpointing the research gaps.

Like the EU study on transport and energy key scenarios by Mantzos and others (2004), many studies are based on economic and mathematical models to support their assumptions in transport energy intensity. The closest publication in the subject area is the *long-term outlook of energy use and CO2 emissions from transport in Central and Eastern Europe* by *Zachariadis* and Kouvaritakis (2003). The paper investigates ten CEE countries as similar to this thesis. Main approach was to model transport energy consumption and carbon dioxide emissions on the basis of macroeconomic data and international energy prices assuming the common conversion of the CEE countries into EU policies and standards (Zachariadis and Kouvaritakis 2003). The study gives important messages such as doubling effects of transport energy consumption and hence a 70% increase of CO2 emissions in the CEE countries between 2000 and 2030. That assumption takes account of the CEE in the follow of European Union's policy and standards in the coming decades. While making use of this study, this thesis examines the real evidence from reliable statistics for the CEE region. It therefore helps to design alternative policy tools reducing the regional transport energy consumption and GHG emissions.

There has been found a key policy research that can generally frame policy direction. The research is titled as *Energy in transition: From the iron curtain to the European Union* by Diana Urge-Vorsatz, Gergana Miladinova, and Laszlo Paizs(2006). This publication reviews framework energy legacies of all sectors, including transport, in the CEE region. The paper highlighted positive policies on sustainable transport sector in the CEE during the centrally planned economy. Then the paper proposes the importance of leapfrogging as the 'positive legacy' for organized transport modes which has been neglected during the post-transition periods in the many transport policies of CEE region. In order to investigate this door of opportunity in the region, facts and real evidence should be collected and calculated.

The European Environment Agency (EEA) publishes a series of review papers on transport and energy themes. Two of the series are relevant to this thesis. These are the followings: *TERM 2003 01 AC + CC - Transport final energy consumption by mode* (2003) and *Climate for a transport change: TERM 2007: indicators tracking transport and environment in the European Union* (2008). Although the EEA papers include the CEE countries under the new EU member country analysis, they do not specifically address the transport energy intensities and their implication to the CEE region.

In spite of CEE, important transport energy studies have been produced, focusing EU-15 countries, such as the transport intensity studies by Stead (2001), and Stead and Banister (2002). Their research methods are adopted and elaborated in the methodology of thesis. Another most recent study is *Energy and transport in comparison: Immaterialisation,* *dematerilisation and decarbonisation in the EU15 between 1790 and 2000* by Taio and others (2007). The study analyzed the countries for an aggregated set of groups by cluster analysis, and studied the data from Eurostat. Existing research studies suggest great needs to review transport and transport energy trends in the CEE for the transition years.

1.2. Scope and limitation

This study generally analyzes the relevance of transport activities and their impact on energy as an indication of regional transport implication to global GHG emissions. It must be noted that the thesis is not a comprehensive analysis to match the exact correlation between the two. There are a number of limitations in this thesis. The following areas determine the main scopes of this research.

Countries Covered: Two main factors are used to select sample countries in this study. First, political geography is given the highest priority. 'New European Union Member' is a recent political terminology for the CEE countries. However this study will use the 'CEE' term to emphasize the importance of transport situation in the previously centrally planned period. Additionally, proximate geographical locations among the countries help to identify major transport trends in the Central and Eastern countries of Europe. The CEE countries in this study are Bulgaria, the Czech Republic, Estonia, Lithuania, Latvia, Hungary, Poland, Romania, the Slovak Republic and Slovenia. Note that Cyprus and Malta are excluded in this group due to lack of data.

The second is availability of data. Indicators vary greatly across countries; however, the quality and quantity are proven to be better for the new EU states and candidate countries than the most of transition economies (Cekota 2005). Thus, the CEE countries are chosen based on their consolidation of converting national transport indicators into common international standards that make comparison easy. It is considerable that the energy intensity analyses in the later chapters will only focus on the CEE countries with available data, such as Romania and Bulgaria are excluded in many analyses due to the lack of data.

Time Scale: Time scale is a priority prerequisite for this study. The study attempts to show how the CEE countries have changed during the transition years. Thus, the data were retrieved as far beyond the 1990s as possible. However, most statistical information is only available after 1990s and even after 1995 for many transport indicators. The appreciating fact belongs to the data of rail sector that maintained information access until 1970s. Even though the data analyses involve the situation in the centrally planned periods, the main focus on time series includes a period of the recent decade and a half.

Transport Mode: The study mainly focuses on road and rail sectors of the CEE transport. Air, marine and inland transport sectors are excluded in this study. Waterways are only relevant to the countries with a greater access to the water routes. The data on air transportation is limited according to the available statistics. Hence, road and rail sectors make up the main composite of transport modes. The results of the studies suggest that road and rail sectors are keys for the transportation development in the CEE.

1.3. Measure of transport energy intensity

Many analyses of this thesis estimate transport indicators and measures with simple analytical methods. The rate of changes, the percentage calculation, explanation and comparison against indicators occupy the most part.

Energy intensity is commonly measured by the ratio of total energy consumption per energy activities (Ang and Zhang 2000). Thus, the transport energy intensity is determined by total transport energy consumption ratio per transport activity (USDE 2003). This study uses a concept that has been widely used in the previous studies including Peake(1994), Scholl et al (1996), Michaelis and Davidson(1996), Stead(2001), and Stead and Banister(2002). For transport sectors, the thesis uses transport activity indicator of *net mass movement*. The net mass movement is a combination of freight and passenger movements into a single unit of tonne kilometre measure (Stead 2001). That measure may indicate the total cumulative movement of transport activities. This study uses Stead's approach that assumes "people with luggage weigh 90kg on average" for tonne-kilometre conversion (Stead 2001). Thus, energy intensity can be expressed by the following formula.

Net Mass Movement = Tkm + Pkm/11.11

Energy per Net Mass Movement = Total Energy Consumption/ Net Mass Movement

Given the transport energy data by sectors, this study separates the energy intensity for road and rail transports. Moreover this thesis examined the energy intensity for passenger and freight activities to see how the modal swift has influenced on these two major transport activities. The study employs a proportion to separate the shares of energy consumption for the transport activities. Here the study used an assumption that transport energy consumption increases in regard to distance traveled. Thus, the percent increase of distance traveled directly contributes to the increase of energy consumption. To find a separate rate of change or percent change, a proportion analysis measures the changes of freight and passenger in regard to the net mass movement indicators. To simplify this analysis, the following formula is used:

(F+P) →100%

F→A% therefore A%= (F*100%)/ (F+P)

Total(road/rail) TOE→100%

F /P Transport Energy → A% thus, F Energy=A%*Total TOE/100

F – Freight activity

P – Passenger activity

TOE – Total transport energy

Then respective transport activity indicators are obtained from the available statistical sources. An actual energy intensity ratio can be therefore determined by the energy intensity calculation.

Complementing the uncertainty and errors in the top-down calculation of energy intensity, the thesis also obtained respective energy intensity indicators for the CEE from the EU scenario study on transport and energy. That study presents the relevant energy intensity indicators using more comprehensive analyses on the basis of macroeconomic data and international energy prices (Mantzos *et al* 2004). As a benchmark against the energy intensity calculation in this thesis, the thesis used the scenario results for transport energy intensity discussion and a link description on transport energy intensity and modal shift in later sectors of the thesis.

1.4. Data collection

The study uses available transport statistical data from European official sources. Transport energy data was taken from the Eurostat online data bank and electronic publication *EU Energy in Figures* (2007). All data are annual basis. The transport focused indicators are collected from the United Nations Economic Commissions for Europe's transport statistics data and the Eurostat as well. More data has been retrieved from the European Conference of Transport Ministries (ECTM) and the European Environmental Agency (EEA) publications where possible to complete the CEE transport conditions. In such cases, the source of data is indicated in each usage.

Chapter 2. CEE transport development issues

The transition from centrally planned economies to market orientation in the CEE region has influenced dramatically on the transport sector. Thus, the transport performance of the CEE countries evolved three main chronic periods. Before explaining the transition stages of the transport sector, this section aims to answer the following main questions: How was the transport situation before the transition? What was the transport trend after the transition? What were the major concerns for the transport sector in the period of EU enlargement? Respective responses then help analyzing transport trends in the next sections.

2.1. Pre-transition period

During the centrally planned periods, the CEE countries had some of the lowest energy efficient transport sectors in the world due to the high utilization of organized transport (USAID 1990, Vorsatz *et al* 2006). Such standing was mainly due the fact that the CEE countries possessed energy efficiency transport modes: for passenger transport activities there were features of frequent and long trips by urban public and rail passenger transports, and for freight transport the rail transport was the dominant mode. The states organized efficient transport modes with cheapest cost (subsidized) and broader networks (Zachariadis and Kouvaritakis 2003, Celinski 1996, Pucher and Buehler 2005). The cities of CEE countries had a record of high public transport trips for example Warsaw and Budapest recorded about 80% share of public transport in the total urban transport trips (Vorsatz 1997). Vorsatz (2006) argues that the two main reasons cause such high share of organized transport:

1. Artificial policy to favor organized trip and to control over personal mobility
2. Low affordability, due to low wages, to use private cars when compared to costs of subsidized public transport.

Moreover the high utility of transport with easy access to main transport lines was preferred as a beneficial alternative to the automobile. Even passenger rail transport had good access of connecting low density villages to the main transportation network (Vorsatz 2006). These factors were the main reasons for the CEE to consume lower energy per passenger kilometre than in OECD and Japan (Vorsatz 1994). According IEA study (1997), transport energy consumption for passenger travel in Poland was less than a quarter of that in Western Europe in 1988.

Many additional background conditions maintained that situation in the region. In terms of transport mode, studies on the pre-transition period argue that the countries had a range of limitation for private cars and road freight. The foremost factor was strong restrictions on individual mobility. It must be noted that in some CEE countries there was an ease of restrictions on car ownership after the 1970s in response to public demand, but that move was not high enough to facilitate determinant modal shift in the region (Pucher and Buehler 2005). According to Pucher and Buehler (2005), the forms of controls were the followings:

- limited private car manufacturing
- bans on imports
- unaffordable high prices for a private car

Nevertheless, the low rate of car utilization was not only government control. The next important factor was social behavior disfavoring passenger cars. The CEE residents preferred the car usage for a few limited purposes unlike more recent car dependency (Pucher and Buehler 2005). By the late 1980s, only 10% of the Czech residents used their cars for commuting to work (Institute of Transportation Engineering 1992). Private cars had only been driven for going to the countryside, to weekend houses, and gardening or during holidays (Pucher and Buehler 2005). Such preference might be due to many reasons such as the low-quality of roads with ‘underdeveloped, obsolete’ infrastructure and sparse petrol stations, low level of technology (low quality vehicles with difficulties of repair) and expensive, bad quality fuel (Zachariadis and Kouvaritakis 2003, Ion *et al.* 2002).

For freight transport, the rail shipping mode was intensively used over road trucks during centrally planned periods (EEA 2003). Further, Suchorzewski (2003) recorded that the shipping and trade over rail transport was concentrated in the COMECOM-Council for Mutual Economic Assistance area and was focused on transporting raw materials and heavy industry products. Such pattern created much higher demand for rail freight transportation in CEE countries than in Western Europe (Major 1983). A well-established infrastructure of organized transport in CEE countries strongly linked the countries through production stages involving longer distances across the region. On other hand, the CEE countries had poor support towards road transport: non-existent motorways (CEEBankwatch 2004), the low-quality fuel (Zachariadis and Kouvaritakis 2003), thus establishing unreliability of road transportation (Landwehr and Marie-Lilliu 2002).

2.2. Post-transition period

When moving to the market-led economies, many transport efficient features of centrally planned economies faced reverse trends in the region. Pucher and Buehler (2005) highlighted important change of transport policy in the early 1990s in such a way that all constraints mentioned in the previous decade were eliminated or restrictions were not enforced, individual mobility started to increase substantially. Empirical evidence proves that the regional transport experienced a significant downturn in the use of rail, buses, and coaches, but there were exponential increases of passenger car ownership and usage (EEA 2002a, Fergusson and Skinner 2001). The road modes became the growing share of the total transport. The next chapters analyze statistical data in regard to this issue.

In passenger transportation, car ownership boomed not only due to economic reasons, but also as a pursuit of individual freedom (Pucher and Buehler 2005). Consequential factors such as growth in income, improvements in technology and infrastructure, and increasing time being available for leisure trips, have led people to travel more often and further (OECD 2006).

As a result of economic recession, wide outcomes were recorded such as unemployment and deteriorating services in the public transport (Celinski 1996; Pucher and Buehler 2005). Then there follows the framework challenges of the financial collapse of the public transport sector. Public transport policies became apparently weak that the sector faced management and financial challenges to keep up transport demands. Central government subsidies for urban public transport were cut and ownership moved to municipalities (Major 2004, Pucher and Buehler 2005). For example, Budapest municipality cut subsidies for public transport by two thirds between 1990 and 2000 (CEE Bankwatch Network 2004). Local governments however could not finance even the maintenance of the existing systems, thus they declined in quality and quantity while they have to increase the fares radically (Major 2004, Pucher and Buehler 2005). Moreover CEE Bankwatch report (2004) points out that big migration of residents moving to suburbs results in elevated increase of cars and decrease of public transport in the city.

The next energy efficient transport - the railways suffered from sharp decreases in both freight and passenger movements since the early 1990s. In addition to unfavorable policies, the underlining factor was the shortage of finance due to the economic downturn of the transition period (Celinski 1996; Pucher and Buehler 2005). For rail freight activity, some CEE countries saw a reduction due to restructuring and modern needs. After the disintegration of COMECON, trade and transport routes have been restructured, and a sudden shift occurred from eastward to westward movement (Celinski 1996). The existing well-developed railway system was not flexible enough to be able to adapt as quickly as the truck transport (Major 2004). Moreover, researchers identified that rail freight activities fell in response to a series of reasons: growing need for elasticity in freight transport, shift from heavy industries, a market gain of small private transport companies, a demand for flexible supply, an increase of shorter distance but smaller volume transportation, etc (Major 2004; Celinski 1996).

2.3. The EU enlargement period

By the time of accession to the European Union, the transport trend in the CEE countries reached a recovery of the transport situation what Boza-Kiss (2005) calls a ‘balance” where restricted mobility and artificially controlled car ownership have changed to levels regulated by affordability, culture and the state of the infrastructure. The CEE countries have adopted EU market structures and environmental legislation, including directives aimed at improving energy efficiency into their local situations (Vorsatz *et al* 2006). The EU directives and policies require member states to adopt and set transport legislative frameworks for facilitating market liberalization that aim to promote better efficiency and good environment mainly through technical and safety standards (World Bank 2004). Ten CEE countries joined the European Union in 2004 and two more in 2007 (EC 2007). In a pace with EU15, the changes of steadily growing GDP, border openings, a wider trade, and all changing lifestyles directly raise more demands for mobility. It can therefore be expected that transport mobility are at the similar level to the EU15 and energy intensities will have dropped to levels close to those in other EU countries. While the rail sector and public transport experience an enormous downturn, road transports (freight and passenger cars) are receiving more emphasis than other modes of transportation to new demand, especially in economies in transition (Person and Backman 1993).

What matters for transport improvement is the finance to create better networks. In the 1990s the European Regional Development Fund (EBRD) and the Cohesion Fund were designed to help overcome regional disparities through financing appropriate projects. At the time, the four poorest EU member states were eligible; Spain, Portugal, Greece, and Ireland (Ion *et al.* 2002). According to United Nations Economic Commission for Europe (UNECE) review

(2008), the EU structural and cohesion funds for co-financing of transport infrastructure projects have been beneficial to the regions lagging behind in per capita incomes. New member states as well as candidate countries can benefit significantly from their access to EIB financing and other forms of EU assistance in their efforts to overcome past underinvestment in the road, rail and urban transport infrastructure (UNECE 2008).

For the development of transport movement, the CEE countries have received various finances to develop transport systems. Investment in the transport infrastructure has increased in EU member states for Central and Eastern Europe reaching about 1.3% of GDP by the mid-2000s (UNECE 2008). Such funds have been managed in different ways depending on receivers. The Instrument for Structural Policies for Pre-Accession (ISPA) grants were mostly invested into road sectors for Romania and Estonia, and the equal amount of distribution for both road and rail in Poland, Lithuania, and Bulgaria (CEE Bankwatch Network 2004). The CEE Bankwatch report (2004) also notes the positive but small trend of investments in the rail sectors for the Czech Republic, Latvia, Hungary, Slovak Republic and Slovenia. Financial support for organized transport takes up a bigger amount in a few cases; EBRD for Bulgarian urban public transport, the rail sector in Czech Republic, Lithuania, Poland and Latvia (CEE Bankwatch 2004). However, in the broad CEE context, the rail sector appears to lack accessibility to EU transport links. Across all EU member countries at current level, the lowest accessibility by rail includes the Baltic States and regions of Romania and Bulgaria (S&W 2007). That shows a door of opportunity to extend the rail networks in broader areas.

A study on the EU road network reports the transport development in the CEE in a meaningful way as “ The development of accessibility indicators between 2001 and 2006 shows the focus of the new member states on prioritizing road infrastructure development at the expense of rail infrastructure and services” (S&W 2007). In general, the large percent of these community grants were flowing into the road sector of CEE transport development, and

Ion and others (2002) estimated that some 40% of grants were actually funding pure road investments. The road sector amounted for about 80% of inland transport investment in the new member states (UNECE 2008). Given the infrastructure development, the road transport movements have dramatically increased, but the high mobility of organized transport in pre-transition record dropped to flat levels (Vorsatz 2006). According to CEE Bank Watch (2004), two thirds of transport loans, accounting some 7.7 billion euros from European Investment bank, were invested in road infrastructure development compared to 17.5% in rail and only 7.5 % in urban transport systems between 1998 and 2003. Having no support and improvements, the grey situation for organized transports are pushing passengers towards individual cars. A poor management of organized transport services include ageing GDR rail due for retirement, less frequent services, discounted lines to less frequent and thus unprofitable areas, and a lack of new lines in freshly developing urban areas (Boza-Kiss 2005). For instance in Budapest, the indicator of passenger-km per person per day is growing in relation to increased resettling outside the capital and that trend facilitates the growing need for longer commuting and private car ownership (Dobrocsi 2005).

International organizations and non-government organizations recommend for the New EU Member States to use the Structural Funds carefully based on the mistakes of the Cohesion Countries. The Bankwatch's study points out that much of the fund was used for road rehabilitation, and in some cases countries abused the projects by taking the opportunity to finance rail investments from ISPA, to concentrate the national budget spending on roads. According to Bankwatch's study (2004), about 56% of the Instrument for Structural Policies for Pre-Accession (ISPA) projects was invested in the road transport sector between 2000 and 2002. The relative share of transport sub-sectors is shown in Figure-1. Similar cases were documented for the developments of the TINA and International Financial Institutions.

Poland even passed a "special law" valid till 2007 to give priority of road construction over environmental protection and other laws (CEEBankwatch 2004).

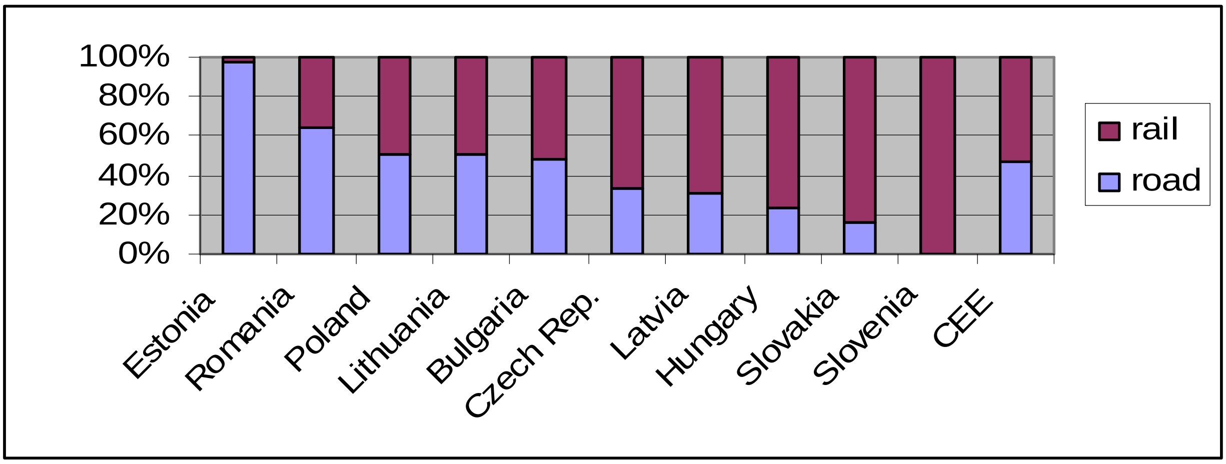


Figure 1. Share of transport sub-sectors of ISPA 2000-2002 grants in CEE-10 countries. Source of data: CEEBankwatch 2004

The road development is likely to increase in the CEE region because some CEE countries still lack accessibility to the EU wide road networks. A study by Spiekermann & Wegener (2007) points out that regions of Baltic States, Bulgaria, Romania are the countries with the lowest potential access while Poland and the Czech Republic, which are called ‘winners’ in terms of road accessibility to the EU, have the highest relative growth in the EU due to infrastructure projects and the reduction of border waiting.

A general growth of road transport directly facilitates transport energy consumption. In fact, transport final energy consumption increased on average by 15% between 1990 and 2000 in the CEE countries mainly due to their growth in road transport energy consumption (EEA 2003).

Consequently, modal split has dramatically changed in recent years. Real road transport has increased passenger and freight activities while rails transport experienced larger declines (OECD 2006). In European Environment Agency’s latest study (2008), more transport policies need to direct reducing energy consumption and GHG emission because the previous and current EU policies on vehicle technology and fuel quality have not been enough to offset increased emissions of transport activities. Effective policies need to use the advantage of energy efficient implication of different modes (EEA 2008). Therefore, the EEA (2008) recognizes additional measures to reduce GHG emissions from transport, of transport mode supportive measures are proposed as following:

- Coordination and optimal use of different modes of transport
- Ensuring shift from less to more energy efficient transport modes
- Construction and maintenance of infrastructure. This can contribute to changing the attractiveness of different modes

In connection with the EU enlargement, some CEE countries are receiving supports for rail freight transportation such as the Trans-European Transport Network (TEN), Pan-European Transport Network (PAN), Transport Infrastructure Needs Assessment (TINA) and Pilot Actions for Combined Transport (PACT) (Lewis et al, 2001). For instance, Baltic countries are implementing the EU funded construction project, Baltic that affects the two transport corridors of the EU that will pass through the Baltics, corridor 1 (Helsinki-Gdansk/Warsaw) and corridor IX Helsinki/Klaipeda/Kaliningrad-Moscow/Odessa/Alexandroupolis (Spens *et al* 2004; Kovacs and Spens 2006). No real economic and environmental studies have conducted in this end yet.

Applying the situation into the CEE's transport situation today, Vorsatz (2006) appraises a window of opportunity for transport policy leapfrogging in favor for energy efficient modes. Researchers (Spens et al 2004) also stress the diverse role of each mode in the logistics chain, and propose a regional market place that facilitates co-operation for a common goal and healthy competitive services to meet the needs of economies.

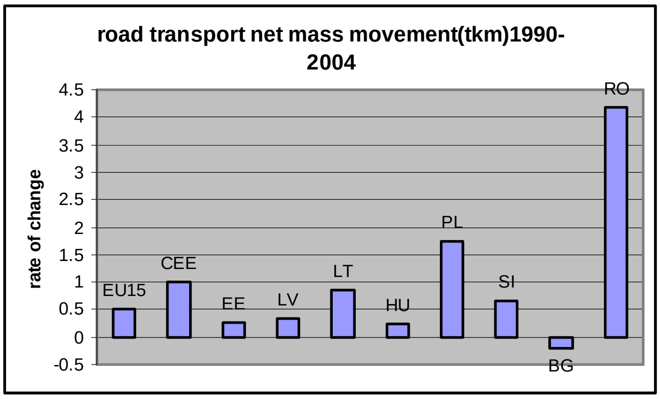
In order to claim the promotion of proper policy on transport modes in the newly emerged market economies, the importance of organized modes and their substitute modes of transport need to be thoroughly examined. Fulfilling such purpose, the following sections will analyze the transport trends since the early 1990s where appropriate include the comparison over centrally planned periods and a benchmarking with mostly the average EU-15 and few other world indicators.

Chapter 3. CEE transport trend data analyses

3.1. CEE regional transport trend since 1990

Following the discussion on regional transport development, this section explores transport indicators across the CEE countries right after the transition. According to the model analysis by Zachariadis and Kouvaritakis (2003), both road passenger and freight transport activities in the CEE are projected to increase 2.5 fold by year 2030 than 2003. It is important to see real statistical evidence on how transport indicators remained in the region. Hence this part of the thesis analyzes the main changes in CEE transportation after the 1990s.

In order to see the transition changes, this section reviews two transport sub-sectors, road and rail. Road and rail sectors each contain an aggregated measure (tonne-kilometre) of both passenger and freight activities. During transition years of a decade and half, the rates of transportation saw large changes across the CEE countries (See Figure-2). Note that the available data are different on road and rail sectors.



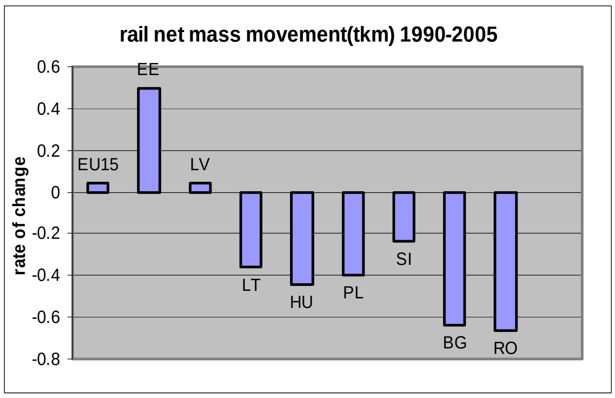


Figure 2. Changes in net mass transport activities **Source: DG TREN, 2006 and ECTM 2007**

As it can be seen on the Figure-2, the CEE countries show a wide diversity of changes over the transition years. Road transport activities have increased by half in the EU-15 average, but the CEE average saw entire fold increases. Only Bulgaria experienced a decline in road transport as opposed to more than four folds of growth for the same indicator for Romania. A huge positive change in Romanian road transport has the opposite consequence in the largest loss in rail transport. Rail transport has about 30% decreases for CEE countries while EU-15 stayed stable with only 4% increase. However, only two newly EU joined Baltic States, Estonia and Latvia show the increase of rail transportation during the transition years.

The underling issue is the share of different modes that make up total transport activities in each sector. In regard to the latest statistics by 2004, the percentages of total inland transportation in global scale are illustrated in Figure-3. For estimating changes, passenger transport activities are indicated by passenger-kilometre, and freight transport activities are indicated by tonne-kilometre.

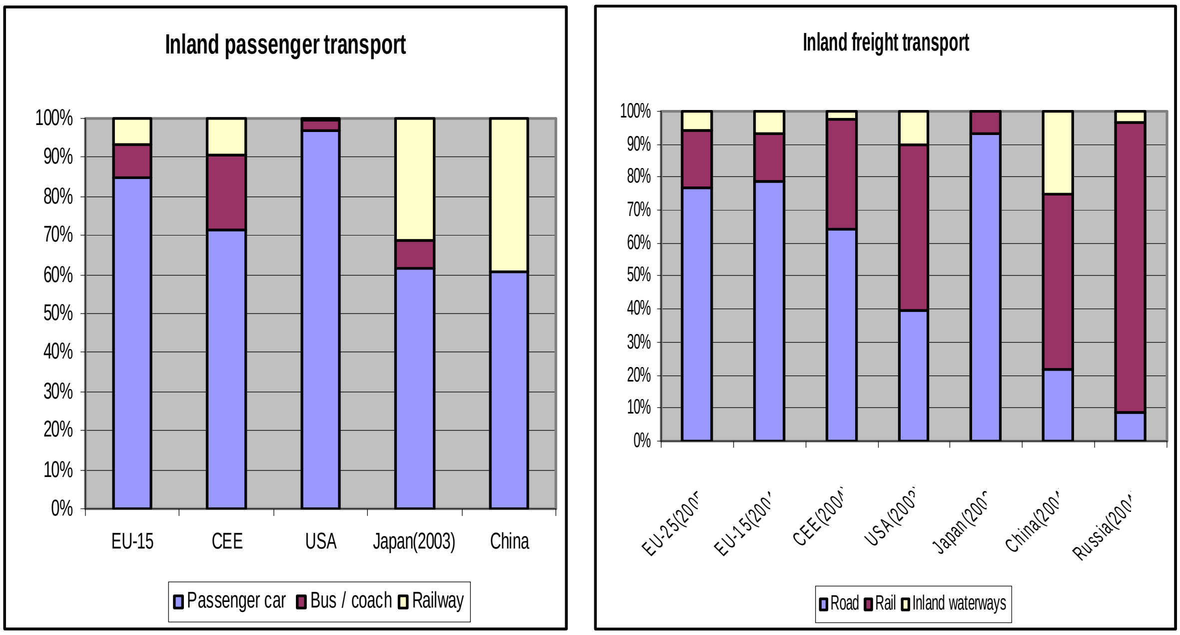


Figure 3. World modal split of total inland transport (tkm&pkm) 2004

Source: TG TREN: Energy and Transport in Figures: Transport , 2006

This comparison suggests that the CEE has the third highest share of road sector (about 70%) for passenger activities, following after USA (95%) and EU-15(83%) by 2004 in the world. The larger portion of public transport and rails in the CEE passenger transport highlights an existing window of opportunity, compared to the EU-15 and USA. In terms of freight activities, the CEE region has the third highest road share (about 65%) after Japan (over 90%) and EU-15 (about 80%). Russia and China enjoy the dominant share of rail transportation, 90% and 60% respectively. Nevertheless, the rail freight transportation still constitutes some 30% of total CEE inland transportation. The next chapters analyze detailed changes in the passenger and freight transport activities over the transition years.

3.2. Passenger transport

Recognizing the diversity over the transport sectors, passenger activity includes passenger car, rail passenger transport and a special section for public transport. Passenger mobility in both rail and road transport experienced substantial changes after the transition. Before the transition, the CEE region had remarkably low mobility compared with Western Europe; rail and public transport were the most frequent modes (USAID 1990). Empirical evidence suggests that the CEE countries saw significant modal shift while EU-15 countries have kept a constant share of transport modes for the last decade and half. To view comparative illustration between the EU-15 and the CEE, see Figure-4.

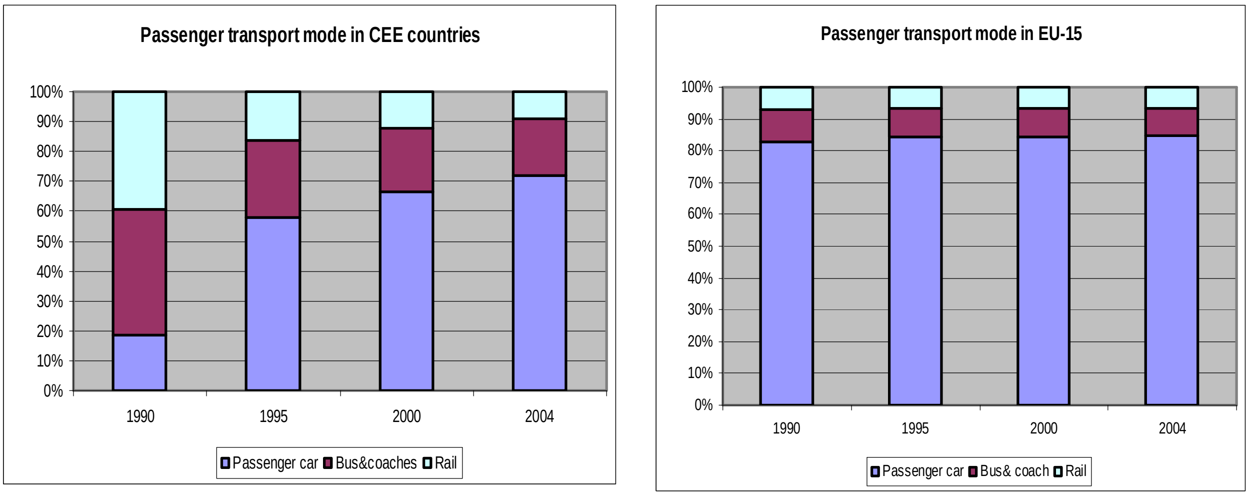


Figure 4. Modal split percentage shares (1000 mio pkm)

Source: DG TREN: Transport 2006

The share of passenger cars in the CEE passenger transportation reached 70% in 2004 from 18% in 1990. On the contrary, rail and buses saw dramatic decline in the share of total passenger movement. Rail passenger transport in the CEE was 40% of modal share by 1990, but decreased its role to less than 20% in 2004. The share of buses and coaches for the CEE decreased from 40% in 1990 to 10% in 2004.

It is therefore imperative to examine how above mentioned modal shift occurred in individual CEE countries over transition years. The study selects major base years to compare the CEE countries and the EU-15.

3.2.1. Passenger car movement

From the early 1990s, passenger cars continue to grow significantly in all CEE countries.

Empirically two main transport indicators (motorization of cars per 1000 inhabitants and utilization of per passenger kilometre) for passenger cars saw significant growth in the CEE countries.

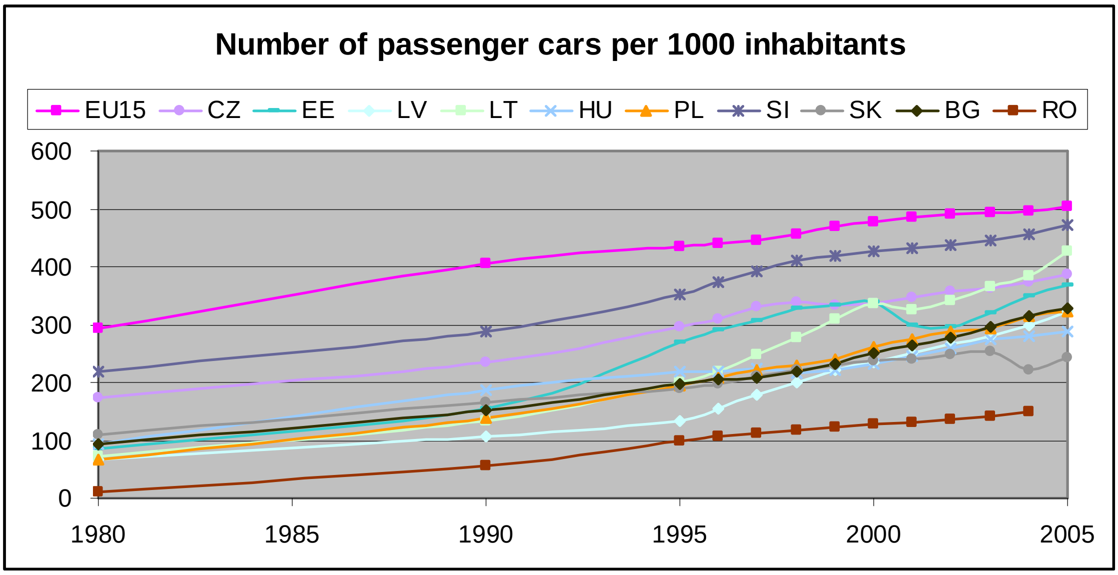


Figure 5. Motorization in Europe **Source: DG TREN: Transport 2006**

The CEE region saw an exponential increase of motorization since after the transition, and especially last decade shows the highest growth (See Figure-5). This motorization is indicated by the number of cars per thousand inhabitants. According to this figure, the CEE countries saw growth ranging from the lowest of 50% increases in Slovakia and Hungary to the highest as over two fold increases in Latvia and Lithuania between 1990 and 2005. At the same time, the EU-15 average indicates about 25 % increases in the same indicator.

Between 1993 and 2005, UNECE transport statistics (2008) show that the highest increase of passenger car ownership growth (82%) was in Poland and the lowest (31%) in Slovakia whilst all countries saw increasing changes ranging between the two positive points. A short trend after year 2000 appears to be important as some CEE countries such as Slovenia and Estonia have reduced growth in car ownership. Besides, the amount of traffic is also influenced by prices, speed and quality of transport, and also by personal preferences and priorities. Those effects are not taken into full consideration in this study.

Data sources prove that the vehicle stock quantity has been utilized with increasing degree in the CEE. See overall regional changes in Figure-6. Car transport mobility (passenger per kilometer) is measured by per capita indicators for the CEE countries.

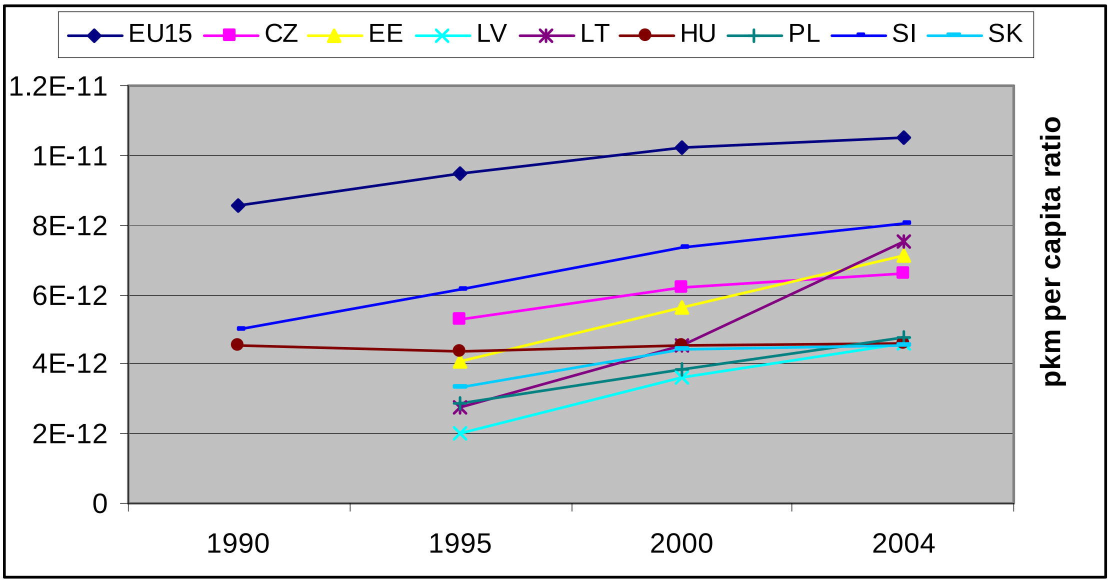


Figure 6. CEE passenger car movement per capita **Source: ECTM 2007 and Eurostat 2008**

Passenger car mobility in the CEE saw enormous increases over the transition years whilst the average EU-15 maintained some 15% increases in the last decade. Still CEE countries show about half amount of the EU-15 average ratio, suggesting further increase of passenger movements in the future. Among the CEE, Slovenia presents the highest ratio and Latvia has the lowest indicator. The highest passenger car utilization reached 160% growth in Lithuania between 1995 and 2005. One exception is Hungary that maintained the utilization in a stable manner over 15 successive years. Poland, the Czech Republic, and Hungary have larger passenger car fleets than the rest of the CEE countries.

3.2.2. Public transport trend

Use of public transport, which was recorded at very high level during the centrally planned economies, has lost importance in the CEE region whereas the average EU-15 has managed to increase the public transportation gradually during the last decade and half. A sustainable transport study from Regional Environmental Center (REC 2004) concludes the public transportation trend in the CEE countries:

> " [a]fter a rapid loss of passengers from 1990 to 1995, varying between 15-25 percent in different countries, public transport in Central and Eastern Europe entered a period of slowed decline in usage, with an average yearly decreases of between 1-3 percent"(p9).

Confirming this conclusion with the latest statistical data on the CEE countries, this section attempts to further study the changes in real terms. Figure-7 displays the trend of public transport modes (buses and coaches, and trams and metros) by 1000 million passenger kilometre indicator.

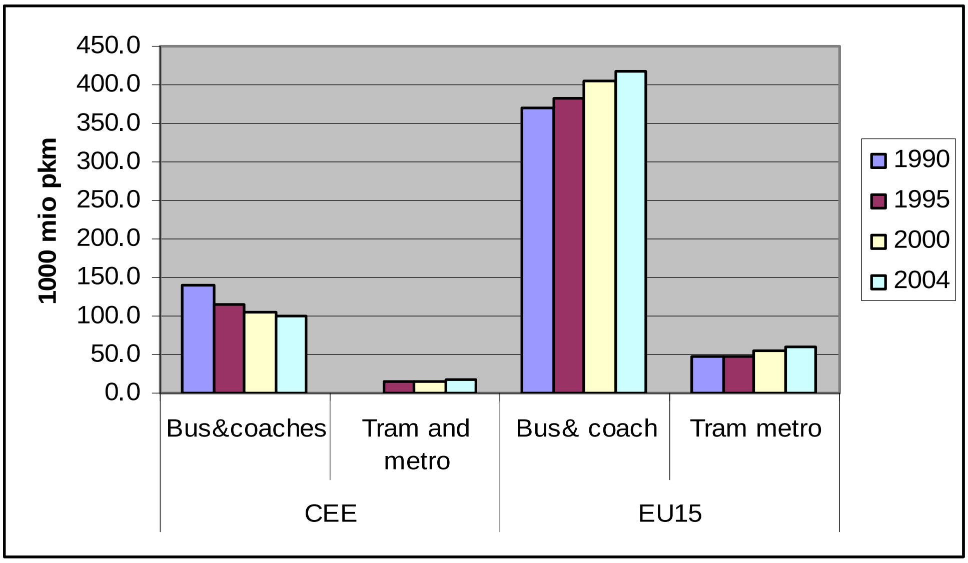


Figure 7. Public transport movement in Europe since 1990

Source: DG TREN: Transport 2006

There are clear differences across the transition years. The CEE countries have a declining trend for buses and a quite stable trend for trams and metros whilst the average EU-15 has a trend of growth for all modes. The average EU-15 has three times bigger volume of buses and more than half larger trams and metros than those of the CEE. In case of buses and coaches, the changes are pictured in Figure-8. The indicator illustrates 1000 million passengers kilometre by per capita ratio. This per capita ratio indicator makes comparison meaningful for the CEE countries and even for a benchmark example of the EU-15 average.

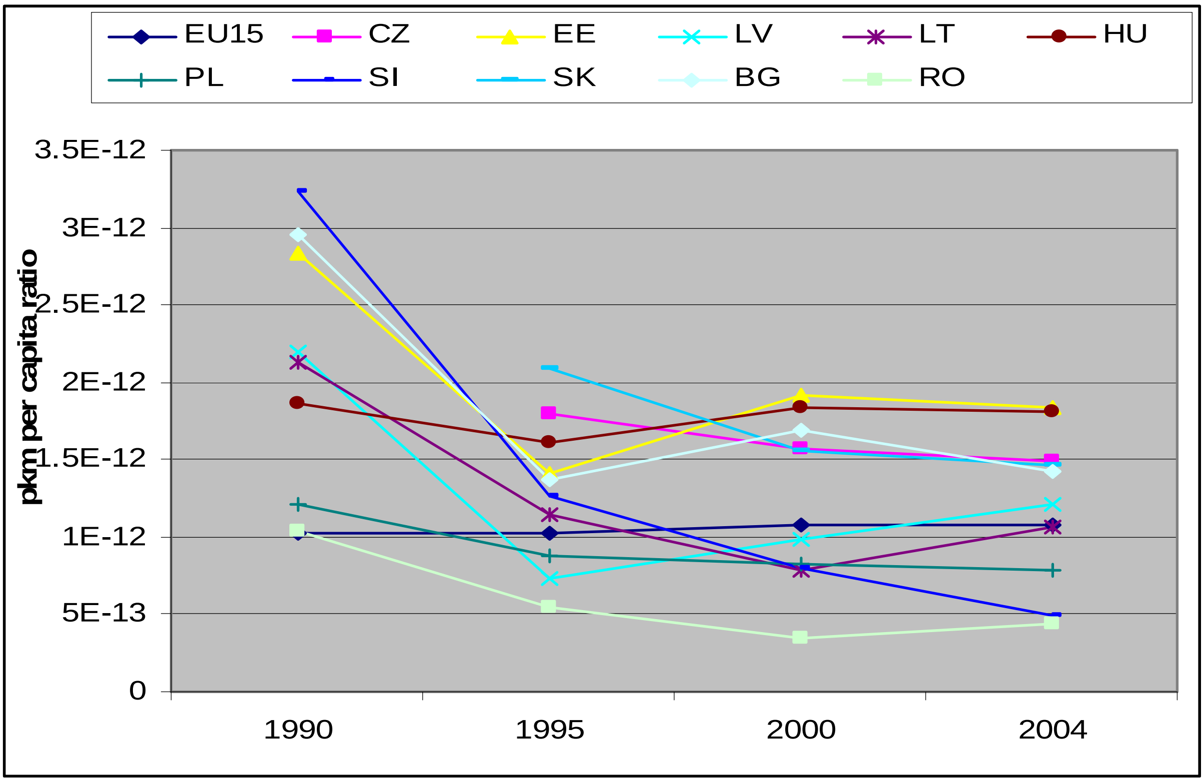


Figure 8. CEE public transport(buses and coaches) movement per capita

Source: Eurostat 2008 and ECMT 2007

Figure-7 displays a huge variability of changes in the CEE as compared to the constant indicator in the EU-15. Only Hungary shows a stable trend with a small reduction (-2%) out of 10 CEE countries. The transition years between 1990 and 2000 saw the biggest loss of public transport amounting to 45% decreases for the average CEE whilst the average EU-15 maintained a stable trend of 5% increase. Although all CEE saw decline in public transport movement, some CEE countries still preserve the highest ridership of buses and coaches by per capita indicator, reporting a higher ratio than EU-15. Those CEE countries are Bulgaria, Hungary, Estonia and the Czech Republic. The important message is that all CEE countries have lost their high utilization of public transport since the early 1990s, in turn more energy consuming transport modes have taken larger share in the total passenger transport activities for the CEE.

Following the EU membership, the CEE countries have a sign of recovery, including the fact that Romania, Latvia and Lithuania have positive recovery, and the rest of CEE countries still continued to decrease public transport ridership between 2000 and 2005.

See the public transport changes of two time periods in Figure-9 (1990 – 2000) and Figure-10 (2000 – 2005). The first decade after the transition shows dramatic losses in the public transport movement, amounting more than 50% decreases. The largest loss was noted in Slovenia reaching more than 75%. Hungary alone implies more or less stable trend with less than 5% decreases. After dramatic losses during the first transition decade, the recent five years reveal positive trends for the CEE. These percentage change losses during the last five years are lower than the same indicators between 1990 and 2000. In recent years, the countries with the highest public transport losses began positive changes, reaching more than 20% increases in Romania, Latvia and Lithuania. The baseline for estimating changes in the last five years is year 2000 when CEE countries had the lowest standing for public transport activities.

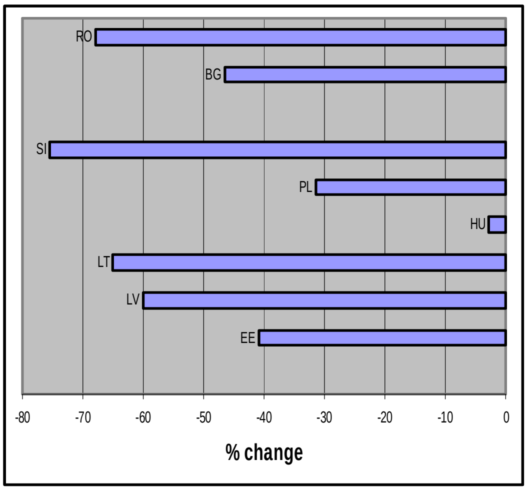


Figure 9. Public transport movement(mio pkm) change between 1990 and 2000

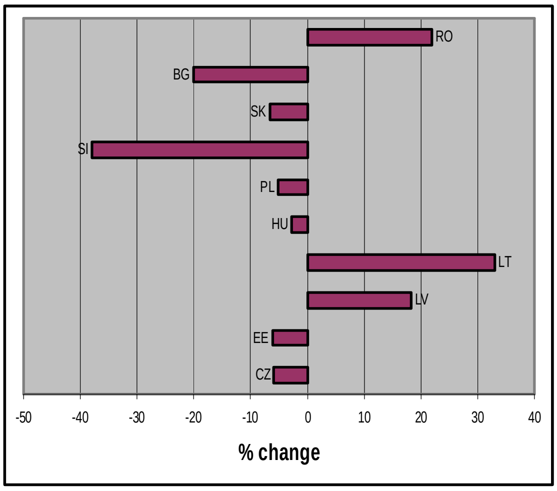


Figure 10. Public transport movement(mio pkm) change between 2000 and 2005

Source: Eurostat 2008 and ECMT 2007

A World Bank study in 2004 stresses the impact of EU membership for Baltic public transport as the new arrangement of tendering allows competitive services. For example, Tartu in

Estonia has gone through transport development changes with support from the EU legislation, and now their performances show better services, which the World Bank study(2004) views as a result of the dominance of the EU market share (Sweden and Finland). Therefore, recent positive trends need to be promoted strongly to achieve wider result of public transport mobility, hence better improvement in the passenger transport energy intensity. Otherwise countries continue losing the share of public transport in passenger movements.

3.2.3. Rail passenger transport

Rail passenger movements show huge differences between the centrally planned period and years after the transition. Figure -11 clearly illustrates the trend of rail passenger per capita in the CEE and the average EU-15. This trend is measured by 1000 million passenger kilometre indicator.

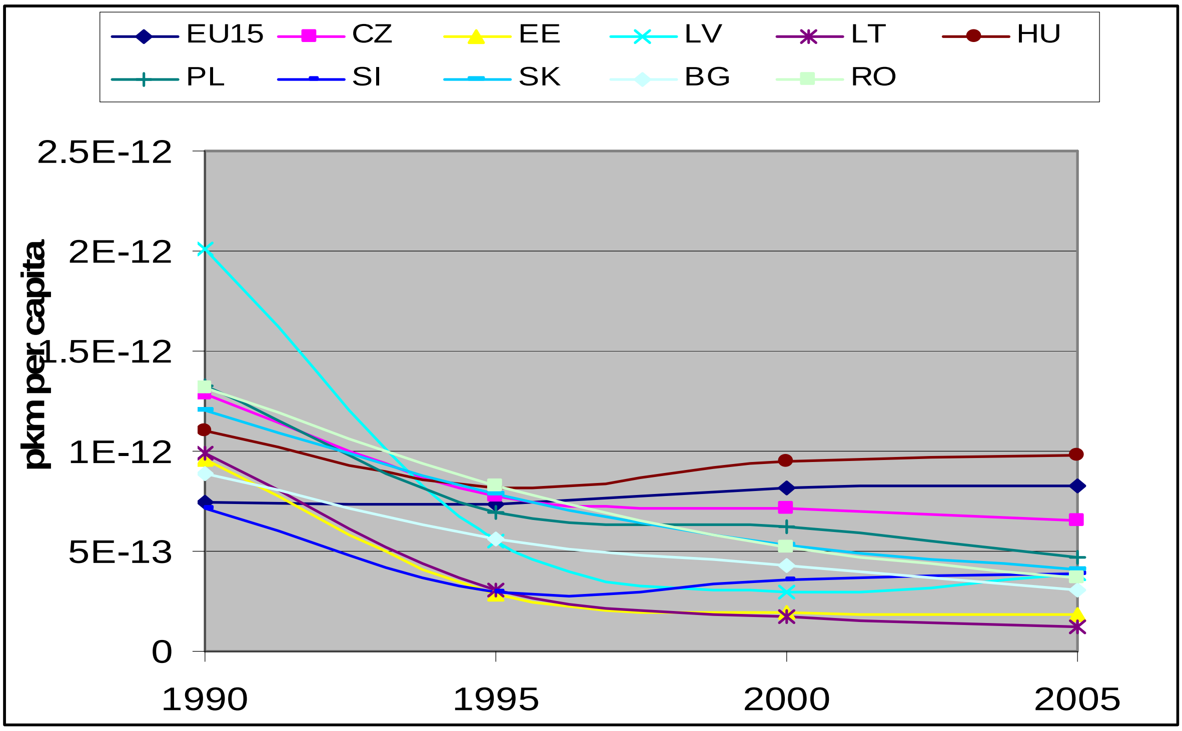


Figure 11. CEE rail passenger movement per capita **Source: EC DG TREN 2007**

According to Figure-11, all CEE countries saw overall decline in rail passenger movement per capita indicators ranging between -50% and - 85% between 1990 and 2005. As an average indicator, the CEE accounts some -60% decline while the average EU-15 kept some 10% increases in the same period. The graph shows a small recovery for some CEE countries since the mid-1990s, but the increase is still way lower than the 1990 level. Hungary accounts the smallest loss (-10%) of rail passenger fleet, but continues to carry higher rail travel per capita than the average EU-15.

The Baltic States of the CEE show the highest percentage of losses. The lowest rail passenger level since 1990 was recorded in 2001 and only domestic traffic was carried in Latvia and Estonia (World Bank 2004). This might be due to the specific destination. For international level, Russia is a main destination accounting about 20% of total rail passenger activity in Lithuania. The World Bank study(2004) acknowledges that the strong loss of passengers is because of better road management in buses and preference for cars in the Baltic States. The losses of rail passenger mobility in each CEE country are presented by percentage in Figure-12.

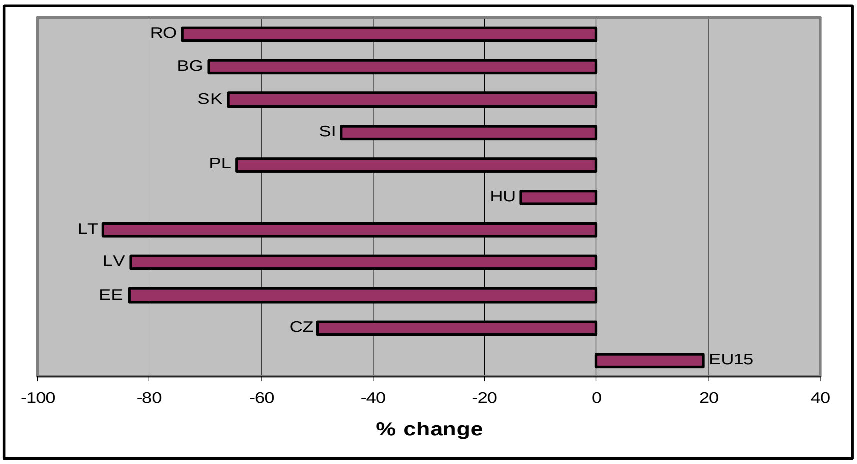


Figure 12. Rail passenger movement(pkm) change in the CEE between 1990 and 2005

Source: EC DG TREN 2007

3.3. Freight transport

The current CEE regional trend appears to have the dominant share of road modes for freight transportation (UNECE 2008). During the centrally planned economies, rail freight constituted the largest amount of transportation in the CEE region. For example, Poland had an extensive railway system that served a major role in moving goods between the Former Soviet Union and Western Europe and between Czechoslovakia and Polish ports (USAID 1990). However, freight shipping has experienced dramatic changes in the CEE during the transition years.

The current trend brings interesting results. It is apparent that road and rail freight fleets exchanged positions in the mid 1990s. At that time, the share of road transport increased strongly, reaching some 65% in 2005 at the expense of rail transport. Researchers such as Zachariadis and Kouvaritakis(2003) discussed similar results for freight transport as well. They projected the future dominance of trucks in freight activities rather than trains, which was higher in the pre-1990s situation. This can be explained primarily by historical preference for rail transport in the centrally planned economies in CEE. European Environment Agency (2008) explains that the liberalization of markets led to the decrease in heavy industry in those economies alongside an increasing demand for more flexible road transport. According to EEA report (2008), economic transition in the new EU member states resulted in slower freight transport growth than their Gross Domestic Product (freight increased by 35%, GDP increased by 50%) between 1995 and 2005.

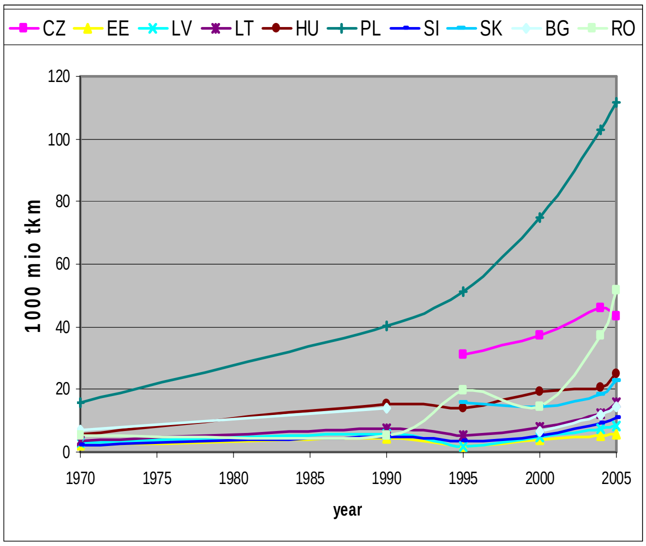


Figure 13. Road freight movement in the CEE

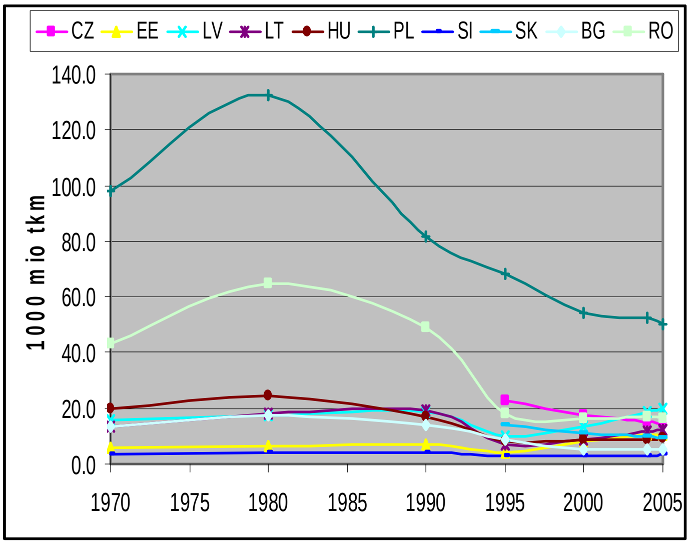


Figure 14. Rail freight movement in the CEE

Source: ECTM 2007

Two contrasting trends in the CEE freight transportation are displayed together in the same time periods at Figure-13 and Figure-14. The trends are indicated by thousand million tonne-kilometre. Between 1990 and 2005, road freight had more than an entire fold increase in all CEE countries including the records of Lithuania (120%), Poland (177%), and Slovenia (125%). The very clear example is Poland. Poland's Rail was 6 folds higher than road mode in 1970s. By 1990s, rail freight was double folds higher in rail than road in 1990, but the trend reversed as road freight took over more than double folds in 2005.

On the contrary, rail freight activity has decreased in all the CEE countries since 1990s, failing its high utilization in the CEE during the centrally planned period. A decade after the transition, all CEE countries report losses of more than 30% of rail shipping. The changes are indicated by percentages in Figure-15. Surprisingly Estonia alone among other CEE countries achieved about 15 % of increases in rail freight during the transition period. This could be linked with the fact that railway labor productivity in Estonia has more than tripled since 1989 and doubled between 2001 and 2006 according to EBRD data. These growths are due to the recent privatization of the rail sector: passenger rail service (South-West Railways) in 2000 and freight carrier (Estonian Railways) in 2001(UNECE 2008). Moreover, Latvia and

Lithuania still had railways under the public sector while Estonia implemented privatization of rail in 2001(World Bank 2004).

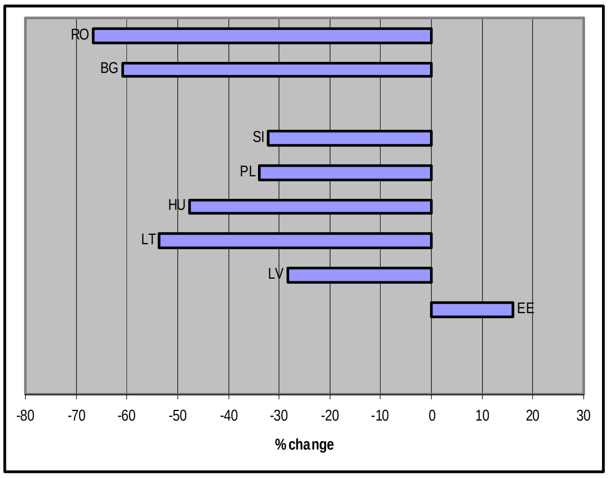


Figure 15. Rail freight movement % change between 1990 and 2000

Source: Eurostat 2008 and ECMT 2007

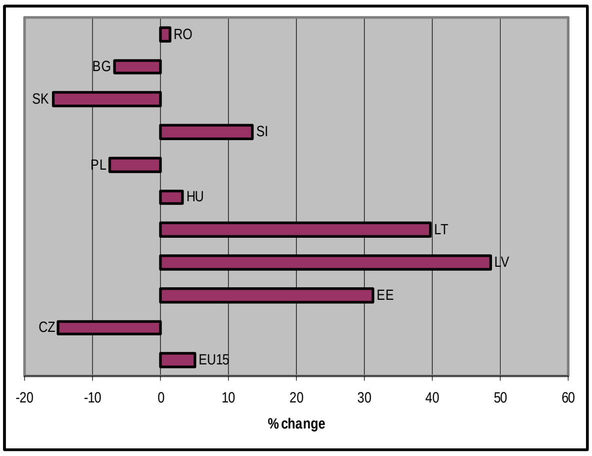


Figure 16. rail freight movement % change between 2000 and 2005

A recent trend of five year changes shows a door of opportunity to facilitate rail freight activities in the region. In fact the European Council of Ministries of Transport (2005) reports that the rail passenger and rail freight shipping started to slowly increase again in the CEE countries just before the EU accession. Many positive changes emerge in some CEE countries, as seen in Figure-16. Like the average EU-15, about half of the CEE countries reveal positive growth in rail freight. The Baltic States, comprising of Latvia, Lithuania and Estonia, carried more goods by rail shipping recent years. Researchers proved a direct correlation between freight transport and economic development (Hesse and Rodrigue 2004; Goh and Ang 2000). Ojala and co-researchers (2004) found out that transport demand was four times faster for Baltic States than their GDP growth and that rate was even three times higher than their counterparts in CEE. According to the World Bank seminar report (2004), rail freight increases in Baltic countries were due to oil transit amounting 80% of Estonian, 70% of Latvian, and 36% of Lithuanian rail freight traffic. A main factor is oil transportation from Russia. The volume of oil and oil products through Baltic States grew from 50 million tons in 1997 to 100millions in 2003, the study notes. Laurila(2003) estimates that some 40% of Russian exports to the rest of EU transported through the Baltic States. Rail Gazette International reported that “ [r]ecent growth in the Russian oil trade has offset the decline of smoke-stack industry, and EVR now enjoys traffic levels almost equivalent to those handled in Soviet times” (Burkhardt and Posner 2002).

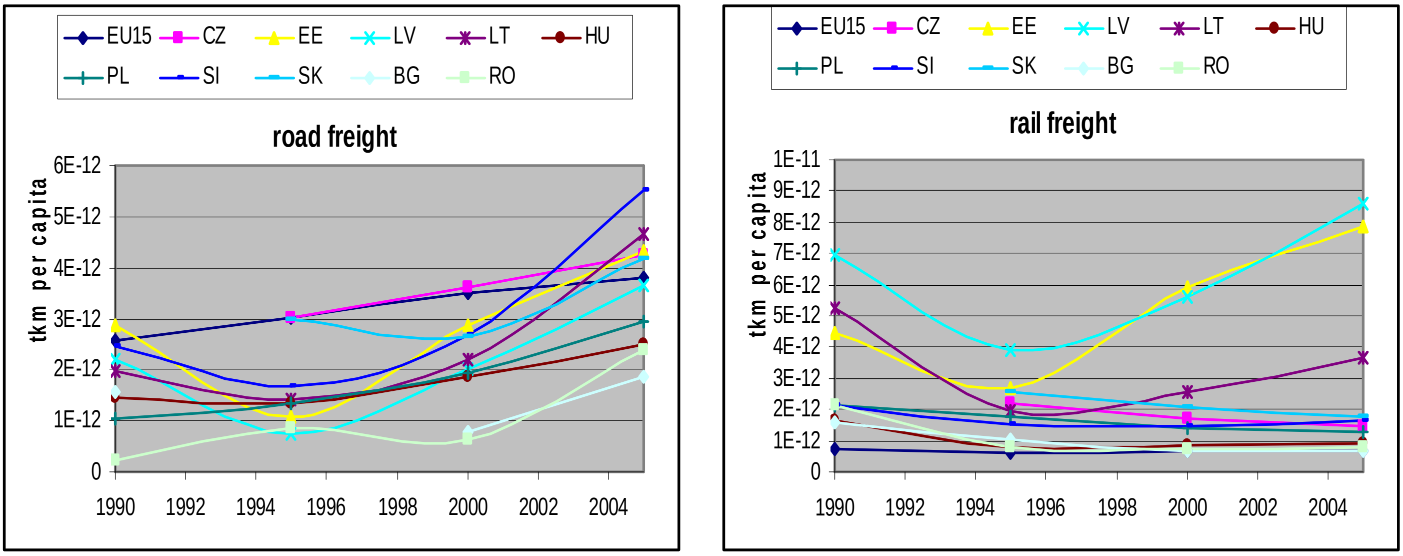


Figure 17. Freight transports per capita **Source: Eurostat 2008 & EC 2007**

To compare the CEE countries one another, the summary is in Figure-17. All CEE countries experienced a sudden drop in their freight activities during the mid-1990s. Most CEE countries saw dramatic increases of road freight activities whilst a gradual increase was observed for the average EU-15 and the Czech Republic whose the ratio is almost equal to the EU-15 average. In recent years some CEE countries, including Baltic States and Slovenia indicate higher freight per capita ratio than the average EU-15 ratio. In rail freight, the most CEE countries show a decline over the years, but the Baltic States managed to overpass their freight ratio of 1990s.

Chapter 4. CEE transport energy and GHG trend data analyses

4.1. CEE transport energy

Transport energy consumption in the CEE region has grown exponentially during the last decade and a half according to the European Union's statistics (Eurostat 2008), but the overall picture contains different waves. There were small reductions in transport energy consumption during the early 1990s, just after the transition. Then, the energy consumption sharply over-passed the 1990's level by the mid-1990s and continues to grow dramatically. Annual energy indicators as tons of oil equivalent (toe) are scaled by thousands in Figure-18.

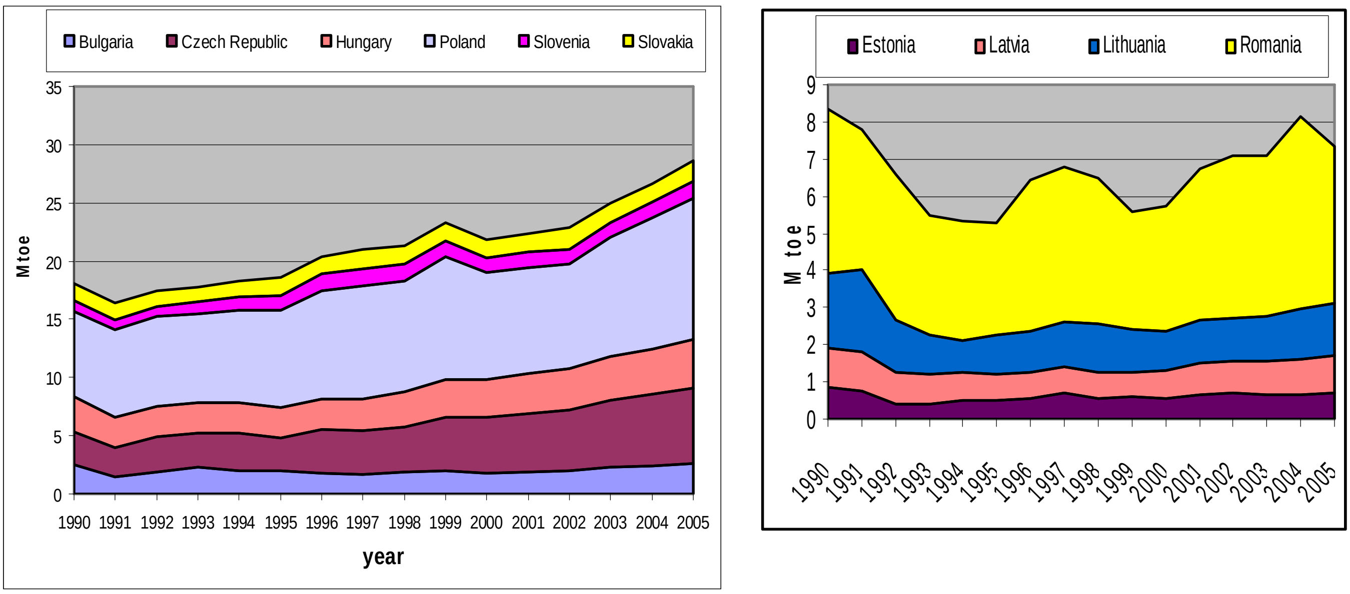


Figure 18. CEE total transport energy consumption **Source: Eurostat 2008**

As shown in the Figure-18, many CEE countries are consuming larger energy for transport over the transition years. Between 1990 and 2005 four CEE countries have reduced their energy consumption: Lithuania (-30%), Estonia (-13%), and more or less stable trend Latvia (-8%) and Romania (-4%). But, further desegregation of total transport energy into specific indicators explains energy implication for individual countries and the regional average.

In order to compare across countries, this section further looks at total transport energy ratio per capita. Figure-19 shows chronic performance of the CEE countries compared with the average EU-15.

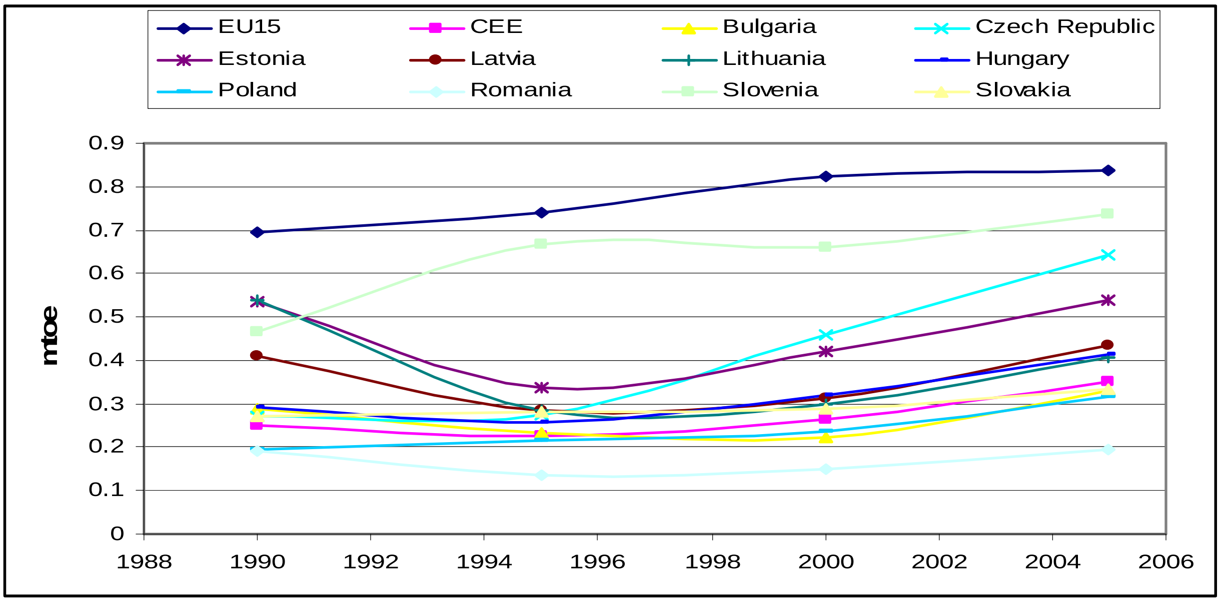


Figure 19. Transport energy per capita.
Source: DG TREN: Energy in Figures 2007 and Eurostat 2008.

Figure-19 indicates that there appear some common trends across the CEE. The countries saw clear reduction in transport energy per capita during the mid-1990s, but continue to overpass the 1990s level in the early 2000s or recent years. Most countries show positive growth between 1990 and 2005, and the Czech Republic accounted as the highest in the region with137%. Estonia shows no growth and follows a stable trend. The only decrease was in Lithuania (-24%) in the same time period. The average ratio for CEE has increased by some 33% between 1990 and 2005. But only about a 20% growth is seen for EU-15.

Overall the CEE countries have about 3 folds lower average energy per capita ratio than that of the average EU-15 in 2005. This implies a future room to increase the transport energy ratio even higher as the CEE economies improve and residents will earn more. For that reason, the EU-15 saw a continuous growth of transport energy per capita in the given time period. However, the EU-15 follows a gradual growth pattern whereas the CEE countries display much fluctuation over the time period. Pacing with the EU-15, Slovenia appears to follow as the same pattern of growth and the same amount of energy per capita indicator as the EU-15. This trend of Slovenia means their transport energy has reached similar maturity as the EU-15 and the rest of CEE countries are likely to follow Slovenia's path.

Researchers such as Wilde and Sijm (2006) argue that increasing energy use per capita can be a result of balancing two sides. One side may include the consolidation of energy improvements in all transport modes and higher load factor; another side means relative swift towards energy intensive modes, large volume vehicles and low loads with high speed logistic chains. Relevant analyses for the CEE countries are discussed in later sections.

4.2. CEE transport GHG emissions

The Intergovernmental Panel on Climate Change reports that major transport fuel is largely dominated by petroleum oil products today, thus transport energy consumption directly facilitates the growth of GHG emissions (Kahn Ribeiro *et al* 2007). Therefore, Figure-20 provides a regional trend of emissions from the transport sector. This GHG growth reflects a similar trend of total transport energy consumption.

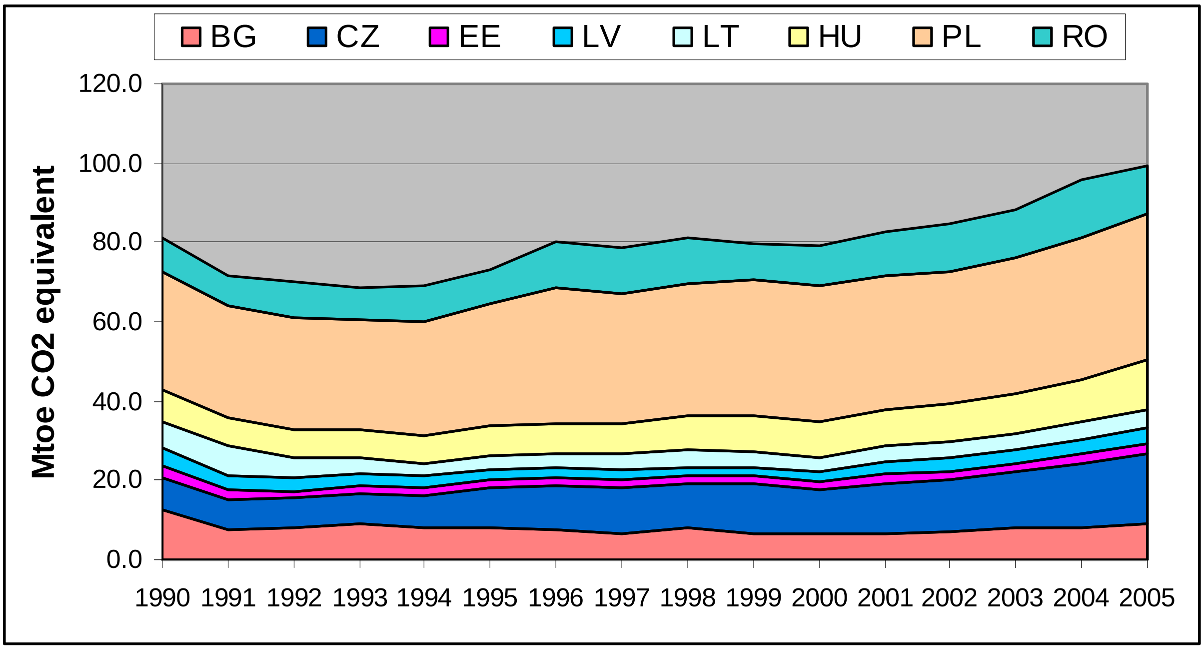


Figure 20. GHG emissions in the CEE countries between 1990 and 2005 Source; EEA 2007

According to the European Environmental Agency's report on transport (2008), the GHG emissions from transport increased more in the 12 new EU Member States (30%) than in the EU15 (26%) between 1990 and 2005. Many CEE countries saw higher increases in GHG emissions from transport, but four CEE countries, Estonia (31%), Lithuania (27%), Bulgaria (25%) and Latvia (20%), report drops in the emissions between 1990 and 2005. Further, the European Topic Centre/ Air and Climate Change data in EEA 2008 review shows individual country figures in Figure-21. Although the amount of percentage change differs country to country, it is imperative to observe a similar patter of growth CO_2 as well (See Figure-22).

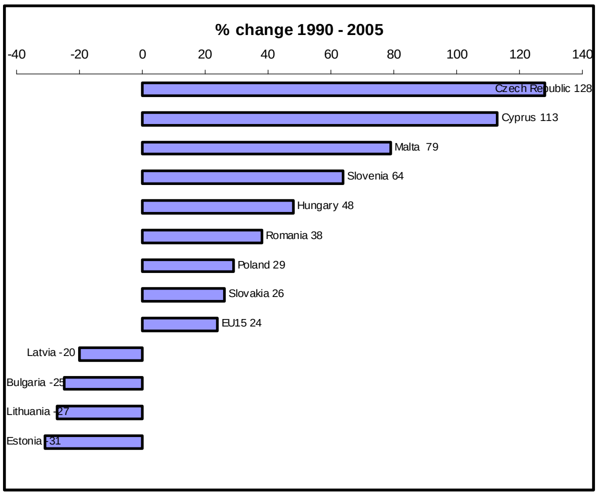


Figure 21. GHG emissions from transport (CO_2 equivalent)

Source: EEA 2008

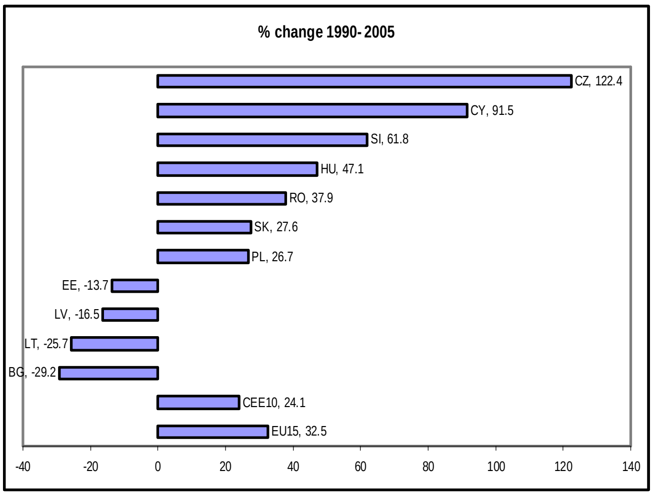


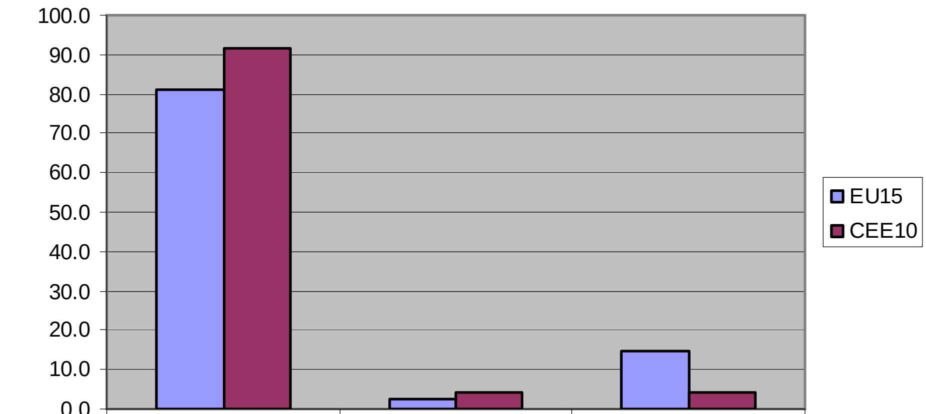
Figure 22. CO_2 emissions from transport

Source: DG TREN: Environment 2007

Most CEE countries report increased GHG emissions ranging between 30% and 120% peak changes. The Baltic States and Bulgaria reveal reductions in the same indicators up to 30%. Despite reductions in some CEE countries, CO2 emissions from transport are foreseen to increase by 70% between 2000 and 2030 even when treating biofuels as CO2 neutral (Zachariadis and Kouvaritakis 2003).

4.3. Road transport energy

This section first looks at the energy situation of road transport modes in recent years for both the CEE and EU-15.



	Road	Railways	Air
EU15	81.1	2.5	14.8
CEE10	91.7	4.1	4.0

Figure 23. 2005 transport energy consumption by percentage in modes

Source: EC EU Energy in Figures 2007

For modal distribution by year 2005, the road sector constitutes larger share of transport energy (91%) in the CEE countries (excluding Malta and Cyprus) as compared to that of 81.1% in the EU-15. Rail and air sectors have almost equal share in the CEE as illustrated in Figure-23.

Road transport plays a determinant role in shaping total transport energy consumption due to the amount of vehicle stock and energy consumption per vehicle. It is clear that the pattern of energy consumption for road transport shapes the total transport energy consumption for the CEE over the transition years (See Figure-24). Most CEE countries saw an increased use of road transport energy. The highest growth was in the Czech Republic, which increased road transport energy by 157% between 1990 and 2005. Only Lithuania (-26%) and Estonia (-15%) show falling trends in road transport energy during the same time period.

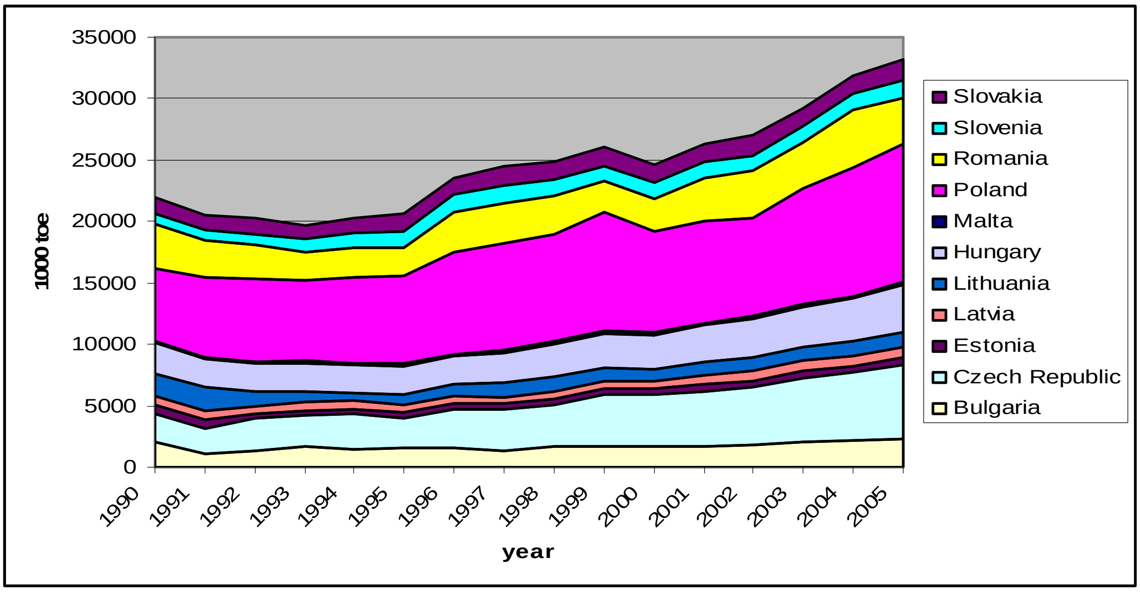


Figure 24. Road transport energy consumption in the CEE countries between 1990 and 2005

Source: Eurostat 2008

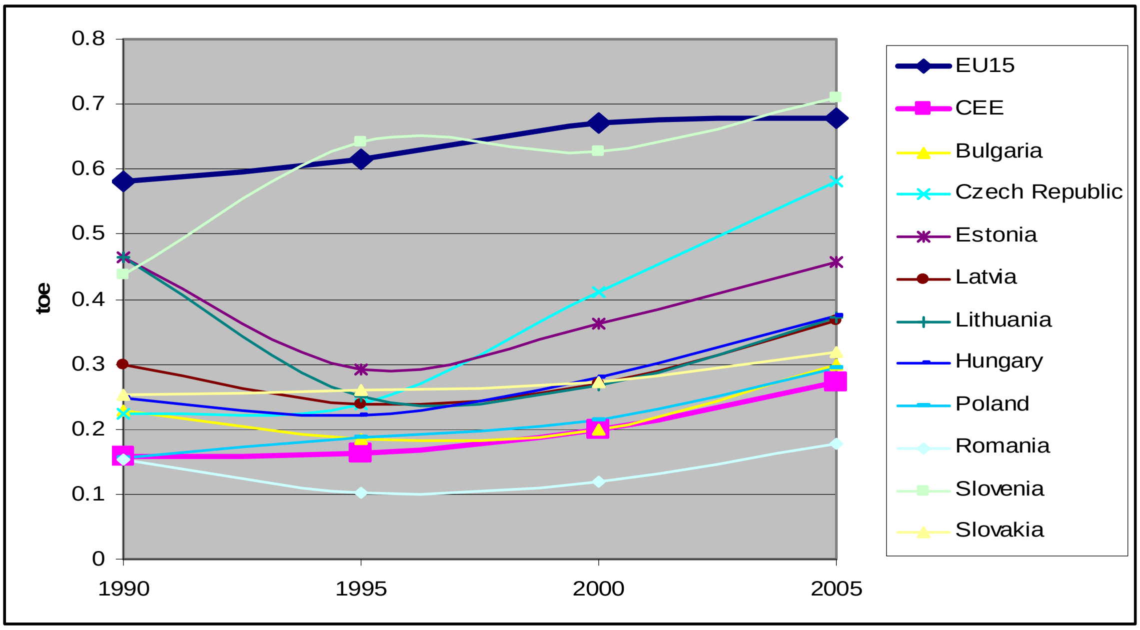


Figure 25. Road transport energy per capita

Source: Eurostat 2008

Even though the total road transport energy increases year by year, the energy ratio per capita implies country specific indicators to compare the CEE country standing within them. Figure-25 shows indicators for the CEE countries and the EU-15 over the transition years. As seen in Figure-25, the CEE had a diverse trend.

Most CEE countries stand at levels below the EU-15 average, which remained a more or less stable trend over the years. Slovenia seems to be maintaining the highest energy consumption per capita pacing with the average EU-15 since the mid-1990s. Most other CEE countries show trends of intensity decline during the mid-1990s from the1990 level, and continue to sharply increase later then. There appear two main trends in road transport energy per capita: slower growth and/or reduction between 1990 and 1995; and all positive sharp growth between 1995 and 2005. By 2005 most countries saw overall growth since after the transition (1990 base year), except Estonia and Lithuania whose recent high growth has not recovered their 1990s level yet.

4.4. Rail transport energy

On the other hand, the share of rail transport energy consumption has shrunk in the CEE after the transition. All CEE countries show decreasing trends in rail transport energy since the 1990 whilst the EU-15 average saw an increase. The overall picture for the CEE is presented at Figure-26.

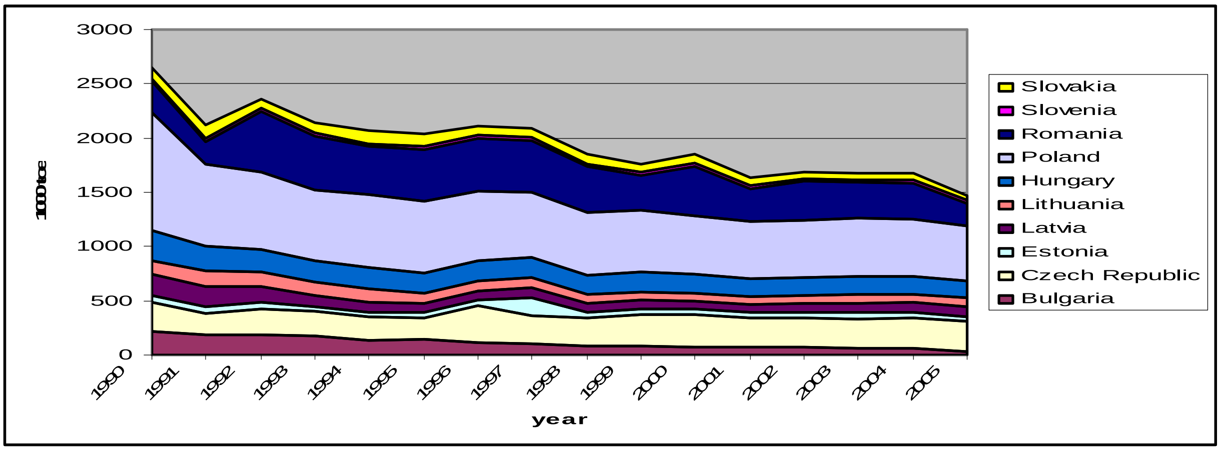


Figure 26. Rail transport energy consumption in the CEE countries between 1990 and 2005

Source: Eurostat 2008

Then, Figure-27 quantifies individual percentage changes between 1990 and 2005. This graph indicates that some 20% of rail energy increases in the EU-15 and up to over 80% reductions in the CEE countries. Although many CEE countries experienced noticeable reductions, Slovenia and the Czech Republic saw no changes in energy consumption for rail transport in the last decade and a half.

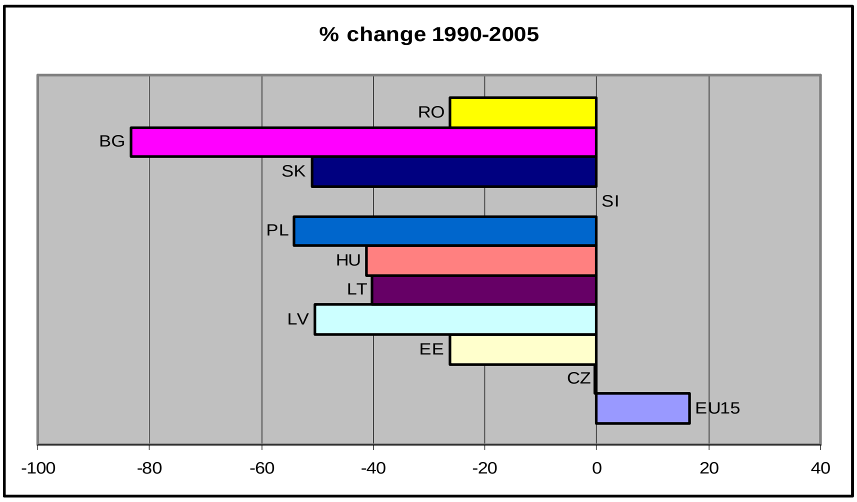


Figure 27. Rail energy changes in Europe Source: Eurostat 2008

In order to compare the countries one another, the CEE rail transport energy consumption per capita is presented (See Figure-28). Figure-28 shows that the CEE average lost some 33% of rail energy per capita ratio during the transition years whilst the average EU-15 had some 10% increases. Although Latvia saw substantial losses of 40% over the years, the country kept its record still higher than the CEE and the average EU-15. At the same time, the Czech Republic and Slovenia remained constant. The biggest loss was in Bulgaria reaching some 80% for the indicator. Many CEE countries still have a higher ratio of rail energy per capita than the average EU-15.

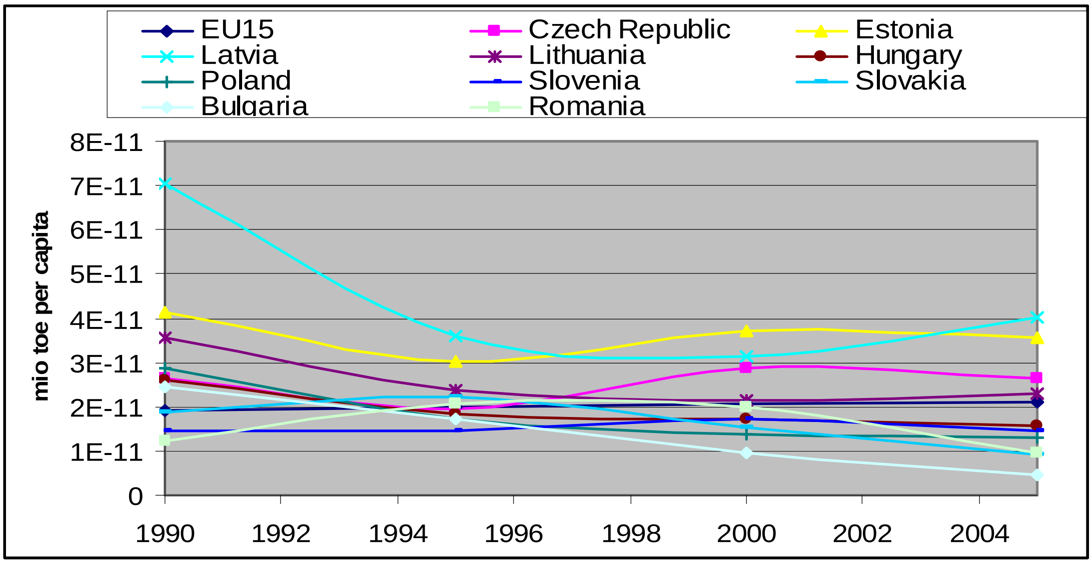
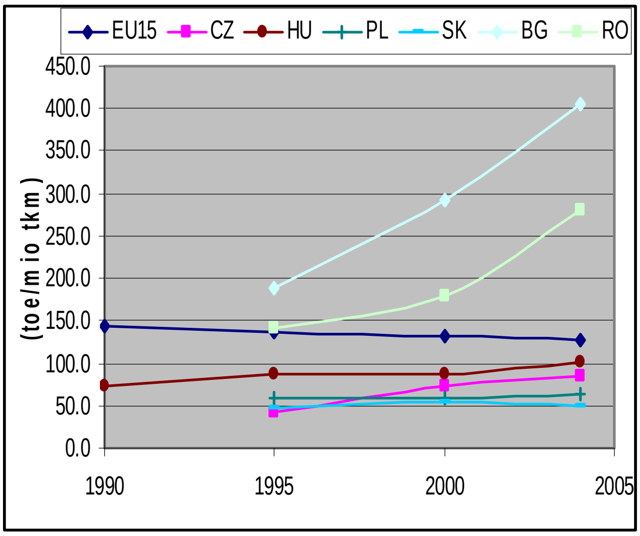


Figure 28. CEE rail energy per capita **Source: Eurostat 2008**

Chapter 5. CEE transport energy intensity analyses

During the last decade and a half, the CEE transport energy intensity has changed dramatically. The results of calculation are shown in Figure-29. There appears a wide variability of trends across the CEE countries and over time scale. Recognizing their common trends, there are two graphs presented below: left hand graph contains the countries with increasing energy intensity; another includes the countries with decline in energy intensity. The average EU-15 is included in the both as a comparison.



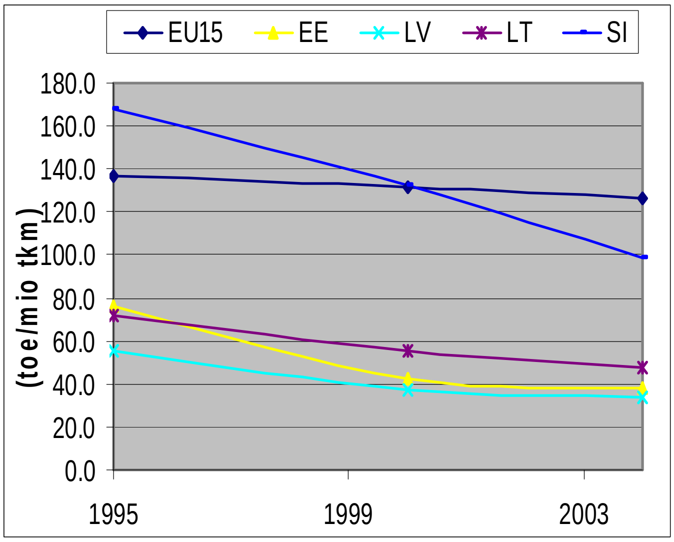


Figure 29.CEE Transport energy intensity (energy consumption/net mass movement)

Source: Eurostat 2008; ECTM 2007; EC DG TREN 2006

The EU-15 average, Hungary and Slovenia show the changes in transport energy intensity over the last decade and a half, but other CEE countries have data only for the last decade. The Czech Republic, Hungary, and Romania report substantial increases in the intensity more than 20% each. Poland and Slovakia saw a small increase (8%). Hungary saw increases in the intensity over the years with a higher rate in last five years and slight lift-up during the mid-1990s.

Slovenia saw dramatic increases during the mid-1990s and substantial reductions in the last decade. The Slovenia's indicators over the last few years are still higher than its 1990 level. The Baltic States (Lithuania, Estonia, and Latvia) saw decreases constituting less than -30%.

In general, less transport energy intensity or less energy use per tonne-movement (net mass) mean the following important implications:

1. Technical improvements in auto vehicles to use less fuel per distance traveled. Nevertheless, the real result of improvements will clearly be apparent as significant efficiency improvements for cars and trucks up to 2020 while the actual implementation takes place between 2000 and 2010 (Zachariadis and Kouvaritakis 2003)
2. Higher intensity of load achieved. In other words, more goods or passengers have been carried per a kilometre distance (IPCC 2007)
3. The share of energy efficient mode in the transport activities (Wright and Fulton 2005)

The following sections attempt to understand if the energy intensity changes in transport activities are as result of modal shifts in the CEE.

5.1. CEE transport energy intensity by activities

5.1.1. Passenger transport

The passenger transport in this section contains the rail passenger transport, the public transport, and the passenger cars. Specific energy consumption for total passenger transport is obtained through the proportion analyses and that method is explained in the earlier section. The energy intensity for CEE passenger transport is illustrated in Figure-30.

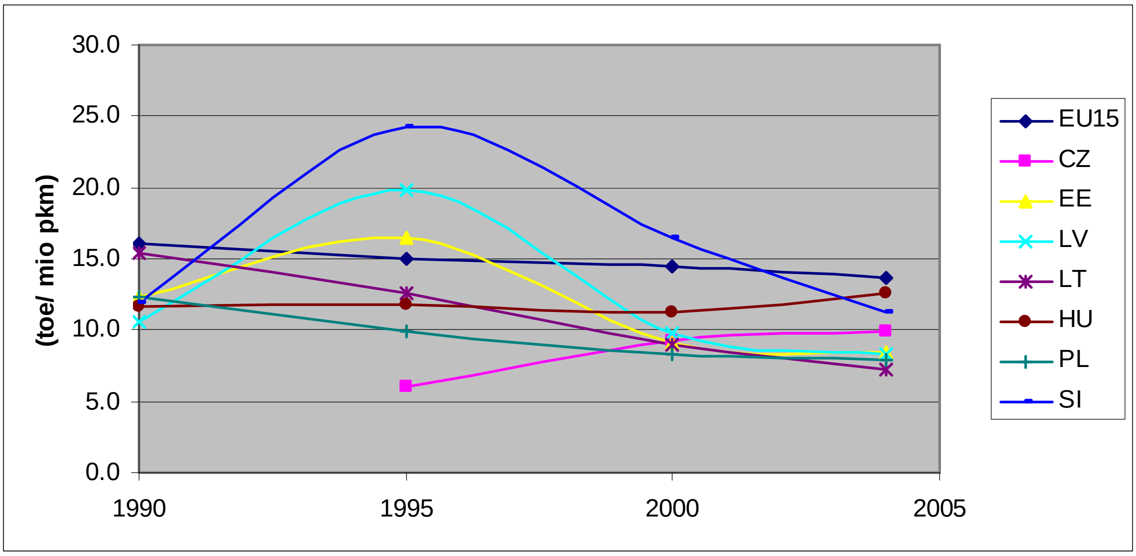


Figure 30. CEE passenger transport energy intensity

Whilst the average EU-15 reveals gradual reduction of some 14%, the CEE contains diverse trends over the transition years. Moreover, the CEE countries maintained lower energy intensity indicators than the EU-15 average in the early 1990s and recent years. During their peak records in the mid-1990s, some CEE countries had the intensity level much higher than the average EU-15. The CEE followed a larger magnitude of changes in their trends. Positive increases in the passenger transport energy intensity is observed in the Czech Republic, Bulgaria and Hungary, but Hungary saw a more or less stable trend with only small increase amounting some 8% across the transition years. Slovenia, Latvia and Estonia show exponential increases during the mid-1990s and the continue dropping dramatically. As improvement in the intensity, Lithuania and Poland continuously reduce the transport energy intensity for passenger activities over the years.

According to the scenario analyses, which was prepared for EU energy and transport (Mantzos *et al* 2004), the most CEE countries saw impressive changes in the passenger transport energy intensities since after the transition (See Table-1).

Table 1. CEE passenger transport energy intensity scenario (toe/mio pkm)

	1990	1995	2000	2005
CZ	16.9	18.1	27.1	27.4
EE	34.3	36.3	32	32.7
HU	27.4	28.3	31.2	31.6
LV	12.4	32.2	26.4	26.5
LT	54.7	35.1	38.6	39.1
PL	20.5	23.2	25.3	25.6
SK	34.6	30.5	34.2	35.4
Sl	31.9	49.2	44.9	45.2
EU15	40.7	39.8	40.2	40

Source: Mantzos *et al* 2004

Whilst the average EU-15 remains very stable trend at the same time period, the CEE countries have two major trends across the countries. The first trend features overall reduction in the energy intensity between 1990 and 2005. Estonia and Latvia show an exponential growth during the mid-1990s and, since then, keep reducing the intensity below the 1990s. Estonia saw a minor loss of less than 10%, but Latvia saw decline of some 30% during the last decade and a half.

The second trend is the general increase of the intensity for the CEE countries over the transition years. Slovakia remained in a stable trend with minor increase of two percent, and Hungary managed some 15% increase over the transition years. The rest of CEE countries had increases more than 30%, including the highest increase of more than a fold in Lithuania and 60% increase in the Czech Republic.

In support for energy efficiency for passenger transport, there have been great changes in technology. USAID report (1990) on energy efficient technology notes that "[d]iesel is slowly replacing gasoline use in trucks and buses" (p17). Concerning over fuel efficiency in passenger cars and public transport, a noticeable discussion has taken place among policy researchers. Gommers (1998) strongly argues that there is big gap in the fuel efficiency measurements between private cars and public transport modes such as buses and coaches.

Much improvement happens for passenger cars because higher public pressure lobbied for and voluntary arguments have been designed between car industries.

5.1.2. Freight transport

A freight transport energy intensity indicator takes account of both rail and road freight transport activities. Their respective energy consumption are considered through calculating the energy intensity indicator. Note that the other modes of freight activities are excluded in this aggregation. For freight transport activity, the CEE countries have different energy intensity trends over the transition years (See Figure-31). As comparison, the average EU-15 expresses a gradual reduction in its energy intensity amounting some -10% declines, but the CEE countries saw increases in energy intensity during the early 1990s and start to diversify various trends since the mid-1990s. Only Slovenia overpasses the average EU-15 during the mid-1990s and radically managed to decrease in the recent years, however Slovenia's reduction is still higher than the 1990s level. Gradually the differences in the intensity ratio between the average EU-15 and some CEE countries (Romania, the Czech Republic, and Hungary) become closer over the time, especially in the recent decade. An appreciating fact is that the Baltic States report reductions up to 50%, but the rest of CEE countries saw increases in the intensity.

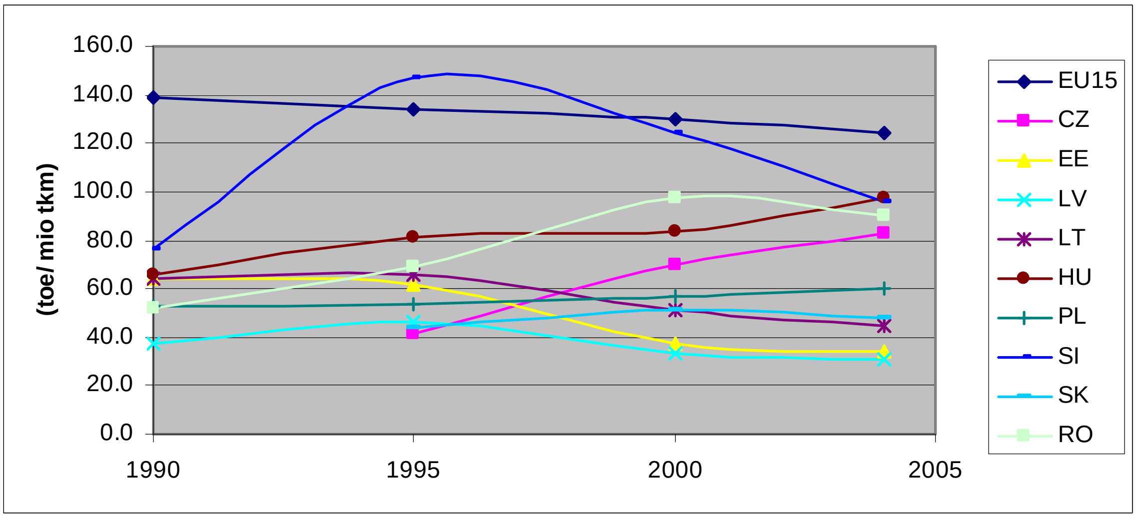


Figure 31. Energy intensity for freight activity (estimation)

Like passenger transport energy intensity estimation in this thesis, Mantzos and others (2004) estimated the scenario of energy intensity for freight transportation as a part of whole EU scenario analyses (See Table-2). These scenario results show that the CEE had dramatic changes in terms of country selection and yearly time scale, but the average EU-15 saw a stable trend with minor increase in the freight transport energy intensity. Estonia alone reduced its intensity level below the 1990s, reaching some 10% declines between 1990 and 2005. During the transition years, Estonia, Hungary, Latvia, and Lithuania saw substantial increases up till the mid-1990s and then all declined remarkably by 2000. The most CEE countries had substantial increases in the intensity indicator. Among them, the lowest growth rate was in Slovenia with 15%, and the Czech Republic had the highest growth of 85% increases.

Table 2. CEE freight transport energy intensity scenario (toe/ mio tkm)

	1990	1995	2000	2005
CZ	17.8	24.1	31.8	33.4
EE	37	32.3	24.8	33
HU	32.3	41.3	39.4	41.6
LV	11.9	16.7	14.2	17.6
LT	24.6	37.2	31.8	36.3
PL	24.1	26.6	28	29.6
SK	27.8	27	26.1	35.1
Sl	44.8	43.5	39.6	51.7
EU15	57.8	58.5	57.3	58.5

Source: Mantzos *et al* 2004

5.2.1. CEE road transport energy intensity

How road transport energy was used implies significant energy intensity degree. These changes are illustrated in Figure-32. The trends show the ratios of energy consumption for aggregated net mass movement which includes both passengers and freight. Whilst the average EU-15 shows a gradual reduction between 1990 and 2004, the CEE countries show various results.

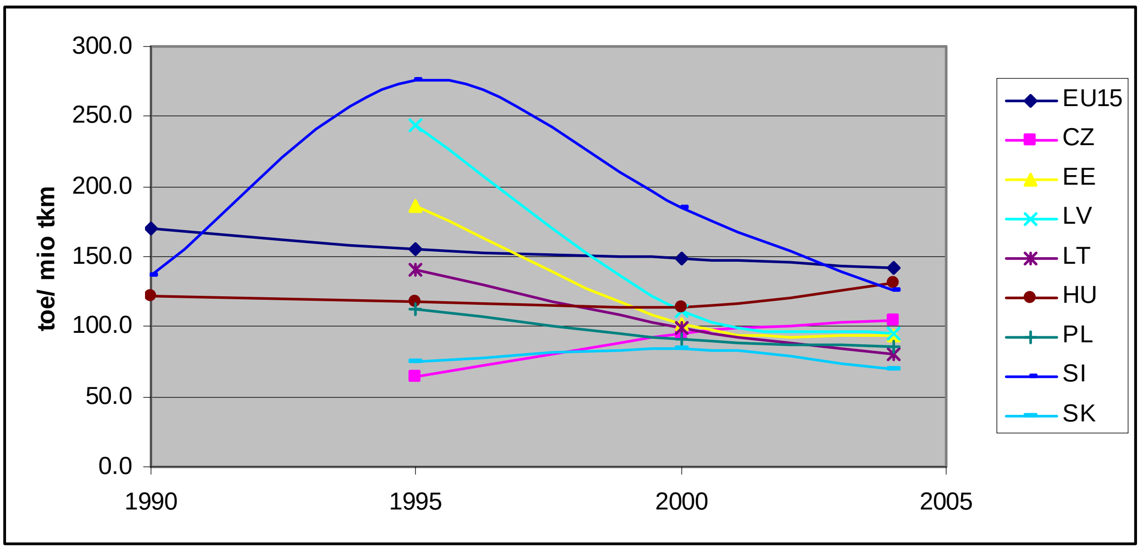


Figure 32. Road transport energy per net mass movement (estimation)

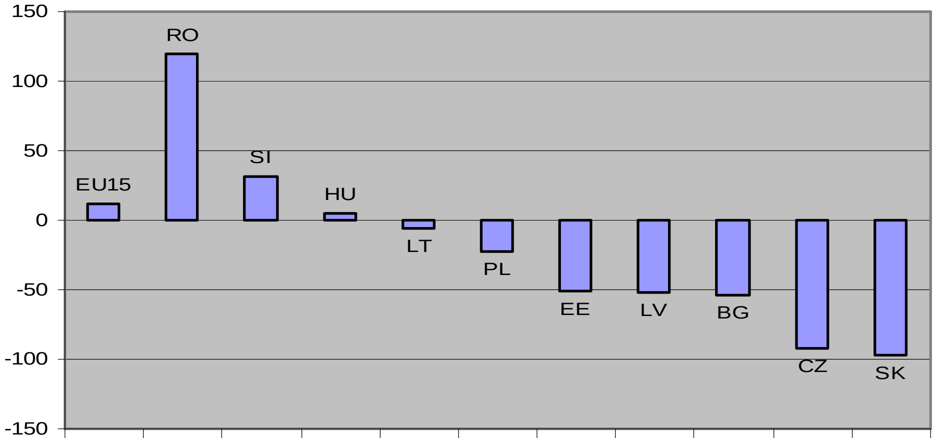
To review the entire transition years, two CEE countries have data available up to 1990. The rest of CEE countries have available data only for the last decade. Slovenia had dramatic increases of road transport energy intensity during the mid-1990s and advances reducing her energy intensity below the 1990s level in the recent years. Hungary stays a more or less stable trend with sudden increases in the recent years.

There is a noticeable diversity of indicators across the countries. Although all CEE countries have lower transport energy intensity than the average EU15 today, some CEE countries reached much higher peaks than the EU-15 during the mid 1990s. Hence, there appear huge decreases in the recent decade as compared to the peak records. Latvia saw the highest reduction of 60%, and other reductions are Slovenia (54%), Estonia (50%), Lithuania (42%), Poland (23%), and Slovakia (7%) between 1995 and 2004. Only the Czech Republic and Hungary show increases in the road transport energy intensity amounting some 60% and 12% respectively in the same time period. Note that Romania and Bulgaria are excluded in this part of analysis due to lack of data.

5.2.2. CEE rail transport energy intensity

The CEE rail transport has different energy intensity implications over the transition years. First, the total rail transport energy intensity means rail energy consumption ratio per net mass movement, which consolidates both passenger and freight activities. As this indicator is not exact measure of energy intensity, the changes over time is taken into consideration for this thesis. Besides, the USAID report on energy efficient technology (1990) notes that “[f]or rail [transport], electricity and diesel have replaced coal and residual oil” in the CEE countries in the early 1990s. It suggests that a future decline in energy intensity is realized in comparison with the centrally planned periods.

In general, many CEE countries show reductions for rail transport energy intensity while the average EU-15 and three other CEE countries report growth during the same time period according to the Figure-33. The percentage changes imply a more or less stable growth for the average EU-15, Hungary and Lithuania.



	EU15	RO	SI	HU	LT	PL	EE	LV	BG	CZ	SK
% change	12	120	31	5	-6	-23	-51	-52	-54	-92	-97

Figure 33. Rail transport energy intensity changes(toe/mio tkm) between 1990 and 2005

Chapter 6. Discussion on transport energy intensity and modal shift

This section discusses key findings from the CEE transport analyses, including transport activity trends and energy implications. As a summary of CEE countries, the detailed indicators for the CEE are presented in Table-3. The table summarizes the results of CEE transport indicators with two time scales: the top section illustrates the entire changes after the transition in the last decade and a half, and the lower section shows changes in the last decade. There are two main reasons for dividing the trends in two time scale. First, as the CEE countries show a turning point in transport and energy trends by 1995, that year serves as a separation. Many CEE countries such as the Baltic States and Slovenia etc, show different trends over the entire transition years and the last decade after 1995. Second, the most CEE countries have a better availability of data after 1995. Thus, many whole analyses are studied for the last decade. The sign ↑ means growth or positive changes, and the sign ↓ means decreases, the **0 –** means no change. Blank indicates no data available for that section.

Table 3. Summary findings of CEE transport

Country/Indicators	Total transport energy	Road transport energy	Rail transport energy	Total transport energy intensity	Energy Intensity by sectors		Energy intensity by activities		Passenger transport movement			Freight transport movement	
					Road	Rail	Freight	Passenger	Passenger car	Public transport	Rail	Rail	Road
1990-2005													
BG	↑	↑	↓			↓	↑			↓	↓	↓	↑
CZ	↑	↑	↓			↑	↑		↑	↓	↓		↑
HU	↑	↑	↓	↑	↑	↑	↑	↑	↓	↓	↓	↓	↑
PL	↑	↑	↓		↓	↓	↑			↓	↓	↓	↑
RO	↑	↑	↓			↑	↑	↓		↓	↓	↓	↑
SK	↑	↑	↓			↓	↑		↑	↓	↓		↑
SL	↑	↑	**0**	↑	↓	↑	↑		↑	↓	↓	↓	↑
EE	↓	↓	↓			↓	↓			↑	↓	↑	↑
LT	↓	↓	↓			↓	↓	↓		↑	↓	↓	↑
LV	↓	↑	↓			↓	↓			↓	↓	↑	↑
1995-2005													
BG	↑	↑	↓	↑		↓	↑	↑		↓	↓	↓	↑
CZ	↑	↑	↑	↑	↑	↑	↑	↑	↑	↓	↓	↓	↑
HU	↑	↑	↓	↑	↑	↓	↑	↑	↑	↑	↑	↑	↑
PL	↑	↑	↓	↑	↓	↑	↑	↓	↑	↓	↓	↓	↑
RO	↑	↑	↓	↑		↓	↑			↓	↓	↓	↑
SK	↑	↑	↓	↑	↓	↓	↑		↑	↓	↓	↓	↑
SL	↑	↑	**0**	↓	↓	↓	↓	↓	↑	↓	↑	↑	↑
EE	↑	↑	↓	↓	↓	↓	↓	↓	↑	↑	↓	↑	↑
LT	↑	↑	↑	↓	↓	↓	↓	↓	↑	↓	↓	↑	↑
LV	↑	↑	↑	↓	↓	↓	↓	↓	↑	↑	↓	↑	↑

6.1. CEE transportation and transport energy

As the individual country trends are presented in Table 3, the overall CEE countries have a 36% increase of total transport energy consumption between 1990 and 2005. The average EU-15 shows an increase in the same indicator by 28% over the same time period. All CEE countries saw a growth of total transport energy in the last decade. While all other CEE countries surpassed the 1990's level, only three Baltics States of the CEE countries (Estonia, Latvia, Lithuania) did not reach that baseline by 2005 yet.

Out of this total consumption, road transport energy grew by 60% while rail transportation reduced the total energy consumption by 80% between 1990 and 2005. The regional energy trend seems to have a clear impact of the transport activities. Road net mass movements doubled (100%) while that of rail transportation reduced by 30% between 1990 and 2005.

6.2. CEE transport energy intensity and modal shift

Considering CEE as a region, this study finds that total transport energy intensity experienced a huge variability of changes as shown in Table 3. To understand the relationship between the energy intensity and transport indicators, the findings are analyzed through both transport sectors and transport activities. The intensity indicators are measured with a method described in the methodology section of this thesis.

6.2.1. Road

For the entire last decade and a half, Slovenia had a sudden increase in the energy intensity during the mid-1990s whilst Hungary remained stable. In the last decade, the CEE countries saw two major trends across countries. The Baltic States and Slovenia had substantial reductions up to 50%. While the rest of CEE countries reveal increases such as the Czech Republic had the highest increase of 60%. These trends are clearly due to transport activities.

In contribution to the intensity indicators, the road sector includes passenger cars, public transport as buses and coaches, and road freight transportation. The CEE region saw some 50% growth for passenger car movements during transition years. A decline in this indicator is observed only in Hungary. Although Hungary continued to grow in the last decade, the travel level in 2005 did not slightly reach that of 1990. The public transportation lost about

30% of busses and coaches in the CEE countries between 1990 and 2005. Only Estonia and Lithuania maintained growing trend in the same time period. For the last decade, Hungary, Estonia and Latvia appear to increase the shares of bus and coach. The road freight transportation had a dramatic increase amounting more than two factors for all the CEE countries between 1990 and 2005.

6.2.2. Rail

The energy intensity for rail transport activities in the CEE presents two main trends. The majority of CEE countries saw a decline of up to 90% and a few (HU, SL, RO) saw increases of up to 30%. Additionally, Hungary and Latvia stayed more or less constant over the indicators. The intensity trends are driven by the trends in rail transport activities. The rail transport trends contain the passenger rail and freight rail transportation.

The CEE rail passenger transport decreased the intensity by about 63% between 1990 and 2005. Interestingly, Hungary and Slovenia began to increase rail passenger movements in the last decade. Rail freight declined up to 30% overall in CEE, but Estonia and Latvia managed to increase rail freight during the periods of transition. In the recent decade, four countries (Hungary, Slovenia, Estonia, Latvia and Lithuania) have growing trends of rail freight while all other CEE countries experienced losses.

6.2.3. Notes on CEE transport energy intensity for transport activities

The thesis estimated the transport energy intensity using the statistical data. This methodology highlights the special side of this research as it wholly based on real evidences. However, it is important to acknowledge academic works, which have produced rigorous transport analyses based on comprehensive modeling that incorporated all financial, socio-economic and environmental assumptions. For transport activities, the EU study on transport and energy have developed a scenario analyses for all EU member states (Mantzos *et al* 2004) and the

CEE countries were included altogether. This scenario was described in methodology and biographical review chapters of this thesis.

In terms of European transport energy intensity, there are huge disparities between the thesis analyses and the scenario results. Although noticeable ranges persist for all energy intensity ratios between the two findings, some trends of growth and decrease appear identical for some CEE countries. If both analyses show the same trend, that pattern of growth implies more accurate assumption for the changes in the energy intensity. Based on transport activity trends, the thesis used this matching results for energy intensity analyses. But, there are the cases where the findings differ enormously; the thesis attempts to relate to transport activity trends and propose rather accurate energy intensity ratio afterwards.

Therefore, the following sub-sections provide the energy intensity analyses for transport activities based on both findings, the thesis estimation and the EU scenario analyses. In turn the analyses provide rather deeper investigation.

6.2.4. Passenger transport

The average EU-15 maintained quite constant shares of passenger transport modes over the transition years. See Table 4. Passenger cars constituted stable shares from 83% to 85% during the last decade and a half. Buses and coaches stand for 9 to 10 percent shares whilst the rail passenger transport kept a constant seven percent share. In turn, the passenger transport energy intensity saw a stable trend in the scenario of Mantzos *et al* (2004) and a constant trend with a minor decrease in the results of energy intensity calculation in this thesis. The average EU-15 intensity ratio is mostly higher than in the CEE countries, but only Slovenia had higher passenger transport energy intensity than the EU-15 since the mid-1990s.

Table 4. CEE Passenger transport modal shares by percentages (mio pkm)

Passenger cars

	1990	**1995**	**2000**	**2004**
EU15	82.9	84.3	84.4	84.8
CZ		67.2	73.1	75.6
EE		70.6	72.7	78.3
LV		60.9	73.7	74.7
LT		65.4	82.6	86.3
HU	60.5	64.4	61.9	62.1
PL		64.6	72.8	78.9
SI	56.0	79.7	86.5	90.2
SK		53.9	67.9	70.6

Public transport (buses and coaches)

	1990	**1995**	**2000**	**2004**
EU15	9.9	9.1	8.9	8.7
CZ		22.9	18.5	17.0
EE		24.4	24.8	20.1
LV		22.4	20.1	19.6
LT		27.3	14.2	12.3
HU	24.8	23.6	25.1	24.3
PL		19.9	15.4	13.1
SI	36.1	16.4	9.4	5.5
SK		33.5	23.9	22.9

Rail passenger

	1990	**1995**	**2000**	**2004**
EU15	7.2	6.5	6.7	6.5
CZ		9.9	8.4	7.4
EE		5.0	2.5	1.6
LV		16.7	6.1	5.7
LT		7.4	3.2	1.5
HU	14.7	12.0	13.0	13.6
PL		15.5	11.7	8.0
SI	8.0	3.9	4.2	4.3
SK		12.6	8.1	6.5

Source: Eurostat 2008, ECMT 2007, EC DG TREN 2006

According to Mantzos *et al* (2004), Slovenia saw an increased intensity by five ratio units over the transition decade and a half. Although calculation in this thesis saw a similar pattern with a sharp increase during the mid-1990s and later reduction, the findings from this calculation differ with an overall reduction from the scenario results. It is therefore important to look up the composition of passenger modal share. Between 1990 and 2005, Slovenia's passenger transport is composed of the following changes: passenger car (56% to 90%), buses and coaches (36% to 5%), rail passenger (8% to 4%) according to Table 4. The passenger cars therefore appear to take over the shares of passenger transport over the public and rail transports, hence influence to increase the intensity ratio.

During the transition years, Hungary had the intensity increase of 15% between 27.5 and 31.5 ratios in the scenario, but this thesis calculation saw only an eight percent increase between 11.6 and 12.6 ratio results. As in Table 4, Hungary shows a lower level of passenger transport energy intensity than that of the average EU-15. The changes are due to the composition of modes during the transition years: passenger cars (60.5%-62%), public transport (25%-24%), and rail passenger transport (14.7%-13.5%). Hungary's modal shares remain more or less stable compared to the other CEE countries.

According to the scenario by Mantzos *et al* (2004), the trends of decline in energy intensity are seen for Estonia and Latvia. Similarly, the intensity calculation in this thesis found reductions in the energy intensity for Estonia, Latvia and Lithuania.

Estonia had reductions of four units from 36 to 32 according to the scenario and eight units or about 50% reductions from 16.5 to 8.4 according to the calculations in this study during the last decade and a half. As shown in Table 4, the holding reason for these reductions can be the modal composition of Estonia's passenger transport, which includes passenger car (70% to 78%), buses and coaches (24% to 20%) and rail passenger (5% to 1.5%) between 1995 and 2005. It is clear that a constant modal share of passenger transport results in reductions for passenger transport energy intensity.

Latvia reduced passenger energy intensity ratio from 32.2 to 26.5 in the scenario study (Mantzos *et al* 2004) and saw more than 50% decline from 19.8 to 8.4 in the calculation of this thesis. Between 1995 and 2004, the passenger transport modal composition was made up from the followings: passenger car (60% to 75%), buses and coaches (22%to 29%), rail passenger (16.7% to 5.7%). See Table 4. Latvia suggests that an increase in the public transport offset a small increase in passenger cars, resulting in the energy intensity reduction.

The findings for Lithuania's passenger transport intensity are contradicted against each other. The scenario found a gradual increase in the energy intensity units from 35 to 39 during last decade, but this thesis points out decrease from 12.6 units to 7.2 during the same time. As seen in the Table 4, the statistical transport passenger data indicate the modal composition as passenger car (65% to 85%), buses and coaches (27% to 12%), and rail passenger (7.4% to

1.5%). Thus, the increase in energy intensity must be a reasonable trend due to a larger increase of passenger car and the losses of public and rail passenger transport.

According to the scenario analysis, the Czech Republic, Slovakia, and Poland show common increases in the passenger transport energy intensity between 1995 and 2005. However, the calculation in this thesis shows gradual minor reductions in Poland, fluctuation in Slovakia, and increases in the Czech Republic between 1995 and 2004.

The Czech Republic had increases in the intensity ratio from 18 to 27 in the scenario, and the study saw 4 units of increase from 6 to 10 units during the last decade. For modal share composition between 1995 and 2005, the Czech Republic had the following composition changes: passenger cars (67% to 65%), buses and coaches (23% to 17%), and rail transport (10% to 7.5%). Like situation in Hungary, it appears that constant modal shares in passenger transport may bring increase in energy intensity over the transition years.

For last decade, Slovakia had 5 unit increases in the energy intensity from 30.5 to 35.4 in the scenario, but the findings in this thesis show decreases from 7 to 6.3 units. As shown in the Table 4, Slovakia's passenger transport had the following compositional changes: passenger car (54% to 70%), buses and coaches (33% to 23%), rail passenger (12.5% to 6.5%). These modal share changes suggest that the scenario results therefore seem to be rather accurate in this case.

According to the scenario, Poland had a gradual increase of 2.4 units from 23.2 to 25.6 during the last decade. But, the intensity analysis in this thesis figures out a decline of two units from 10 to 8 at the same time period. To justify the possible reasons, the transport data for the same time frame indicates the following composition changes for Poland: passenger car (64% to 80%), buses and coaches (20% to 13%), and rail passenger (15.5% to 8%). See Table 4. Increasing passenger car modes and declining public and rail transport support the trend of increasing energy intensity.

6.2.5. Freight transport

Unlike the passenger transport, the freight transport implies straightforward outcomes because the study selects two dominant modes of freight, rail and road. The two modes then might directly show a connection between the transport activity volume and the energy intensity. As a basis benchmark, the average EU-15 saw a quite stable transport energy intensity trend with minor fluctuation during the last decade and a half in the scenario analysis. According to the intensity estimation in this thesis, the freight transport energy intensity trend appears to gradually decrease in the intensity for the average EU-15 amounting some -10% decline between 1990 and 2005. That trend was directly influenced by the changes in modal share for the transition years. The EU freight transport had shares of road (78% to 85%) and rail (21% to 15%). See Table 5.

Table 5. CEE freight transport modal shares by percentages(mio tkm)

Road

	1990	1995	2000	2004	2005
EU15	78	84	84	85	85
CZ		58	68	75	75
EE	39	29	33	33	35
LV	24	16	26	28	30
LT	27	42	47	51	56
HU	48	62	68	70	73
PL	33	43	58	66	69
SI	54	52	65	74	77
SK		54	56	66	70
BG	49		54	70	74
RO	10	52	47	69	76

Rail

	1990	1995	2000	2004	2005
EU15	22	16	16	15	15
CZ		42	32	25	25
EE	61	71	67	67	65
LV	76	84	74	72	70
LT	73	58	53	49	44
HU	53	38	32	30	27
PL	67	57	42	34	31
SI	46	48	35	26	23
SK		46	44	34	30
BG	51		46	30	26
RO	90	48	53	31	24

Source: Eurostat 2008, ECTM 2007, EC DG TREN 2006

The freight transport data for the entire transition years are obtained for more countries in the CEE than the passenger transport. Overall trend suggests a wide variability of trends for the CEE countries over the transition years. As reported in the scenario analysis, only two CEE countries show trend of reduction in the intensity ratio; those are Estonia and Lithuania. Similarly, the intensity ratios in this study show the reductions for the Baltic States.

During the last decade and a half, Estonia had gradual reductions in the intensity from 37 to 33 units as analyzed in the scenario. In this thesis, Estonia's freight transport saw some 50% decreases in the intensity. As contribution to this trend, the freight transport in Estonia has major changes in the modal composite during the transition years. Estonia saw a decrease in road freight transport (40% to 35%) and an increase in rail freight (60% to 65%). See Table 5.

Lithuania also saw a decrease in freight transport energy intensity in the last decade from 37 to 36 according to the scenario analysis. The estimation in this study found reduction by 20 units from 65 to 44 between 1995 and 2004. These reductions in the last decade might be due to the changes in the freight transport composition. As shown in Table 5, Lithuania saw road freight shares from 40% to 56%, and rail share from 58% to 44% between 1995 and 2005. As in this case, a small increase in road mode and a decrease in rail modes still result in a decline for the energy intensity, suggesting improvements in vehicle fuels rather than modal share contribution. This trend also confirms that a stable trend over the modal share helps to reduce the energy intensity in freight transport.

Very fluctuating trends in freight transport energy intensity were seen for Latvia across the transition years as in the scenario analysis. There was an increase by five units during the mid-1990s and then a small decrease by year 2000. Since then, Latvia began to increase the intensity by three units. The Estonia's freight transport intensity estimation in this thesis found a sharp growth in the intensity during the mid-1990s, and then saw a continuous decline from 46 ratio unit till 30. For a direct transport indicator, Latvia had road freight share from 24% to 30%, and rail share from 75% to 70% during the transition decade and half. See Table 5. Thus, the growth in energy intensity is as result of increasing road share and decreasing rail share in the freight transport.

In the scenario analysis, Slovenia had a decline in the intensity until the 2000 and suddenly grew up higher in the later years. The results from this thesis show a sharp increase just after the transition and then a gradual decrease in the intensity since the mid-1990s. The later decrease saw some -35% reductions for the last decade. In both estimations, Slovenia appears to be the highest level of energy intensity ratio which is almost equal to the EU-15 but much higher than the rest of CEE standings. According to Table 5, the outcomes of energy intensity are driven by the fact that the freight transport shares during the transition years saw large modal percentage changes in the road (50% to 77%) and rail (46% to 23%) sectors in Slovenia.

Hungary and Poland followed continuous increases in the energy intensity over the transition years both in the scenario and in this thesis. Hungary's freight transport energy intensity saw 30% increases in the scenario and some 50% increases in the estimation in this thesis. In terms of modal share in freight transport, Hungary had road freight (45% to 73%) and rail freight (52% to 26%) shifts between 1990 and 2005. Similarly, Poland saw increases of the intensity as 22% by the scenario and 5% by this thesis between 1990 and 2005. Contributing transport modal changes are road sector (33% to 70%) and rail sector (70% to 30%). See Table 5.

The next two CEE countries are analyzed only after the mid-1990 due to data availability. Slovakia and the Czech Republics have growing trends with different rate of growth in the freight transport energy intensity over the transition years. Slovakia had 3% increase in the scenario analysis and 8% increases in this study for the last decade. As shown in Table 5, the modal composition in Slovakia comprises of road (53% to 70%) and rail (46% to 30%) at the same time. Nevertheless, the Czech Republic saw 30% growth in the intensity in the scenario and an entire fold increase in this thesis during the last decade. Modal share changes in the Czech Republic are seen in the road (58% to 75%) and rail (40% to 25%).

6.3 The Importance of modal shift on transport energy and GHG emissions

Transport modal shifts appear to have a significant impact on transport energy intensity. The CEE countries clearly illustrate the importance of modal shares for transport energy intensity. When the energy efficient transport modes constitute larger shares in transport activities, the transport runs with less energy intensity, meaning reduced energy consumption for certain transport activities. In turn, the transport sector contributes a lower level of GHG emissions than what the energy intense transport modes could otherwise do. The existence of different modes offers the advantage of reducing carbon intensity by shifting the share of modes. Wright and Fulton (2005) carried out a research on cost effectiveness of GHG emission reduction from fuel technology measures to promote mode shifting. They found that "shifting mode share from high-emitting sources (private vehicles) to lower-emitting sources (public transport and non-motorized options)) produced emission reduction costs between US$148 to over US$66/tonne of CO_2."(Wright and Fulton 2005, p 715). In order to understand energy intensity of modal split, this thesis examines the energy intensity of CEE based on their transport data.

For transport activities, transport modes result in remarkable energy intensity outcomes. In passenger transport, three modes are essential for inland passenger mobility: the rail passenger transport, the public transport, and the passenger cars. Personal vehicles consume more energy per passenger-km than public or collective passenger modes (IPCC 2007). The passenger cars tend to overtake a larger share for passenger transport in the CEE countries. A comparison study on the CEE clearly reveals that the transport energy intensity peaks higher levels when the passenger car mobility takes up a larger portion in the passenger transport.

On the contrary, it is important to maintain substantial shares of rail and public transport modes due to their energy efficiency and a higher load per transport distance. From environmental point, the public and rail transport help to mitigate the transport emissions whilst they serve the purpose of passenger mobility.

Inland freight transport implies straightforward outcomes by composition of rail and road modes. Rail track and provision of rolling stocks specify the rail transport with expensive initial capital cost, and have an advantage of carrying large quantity of goods over a long distance (Rodrigue *et al* 2006). The rail freight is as twice energy efficient as road freight modes (Bonnafous and Raux 2003). Nevertheless, the road freight has been unequally facilitated to make up a dominant role in the CEE countries. For example, the Baltic States of CEE countries show concrete facts that a preference for rail freight, such as growing share of rail in freight transport, remarkably results in a decline of energy intensity while road freight simultaneously grows.

The trend of transport energy intensity in the CEE shows clear effects of modal split over the transition years. The post-transition periods show a dramatic increase of transport energy intensity due to the sharp growth of passenger car mobility and road freight activities at the same time when the CEE countries began losing the shares of rail transports and the public transport. Since the post-transition period of the mid-1990s, some CEE countries continue to follow the path of increasing the intensity levels, but there appears a door of opportunities for a few CEE countries as they improved to reduce the energy intensity through effectively managing energy efficient transport modes, as such concrete examples of rail shipping and the public transports in the Baltic States.

Overall, the findings from the CEE data analyses suggest important messages for transport energy efficiency. First, the CEE countries have chance to mitigate transport energy and GHG emissions through using their built infrastructure for energy efficient modes, and they might need to leapfrog management policy tools for rail and public transports instead of copy-pasting the 'Western' transport policies (Vorsatz *et al* 2006). The CEE countries with higher transport energy intensity might need to take decisive actions for energy efficient transport modes. Second, that modal splits contribute significantly to energy intensity is an important lesson for other developing countries (Wright and Fulton 2005). For better transport modes, the infrastructure and pre-planning are prerequisite for mitigating GHG emissions from transport sector. Therefore, the developing countries ought to make key decisions for energy efficient transport modes in their early development of transport and supporting infrastructure.

Conclusions and Policy Discussion

The empirical findings of this study prove that transport modal shifts are important for transport energy consumption, contributing relevant GHG emissions from the transport sector. The share of each transport mode seems to have a direct effect on the energy intensity; this in turn establishes the respective energy demand of the transport activity. A larger share of the energy intensive transport modes appears to consume a larger portion of energy and therefore emits higher levels of GHG emissions than what the energy efficient transport modes would do if they constituted larger share. At various temporal conditions the CEE countries reveal that the transport energy intensity can be reduced through increasing shares of energy efficient transport modes. In fact, the overall CEE trends have exponentially faced growing energy intensive patterns over the post-transition period. However, the recent trend of reduction in energy intensity for a few CEE countries indicates a room for improvements that other CEE countries can benefit if they maintain substantial share of the energy efficient transport modes through the appropriate policy tools established in favor of the modes.

The available literature and empirical evidence show that the CEE countries have gone through substantial changes in the transport sector; hence their transport energy experienced shifts, both as common feature and considerable variability. As a region, the common transport challenges and related development issues seem to shape the similar pattern of transport activities in the CEE. It is important to highlight the variability of specific country standings because the CEE countries display the different results of transport indicators in regard to the geographical, political and economic differences. The differences are clear, both over time periods and at a specific year base. Further, these disparities may also indicate the limitations of selected data reporting, estimation errors, and generalization. Moreover the disparities help to recognize the future needs to apply detailed methods on transport energy estimations for similar studies; the need for a systematic book-keeping of transport-related data statistics is also paramount.

Evidence proves that the share of road transport modes is overtaking over other transport modes of rail and public transports during the transition years. In response to that transport framework, the CEE had a 36% increase of total transport energy consumption, constituting a 60% growth in the road transport energy and an 80% decline in rail transport energy consumption during the transition decade and a half. These changes are directly facilitated by respective transport activity, but the degrees of changes do not match the same percent. The road transport movement (mio tkm) doubled (100%) while that of rail transportation reduced by 30% during the same time period. The growth in road transport was due to passenger car movements (50% growth in mio pkm) and freight transport (factor 2 increase in mio tkm), but the public transport saw a 30% loss in the CEE. The decline in rail transport was because of the same rate of changes in both passenger and freight transports, amounting to some 30% decline in each. Among a wide range of changes across the CEE countries, the changes towards energy efficient modes were observed in Hungary, Slovenia and the Baltic States. Hungary managed its transport at a stable level for passenger transport (rail, cars and public transport) and rail freight transport as well, but still follows a substantial growth in road freight. Slovenia improved rail transportation through growth in both passenger and freight activities. The Baltic States increased movements in public transport and rail freight transport.

Consequently, the CEE countries are proven to have substantial changes in the transport energy intensity as seen on the intensity analyses of this thesis and the scenario findings in the EU study (Mantzos *et al* 2004). The shifts in the transport modal shares for the CEE countries show a clear correlation with the energy intensity ratio over the transition years. The examination of a number of CEE countries reveals a common trend of increase in transport energy intensity over the years due to the growing share of road transport modes. According to both estimations (thesis calculation and the EU scenario), the increased share of passenger cars and the losses of two energy efficient modes (rail and public transport) altogether result in the increase of passenger transport energy intensity for the Czech Republic and Slovakia. However the two estimations show different results for Poland and Slovenia. In accordance with the transport activity trend, the EU scenario on transport energy intensity appears to be rather accurate as the intensity increases are correlated to the transport modal composition for Poland and Slovenia. Their shares of passenger cars take up a larger portion over the rail and public transport modes for the transition years.

The most important modal implication for transport energy intensity is observed in the outcomes of the Baltic States. A minor decline in public and rail passenger transportation results in a remarkable decrease in the passenger transport energy intensity whilst the two Baltic States (Latvia and Lithuania) have a small increase in the share of passenger cars. Both findings show the same trends for the Baltic States. This message is very promotable for the other CEE countries. There is a specific trend in Estonia for passenger transport energy intensity. Although Estonia saw increases in passenger cars, declines in public transport and rail transport, the passenger transport energy intensity shows a decline in both analyses. But, this outcome might be a result of fallacy in data reporting. Hungary is the only CEE country with a constant trend of passenger transport energy intensity ratio over the last decade and a half due to stable shares of all modes in balance.

In terms of freight transport, many CEE countries have growing energy intensity due to the increasing share of road freight activities over the transition years. However, the Baltic States (Estonia, Latvia, and Lithuania) show a decline in the energy intensity due to the growing share of rail freight in the last decade. The energy intensity estimation in this thesis show rather relevant rate of changes for Poland and Hungary than the scenario results. Thus, the two energy intensity results complement each other for proximate relevance to transport modal split.

As a benchmark, the average EU-15 shows identical trends of changes in both analyses although the actual ratio shows different outcomes. The EU-15 shows an overall stable trend with a minor decline in passenger and freight transport energy intensity over the years. While the shares of modes remain constant for the EU-15 transport indicators, the energy intensity decline suggests some effect of fuel efficiency in passenger and freight vehicles in the region for the last decade and a half.

Policy Consideration

A regional contribution to reduce transport related GHG emissions and energy consumption appears to rely on a number of actions and policies. In regard to the findings of CEE transport trends, the EEA (2008) reports that "…policies have not been enough to succeed in reducing GHG from transport" (p4), and much of mitigation efforts offset by the increasing transport volume of energy intensive modes, including passenger cars and road freight movements. The results from the data analyses suggest important points for transport policy considerations:

- Transport infrastructure development and restructuring funds might need to allocate larger shares on environmentally benign transport modes, such as rail transportation and public transports.
- Policy and regulations should foster leapfrogging the intensive usage of energy efficient transport modes during the centrally planned periods with accurate adjustments to the market oriented economic development
- Transport policy instruments and measures need to strengthen the existing transport routes for organized transport and new additions to meet growing transport demands such as flexible rail ways for freight shipping, and more destinations for local and

international rail passenger transportation, and diversified routes and faster frequent for public transport routes (metros and buses).

- Outside transport policy instruments to support the efficient modes, such as land use planning, and non-motorized ways etc, should be prioritized
- It is necessary to support freight activities to take an advantage of existing logistics of rail transportation with addition of wider connection and more flexibility.

Meantime the CEE countries need to consider their local circumstances when they apply the policy recommendations such as the modal shares, local infrastructure costs and cultural preferences for specific modes (Wright and Fulton 2005). Energy policy researchers (such as Vorsatz *et al* (2006)) argue that the maintenance of organized transport could result in developing a more sustainable transport system in the CEE countries.

In fact, it is impossible to reverse today's rate of road transportation (passenger and freight), and unlikely to reach the same share of organized transport modes as that in centrally planned periods in the CEE. The promise lies in the aim to achieve substantial GHG and CO_2 reductions in the transport sector through policies to ensure a higher capacity utilization of efficient transport modes that have an excellent infrastructure for the CEE countries.

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Appendices

Road : national and international haulage
haulage by vehicles registered in the reporting country
(including cross-trade and cabotage)
1000 mio tkm

	1970	**1980**	**1990**	**1995**	**2000**	**2004**	**2005**
EU15	438.3		928.4	1 124.1	1 317.4	1 459.3	1 478.1
CZ				31.3	37.3	46.0	43.4
EE	2.3		4.5	1.5	3.9	5.1	5.8
LV	2.9		5.9	1.8	4.8	7.4	8.4
LT	3.4		7.3	5.2	7.8	12.3	15.9
HU	5.8		15.2	*13.8*	19.1	20.6	25.2
PL	15.8		40.3	51.2	75.0	102.8	111.8
SI	2.1		4.9	*3.3*	5.3	9.0	11.0
SK				*15.9*	14.3	18.5	22.6
BG	7		13.8		6.4	12.0	14.3
RO	5.2		5.2	19.7	14.3	37.2	51.5

Source : Eurostat, European Conference of Ministers of Transport (ECMT)

Railways: national and international haulage
1000 mio tkm

	1970	**1980**	**1990**	**1995**	**2000**	**2004**	**2005**
EU15	**282.5**	**289.8**	**254.9**	**221.6**	**249.4**	**262.5**	**262.0**
CZ				22.6	17.5	15.1	14.9
EE	5.7	6.5	7.0	3.8	8.1	10.5	10.6
LV	15.5	17.6	18.5	9.8	13.3	18.6	19.8
LT	13.6	18.2	19.3	7.2	8.9	11.6	12.5
HU	19.8	24.4	16.8	8.4	8.8	8.7	9.1
PL	98.0	132.4	81.6	68.2	54.0	52.3	50.0
SI	3.3	3.8	4.2	3.1	2.9	3.1	3.2
SK				13.8	11.2	9.7	9.5
BG	13.7	17.7	14.1	8.6	5.5	5.2	5.2
RO	43.1	64.8	48.9	17.9	16.4	17.0	16.6

Source : Union Internationale des Chemins de Fer, European Conference of Ministers of Transport, Eurostat

Passenger cars

1000 mio pkm

	1970	1980	1990	1995	2000	2004
EU15	**1,546.2**	**2,220.8**	**3,100.9**	**3,521.8**	**3,861.6**	**4,071.2**
CZ				54.5	63.9	67.6
EE				*5.9*	*7.7*	*9.6*
LV				*5.0*	*8.6*	*10.6*
LT				*10.0*	*16.0*	25.8
HU			47.0	45.4	46.2	46.5
PL				110.7	149.7	181.5
SI			*10.0*	*12.2*	*14.6*	*16.0*
SK				18.0	23.9	24.3
BG			4.5			
RO						

Buses & coaches

1000 mio pkm

	1970	1980	1990	1995	2000	2004
EU15	**269.0**	**344.8**	**371.0**	**382.0**	**406.4**	**418.7**
CZ				18.6	16.2	15.2
EE	2.6	3.7	4.5	2.0	2.6	2.5
LV	3.3	4.6	5.9	1.8	2.3	2.8
LT			7.9	4.2	2.8	3.7
HU			19.3	16.6	18.7	18.2
PL	29.1	49.2	46.3	34.0	31.7	30.1
SI			6.4	2.5	1.6	1.0
SK				11.2	8.4	7.9
BG			*26.0*	11.6	13.9	11.1
RO	8.2	24.9	24.0	12.3	7.7	9.4

Railways (1000 mio pkm)

	1970	1980	1990	1995	2000	2004
EU15	**220.2**	**246.9**	**269.1**	**273.0**	**306.5**	**312.1**
CZ			13.3	8.0	7.3	6.6
EE	1.2	1.6	1.5	0.4	0.3	0.2
LV	3.7	4.7	5.4	1.4	0.7	0.8
LT	2.1	3.3	3.6	1.1	0.6	0.4
HU	16.4	13.5	11.4	8.4	9.7	10.2
PL	36.9	46.3	50.4	26.6	24.1	18.4
SI	1.4	1.4	1.4	0.6	0.7	0.8
SK			6.4	4.2	2.9	2.2
BG	6.2	7.1	7.8	4.7	3.5	2.4
RO	17.8	23.2	30.6	18.9	11.6	8.6
Source: European Conference of Ministers of Transport, Eurostat						

Final energy consumption on transport (1000 toe)

	1990	1995	2000	2004	2005
EU15	252358	274846	310437	323342	324417
CEE	26603	24160	27823	35073	36318
Bulgaria	2518	1976	1817	2366	2560
Czech Republic	2804	2839	4721	6167	6569
Estonia	839	490	577	667	725
Latvia	1094	712	744	959	999
Lithuania	1990	1037	1048	1320	1397
Hungary	3024	2653	3252	3868	4175
Malta	221	304	237	267	328
Poland	7338	8256	9185	11316	12087
Romania	4407	3058	3384	5178	4204
Slovenia	928	1326	1309	1379	1469
Slovakia	1440	1509	1549	1586	1805

Source : Eurostat 2008

Final energy consumption on road transport ***1000toe***

	1990	1995	2000	2004	2005
EU15	211520	228287	253199	264335	262993
CZ	2311	2450	4220	5550	5945
EE	730	423	497	581	617
LV	798	596	642	818	847
LT	1719	909	943	1197	1272
HU	2580	2281	2855	3480	3785
PL	5940	7183	8268	10503	11260
SI	872	1276	1249	1330	1417
SK	1340	1390	1466	1499	1717
BG	2000	1548	1638	2128	2323
RO	3579	2298	2687	4664	3824

Final energy consumption on rail transport ***1000toe***

	1990	1995	2000	2004	2005
EU15	6970	7382	7868	7969	8120
CZ	272	200	295	277	271
EE	65	44	51	48	48
LV	188	90	75	93	93
LT	132	86	75	77	79
HU	271	190	175	166	159
PL	1095	667	539	528	502
SI	29	29	34	28	29
SK	100	119	83	61	49
BG	216	144	77	65	36
RO	282	471	449	333	208

Source : Eurostat 2008

Population

	1990	1995	2000	2005
EU15	363492622	370667068	377238033	387498474
CZ	10362102	10333161	10278098	10220577
EE	1570599	1448075	1372071	1347510
LV	2668140	2500580	2381715	2306434
LT	3693708	3642991	3512074	3425324
HU	10374823	10336700	10221644	10097549
PL	38038403	38580597	38653559	38173835
SI	1996377	1989477	1987755	1997590
SK	5287663	5356207	5398657	5384822
BG	8767308	8427418	8190876	7761049
RO	23211395	22712394	22455485	21658528

Road transport energy intensity (toe/tkm)

	1990	1995	2000	2004
EU15	170.5	154.7	148.8	141.9
CZ		64.7	94.8	103.8
EE		186.5	102.2	93.9
LV		243.7	111.2	95.3
LT		140.4	99.7	80.2
HU	121.9	117.7	114.4	131.7
PL		111.8	90.5	86.2
SI	136.7	276.0	184.9	126.2
SK		75.0	85.0	70.0

Rail transport energy intensity (toe/tkm)

	1990	1995	2000	2004	2005
EU15	25.0	30.0	28.4	27.4	27.9
CZ	227.0	8.6	16.3	17.7	17.5
EE	9.1	11.3	6.3	4.6	4.5
LV	9.9	9.1	5.6	5.0	4.7
LT	6.7	11.8	8.4	6.6	6.3
HU	15.2	20.7	18.1	17.2	15.9
PL	12.7	9.4	9.6	9.8	9.7
SI	6.7	9.3	11.6	8.7	8.7
SK	174.1	8.4	7.2	6.2	5.1
BG	14.6	16.0	13.2	12.0	6.7
RO	5.5	24.0	25.8	18.7	12.0

Passenger transport energy intensity (toe/pkm)

	1990	1995	2000	2004
EU15	16.0	15.0	14.4	13.7
CZ		6.1	9.2	10.0
EE	9.1	16.5	9.1	8.4
LV	9.9	19.8	9.7	8.4
LT	6.7	12.6	9.0	7.2
HU	11.6	11.8	11.3	12.6
PL	12.7	10.0	8.3	7.9
SI	11.9	24.2	16.4	11.2
SK		7.0	7.6	6.3

Freight transport energy intensity (toe/tkm)

	1990	1995	2000	2004
EU15	139.1	134.2	129.6	124.4
CZ		41.1	69.7	82.5
EE	69.1	61.6	37.6	33.8
LV	40.1	46.2	33.5	30.6
LT	69.6	65.7	50.9	44.4
HU	65.9	81.0	84.0	97.6
PL	57.2	53.4	56.6	60.4
SI	76.6	147.3	124.2	95.8
SK		44.1	50.8	48.0