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Could Thermodynamics Solve the Problem of Sustainability?

Socio-economics, natural capital and other esoteric notions prove themselves to be inadequate again and again when researchers and economists attempt to quantify the degree of sustainability. But, what if consumption of resources by a society or other complex system were simply viewed as a flow of exergy, the useful "work" a system can do? When approached in this way, the concept of sustainability becomes a question of thermodynamics where thresholds can be calculated above or below which a system is either consuming "too much" or "too little" respectively, and so is not in a self-preserving state of equilibrium. affect its sustainability the most and so could allow policy makers to focus only on the important factors rather than trivial points.

Enrico Sciubba from the Department of Mechanical and Aerospace Engineering, at the University of Roma La Sapienza, and physicist Federico Zullo of the University of Roma Tre, in Italy, has developed a simplified thermodynamic model of sustainability. They describe details of their model in the International Journal of Exergy. The model is an approximation of how complex systems, whether economic or ecological behave under different conditions and provides the foundations for building a more sophisticated representation that can be used to determine whether a system can exist in a sustainable state.

The starting point of the approach is to look at just a single population in a system using a reservoir of non-renewable resources, energy and materials and so on. The term exergy rate, i.e. the total amount of exergy "used up" by the population per unit time, is then used to build a set of thermodynamics equations that model the birth and death rates of the population and the use of resources.

The model ignores social, ethical, political and medical considerations the authors of the research paper explain. Nevertheless, for those aspects of any system to be sustainable the flow of resources, the inputs and outputs, must first be sustainable, otherwise the system will never achieve equilibrium. Number-crunching the thermodynamic model leads to some perhaps obvious conclusions.

"The role played by the resource consumption rate in our model is clear: a change in an ecosystem means a change in the amount of exergetic resources available to the population," the team explains. "This is reflected in a variation of the 'source' terms in the model. The sustainability limit is negated for a system, or society, thriving solely on non-renewables, and the limit for a renewables-based society is shown to depend both on the amount of renewable resources the population is able to exploit and on its consumption rate."

However, while the conclusions might seem obvious, providing a mathematical basis for such conclusions opens up the possibility of determining which aspects of a system affect its sustainability the most and so could allow policy makers to focus only on the important factors rather than trivial points.