Economy Wide Material Flow Accounts of Estonia

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Introduction

In Estonia environmental accounting is a new and not yet highly developed branch of environmental statistics, which up to now has been limited to a few pilot projects done by Statistics Estonia. Considering the high priority of Economy Wide Material Flow Accounts (MFA) for Eurostat and upcoming regulation of European Commission obliging all Member States to present on a regular bases the data on MFA from one side and lack of any experience in compiling MFA in Estonia from other side, Statistics Estonia has now carried out a pilot project on compiling Economy Wide Material Flow Accounts. In a current article some Material Flow Accounts and Indicators were calculated and analyzed briefly.

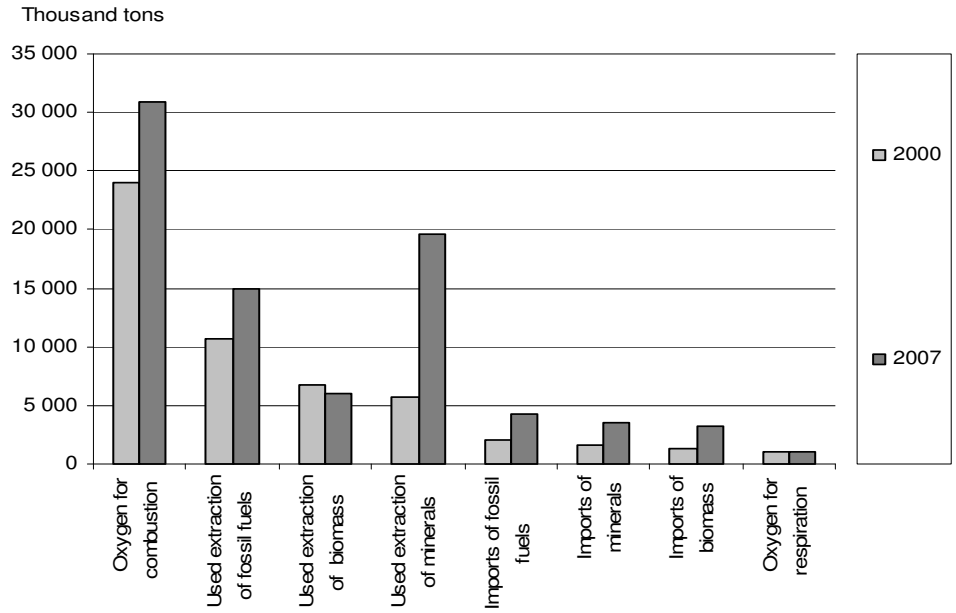
As this project was a first attempt to investigate the movements of physical material flows through Estonian economy, attention was paid on revealing the direct material flows. Indirect material flows associated with export and import were not estimated. From hidden material flows only unused domestic extraction was estimated. Memorandum items for balancing were compiled as far as were asked in Eurostat' MFA questionnaire 2009.

The carried out study revealed that direct material flow was about 70% bigger in 2007 than it was in 2000 in Estonia. Material flow into and out from domestic economy in Estonia has increased in 2007 compare to 2000.

Material flow balance accounts

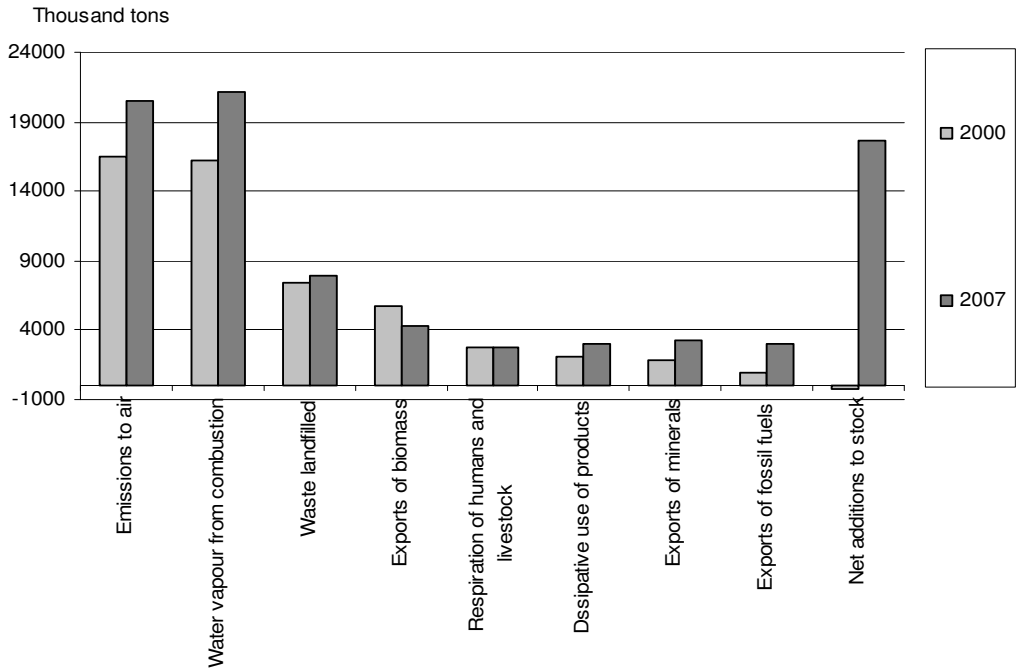
In material flow balance accounts just direct material flows were considered, indirect material flows associated with the export and import were not estimated. Direct material flow balance accounts allow the presenting of a flow of direct material inputs and outputs. In 2007 the Estonian direct material flow was about 70% bigger than in 2000 as mentioned above. A direct material flow balance account for 2000 and 2007 are presented in the table 1 and table 2. On the figure 1 the bigger items of input side of direct material flow balance for 2000 and 2007 are compared. As it is seen from the figure the increase of material flow has occurred mainly due to substantial increase of excavation of minerals and also increased excavation of fossil fuels. Balancing item oxygen for combustion has noticeably increased also, which is natural consequence of increased use of fossil fuels.

Figure 1. Input side of direct material flow balance for 2000 and 2007



On the next figure 2 the bigger items of output side of direct material flow balance for 2000 and 2007 are compared. As it is seen from the figure the increase of material flow has occurred mainly due to substantial increase of net additions to stock. Considerable increase occurred also in quantity of air emissions and balancing item water vapour for combustion.

Figure 2. Output side of direct material flow balance for 2000 and 2007



It could be concluded, that material flow into and out from domestic economy in Estonia has increased in 2007 compared to 2000 due to substantial increase of domestic extraction of

construction minerals and consequent increase of stock (buildings). Another considerable factor of increase of material flow is increased domestic extraction of oil shale (increase of production of electricity) and consequent increase of air emissions.

Table 1. Direct material flow balance accounts for 2000, thousand tons

RESOURCES		USES	
Used domestic extraction	**23 087,2**	**Exports**	**9 090,7**
Fossil fuels	***10 729,7***	***Raw materials***	***5 698,8***
Oil shale	9 970,0	Fossil fuels	802,9
Peat	759,7	Minerals	364,1
Minerals	***5 657,6***	Biomass	4 512,5
Industrial minerals	967,5	Secondary raw materials	19,3
Special clays	246,3	***Semi-manufactured products***	***1 860,9***
Special sands	76,1	From fossil fuels	175,1
Technological limestone and limestone for cement	643,8	From minerals	1 014,6
Other	1,3	From biomass	671,2
Construction minerals	4 690,1	***Finished products***	***1 531,0***
Sand and gravel	1 580,8	Predominately from minerals	376,5
Crushed stones	849,4	Predominately from biomass	367,3
Dimension stones	1 763,4	Other products	787,2
Soil	68,9	Other products of abiotic kind	133,8
Excavation by-products (oil shale excavation wastes)	427,4	Other products of biotic kind	136,6
Biomass	***6 699,9***	Other products n.e.c.	516,8
Biomass from agriculture	2 786,0	***Waste exported for final treatment and disposal***	***0,0***
Biomass from agriculture harvest	1 294,0	**Emissions and wastes**	**23 854,7**
Cereals	697,0	***Emissions to air***	***16 423,0***
Roots	472,0	***Waste land filled***	***7 423,4***
Pulses	7,0	***Emissions to water***	***8,3***
Oil crops	39,0	**Dissipative use of products and losses**	**2 143,0**
Vegetables	53,0	***Dissipative use of products***	***2 127,2***
Fruits	26,0	Dissipative use on agricultural land	2 117,1
Fiber crops	0,0	Mineral fertilizers	32,4
Other	0,0	Farmyard manure	1 863,6
Biomass from agriculture by-products of harvest	42,5	Sewage sludge	19,5
Crop residues used as fodder	42,5	Compost	34,0
Fodder crops	1 166,7	Pesticides	0,3
Biomass from grazing of agricultural animals	282,8	Seeds	167,4
Biomass from forestry	3 790,6	Dissipative use on roads	5,9
Wood	3 790,6	Dissipative use of solvents	4,2
Biomass from fishing	113,1	***Dissipative losses***	***15,8***
Marine fish catch	97,1	Abrasion of tyres and breaks	8,1
Inland waters fish catch	3,2	Leakages	1,0
Other aquatic animals and plants	12,8	Erosion of roads	6,7
Biomass from hunting	1,6	**Memorandum items for balancing**	**18 964,9**
Biomass from other activities	8,6	***Water vapour from combustion***	***16 178,8***
Honey	0,3	From water contents of fuels	2 172,7

Gathering of berries and mushrooms	8,3	From hydrogrn contents of fuels	14 006,1
Imports	**5 590,8**	***Respiration of humans and livestock***	***2 786,1***
Raw materials	***2 371,4***	CO2	1 292,1
Fossil fuels	1 240,7	Water vapour	1 494,0
Minerals	534,5	**Net additions to stock**	**-275,3**
Biomass	591,0		
Secondary raw materials	5,2		
Semi-manufactured products	***1 495,4***		
From fossil fuels	740,5		
From minerals	595,6		
From biomass	159,3		
Finished products	***1 724,0***		
Predominately from minerals	429,0		
Predominately from biomass	191,3		
Other products	1 103,7		
Other products of abiotic kind	70,9		
Other products of biotic kind	392,1		
Other products n.e.c.	640,6		
Waste imported for final treatment and disposal	***0,0***		
Memorandum items for balancing	**25 100,0**		
Oxygen for combustion	***24 016,5***		
Oxygen for respiration	***1 083,5***		
	53 778,0		**53 778,0**

Table 2. Direct material flow balance accounts for 2007, thousand tons

RESOURCES		USES	
Used domestic extraction	**40 576,4**	**Exports**	**11 573,0**
Fossil fuels	***14 893,0***	***Raw materials***	***4 174,8***
Oil shale	13 992,2	Fossil fuels	897,2
Peat	900,8	Minerals	735,2
Minerals	***19 657,5***	Biomass	2 541,8
Industrial minerals	1 464,1	Secondary raw materials	0,6
Special clays	457,6	***Semi-manufactured products***	***4 283,2***
Special sands	80,0	From fossil fuels	2 107,8
Technological limestone and limestone for cement	926,1	From minerals	1 510,0
Other	0,4	From biomass	665,4
Construction minerals	18 193,4	***Finished products***	***3 115,0***
Sand and gravel	6 531,9	Predominately from minerals	974,8
Crushed stones	3 675,3	Predominately from biomass	642,3
Dimension stones	4 974,4	Other products	1 497,9
Soil	1 302,7	Other products of abiotic kind	100,5
Excavation by-products (oil shale excavation wastes)	1 709,1	Other products of biotic kind	418,2
Biomass	***6 025,9***	Other products n.e.c.	979,2
Biomass from agriculture	2 119,7	***Waste exported for final treatment and disposal***	***0,0***
Biomass from agriculture harvest	1 292,0	**Emissions and wastes**	**28 431,7**
Cereals	879,0	***Emissions to air***	***20 440,6***
Roots	192,0	***Waste land filled***	***7 984,9***

Pulses	9,0	***Emissions to water***	***6,1***
Oil crops	133,0	**Dissipative use of products and losses**	**3 084,7**
Vegetables	72,0	***Dissipative use of products***	***3 067,8***
Fruits	7,0	Dissipative use on agricultural land	3 053,3
Fiber crops	0,0	Mineral fertilizers	45,5
Other	0,0	Farmyard manure	2 704,3
Biomass from agriculture by-products of harvest	35,1	Sewage sludge	22,8
Crop residues used as fodder	35,1	Compost	171,4
Fodder crops	553,0	Pesticides	0,9
Biomass from grazing of agricultural animals	239,5	Seeds	108,4
Biomass from forestry	3 795,4	Dissipative use on roads	9,7
Wood	3 795,4	Dissipative use of solvents	4,8
Biomass from fishing	99,3	***Dissipative losses***	***16,9***
Marine fish catch	81,1	Abrasion of tyres and breaks	9,1
Inland waters fish catch	2,6	Leakages	0,0
Other aquatic animals and plants	15,7	Erosion of roads	7,8
Biomass from hunting	2,4	**Memorandum items for balancing**	**23 941,9**
Biomass from other activities	9,0	***Water vapour from combustion***	***21 198,1***
Honey	0,8	From water contents of fuels	2 827,6
Gathering of berries and mushrooms	8,3	From hydrogen contents of fuels	18 370,5
Imports	**12 140,6**	***Respiration of humans and livestock***	***2 743,8***
Raw materials	***4 012,0***	CO2	1 272,5
Fossil fuels	1 030,8	Water vapour	1 471,3
Minerals	1 354,8	**Net additions to stock**	**17 594,5**
Biomass	1 626,3		
Secondary raw materials	0,0		
Semi-manufactured products	***4 581,7***		
From fossil fuels	3 165,6		
From minerals	875,7		
From biomass	540,4		
Finished products	***3 545,8***		
Predominately from minerals	1 164,9		
Predominately from biomass	447,8		
Other products	1 933,2		
Other products of abiotic kind	172,5		
Other products of biotic kind	629,1		
Other products n.e.c.	1 131,6		
Waste imported for final treatment and disposal	***1,0***		
Memorandum items for balancing	**31 908,8**		
Oxygen for combustion	***30 841,8***		
Oxygen for respiration	***1 067,0***		
	84 625,8		**84 625,8**

Indicators

This chapter gives an overview of the **material flow indicators** derived from the material flow accounts. With the help of these indicators the flows of materials between Estonian economy and environment are characterized. Indicators (input indicators, consumption and

balance indicators and output indicators) were combined with other economic indicators in order to characterize various aspects of the Estonia's resource use and efficiency measures both in time horizon and in international comparison.

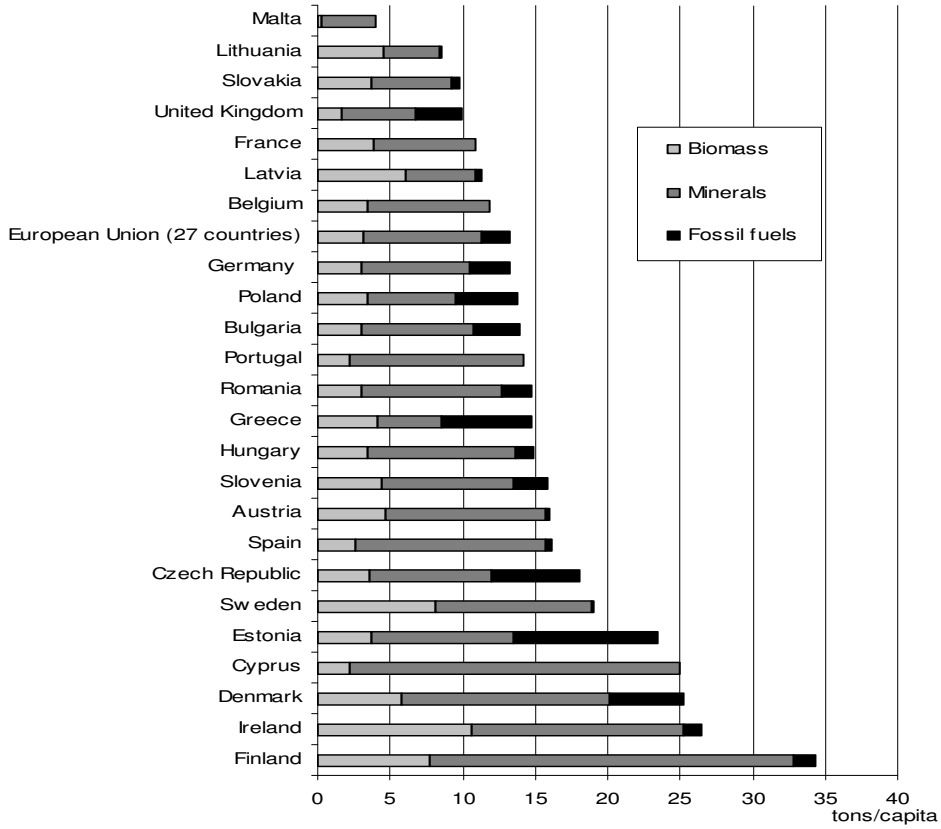
Direct material input

Direct material input is the indicator which represents materials supply. It measures the direct input of materials into the economy. Direct material input consists of all solid, liquid and gaseous materials which are of economic value and are used in production and consumption activities. Direct material input is defined as a sum of used domestic extraction and imports.

Both components, the used domestic extraction and imports, constantly increased during time period 2000-2007. The domestic extraction makes up a majority of direct material input during considered time period. Though quantity of imports is still rather small, the share of imports in direct material input is increasing (from 19% in 2000 to 23% in 2007).

The figure 3. compares the domestic extraction of EU27 Member States in 2005. Estonian domestic extraction was one of the biggest in the EU 27.

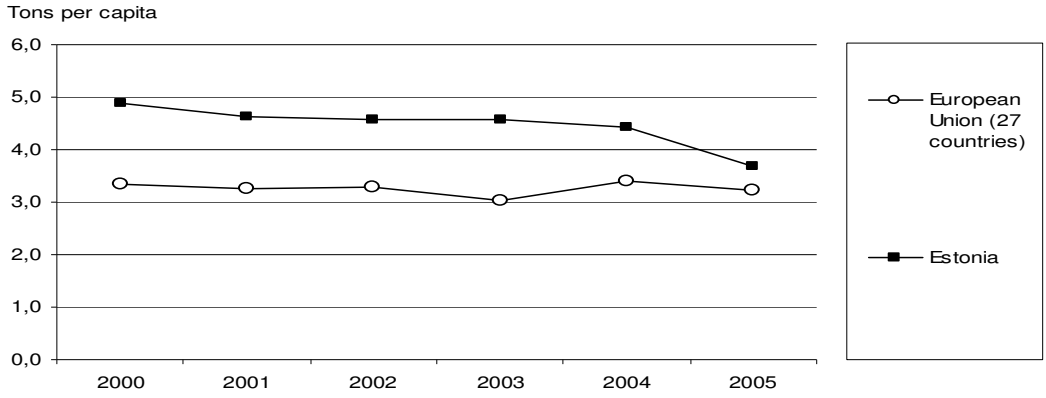
Figure 3. Domestic extraction, 2005, tons per capita



Source: Estonia- Statistics Estonia; the other countries - Eurostat

The trends of domestic extraction of the main material types compared to EU average are presented on the next figures.

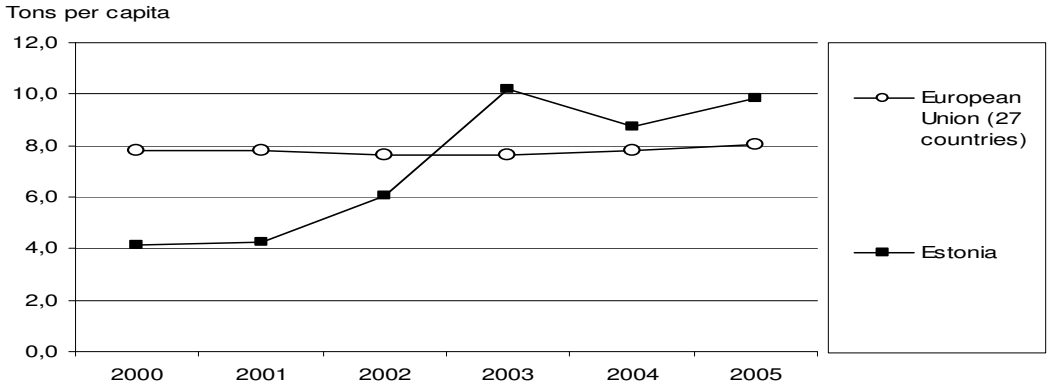
Figure 4. Domestic extraction of biomass, tons per capita



Source: Estonia- Statistics Estonia; the other countries - Eurostat

Domestic extraction of biomass stayed considerably higher than average of EU27 at all the considered time period. Biomass from forestry makes up 60-70% of extracted biomass in Estonia. However, in last yearsd omestic extractionof biomass in Estonia is declining and coming closer to average of European Union.

Figure 5. Domestic extraction of minerals, tons per capita

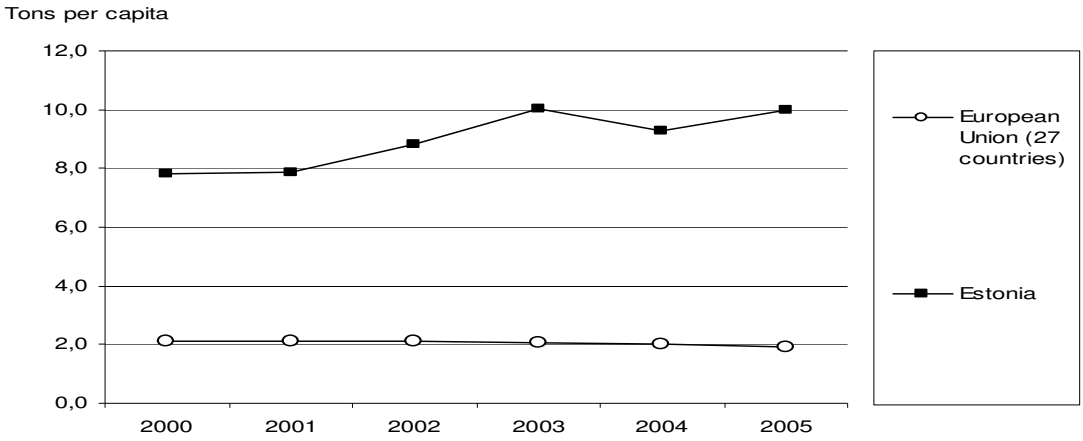


Source: Estonia- Statistics Estonia; the other countries - Eurostat

Extraction of minerals has increased a lot during 2000 - 2007. In 2000 non metallic minerals shared to 17% of domestic extraction. The domestic extraction of minerals was about twice lower than average of EU 27. In 2003, the domestic extraction of minerals already exceeded the average of EU27 and stayed as such since. In 2007, extraction of non metallic minerals has increased almost three times and shared to one third of domestic extraction. About 90% of non-metallic minerals are used in construction. Considerable increase of domestic extraction

of construction minerals is understandable as construction activity has increased remarkably in these years also.

Figure 6. Domestic extraction of fossil fuels, tons per capita



Source: Estonia- Statistics Estonia; the other countries - Eurostat

Domestic extraction of fossil fuels in Estonia is highest among EU27 countries. Indicator exceeds the average of EU27 by 4-5 times and is constantly increasing. Oil shale makes up more than 90% of domestic extraction of fossil fuels.

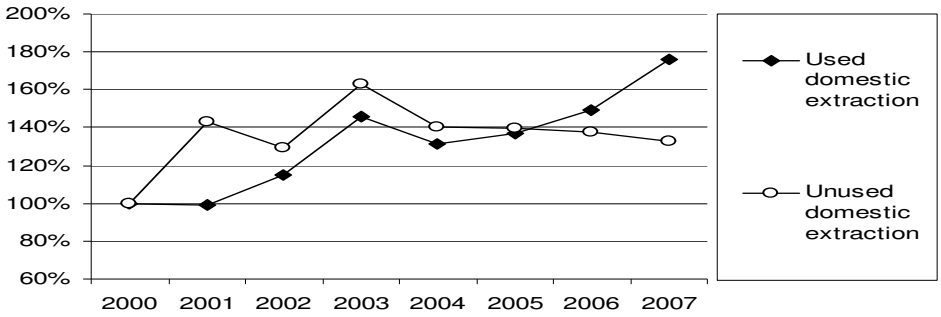
Unused domestic extraction

Unused domestic extraction refers to the materials that are moved by economic activities but which do not serve as input for production or consumption activities (mining overburden, etc.). The quantity of unused extraction is relatively low (less than 15% of total material input) and it stays almost the same (about 5 million tons) on this time period.

Waste from oil shale excavation make up about 90% of unused domestic extraction. In 2007 the quantity of unused domestic extraction has increased by about 30% compared to 2000. The used domestic extraction has increased by 75% at the same time. In 2000 the quantity of unused domestic extraction was about 15% compared to the used domestic extraction. In 2007 the relative quantity of unused extraction decreased to about 11%.

Next figure 7 presents the changes both in used and unused domestic extraction during the period 2000-2007 compared to 2000.

Figure 7. Changes in used and unused domestic extractions, 2000=100%



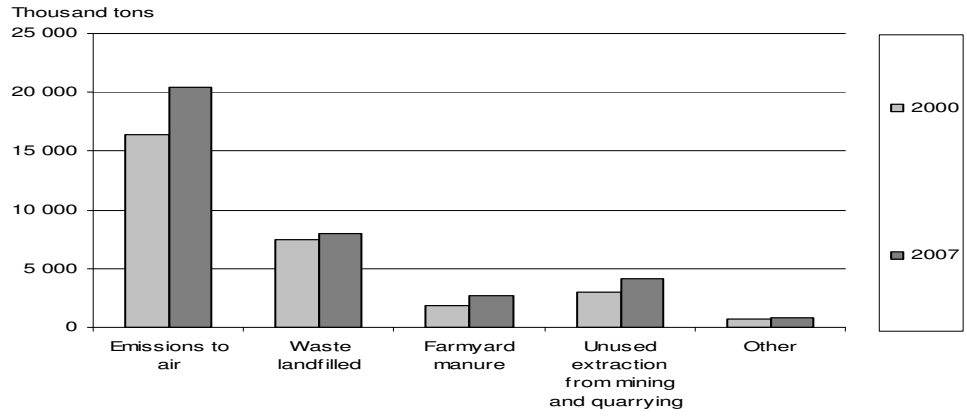
Even though the quantity of unused extraction has not changed considerably during the years, the important positive change has occurred lately. In 2000-2003 the unused domestic extraction was increasing quicker than the used extraction: since 2003 the quantity of unused domestic extraction is declining although used domestic extraction is increasing. Oil shale excavation wastes made up majority of unused domestic extraction; recycling of oil shale excavation wastes has increased in the recent years which had an effect also on the increase of total quantity of unused extraction.

Total domestic output

The increase of the material inflow in 2000 - 2007 brought also the increase of the outflow: both the production and consumption activities in Estonia increased much in this period. The outflow, which accounted for materials which were used in the economy and subsequently left the economy either in the form of emissions and waste or in the form of exports, increased also.

For the end of the year 2007, total domestic output has increased by 22% compare to 2000 (29 thousand tons in 2000 and 36 thousand tons in 2007). The figure 8 below illustrates the main material flows of total domestic output in these two years. The emissions to air are biggest materials output flows and also this flow increased the most during in 2000 - 2007.

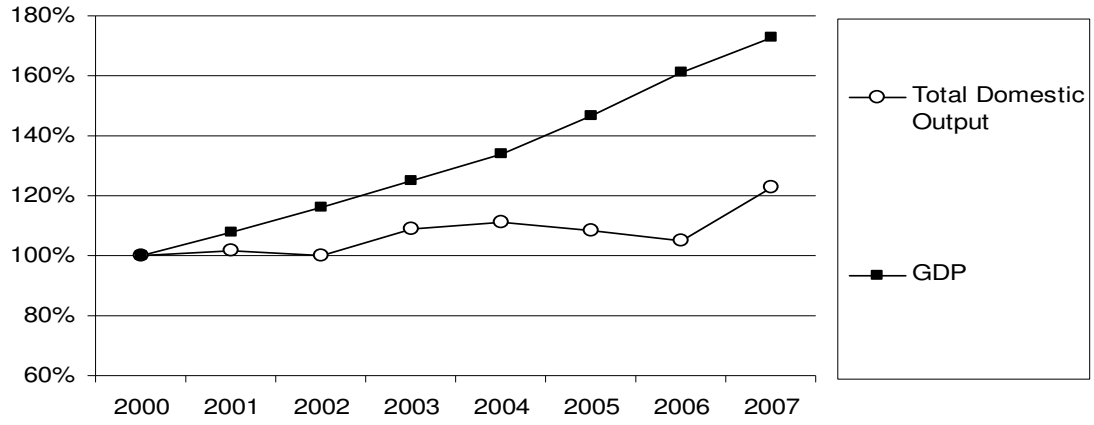
Figure 8. The main material flows of TDO in 2000 and 2007, thousand tons



Most of the air emissions originated from electricity production based on oil shale burning. Oil shale excavation and electricity production from oil shale generates the big quantity of wastes which appear in various locations in total domestic output: - excavation wastes appear in total domestic output accounts as disposal of unused domestic extraction but oil shale ashes (which made up the greatest share of oil shale waste) appear as landfilled wastes. The increase of electricity production at the recent years had the bigger influence on quantity of air emissions than on the quantity of land filled wastes and disposal of unused extraction.

The decoupling of GDP and quantities of output of materials could be also observed. The substantial growth of GDP was not accompanied with the same increase of quantities of output materials.

Figure 9. Changes in GDP and total domestic output, 2000=100%



The above Figure 9 illustrates the trends of total domestic output and GDP and shows that GDP is growing quicker than domestic output. The latter was influenced in one hand by the increase of the quantity of exported materials and in other hand by the vast growth of the GDP during the economic "boom".

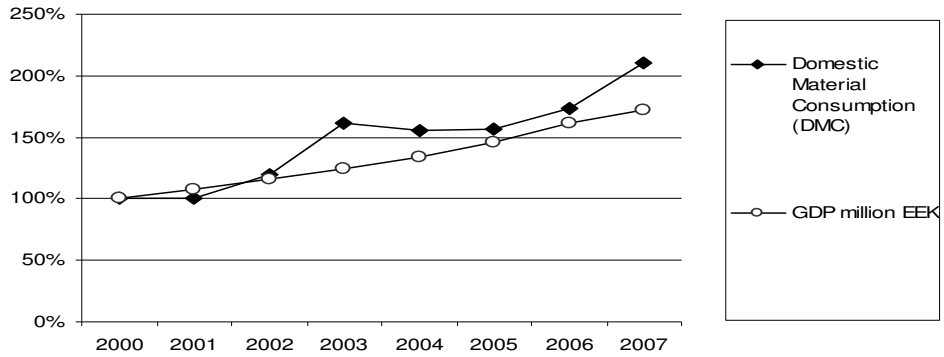
Recourse productivity

There are two aspects of the use of natural resources: the total quantity used and the efficiency of use. In order to reduce the quantitative resource use principally the efficiency should be increased. So also the statististics should calculate and analyze in addition to the indicators characterizing the resources' absolute use levels (input and consumption indicators) also resource efficiency or productivity indicators. For that purposes the various aspects of the material flow accounts indicators are connected to (macro) economical indicators.

Resource productivity indicators compare natural resources use with economic growth. For calculating resource productivity natural resources use might be expressed either by input indicators (GDP/DMI – direct material productivity) or consumption indicators (GDP/DMC - domestic material productivity). Both productivity indicators from input and consumption bases were calculated.

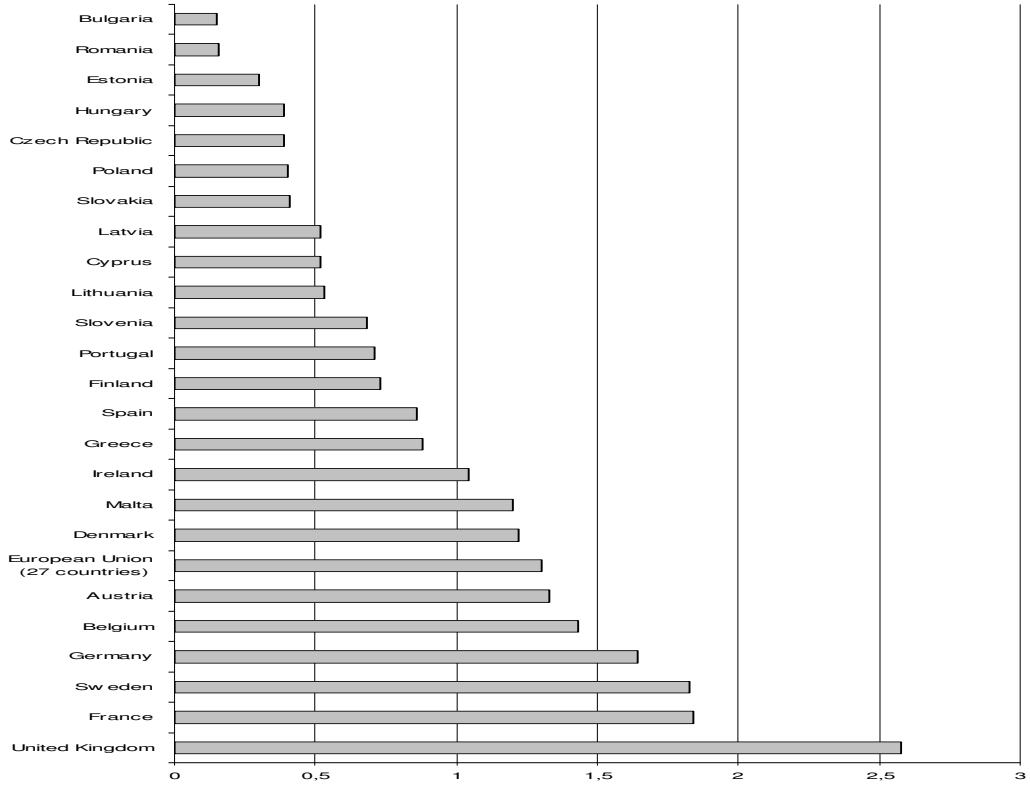
Resource productivity in 2000-2007 is declining. If in 2000 315 EUROs was generated per one ton of consumed materials than in 2007 just 259 EUROs respectively. The following figure 10 illustrates the changes in **domestic material consumption** and GDP. It is clearly seen, that domestic material consumption increases quicker than GDP.

Figure 10. Changes in domestic material consumption and GDP, 2000=100%



Regarding the input type of resource productivity indicators, the difference between **direct material productivity** and **domestic material productivity** is that exported materials are included for the calculation of the first one: direct material productivity. Currently just the domestic material productivity is used in following analysis as international data for this indicator were available in Eurostat. On the following figure 11, the resource productivities of EU countries in 2005 expressed as GDP per domestic material consumption are presented. Estonia ranks on third position among three least resource efficient EU States exceeding only resource productivity of Rumenia and Bulgaria.

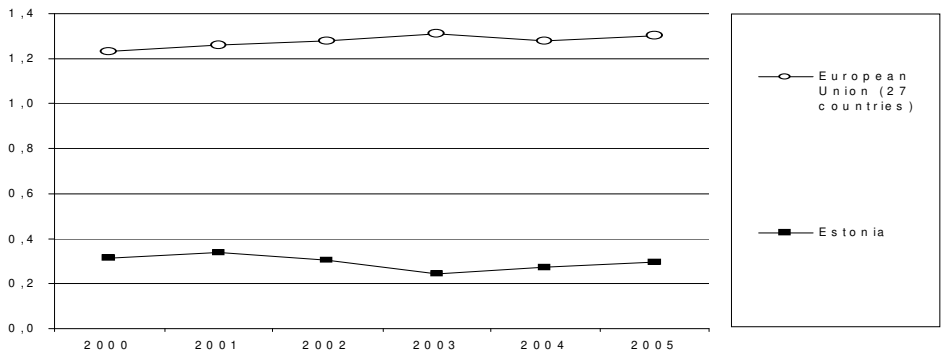
Figure 11. Resource Productivity (GDP/DMC), 2005



Source: Estonia- Statistics Estonia; the other countries - Eurostat

Next figure 12 evaluates also the trends of resource productivities of Estonia and in EU 27 in average during 2000-2005. It is seen that the average resource productivity of EU 27 countries is about 4 times higher than in Estonia and the difference is growing. The trend of resource productivity of EU 27 average is slightly increasing; the trend of indicator for Estonia is slightly decreasing at the same time.

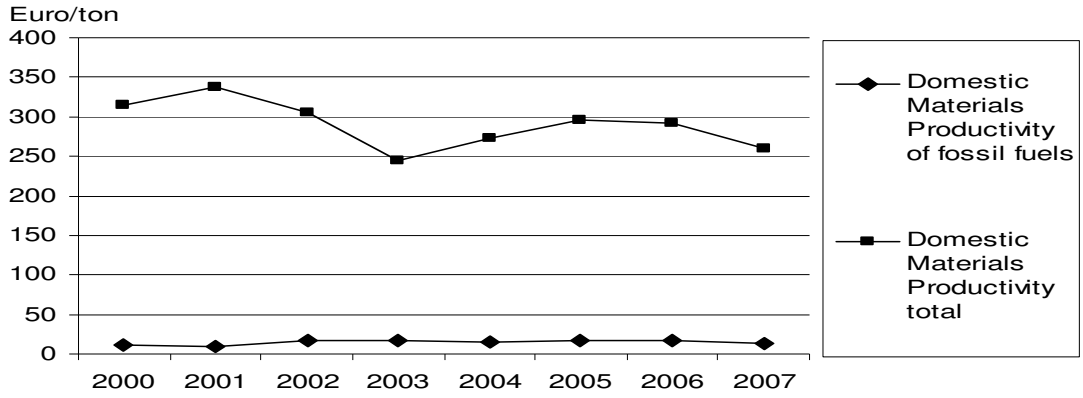
Figure 12. Resource Productivity (GDP/DMC), 2000 - 2007



Source: Estonia- Statistics Estonia; the other countries - Eurostat

One reason of so low resource productivity in Estonia is oil shale based electricity production in Estonia. Considering that more than 90% of electricity is produced from oil shale, and in turn, oil shale is mostly used for electricity production, allow us to point out the resource productivity of fossil fuels. This indicator was calculated using GDP by expenditure approach in chain-linked volume (reference year 2000). GDP generated in electricity, gas and water supply was used as denominator for domestic material productivity of fossil fuels. Peat was included to domestic extraction of fossil fuels, but its share was irrelevant. Domestic material productivity of fossil fuels is presented on the figure 13.

Figure 13. Comparison of total DMP with DMP of fossil fuels 2000-2007



Resource productivity of fossil fuels in Estonia is extremely low. Fossil fuels made up 40-50% of total domestic extraction, at the same time energy sector generates only 2-3% of GDP. This means, that use of oil shale for electricity production has huge impact on the Estonian total resource productivity and till the electricity production will be based on oil shale, the Estonian resource productivity will stay very low compare to other EU Member States.

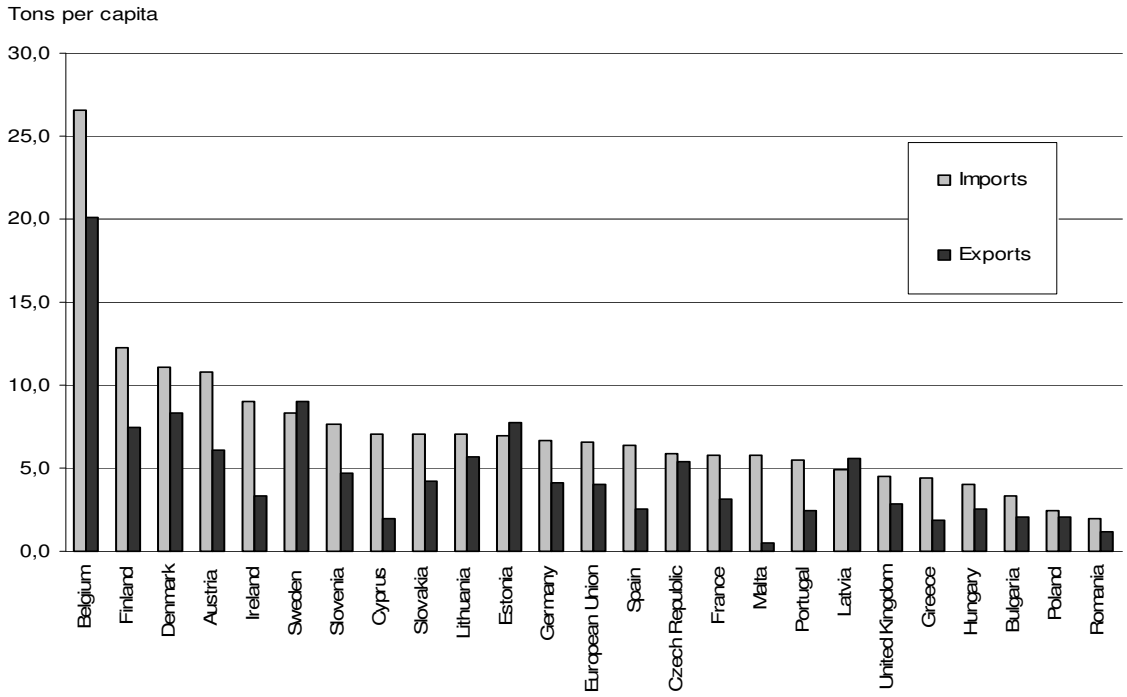
From the other hand it indicates, that total resource productivity is not the best characteristic for Estonian total economy and the productivity analysis should rather be done on the material type bases. The work in this field will be the task for future development.

Physical trade balance

Physical trade balance (PTB), which measures the physical trade surplus or deficit of an economy has changed in Estonia from deficit at the beginning of century to surplus since 2006. PTB equals imports minus exports. In another hand both, imports and exports in Estonia have been growing in monetary and physical terms. However the growth of import was considerably quicker than the growth of export.

Physical trade of EU countries in 2005 is compared on the figure 14. Both, the Estonian physical imports and physical exports were on the average EU level, at the same time Estonia was one of the only three Member States were export exceeded the imports in 2005.

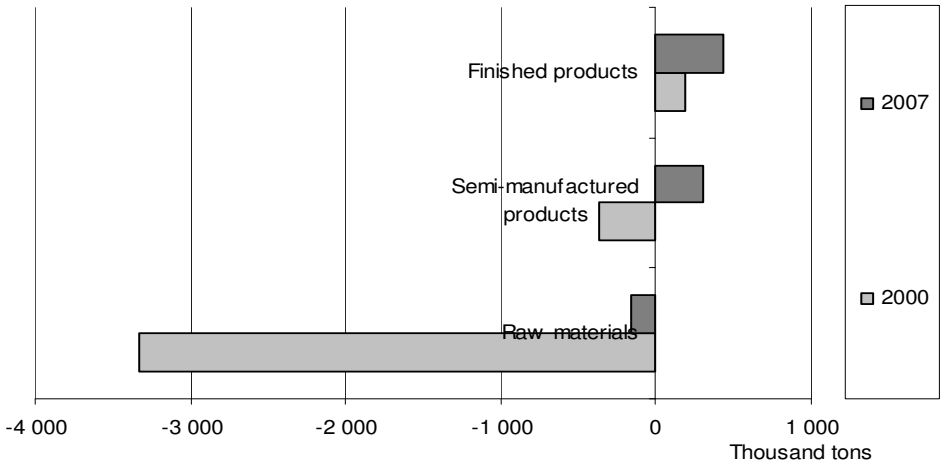
Figure 14. Physical imports and exports 2005, ton/capita



Source: Estonia- Statistics Estonia; the other countries - Eurostat

During the time period 2000-2007 the Estonian physical trade balance has changed from deficit (-3 499.9 thousand tons) in 2000 to surplus (567.5 thousand tons in 2007). The figure 15 illustrates the changes in physical trade balance of materials with different degree of processing in 2007 compared to 2000. Figure 15 outlines that the main reason for change of PTB from deficit to surplus is PTB of raw materials. In 2000 about 2.5 times more of raw materials were exported than imported. Raw materials made up 63% of all exported materials. In 2007 the quantities of imported and exported raw materials were almost the same. The change occurs due to considerable increase of import of raw materials, whereas a physical export of raw materials has slightly decreased also over the years.

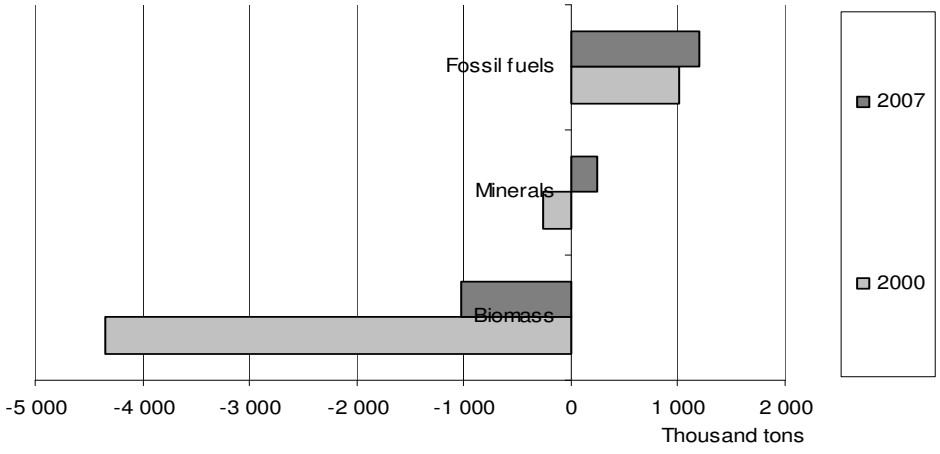
Figure 15. Physical Trade Balance of materials with different processing level in 2000 and 2007, thousand tons



The next figure 16 illustrates the changes in physical trade balance of main materials groups in 2007 compared to 2000. It is seen from the figure, that biomass has the biggest impact on the change of PTB from deficit to surplus. In 2000 biomass made up 59% of total physical exports and 24% of total physical import; 4 times more of biomass was exported than imported. Raw biomass from forestry shared to 83% of exported biomass. In 2007 biomass shared to 36% of total physical exports and 33% of total physical imports. Quantity of exported biomass still exceeded the quantity of imported biomass by 30%, but has considerably decreased since 2000. In 2007 raw biomass from forestry shared to 53% of exported biomass.

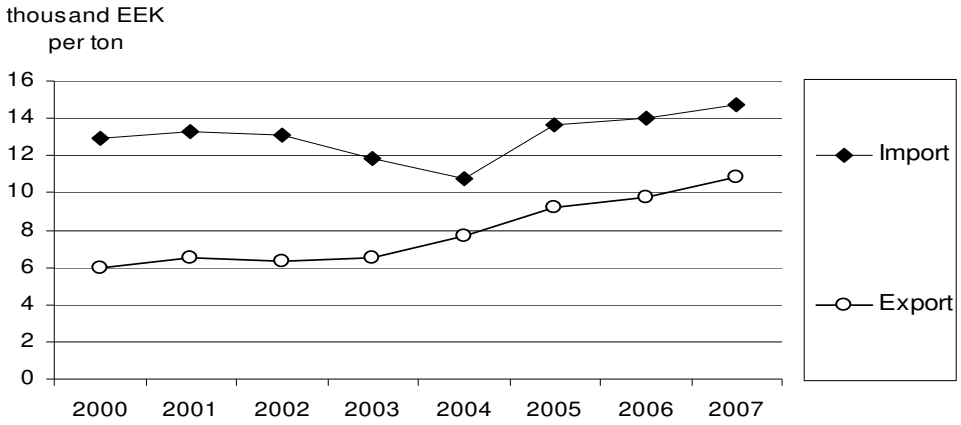
It could be concluded, that decrease of forestry raw materials export had the biggest influence on change of physical trade balance from deficit to surplus in 2007 compared to 2000.

Figure 16. Physical Trade Balance of main material types in 2000 and 2007, thousand tons



The value of one ton of imported material is almost twice higher than the value of the same quantity of exported material as is illustrated on figure 17. This means, that Estonia imports the commodities of higher value and exports the commodities of lower value. Nevertheless the value of one ton of physical exports is constantly increasing since 2003 and difference between values per ton of exported and imported material is slightly diminishing.

Figure 17. The value of one ton of imported and exported materials, 2000-2007



Synthesis and conclusions

In 2007 the Estonian direct material flow was about 70% bigger than in 2000. This increase happened mainly due to substantial increase of domestic extraction of construction minerals and consequent increase of stock (buildings). Another considerable factor of increase of material flow is increased domestic extraction of oil shale (increase of production of electricity) and consequent increase of air emissions.

Estonian economy is depending almost totally on domestic raw material supply (80%), nevertheless the share of imported raw materials is slightly increasing. Estonian domestic extraction is one of the biggest in the EU 27. Especially high (the highest among EU27 countries) is domestic extraction of fossil fuels. Indicator exceeds the average of EU27 by 4-5 times and is constantly increasing. Oil shale makes up more than 90% of domestic extraction of fossil fuels.

The emissions to air are the biggest materials output flows and also were the most increased flow during time period 2000-2007. The most of the air emissions originated from electricity production based on oil shale burning. At the same time increase of air emissions is smaller than increase of oil shale excavation, which indicates that emissions due to oil shale burning

are decreasing. Oil shale excavation and electricity production from oil shale generates also the big quantity of wastes. Quantity of land filled waste was decreasing during considered time period as the result of considerable increase of recycling of oil shale connected wastes. The increased recycling of oil shale wastes is the main factor why the decoupling of GDP and quantities of output of materials could be observed. The substantial growth of GDP during 2000 – 2007 was not accompanied with the same increase in quantities of output materials.

Estonian resource productivity is one of the lowest among EU27 Member States. The trend of resource productivity of EU27 average is slightly increasing; the trend of indicator for Estonia is slightly decreasing at the same time.

The reasons Estonian resource productivity is decreasing are the increase of oil shale excavation from one side and very low resource productivity of fossil fuels from other side. As far as electricity production will be based on oil shale, the Estonian resource productivity stays very low compared to other EU Member States.

During the time period 2000-2007 the Estonian physical trades balance has changed from deficit in 2000 to surplus in 2007. This occurred mainly due to decrease of export of raw materials from forestry but also the export of semi manufactured products has increased also.

Comparing the physical and monetary trade shows that Estonia imports the commodities of higher value and exports the commodities of lower value. Nevertheless difference between values per ton of exported and imported material is slightly diminishing.