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Editorial

Can we break the addiction to fossil energy?☆

1. Modelling society's energy metabolism

The link between energy consumption, economic development and the environment has long been a major topic of interest among scientists and laymen alike. However, the term *societal metabolism* has come into use relatively recently to refer in general to the modelling and analysis of the economic process from a biophysical perspective (Martínez-Alier, 1987; Ayres and Simonis, 1994; Adriaanse et al., 1997; Duchin, 1998; Fischer-Kowalski, 1998; Matthews et al., 2000; Giampietro et al., 2011). The rationale behind this term is based on several theoretical concepts and models related to the special status of complex adaptive systems, such as the concept of self-organizing systems in the field of non-equilibrium thermodynamics (Prigogine, 1978; Prigogine and Stengers, 1981); the concept of autopoietic systems – systems capable of making themselves – proposed by Maturana and Varela (1980) in the field of complex system theory; the flow-fund model proposed by Georgescu-Roegen (1971) to analyze the pattern of production and consumption in the economic process in the new field of bioeconomics; the concept of ecological organization through informed autocatalytic cycles proposed by Odum (1971, 1983) in the field of theoretical ecology; and the basic rationale of energy analysis applied to the study of human societies (Cottrell, 1955; Lotka, 1956; White, 1959). Building on these scientific contributions, the concept of societal metabolism aims to focus the analysis on how energy is used by society to keep the economic process running and, at the same time, on the constraints associated with the ecological processes required to guarantee the stability of boundary conditions. As a matter of fact, since the 1970s, the concept of energy and material metabolism of human society has been widely applied, albeit under different names, to describe and analyze the sustainability of farming systems, economic systems, and more in general the interaction of socioeconomic systems with their environment (e.g., Georgescu-Roegen, 1971; Odum, 1971, 1983; Rappaport, 1971; Leach, 1976; Gilliland, 1978; Slesser, 1978; Pimentel and Pimentel, 1979; Morowitz, 1979; Costanza, 1980; Herendeen, 1981; Hall et al., 1986; Smil, 1987; Ayres and Simonis, 1994).

More recently, the link between energy, economic development and the environment has also gained the interest of energy economists from both theoretical and empirical standpoints (Reister, 1987; Asafu-Adjaye, 2000; Stern and Cleveland, 2004; Lee, 2005; Zachariadis, 2007; Warr and Ayres, 2010). This interest can be ascribed to: (a) the progressive acknowledgment by the media of the troubles on the energy side, most notably the spike in oil prices that reached a maximum in July of 2008, the continuous growth in oil demand by emerging economies, and the consolidation of the peak oil hypothesis (Hubbert, 1956; Campbell and Laherrere, 1998); (b) the economic and financial crisis that started in the year 2008 and has been continuously worsening since then; and (c) the growing public awareness of environmental problems, such as climate change, loss of habitats and biodiversity, and peak water. As a result, the link between energy consumption, economic development and the environment has finally become a hot topic on the political agenda.

2. Modelling societal energy metabolism in relation to the addiction to fossil energy

From 1998 onwards, every other two years, the Biennial International Workshop "Advances in Energy Studies" (BIWAES) gathers experts in what can be called *energy analysis* to present and discuss advances, innovations and visions in energy and energy-related environmental and socioeconomic issues and models. Renowned energy experts and ecologists, such as H.T. Odum, James Kay, Charles Hall, Tim Allen, Vaclav Smil, Robert Herendeen, Jan Szargut, Joseph Tainter and Robert Ulanowicz among others, have discussed at the BIWAES the importance of energy in our society and ecosystems and the ways to better analyze and model their complex relationships. Previous editions of BIWAES have focused on energy flows in ecology and economy; analysis of the supply side; the ecological consequences of energy sources exploitation; and the role of renewable energy sources and new energy carriers. The workshop presented in this special issue, held in Barcelona, Spain, 19–21 October, 2010,[1] addressed society's addiction to fossil energy.

After the oil price spike of July 2008 and the following global financial crisis, fossil energy re-emerged as a hot topic, not only for theoretical research, but also and mainly for its huge policy implications. The workshop explicitly addressed the complexity of this issue by focusing on three main topics: (i) analysis of the metabolic pattern of societies; (ii) analysis of the viability of alternative energy sources, and (iii) scenarios of energy transition away from fossil energy. For this Special Issue we have selected ten papers that cover these main topics of the workshop and that want to represent a challenge to existing politically correct discourses regarding energy

☆ 7th Biennial International Workshop "Advances in Energy Studies" Barcelona, Spain, 19–21 October, 2010.

[1] 7th Biennial International Workshop *Advances in Energy Studies*: Can We Break the Addiction to Fossil Energy? Barcelona, Spain, 19–21 October, 2010: http://www.societalmetabolism.org/aes2010.html.

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efficiency, bioenergy, economic growth, urbanization, and even the generation of energy statistics by national and international bodies.

The first group of papers deals with the energy metabolism of societies from various perspectives. Brown and Ulgiati (in this issue) provide a biophysical perspective based on eMergy accounting to the current economic and environmental crisis we face worldwide, to conclude that simply doing more of the same is not an option. Zhang et al. (in this issue) move down to the level of urban metabolism to compare the use of different models (with different degrees of depth in the hierarchical scale of the system analyzed) for the analysis of their energy metabolism, by applying network through-flow analysis. On the same topic but with a different approach, Hall (in this issue) introduces the socio-ecological metabolism of three neighborhoods and their relationship with the surrounding environment, putting in perspective human-induced energy consumption as compared to that available for ecosystems. Freire (in this issue) addresses the important issue of energy-saving technologies, and presents methods to estimate the rebound effect one may encounter at the household level based on economic input–output methods that also allow for scenario analysis. Finally, Şorman and Giampietro (in this issue) reflect on some pitfalls of current biophysical analyses, especially the neglect of the issue of scale, and ways of improving them in order to get better indicators for energy analysis and more robust scenarios.

The second group of papers contains an analysis of the viability of both nonrenewable and renewable energy sources. Bardi et al. (in this issue) analyze the energy return on energy invested (EROEI) and the net energy provision for the rest of the society of nonrenewable energy sources, by applying a version of the Lotka–Volterra "predator–prey" model. On the other hand, Cherubini et al. (in this issue), using a life-cycle perspective, take on the CO_2 emissions derived from bioenergy from managing boreal forests, challenging in this way what was supposed to be one of the main future energy sources in developed countries.

Finally, the third group of papers present and discuss scenarios of energy transitions in different parts of the world. Murphy and Hall (in this issue) stress the need for adaptation of economic systems to a new era characterized by increasing relative scarcity of oil and higher energy prices, meaning that more economic growth to get out of the current economic crisis will just buy us some more time. Foran (in this issue) and Häyhä et al. (in this issue), in relation to this same point, present scenarios of low carbon (or low fossil fuel use) options for Australia and Finland, respectively.

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