Abstract

In order for an economic system to function and produce goods and services necessary for meeting human needs, it behaves similarly to a living organism. It absorbs materials from the surrounding environment and transforms them into products, but ultimately all the materials are transformed into some kind of waste and emitted back into the environment. This flow of materials is referred to as industrial or socio-economic metabolism (Baccini and Brunner, 1991; Fischer-Kowalski and Haberl, 1993; Ayres and Simonis, 1994). Extraction of resources, consumption of materials and related emissions exert some pressure on the environment. So far, there has been a positive relation between meeting human needs and this pressure. The overall goal of developed countries within their strategies of sustainable development is to break the relation between pressure exerted on the environment and economic growth, which represents meeting of human needs and improvements in the standard of living. This phenomenon is called decoupling (EC, 2002, 2005, 2006; OECD, 2002; UN, 2002).

One of the methods for assessing environmental pressure related to extraction and consumption of resources and materials is material flow analysis. In the case of economy-wide material flow analysis (EW-MFA), this method aims at quantification of physical input flows into the economy, accumulation of materials in the economy, and physical output flows to other economies and back into the environment. The key idea of the EW-MFA is a material balance of the whole system. Based on the input and output flows, a large array of EW-MFA indicators can be compiled. EW-MFA calculates these indicators as a sum of physical quantities of particular flows, both on the input and output sides of the material balance. It can be assumed that growing volume/mass of any material flow will result in growing environmental pressure and vice versa (Schmidt-Bleek, 1993; Weizsäcker et al., 1996; Bringezu et al., 2003).

This PhD thesis has several goals which try to contribute to the solution of selected research questions relevant for EW-MFA. These goals are principally fourfold: (I) Quantification of EW-MFA indicators for the Czech Republic for 1990-2002, analysis of their trends and their international comparison; (II) Application of these indicators in a decoupling analysis and analysis of material intensity, international comparison of these phenomena and suggestion of methodology for graphical representation of decoupling; (III) Quantification of the net additions to stock indicator using both the direct and indirect method of calculation and comparison of results obtained using these two approaches; (IV) Quantification of uncertainties related to the EW-MFA indicators calculated for the Czech Republic.

The quantification of the EW-MFA indicators was based on a standardised Eurostat methodology (2001). All calculated indicators recorded a profound decrease over the period studied. This decrease was caused by a combination of the following factors: a drop in economic performance at the beginning of the 1990s, a damping of energy-demanding industries and an increase in the share of services, by substitution of coal with liquid and gaseous fuels, and an increase in energy efficiency due to modernisation. The international comparison showed that the EW-MFA indicators per capita in the Czech Republic were somewhat above average compared to EU 15 and other developed countries (USA). In EU 10 countries, however, the material consumption was quite a bit lower.

Material and emission intensity in the Czech Republic expressed by input and output EW-MFA indicators went down in 1990-2002. International comparison, however, showed that both material and emission intensity were significantly higher in the Czech Republic compared to other EU countries. The Czech Republic also recorded a profound decoupling of environmental pressure from economic performance. In order to increase the analytic potential of decoupling analysis, a new approach to graphical representation of decoupling was suggested, which allowed an assessment of the contributions of particular components of the EW-MFA indicators to the overall decoupling in these indicators.

The NAS indicator calculated using an indirect method went down by more than 47 percent in 1999-2002. A calculation of the NAS using a direct method was carried out for 2000-2002. While the indirect NAS decreased by 2.5 percent in 2000-2002, the direct NAS went down by mere 0.4 percent and its overall values were approximately one-third lower. It was showed that the total NAS was dominated by net additions in the category of Infrastructures and buildings, the share of which amounted to approx. 98 percent on average. With respect to the increase in future waste flows, these additions are important in the long-term perspective. The rest of the NAS consisted of Durables, which, as regards future waste flows, are rather important from the short-term perspective.

Uncertainties for the particular EW-MFA indicators calculated for the Czech Republic quite significantly differed, which influenced the analytical potential of these indicators. It was revealed that the lowest uncertainties were related to the DMI and DMC indicators. The uncertainties for the DMI ranged from +6/-3 percent to +7/-3 percent; and those for the DMC, from +8/-3 percent to +9/-4 percent over the period studied. The largest positive uncertainties were related to the NAS (from 30 percent to 40 percent) followed by the TMC (from 27 percent to 39 percent) and the TMR (from 25 percent to 28 percent). The largest negative uncertainties were again related to the NAS (from -19 percent to -27 percent) and to the TMC (from -3 percent to -20 percent) and the DPO indicators (from -10 percent to -15 percent).

Keywords: economy-wide material flow analysis (EW-MFA), environmental pressure, material flow indicators, decoupling, physical stocks, uncertainties