

Thermoeconomics: a holistic approach to technical development

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# Thermoeconomics: a holistic approach to technical development

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## Introduction

The present days represent a crossroad in the history of humanity, and of the whole Earth. Complex dynamics both of growing the poverty distribution, and of increasing of ecological environmental and socio-economic degradation, are generating a difficult socio-economic system of despair from which it is very difficult to escape. Engineering and technological improvements can represent new possibilities for the renewal of the world, but a new indicator for the decision makers is required.

## Objective

Sustainable consumption of resources, production and energy policies are the keys for a sustainable development. Moreover, a growing request in bio-based industrial raw materials requires a reorganization of the chains of the energy and industrial sectors. This

is based on new technological choices, with the need of sustainable measurements of their impacts on the environment, society and economy. In this context, social and economic requirements must be taken into account, too. Sustainable policies require new indicators, able to link economics, technologies and social well-being, together. Here, an irreversible thermodynamic approach is developed in order to introduce the Thermodynamics Human Development Index, an indicator based on the thermodynamic optimisation approach, and linked to socio-economic and ecological evaluation.

## Materials and Methods

Human Development Index is an indicator of the developing level of a country, related to education, health, salary conditions, defined as  $HDI=(LEI \cdot EI \cdot II)^{1/3}$  where  $LEI=(LE-20)/(65)$  is the Life Expectancy Index, with  $LE$  Life expectancy at birth,  $EI=(MYSI+EYSI)/2$  is the Education Index, with  $MYSI$  the Mean Years of Schooling

Index and  $EYSI=EYSI/18$  Expected Years of Schooling Index, and  $II=\ln(GNI_{pc}/100)/\ln(750)$  the Normalised Income Index, where  $GNI_{pc}$  is the gross national income per capita. But,  $HDI$  doesn't take into account the technological and ecological level. So, we introduce a new indicator, based on the Gouy Stodola theorem, useful in engineering optimisation, the Thermodynamic Human Development Index

$$THDI = \sqrt[3]{\frac{LEI \cdot EI}{I_T}}$$

with  $I_T = T_0 m_{CO_2} s_g / (W \cdot GNI_{pc})$ , with  $T_0$  environmental temperature,  $m_{CO_2}$  carbon dioxide mass emission,  $s_g$  specific entropy generation, and  $W$  useful work produced.

## Results & Conclusions

The result,  $THDI$ , improves the usual  $HDI$ , by taking into account also the technical and ecological level by using the  $CO_2$  emissions and the  $s_g$  quantities, related to the irreversibility of a process.