

ECONOMY-WIDE MATERIAL FLOW ACCOUNT OF ESTONIA

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Economy-Wide Material Flow Account is one of the modules of Environmental Accounting. According to this model the modern society could be considered as living organism whose vital activity has an impact on the environment through extraction of materials and energy and return of emissions and wastes. Using different material flow indicators (e.g. domestic extraction, domestic material consumption, domestic resource productivity and physical trade balances) derived from material balances (direct material flow balance) the use of materials and productivity of Estonian economy during 2000–2007 are characterised. Comparisons with corresponding indicators of other European Union Member States were drawn.

Introduction

Economy-wide material flow accounts is consistent compilations of the overall material inputs into national economies, the changes of material stock within the economic system and the material outputs to economies of other countries or to the environment, made in physical units. Up to now in Estonia economy-wide material flow accounts was not compiled. The article presents the results of the pilot project made in Statistics Estonia, which was the first attempt to compile economy-wide material flow accounts for Estonia.

MFA comprises two main elements: material balance sheets compiled in physical units and material flow indicators derived from these tables. In input side of balance sheets all materials used in domestic economy – extracted from domestic economy and also imported – are indicated. Materials are classified according to the basic material categories to biomass, mineral resources and fossil fuels. For comparability all imported materials are recalculated for their basic natural resources indicating their processing level: raw material, semi-manufactured products and finished products. For example a refrigerator made mostly of metals is accounted as finished product of mineral resources, as metallic minerals were extracted for its production.

All emissions, land filled wastes and also exported materials as basic natural resources indicating their processing level are accounted on output side of material balance sheets. Direct material flow accounts of Estonia for years 2000–2007 were compiled during this pilot project. The direct material balance sheets will be presented on the website of Statistics Estonia in the nearest future.

The material balance sheets include lot of detailed information, but are difficult to interpret for general public. Thereby a number of material flow indicators are derived from balance sheets, which are easily understandable and usable both in social decision-making and for journalists in informing the publicity. At the same time material flow indicators contain substantial information about special characteristics of domestic material use, its intensity and productivity and environmental risks connected with the use of natural resources. Material flow indicators are usually classified as material input, consumption, resource productivity and intensity, material output and balance indicators. In this article some Estonian material flow indicators are described and compared with the respective indicators of the European Union Member States.

Material input indicators

Input indicators are worked out to answer the questions like what is the material requirements of state economy; which material resources are mainly used; how much non-renewable resources are used; how dependent is the state economy on imported raw materials, etc.

One the most used material input indicator is domestic extraction used. Domestic extraction used consists of all solid, liquid and gaseous materials which are of economic value and are used in production and consumption activities.

Figure 1 (p. 43) compares the domestic extraction of EU-27 Member States in 2007. Estonian domestic extraction was one of the biggest in the EU-27.

The trends of domestic extractions in 2000–2007 by main material types separately compared to the EU average are presented on Figure 2 (p. 44). As metallic minerals are not extracted in Estonia, for comparisons only non-metallic minerals are included in mineral resources.

Domestic extraction of biomass was considerably higher than the average of EU-27 during the period under observation. Biomass from forestry accounts for 60–70% of the extracted biomass. However, during the last years DE of biomass in Estonia has declined and the gap with the EU average indicator has decreased.

Domestic extraction of minerals has increased tremendously during the period under observation. In 2000, non-metallic minerals accounted for 17% of domestic extraction and DE of minerals was about twice smaller than the average of EU-27. In 2003, the domestic extraction of minerals already exceeded the average of EU-27 and stayed as such since. In 2007, extraction of non-metallic minerals has increased almost three times and accounted for nearly one third of DE. 90% of non-metallic minerals are used in construction.

Domestic extraction of fossil fuels in Estonia is the highest among EU-27 countries. The indicator exceeds the average of EU-27 by 4–5 times and is constantly increasing. The trend of domestic extraction of fossil fuels in Estonia was constantly growing whereas the average domestic extraction on fossil fuels of 27 EU Member States was declining. Oil shale makes up 90% of domestic extraction of fossil fuels.

Direct material input is the indicator which represents the quantity of materials really used in domestic economy. In addition to domestic extraction used the imported materials were included in direct material input. In Estonia in 2000–2007 the both components of direct material input (domestic extraction used and physical import) increased. Although the quantity of imported materials is continuously increasing from year to year, the share of import in direct material input was rather small – 19% in 2000 and 23% in 2007.

Material consumption indicators

Material consumption indicators describe the materials consumed by economic activities. Domestic material consumption measures the total amount of material directly used in domestic economy. The difference between direct material input and domestic material consumption lies in the fact that exported materials are subtracted from domestic material consumption. Thus domestic material consumption describes material flow used only inside domestic economy. At the same time domestic material consumption reflects the potential quantity of emissions and wastes which might be released to domestic environment.

Estonian domestic material consumption has constantly increased during 2000–2007. At the same time the share of different material types in domestic material consumption has changed. If oil shale made up 60% of domestic material consumption in 2000, then for 2007 the share of oil shale had decreased to 39% and the dominating material type was construction minerals (47% of domestic material consumption) (Figure 3, p. 45).

Comparing the Estonian domestic material consumption with the respective indicator of other EU Member States in 2007, it can be noticed that Estonian domestic material consumption is more

close to the average of EU-27 than domestic extraction used. This indicates that quite a big share of domestic extraction used was exported.

Resource productivity indicators

There are two aspects in the use of natural resources: the total quantity used and the efficiency of use. In order to reduce the total quantity usage natural resources sustaining the same production level, efficiency of natural resources' use should be increased. This means that in addition to indicators characterising the absolute level of natural resources' use (input and consumption indicators) also indicators expressing the efficiency use of natural resources are needed. For that purpose the material flow indicators are connected to (macro) economic indicators.

Resource productivity indicators compare natural resources' use with economic growth. For calculating resource productivity, natural resources' use might be expressed by input indicators (direct material productivity) or consumption indicators (domestic material productivity). The difference between these two indicators: imported materials are included for calculation of the direct material productivity whereas only materials extracted from domestic environment are included for calculation of the domestic material productivity. Domestic material productivity will be observed next in the analysis. GDP in chain-linked volume, reference year 2000 is used for the analysis.

During 2000–2007, In Estonia the overall trend of domestic material productivity was declining. If in 2000 4,900 kroons (313 euros) was generated per one ton of consumed materials, then in 2007 one ton of consumed materials generated 4,000 kroons (256 euros). Figure 4 (p. 46) presents the comparison of the domestic resource productivity between the EU Member States in 2007. It is seen, that domestic resource productivity in Estonia is one of the lowest among the EU Member States, and the value of this indicator was exceeding only the respective indicator of Romania and Bulgaria.

Figure 5 (p. 47) illustrates the change of domestic resource productivity of Estonia in 2000–2007 in comparison with the average of the European Union. It can be seen that the average resource productivity of EU-27 countries was about 4 times higher than in Estonia and the difference was growing from year to year. The trend of resource productivity of EU 27 average was slowly increasing (the recourse productivity increased); at the same time the trend of the respective indicator for Estonia was slightly decreasing (the resource productivity declined).

What is the reason for such low resource productivity in Estonia compared to the most of EU Member States? It is seen from material composition of domestic extraction used that oil shale made up 42% of total domestic extraction used. The most of oil shale is used for electricity production. This means that electricity production consumes more than 40% of all domestic resources. At the same time energy sector (which in fact is broader than just electricity production) produces only 2–3% of GDP. This indicates that the use of oil shale for electricity production has enormous effect on total domestic resource productivity in Estonia. Consequently, the main reason for very low domestic resource productivity is oil shale based electricity production in Estonia and until electricity production will be based on oil shale, Estonian resource productivity stays very low compared to other EU Member States.

Material output indicators

Material output indicators describe the material flow that has been used in the economy, but are now leaving it either in the form of emissions and waste, or as exported materials.

Domestic processed output is a material flow indicator, which measures the total quantity of materials (extracted from the domestic environment and imported), which after use in the domestic economy flow back to the environment. These flows are emissions to air and material loads in wastewater arising during production and consumption processes, wastes deposited in

landfills, and materials dispersed into the environment as a result of product use (dissipative use of products and dissipative losses).

If domestic processed output describes the environmental burden from materials used by domestic economy, then the other material flow indicator – total domestic output – represents the total quantity of material outputs to the environment. In addition to domestic processed output the so-called unused domestic extraction is included in total domestic output. Unused domestic extraction comprises materials, which are moved or extracted from the environment during economic activity, but which were not used in production or consumption process (for example mining overburden, soil and rock excavated during construction and not used elsewhere and harvest residues). At the same time every movement of materials from one place to another has potential influence on the environment generating the additional quantity of wastes/emissions, disrupting habitats, or altering landscapes. Unused domestic extraction is not a part of direct material flow balance but is used as separate indicator and is also included in some input and output indicators. Figure 6 (p. 48) provides a comparison of the biggest material flows of the total domestic output in 2000 and 2007.

In 2007, the total domestic output was about one fifth bigger than in 2000 (29,000 tons in 2000 and 36,000 tons in 2007). In both years the emissions to air were the biggest material output flows. The growth of air emissions was also the main reason for the increase of the total domestic output.

Most of air emissions originate from electricity production based on oil shale burning. Excavation and use of oil shale (burning for electricity production and production of shale oil) generates in addition a big quantity of wastes of which excavation wastes are included in disposal of unused domestic extraction, and oil shale ashes make up the largest share of land filled wastes. At the same time due to the considerable increase of recycling of oil shale wastes the increase of electricity production in recent years had bigger influence on the quantity of air emissions than on the quantity of land filled wastes and disposal of unused extraction.

Material balance indicators

Material balance indicators describe physical growth of materials within economy. Balance indicators express the difference of materials input and materials output of the economy. One of the often used balance indicators is physical trade balance. Physical trade balance measures surplus or deficit of the physical trade of a country's economy. Physical trade balance equals imports minus exports. Positive physical trade balance indicates that a country uses more natural resources of other countries than exports its own. Negative physical trade balance indicates that more domestic natural resources are exported than natural resources of other countries are imported.

During 2000–2007 the Estonian physical trade balance has changed from deficit (-3,499,000 tons) in 2000 to surplus (567,500 tons in 2007). In order to find out the reason for this change, the degree of processing of imported and exported materials should be observed. All materials could be divided according to their degree of processing into raw materials, semi-manufactured products and finished products. Figure 7 (p. 49) illustrates the physical trade balance of materials with different degree of processing in 2000 and 2007.

In 2000, about 2.5 times more raw materials were exported than imported. Raw materials made up more than 60% of all exported materials. In 2007 due to the considerable increase of imports and some decrease of exports of raw materials the quantity of imported and exported raw materials was almost equal. The changes occurred during this time period in physical trade balance of semi-manufactured products and finished products were much smaller. Figure 8 (p. 49) illustrates the changes in physical trade balance of main material groups in 2000 and 2007.

The biggest change has occurred in the physical trade balance of biomass. In 2000, 4 times more biomass was exported than imported; biomass accounted for 59% of total physical exports and 24% of total physical imports. Raw biomass from forestry accounted for more than 80% of

exported biomass. In 2007, a considerable decrease occurred in both: in the share of biomass of total physical exports (to 37%) and in the share of raw materials of exported biomass (to 53%). So it could be concluded that one of the main reasons for the change of physical trade balance from deficit in 2000 to surplus in 2007 is the decrease of exports of raw material from forestry.

Figure 9 (p. 50) compares physical trade balance of the European Union Member States in 2007. It is seen from the figure that in Estonia the physical quantity of exported and imported materials were almost equal.

At the same time when to compare the values of imported and exported materials it can be noticed that the value of one ton of imported material was almost twice higher than the value of one ton of exported material. For example in 2000, the value of 1 ton of imported material was 13,000 kroons whereas the value of one ton of exported material was 6,000 kroons. This means that Estonia imported the commodities of higher value and exported the commodities of lower value. Nevertheless the value of one ton of physical exports was constantly increasing and in 2007 the difference between values per ton of exported and imported material was diminishing to 15,000 and 11,000 kroons, respectively.

Summary

In 2007, Estonian direct material flow was 70% bigger than in 2000. This increase occurred mainly due to the substantial increase of domestic extraction of construction minerals and consequent increase of stock (buildings and civil engineering account for the main share of the increased stock). Another considerable factor that increased material flow was the increase in domestic extraction of oil shale (increase of production of electricity) and consequent increase of air emissions.

The results of Economy-Wide Material Flow Account allowed concluding that Estonian economy was depending mainly on domestic raw material supply although the share of imported raw materials was slightly increasing. Estonian domestic extraction was one of the biggest in the EU-27. Especially high (the highest among EU-27 countries) was domestic extraction of fossil fuels, the indicator of which exceeds the average of EU-27 by 4–5 times and was constantly increasing. Oil shale made up more than 90% of domestic extraction of fossil fuels.

The emissions to air were the biggest material output flows and were also the most increased flow during 2000–2007. Most of air emissions originated from electricity production based on oil shale burning. At the same time the increase of air emissions is smaller than the increase of oil shale excavation (burning), which indicates that emissions from one ton of oil shale burning are decreasing.

Oil shale excavation and electricity production from oil shale also generates a big quantity of wastes. At the same time the quantity of land filled waste decreased during the period under observation as a result of considerable increase of recycling of oil shale related wastes.

In 2000–2007, Estonian physical trade balance changed from deficit in 2000 to surplus in 2007. This occurred mainly due to the decrease of exports of raw materials from forestry. Comparison of physical and monetary trade shows that Estonia imports the commodities of higher monetary value and exports the commodities of lower monetary value. Nevertheless the difference between values per ton of exported and imported material was decreasing.

Estonian resource productivity was one of the lowest among EU-27 Member States. The trend of resource productivity of EU-27 average was slightly increasing; at the same time Estonian resource productivity decreased. The main reason for the decrease of Estonian resource productivity was the substantial increase of oil shale excavation on the one hand and very low resource productivity of fossil fuels on the other hand. As far as electricity production will be based on oil shale, Estonian resource productivity stays very low compared to other EU Member States. As a huge quantity of used oil shale dominates over other material types and shadows the resource productivity of other materials, it could be concluded that the total resource productivity is not a good indicator for Estonian economy and the productivity analysis should rather be performed on the basis of material type. This kind of analysis stays outside the system boundaries of Economy-Wide Material Flow Analysis.