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Analysis of Energy Consumption and Energy Intensity Indicators in Central and Eastern European Countries

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ABSTRACT

This paper focuses on changes in the national economies and on the final energy consumption during the transformation period in Lithuania, Latvia, Estonia and other Central and Eastern European countries. One of the legacies in countries with central planning in the economy and energy sector is the inefficient use of energy. An increase in energy efficiency is one of the most important strategic goals in these countries. Achievements in countries with transition economies during the last decade clearly demonstrate significant progress in this area. However, the methodology of energy efficiency comparison in developed and developing countries is still under discussion. This paper presents the comparison of various indicators such as energy consumption per unit of Gross Domestic Product (GDP) and energy consumption per capita as well as their changes in the countries of Central and Eastern Europe. The paper also focuses on the assessment of real differences in energy efficiency in the EU-15 countries and the new member states of the EU-25.

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1. INTRODUCTION

Central and Eastern European countries that were in transition from centrally planned economies to a free market economy were experiencing fundamental transformations. These countries had inherited, from the former socialistic system economies and energy sectors, a relatively good technical structure. However, the high dependency of these countries on imports of primary energy and raw materials and on exports of goods to Eastern markets as well as inappropriate management were serious deficiencies on the way to integrate into the European Union (EU). Because of this, these economies experienced a recession during the transition period which was followed by dramatic structural changes, alteration of energy policy and gradual creation of market conditions.

For several decades, incentives for efficient use of energy resources and raw materials were very weak because the main goal of the former Eastern Block was the creation of a very integrated economy which could concentrate all necessary resources to compete with developed Western countries in the prestigious areas of space exploration, new technologies and military technique. In many cases, priority was given to economic growth and increasing production volumes without taking into account attention on energy efficiency.

Comparison of the economic conditions and energy consumption in developed countries of the EU-15 to the new member states cannot be performed without consistent statistical information describing the relationships of energy systems and their relationship with national economies. However, methodology of energy statistics has some peculiarities and differences in various countries and even international organizations (Eurostat, International Energy Agency, Directorate-General for Energy of the European Commission, British Petroleum, etc.). In the statistics of the former centrally planned economies, many difficulties have arisen because of the application of international principles in statistical data system management. At the beginning of transition period, additional problems were related with significant changes in national economies, inaccurate registration of fuel import/export in customs declarations, interests of commercial suppliers to hide right information, privatization of industrial enterprises and formation of new small companies, disintegration of big collective farms in agriculture and growth of comparatively small private farms. Therefore, such comparative analysis is rather complicated.

The comparison of energy efficiency in various countries could be based on several indicators: primary energy intensity, final energy intensity and electricity intensity. In general, the indicator of primary energy intensity, defined as a ratio of the gross primary energy consumption (or total supplied

primary energy) and Gross Domestic Product (GDP), is used. However, this indicator does not reflect the real differences of energy efficiency between Western developed countries and countries of the former Eastern Block, in particular when GDP in each country is converted from the national currencies into a common currency. A better comparison of energy efficiency in developing and developed countries should be based on the comparison of primary energy and final energy intensity indicators when GDP is defined using estimates of Purchasing Power Parity or Purchasing Power Standards.

The main objectives of the paper are:

1) To perform an analysis of the economic development in the countries of Central and Eastern Europe
2) To discuss changes in the energy consumption by sectors in these countries during the period from 1991-2002
3) To examine the alteration of energy efficiency in the countries who are new members of the European Union
4) To discuss the methodology of comparing energy efficiency indicators in countries with different level of economy development
5) To assess real differences of energy efficiency in the EU-15 countries and new member states of the EU-25.

2. CHANGES IN THE ECONOMIC DEVELOPMENT

Conditions of the economic development in the countries of Central and Eastern Europe greatly differed in comparison to economic conditions in Western Europe over several decades. All countries of the former Eastern Block could be characterized by:

1) A certain degree of integration within the common system of exchange of goods and energy resources
2) Dependency on imports of many raw materials and primary energy resources, in particular, oil and natural gas mostly from Russia
3) Specialization in the production of goods for a comparatively closed area within these countries and the tight integration of industries
4) Relatively low prices of energy resources together with low energy efficiency. Unsurprisingly, the transition to a free market economy led to a deep economic decline in these countries.

After the collapse of the Former Soviet Union (FSU), almost all the countries that had centrally planned economies experienced a large reduction in economic activities. However, former socialistic countries in the Central and Eastern Europe had been experimenting with market oriented economic reforms since the sixties. A decline of the GDP in these countries started in early nineties of the last century. From 1991 to 1993, based on the analysis of indicators prepared by the International Energy Agency (IEA, 2004a), GDP

dropped in the Slovak Republic, Hungary, Slovenia, Czech Republic and Poland from 80 to 93% of the 1990 levels. The period of economic slump was comparatively short in these countries. Processes of transition in the Commonwealth of Independent States (CIS) have been more dramatic and the decline of the economy was much higher. GDP dropped in Georgia to 28.4%, in Ukraine to 40.7%, in Russia to 57.5 % of the 1990 levels. In addition, dramatic consequences of transition period are still evident in most of these countries (Fig. 1).

As shown in Miskinis, 2002, at the end of 1994, the GDP dropped to 50.1% in Latvia, 56.1% in Lithuania and 65.1% in Estonia of the 1990 levels. The economic slump in the Baltic States was lower than in the majority of the CIS countries. The year 1995, when increase of GDP was fixed, could be considered as the turning point during the transition period in the Baltic States. Only once, in 1999, as a consequence of the financial and economic crisis in Russia did the GDP in Lithuania and Estonia slightly decrease. During the last few years, according to data (Statistics Lithuania, 2005), economic growth in the Baltic States was very rapid. In 2003, the GDP growth rates were correspondingly 6.7% in Estonia, 7.5% in Latvia and 10.5% in Lithuania.

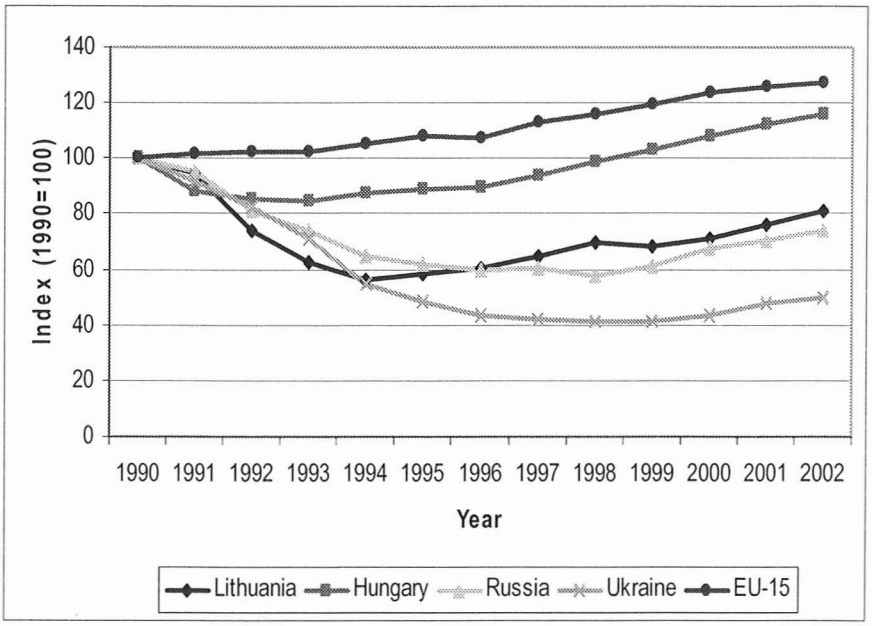
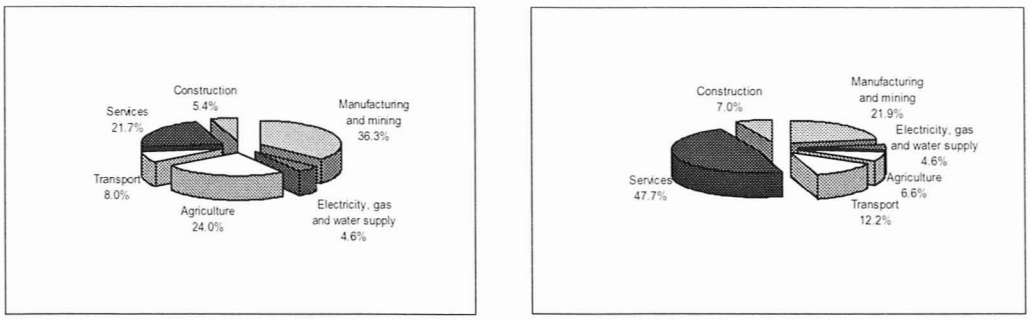


Figure 1. Indexes of GDP growth in selected countries

The transition period in the Baltic States was rather long and severe in many aspects. However, steady progress in strengthening the performance of market-supporting institutions and undertaking necessary reforms confirms possibilities for strong and long-term economic recovery. This progress could be characterized by several transition indicators, such as growing private sector share of GDP, pace of privatization, price liberalization, removal of restrictions and tariff barriers on trade and foreign exchange, progress on creation of competition policy, commercialization and regulation of telecommunications, restructuring of the energy sector, establishment of bank solvency and liberalization of interest rates, and emergence of non-bank financial institutions.



a) b)

Figure 2. Structure of gross value added in Lithuania in 1990 (a) and 2003 (b)

One of the most important results of the reforms for all the countries of the Central and Eastern Europe is related to the significant structural changes in their economies. These changes can be illustrated by comparing the structure of the Lithuanian gross value added in 1990 and 2003. Its structure, inherited from the Soviet past, was characterized by domination of two branches, industry and agriculture (Fig. 2). In the current structure, the sector of services (including transport and communication) accounts for approximately 60% of gross value added in Lithuania.

3. CHANGES IN THE ENERGY CONSUMPTION

Energy sectors in the Central and Eastern European countries have some common features and some discernable differences. The three Baltic States were much more integrated into the unified economy of the FSU and their energy sectors were planned over decades as the components of large energy systems. Capacities of the main power plants were planned taking into consideration not only rapid growth of local needs but also requirements of the much larger North-Western region of the FSU. The Czech Republic, Hungary, Poland, Slovak Republic and Slovenia were more independent in their energy sectors and were more appropriate in terms of size, location and access to primary energy. Nevertheless, all the Central and Eastern European countries were dependent on the primary energy supply from Russia or other republics of the FSU. The former economy was characterized by rather large share of heavy and energy intensive industries, which were dependent on import of raw materials and exports of products also mainly to the FSU.

A rapid increase in prices of energy resources and raw materials have resulted in the loss of the former Eastern markets for goods from manufacturing and agriculture, in particular in the Baltic States. Decline of economic activities and even bankruptcy of great number of enterprises in manufacturing and other branches of economy have stipulated a large reduction of energy consumption in all the Central and Eastern European countries. To perform consistent comparison of changes, information about energy consumption in these countries was analyzed using one source (Eurostat database, 2005). Results of the performed analysis are summarized in Table 1.

Table 1. Indices of energy consumption in 2002 (1991=100)

Country	Gross inland consumption	Final energy Consumption	Industry	Agriculture	Transport	Household	Services
Czech Republic	95.6	74.7	58.5	18.4	231.9	69.4	96.2
Estonia	53.9	45.3	20.6	15.3	88.1	83.1	136.1
Hungary	95.2	95.8	68.9	70.9	130.1	96.1	125.3
Latvia	62.5	67.5	40.2	30.0	77.9	95.6	37.1
Lithuania	52.0	39.4	23.1	15.7	53.2	75.2	25.1
Poland	90.3	90.5	73.0	145.8	119.2	88.6	89.4
Slovak Republic	98.8	80.6	57.9	68.0	125.3	125.5	77.2
Slovenia	127.7	137.8	99.4		162.4	114.5	430.1
EU-15	110.2	109.2	104.7	102.3	122.7	98.8	121.3

In all the Central and Eastern European countries, a decline in the economy was followed by a corresponding reduction in primary energy consumption (or gross inland consumption) and final energy consumption in branches of the economy. A deeper decline of economic activities has resulted larger reduction of energy consumption. The most dramatic structural changes and the largest reduction of energy consumption have occurred in the agriculture, manufacturing and transport sectors in the Baltic States.

In the countries of this region, the agricultural sector was traditionally one of the most important for the national economies. For example, the Baltic States constituted only 0.8% of the area and 2.8% of population of the FSU, but in 1980s they produced about 7% of the meat and about 8% of the milk. These figures were achieved by extensive cattle-breeding and production which were concentrated on big farms that consumed a large amount of energy resources, in particular of electricity. In 1990, the share of this sector was about 9% of the energy available for final consumption (Eurostat database, 2005). In the early 1990's, after enactment of new property laws, large collective farms were destroyed and energy consumption in agriculture in Estonia and Lithuania decreased by 6.5 times, in Latvia by 3.3 times. Similar changes in this sector, with a slight delay, occurred in the Czech Republic where energy consumption decreased by 5.5 times (Fig.3).

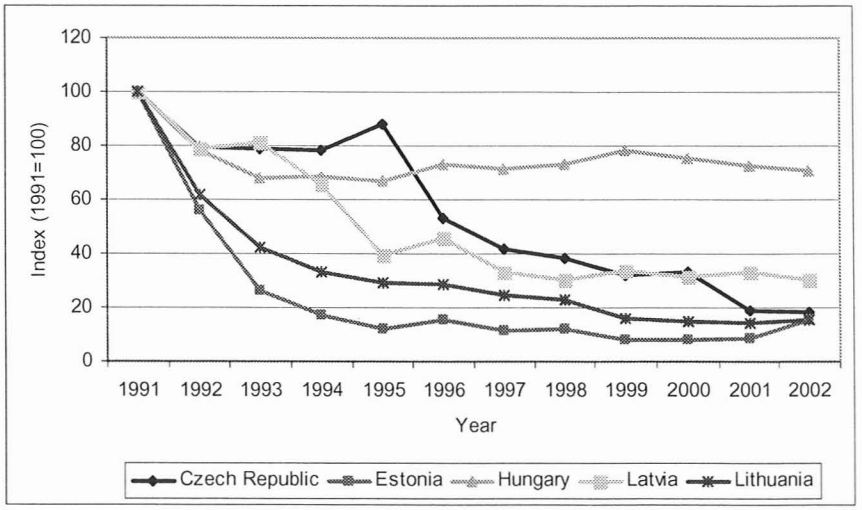


Figure 3. Development of energy consumption in agriculture

However, in Hungary and the Slovak Republic, energy consumption in 2002 was only by 1.4 times lower than in 1991 and energy consumption in the agriculture sector of Poland increased by almost 1.5 times during the same period.

The main trend in economic development in the countries of Central and Eastern Europe was the rapid industrial development of the traditional light and food industries but also with construction of such energy intensive industries as chemicals, oil refining, building materials, and machinery. Thus, the main energy consumer in these countries was industrial branches. In 1990, the share of industrial use in the Czech Republic was almost 55%, in Estonia 48% and in the Slovak Republic 47%. On average, the Baltic States had 35% of the energy available for final consumption (Eurostat database, 2005). During the transition period from centrally planned to a free market economy, industrial production decreased dramatically in Estonia and Lithuania, and its structure changed significantly. The share of the machinery industry which was tightly connected with that industry in the FSU shrank; some enterprises were renovated and equipped with modern technologies. Therefore, energy consumption in the industrial sector decreased in these countries by almost 5 times (Fig.4). Alteration of energy consumption in other countries of Central and Eastern Europe was less significant.

As one can see from Table 1, energy consumption in the transport sector decreased only in the Baltic States. This is related with significant changes in the structure of vehicles (almost all soviet cars, tracks and buses were changed and imported from Western countries) and also because in early 1990's, a rather large share of gasoline, kerosene and diesel oil was used for military needs (mostly transportation) of the Soviet Army.

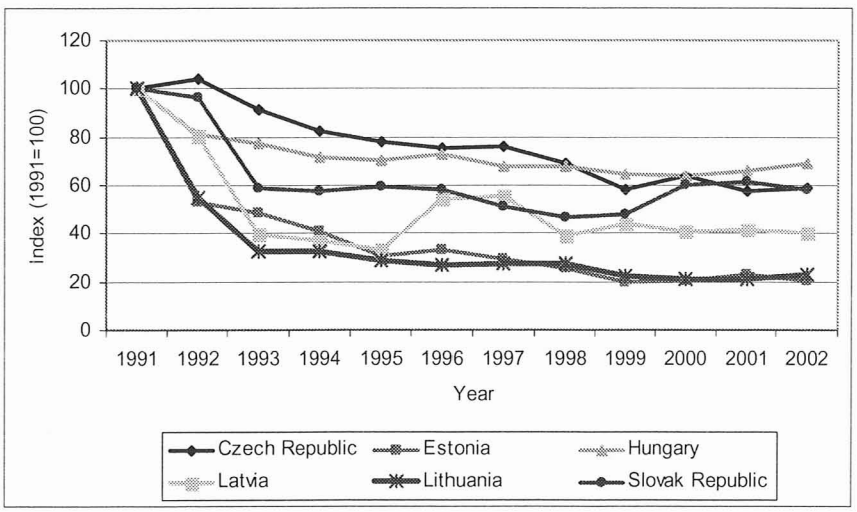


Figure 4. Development of energy consumption in the industry sector

Final energy consumption has decreased in all countries of Central and Eastern Europe (the new member states of the EU), except for Slovenia.

Although the economy in these countries has been recovering since 1995, the lowest index of the final energy consumption was fixed in 1998-2000 due to a significant increase in energy efficiency. In Slovenia, the small reduction of final energy consumption was fixed only in early nineties and since 1993, energy demand has been growing very fast because of modernization of infrastructure in the services sector, improved living standards as well as increased mobility of the population. Vice versa, energy consumption in Lithuania and Latvia has decreased significantly in the services, transport and households sectors because of the lack of necessary investments and the lowering of the general quality of life, especially in rural area.

4. CHANGES OF ENERGY EFFICIENCY

One of the legacies of central planning was the inefficient use of energy in all transition countries. High energy intensity in these countries was due to several factors: the existence of very low energy prices; old and inefficient equipment and technologies; low thermal performance of dwellings and public buildings; comparatively large number of old private cars; lack of incentives for energy efficiency; inadequate or even non-existent metering and control of energy consumption. Therefore, energy efficiency enhancement was and remains one of the most important strategic objectives in Central and Eastern European countries. Since beginning of the transition period, energy intensity, measured as the gross inland energy consumption per unit of GDP at constant prices, has been decreasing in all countries. Only in Slovenia did energy intensity increase up to 1996. Based on indicators about energy consumption and GDP development presented in IEA, 2004 and Eurostat database, 2005, primary energy consumed per unit of GDP in Estonia has decreased during the period 1991-2002 almost 2 times, in Lithuania and Poland 1.7 times (Fig. 5).

An assessment of energy efficiency and potential of energy saving in former centrally planned economies, could be based on the relative energy consumption in developed countries by comparing several indicators, such as primary energy intensity, final energy intensity and energy consumption per capita (overall or detailed by energy forms). The most popular is the indicator of primary energy intensity. This indicator is defined as the ratio of gross inland consumption of primary energy (or total supplied primary energy) and GDP using exchange rates. It is used in many studies prepared by the Eurostat, International Energy Agency, the European Commission and is presented in various statistical publications (European Commission, 1999, 2000, 2002, 2004; IAE, 2004a, 2004b, 2004c). In 2002, according to data presented in European Commission, 2004 and Eurostat database, 2005,

primary energy intensity in transition countries was significantly higher than in developed countries.

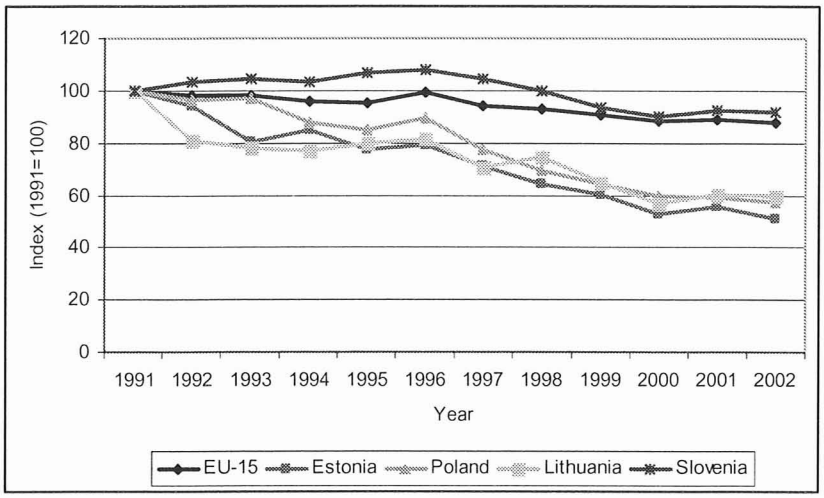


Figure 5. Development of primary energy intensity in selected countries

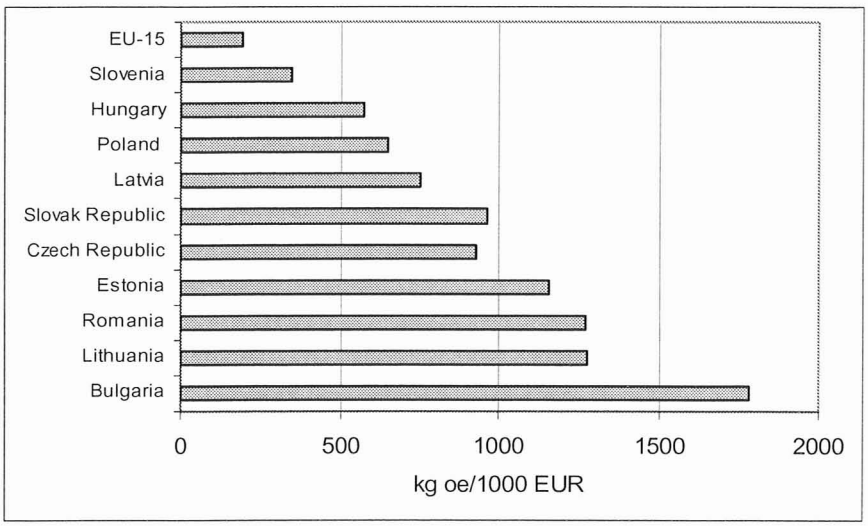


Figure 6. Primary energy intensity in Central and East European countries in 2002

For example, in Latvia, Czech Republic, Hungary, Slovak Republic, Estonia and Lithuania, it was by 4 to 7 times higher, and in Bulgaria more than 9 times higher than the average in the EU-15 countries (Fig. 6). Based on an analysis of these indicators, a conclusion about the possibility of reducing primary energy intensity in the Central and Eastern European countries by several times could be made. However, such a conclusion is not correct because the real possibility for reduction of relative primary energy consumption per unit of GDP is much lower.

Let's assume that there are possibilities to reduce gross inland energy consumption through the implementation of energy efficiency measures in all sectors the national economies, which are really very large (by several times), and that the minimum amount of gross primary energy demand is equal in each Central and Eastern European country to the current final energy consumption in the household sector. This means that all economic activities in all sectors of the economy, excluding household, should be performed without any energy consumption. Even in this case, energy intensity defined using the same methodology and using the same economic data (Eurostat database, 2005) in the Baltic States, Bulgaria and Romania would be higher than current average of primary energy intensity in the EU-15 (Fig.7).

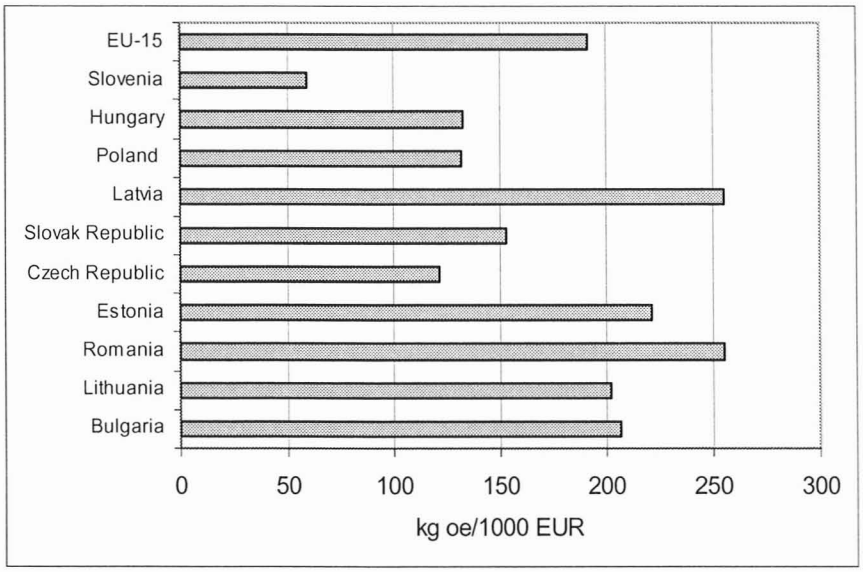


Figure 7. Primary energy intensity in the EU-15 and relative energy consumption in the household sector per unit of GDP in the Central and East European countries in 2002

Thus, the indicator of primary energy consumption per unit of GDP using exchange rates does not reflect the real differences between energy efficiency in developed countries of Western Europe and countries of the former Eastern Block. It is necessary to underline that in principle, high primary energy intensity in the former centrally planned economies is determined first of all by the very low level of GDP in these countries. It is caused by price distortions and the differences in GDP evaluation. The gross value added of similar goods produced and particularly of services rendered in countries of the former Eastern Block is still much lower than in developed countries. Therefore, a method of Purchasing Power Parity (PPP) should be used when seeking to compare levels of GDP in developed countries and countries with transition economies. In this case, the indicators of primary energy intensity in various countries could be assessed more precisely. Using estimates of Purchasing Power Parity, presented in IEA, 2004a, primary energy intensity in countries of Central and Eastern Europe is only 1.3 to 2.2 times higher than the average in the EU-15 countries (Fig. 8). Similar differences in the primary energy intensity in these countries could be defined in a case when GDP is expressed in Purchasing Power Standards, presented in the Eurostat database (Eurostat database, 2005). Thus, real differences in energy intensity between countries of the former Eastern Block and developed Western countries are much lower than it is presented in many statistical publications.

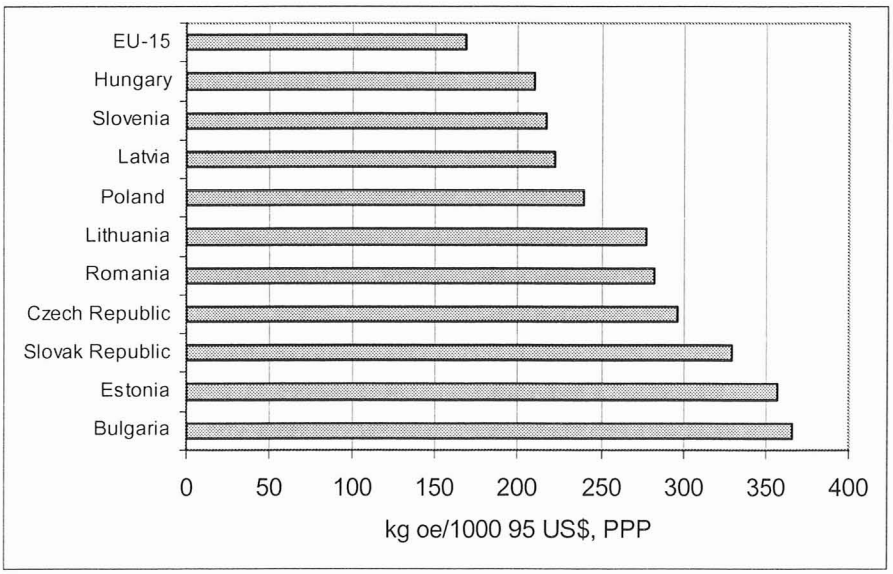


Figure 8. Primary energy intensity using estimates of Purchasing Power Parity in 2002

Application of primary energy intensity indicators gives a possibility to compare overall energy efficiency in various countries. However in principle, such comparison of energy efficiency in various countries is not totally correct (Miskinis 2003; Miskinis, Vilemas, 2003) because the structure of primary energy consumers in each country is different. On the basis of analysis of energy balances, presented in IEA, 2004b, 2004c, one can state that the structure of primary energy consumption (losses of primary energy in a transformation sector, own use of power plants, non-energy consumption, transmission and distribution losses, and final energy consumption) in different countries varies greatly. For example, according to the methodology of international statistics, output of the same amount of electricity from hydro power plants requires three times less input of primary energy than from nuclear power plants. Thus, primary energy consumption, necessary to meet requirements for electricity in each country, per unit of GDP depends very much on the structure of electricity generating capacities. Similarly, an indicator of primary energy intensity is dependent on the role of the energy sector for the country's economy in terms of absolute and relative energy consumption and on volumes of primary energy consumption for non-energy purposes. In addition, the amount of primary energy consumption in each country depends very much whether a country is importing electricity (like Italy, Latvia, Luxembourg, Netherlands) or exporting electricity (like France, Lithuania, Estonia), especially when electricity generation is based on conventional power plants and nuclear power plants with comparatively low efficiency. To modernize equipment in the energy transformation sector and to increase efficiency of energy generating capacities, a longer period of time and larger investments are required. Energy efficiency in the Central and Eastern European countries has been increasing since beginning of transition period initially on the consumer side due to significant structural changes in the national economies and implementation of appropriate energy saving measures. Final energy, i.e. that part of the primary energy and secondary energy resources, which are used by the final consumers, is the real basis for the production of various goods and for the delivery of services.

It is important to note that according to the methodology of the International Energy Agency "total final consumption" is the sum of consumption by the different end-use sectors, including petrochemical feedstocks and other non-energy use. Analysis of energy balances in various countries, presented in IEA, 2004b, 2004c and Eurostat database, 2005, shows that a share of non-energy use in the balance of total energy available for final consumption varies greatly. In 2002, Denmark, Finland, Latvia, Slovenia and Estonia share of non-energy use was less than 5%, the average in the EU-15 countries was 8.8%, and in Lithuania – 17.1%. (Fig. 9)

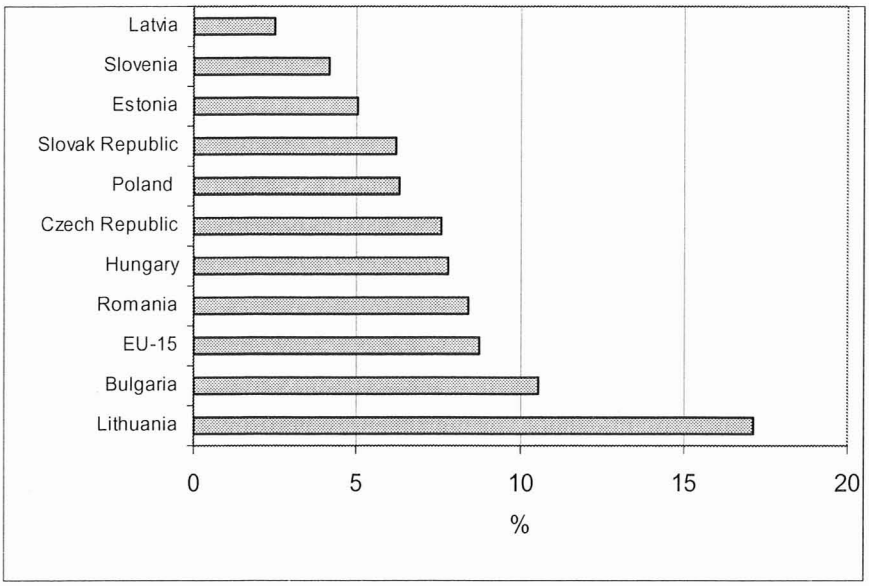


Figure 9. Share of non-energy use in the balance of total final consumption

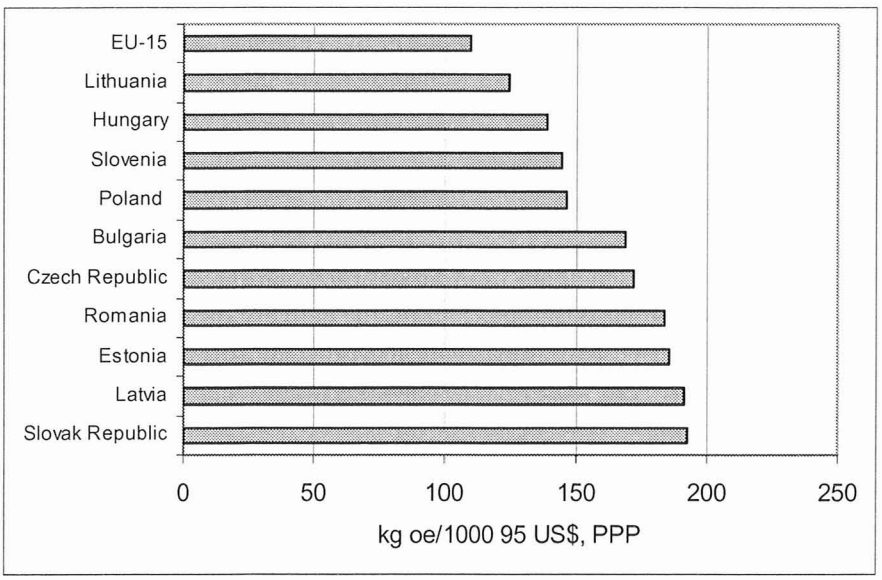


Figure 10. Final energy intensity using estimates of Purchasing Power Parity in 2002

To have a better comparison of energy intensity, as an indicator for assessment of end-use efficiency in various countries, final energy consumption (excluding non-energy use) should be divided by GDP expressed in Purchasing Power Parities. In 2002, the lowest energy intensity (but still by 1.2-1.3 times higher than on average in the EU-15 countries) was in Lithuania, Hungary, Slovenia and Poland (Fig. 10). Specific final energy consumption per GDP unit in the Slovak Republic, Latvia, Estonia, Romania, Czech Republic and Bulgaria is 50-75% higher than on average in the EU-15 countries.

Final energy intensity could be assessed as the best indicator for comparison of end-use efficiency in various countries. However, the amount of final energy consumption, in particular in the households and services sector, is dependent very much on many factors, such as climatic conditions, dwelling area per capita, service floor area per capita, types of heating systems, thermal performance of living houses and public buildings, penetration of electrical appliances and quality of living standards. To avoid the different climatic conditions in the various countries, energy consumption for heating purposes should be corrected by indicator of degree days.

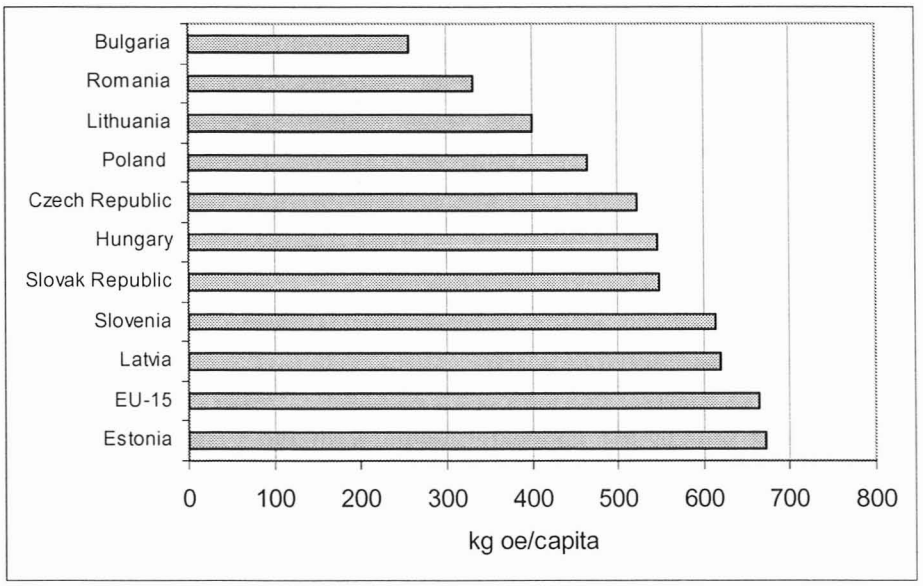


Figure 11. Enegy consumption in household sector per capita in 2002

During the transition period, total energy consumption in the households sector was decreasing in many Central and Eastern European countries.

Reduction of energy consumption resulted in the replacement of single glazed windows with modern double glazed insulated windows, improved insulation of buildings, implementation of various energy saving schemes and in some cases, by the reduction of living standards. Since 1998-2000, rapid economic growth was followed by the increase of energy consumption in households but in 2002, it was still 10-30% lower than in 1991. During the transition period, energy consumption in this sector was growing only in Slovenia and Slovak Republic, and in 2002 it was increasing at a rate 15 and 25% respectively, higher than in 1991. The comparison of energy consumption in households per capita in Central and East European countries is presented in Fig.11.

Specific energy consumption per capita and per dwelling in the Central and Eastern European countries is comparatively low. In 2002, energy consumption in Bulgaria and Romania was 50% less, in Lithuania 40% less, in Poland 30% less, and in the Czech Republic 20% less than the average of the EU-15 countries. According to this indicator, energy consumption in the households sector is similar to the average in the EU-15 countries only in Slovenia, Latvia and Estonia. In addition, electricity consumption per capita and other indicators of living standards in the Baltic States, Romania, Bulgaria and Poland are much lower than in developed Western countries. Therefore, energy saving potential in the Central and East European countries in the households and the services sector is limited because the increase of energy efficiency and increase of living standards are factors that may counteract each other.

CONCLUSIONS

1. Deep recession of the national economies in the Central and Eastern European countries at the beginning of transition period was followed by significant reduction of energy consumption, in particular in manufacturing and agriculture. In 2002, total primary energy consumption in all Central and Eastern European countries (members of the EU-25) was 12% lower than in 1991. However, it is necessary to underline that the index of gross inland consumption in 2002 (1991=100) in the Baltic States and in the other countries of Central and Eastern Europe differ greatly: in Lithuania it was 52, Estonia 54, Latvia 63, but in Poland it was 90, Czech Republic 95, Hungary 96, Slovak Republic 99 and in Slovenia 128.

2. Dramatic structural changes in economies, decline of economic activities in energy intensive industries, implementation of energy efficiency policies and other factors have stipulated a large reduction of energy consumption in all Central and Eastern European countries. Gross inland energy consumption per unit of GDP at constant prices during the period 1991-2002 in Estonia has decreased almost 2 times, in Lithuania and Poland 1.7 times. In other countries of this region energy intensity has decreased 1.3-1.5 times, only in Slovenia was there a smaller reduction of this indicator which was about 9% or similar to an average of 14% in the EU-15 countries.

3. Indicator of the primary energy intensity (gross inland consumption of energy divided by GDP using exchange rates), presented in the Eurostat database, in transition countries is still significantly higher than in developed countries. In Latvia, Czech Republic, Hungary, Slovak Republic, Estonia and Lithuania in 2002, it was 4-7 times higher, and in Bulgaria it was more than 9 times higher than the average in the EU-15 countries. However, this indicator does not reflect the real differences in energy efficiency between developed countries in Western Europe and countries of the former Eastern Block.

4. For comparison of energy efficiency in developed countries and countries in transition, the best indicator is the ratio between final energy intensity and GDP using estimates of Purchasing Power Parity (or Purchasing Power Standards). According to this indicator, energy intensity in Lithuania, Hungary, Slovenia and Poland in 2002 was only 15-35% higher, and in the Slovak Republic, Latvia, Estonia, Romania, Czech Republic and Bulgaria 50-75% higher than on average of the EU-15 countries. These figures reflect a more realistic difference of energy efficiency in the EU-15 countries and new member states of the EU-25.

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