

Preface

Among the large multiplicity of natural resources, non-renewable primary fossil fuels, namely coal, crude oil and natural gas, play a crucial role in sustaining the human economies and their production activities. Nowadays, scarcity of stocks and emissions of pollutant and greenhouse gases are the main concerns related to fossil fuels depletion, and many political and research initiatives are facing these issues by promoting a rational use of primary energy. This objective could be achieved acting in two main ways: (1) fostering a transition toward alternative and more efficient energy conversion systems (e.g., increase efficiency of conventional power systems, or increase penetration of renewables); (2) reducing the primary energy *embodied in goods and services produced by national economies*.

Primary energy *embodied* in goods and services, also called *energy cost*, is defined as the amount of primary fossil fuels *directly* and *indirectly* required to deliver such products. Reduction of the embodied energy of products can be performed by developing innovative production policies or by improving production processes and supply chains. However, in order to check whether these interventions result in a net reduction of the overall primary energy requirements, an accurate evaluation of the energy embodied in products is crucial. The domain of the second activity lies in the field of *Life Cycle Assessment* (LCA), and encompasses both technological and economic aspects related to supply chains operation.

This book introduces and formalizes the *Exergy-based Input–Output framework* (ExIO), a comprehensive methodology useful to account for the primary fossil fuels required for the production of goods and services within a given national economy. The main features of the developed framework are aimed at dealing with the flaws of current state-of-the-art methodologies: (1) *Exergy* is here assumed as the unique metric for fossil fuels characterization and for energy conversion systems analysis; (2) *Input–Output analysis* is assumed as the computational structure of ExIO: this approach relies on standard and freely available data sources, making its application simpler and faster with respect to other process-based methods; (3) the *Hybrid* approach have been developed to increase the accuracy of results and to analyze

energy conversion systems, assessing and maximizing their overall thermodynamic efficiencies based on suited indicators; (4) the *Bioeconomic ExIO model* has been finally proposed to internalize the effects of human labour within the primary embodied energy of products.

The book is the result of 3 years of research carried out at the Department of Energy, Politecnico di Milano: it ought to be a step forward in the fields of *Thermodynamics methodologies for system analysis* and *Life Cycle Assessment*.

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An Input - Output Approach

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