The worldâ€™s energy history: a temporal and spatial SDA of global and country-wise energy flows in the period 1960-2020

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Energy is one of the most significant environmental flows on a global scale and for each country in the world. It supports and fosters every human activity, therefore helping satisfy the most fundamental human needs and promoting social and economic development. However, along with these undeniable benefits that energy flows have brought and continue bringing to our global society, they are simultaneously responsible for the largest share of historic GHG emissions generation, account for many other environmental impacts and exert pressure on regional resource scarcity. The bidirectional links between the economic size and dynamics and the trend of energy use have been extensively documented and demonstrated. Energy use influences and gets influenced by the structural trajectories of economies and the iconic moments in each countryâ€™s history. Also, it clearly describes the fundamental characteristics of economic and social operations worldwide. Understanding how energy use has transitioned historically within modern societies is crucial for unveiling the mechanisms and opportunities to minimize its negative impacts, enhance the positive contributions that energy flows offer and ultimately support a sustainable energy transition. Based on this premise, this work presents a temporal and spatial structural decomposition analysis of energy use trends of most worldâ€™s countries during the period 1960-2020 to identify the fundamental factors in the chain of energy transformations that have influenced energy use trends in these countriesâ€™ economies. To do so, we propose an energy input-output model based on the multi-factor environmental input-output modeling framework by Guevara and Domingos (2017), which provides a detail description of energy intersectoral flows according to the physical transformations that these flows experience across the economy, allowing for a thorough examination of key factors within the energy transformation chain. This model does not only account for primary and final energy flows as most works in the literature, but also for useful energy flows at the end of the energy transformation chain, which in fact are those that directly satisfy the needs of industrial and residential consumers. In addition, the proposed model contributes to the literature with a more detailed energy efficiency trends, and the inclusion of some unconventional factors compared to similar conventional studies. We obtained world and country-wise physical supply-use energy flow data from the Materials and Energy eXERgy database (i.e., MEXER database, https://mexer.site/, Brockway et al. 2024 & Heun et al. 2024), which organized and handled the World Energy Balances and Statistics from the International Energy Agency and estimated historically useful energy flows for every country and region in the database. It is worth mentioning that during the implementation of the present study, we contributed to correcting and consolidating the physical supply and use data in the MEXER database and directly constructed the structural elements of the model related to useful energy flows. The results reveal substantial energy use disparities among developed and developing countries. Also, they illustrate transitions such as energy decoupling and deindustrialization in certain economies. In particular, the United States emerges as an outlier in terms of both overall energy use and the trajectories of the factors of the energy transformation chain. Interregional and country-wise differences are primarily based on the different technological composition of final to useful energy conversion and the efficiency of the energy sector, whereas intraregional differences are more evident in end-user consumption preferences, especially among industries.

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