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The global socioeconomic energetic metabolism as a sustainability problem

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Abstract

This paper discusses sustainability problems related to socioeconomic energy flows based upon the societal metabolism approach. Contrary to conventional energy statistics that only include energy used in technical devices, this approach considers all kinds of energy flows related to human societies, including nutritional energy flows of humans and domesticated animals. Based upon human population data and data on the pro capite energy metabolism of hunter-gatherers and agricultural societies as well as on statistical data on industrial energy flows a time series of the global socioeconomic energetic metabolism for the last 10^6 years and a scenario for the next 50 years is derived. These estimates show that the total energy input of mankind has risen by several orders of magnitude since the Neolithic revolution about 10,000 years ago. Whereas the energy input of agricultural societies prior to the advent of industrial societies about 200–300 years ago did not exceed 5% of global terrestrial net primary productivity (NPP), humanity's energy input currently amounts to about 30% of global terrestrial NPP and is likely to surpass 50% in about 2050. This shows that the sheer magnitude of human-induced flows is historically unprecedented and poses at least two closely interrelated sustainability challenges: (1) a reduction of energy available to ecosystem processes that can be assessed using the concept of 'human appropriation of net primary productivity' and (2) the changes in the global carbon cycle resulting from land-use change and fossil-energy combustion.

1. Introduction

One idea behind the notion of a 'socioeconomic metabolism with nature' [1–5] is that describing human society as an ecosystem component is a useful approach toward analyzing society–nature

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interrelations [6,7]. Basically, the metabolism approach regards society as a physical input–output system drawing material and energy from its environment, maintaining internal physical processes and dissipating wastes, emissions and low-quality energy to the environment. Of course, it would not be valid to reduce the notion of society merely to a physical process, but with respect to sustainable development these physical aspects of society are of high importance.[1] The analysis of physical aspects of human society—e.g. socioeconomic metabolism—also has important advantages over the widespread conception among ecologists of 'humans causing disturbances in ecosystems', because it allows to conceptualize society–nature interrelation as a historical process of the interaction of two complex, autopoietic systems, a point of view that offers good starting points for interdisciplinary cooperation of natural and social scientists in sustainability research [1].

In recent years, there has been a surge of societal metabolism studies; that is, of studies that elaborate on physical exchange processes between societies and their natural environment. This approach can be traced back well into the 19th century (see recent reviews by Martinez-Alier [8] and Fischer-Kowalski [9]). Whereas earlier work focused mostly on energy flows [10–12], recent studies concentrate on material flows [3–5,13]. Meanwhile a vivid international scientific community has emerged that advances the methods and applications of material flow accounting (MFA). Despite the fact that, with respect to sustainable development, energy flows are probably at least as interesting as material flows, most current metabolism research concentrates on material flows [14].

This paper applies MFA standards established in recent years in a collaborative effort [5,13,15] to socioeconomic energy flows, based upon methods proposed in recent work [14,16]. Using these method, a time series of global socioeconomic energy metabolism is derived and the relevance of these results for sustainable development is discussed.

2. Methods for analyzing society's energetic metabolism

One reason for the lacking interest of the MFA community in energy flows might be that the energy use of industrial countries is regularly reported in energy statistics and energy balances. It has been an important goal of MFA research to develop methods for national material balances that can be included in standard environmental and economic reporting systems. This goal has, for example, been achieved in Austria [17] and Germany [18]. Eurostat, the Statistical Office of the EU, has recently developed a methodological guide for national material flow accounts [15] which it endorses for use by the national statistical offices of the EU countries in environmental statistics.

However, there are important methodological differences between national material balances and the energy balances published by national statistical offices or international bodies [19–21]. National material balances account for all materials crossing the boundary of the socioeconomic system under scrutiny, regardless whether the material is used as an energy carrier or as a raw material. The flow of biomass used for human nutrition or as fodder for live-stock is, therefore, included in material flow accounts—just like coal, oil and natural gas that flow through the economy under consideration [13]. In contrast, conventional energy balances and statistics only account for energy carriers used in technical energy conversions as, for example, combustion in furnaces, steam engines or

[1] For a more elaborated discussion of these issues, see Fischer-Kowalski and Weisz [64].