Towards a Metric of Sustainability

Abstract

A significant problem for the advocates of sustainable technologies is the lack of a generally accepted definition and metric of sustainability. Further, the term itself is being applied to so wide a range of issues that it can no longer retain only a single meaning In response, this paper suggests narrowing the use of the term strictly to physical processes, for this appears the only way to achieve the establishment of a secure and robust metric of sustainability against about which actions can be proposed and results evaluated. The paper argues for a rigorous metric of sustainability derived from basic scientific principles, and avoiding the application of the term to sociological issues such as the longevity of an organization or society. The suggested metric of sustainability is the energy of reclamation of waste product - the energy needed to regenerate waste into useful material for other processes in the system.

Paper

Time and reality are presently conspiring to undermine the earlier widely held view that energy should be largely free and the earth has an infinite capacity both for supplying raw materials and absorbing waste. Such an optimistic viewpoint stems from the lack of any generally accepted measure of ecological 'goodness' (such as sustainability) readily representable in conventional economics [1]. On the basis that 'if you can't measure it, it probably doesn't exist', economic rationalism has rejected the concept that sustainability is more than a convenient term to describe a natural process occurring in all 'well managed' and profitable companies.

Applying conventional economic analysis to ecological systems is very difficult because such systems do not naturally contain the concept of money, and their concepts of value are subtle and vary between domains. Nevertheless, witness the concept of the Triple Bottom Line, some form of control - or at least management - of ecological aspects of human systems seems essential [2]. This strongly suggests that a means has to be identified of monitoring the ecological aspects of modern socio economic systems; in particular, identifying a robust metric for sustainability. The fact that this does not at present exist is clearly evident from the many assertions and claims for sustainability from many groups around the world. Unlike the profit or loss of an organization, which is minutely quantifiable, sustainability is referred to more in qualitative terms, such as 'good' and 'bad'. In the author's viewpoint it is time that a means be found to quantify this aspect of ecological economics, so that accurate measures can be made of the sustainability of any process including assessing the value of any modifications to the process claiming to improve it.

Yet current attempts to express a measure of sustainability in terms analogous to those used in financial accounting require, as in economics, the assignment of value to some property of the system. By maximizing – or minimizing – the value of this property, it is contended that the sustainability of the system can be likewise maximized. The assignment of value, which is a socioeconomic construct, is however difficult and contentious. The derivation of the value of something from the values of other things is more certain, providing the input values are accurate, and the mathematical processes used to manipulate value are justifiable. It is apparent, however, that value to most human beings is a multidimensional construct, and one cannot treat such constructs as if they were scalars and simply add and subtract them. One needs to treat them like vectors, and this is not normally done in analyses of sustainability. For example, if A and B are two vectors, then the resultant C is given by

$$\vec{C} = \vec{A} + \vec{B}$$

But unless A and B are collinear, which they almost never will be,

$$|C| \neq |A| + |B|$$

As assumed in all financial manipulations of value. Some other form of metric could usefully be sought, of scalar form, and which can be manipulated arithmetically. Such a metric might be energy, and this paper examines a novel manner in which energy might be used to provide a measure of sustainability.

The world is a complex interacting system comprising at least three identifiable spheres of activity. Such a system may be regarded as a geosphere and a biosphere [3]; we may also add a technosphere comprising articles of anthropogenic origin. Each sphere comprises material, energy and capital, providing capital is defined more generally, like "material fashioned in the form of a catalyst which permits the transformation of other material at a much lower energetic cost than otherwise would be required". The difference between the biosphere and the technosphere is the latter's propensity to generate useless product which no processes in any of the spheres can readily reclaim. This ends up cluttering the geosphere with increasing quantities of junk. Much of this will be lost to both the biosphere and the technosphere over timescales of millennia, or permanently.

The system is driven almost entirely by solar energy, directly and indirectly via fossils fuels, and to a small extent, by tidal energy and seepage of energy containing chemicals from the planetary crust. There is in this the natural model no concept of money, hence no concept of profit or loss in the conventional sense. Surely, organisms die and dissolve back into the biosphere and geosphere when they cannot sustain themselves further, but the measure of sustainability that the natural world uses is not an abstract single dimensional quantity. It is an integrated total of the circumstances in which they find themselves.

What is required is the extraction from the overall systems' basic patterns some feature, preferably based on energy, which is indicative of a measure of sustainability, and to express it in a form which is amenable to simple arithmetic in much the manner as money in present accounting practice. This should immediately indicate what is and is not sustainable over a long timescale, and offer a quantitive evaluation of activities claimed to increase sustainability. Such a metric, where presented unambiguously, can then be used to guide the policies of regulatory agencies. A good start has been made by Lovins and colleagues with the concept of natural capital [4], but this is just a first step in the right direction. Such literature sometimes tends to confuse the *sustainability* of processes and the *longevity* of the society which uses them. The former is an ecological issue, the latter totally sociological; they are far from identical.

An important attribute any system requires in order to be sustainable over really long timescales would be the minimal production of waste. In fact, it seems to matter little from the sustainability standpoint what either of the biosphere and technosphere do as long as material in not lost from them in a form that requires undue energy to reclaim. The measure of sustainability therefore becomes the amount of energy that is NOT used to reclaim waste. Minimising the energy of reclamation alone will do much to assuring sustainability, and while it alone may not be enough, it is clearly an essential component because continuous massive material loss cannot be sustainable over any long timescale.

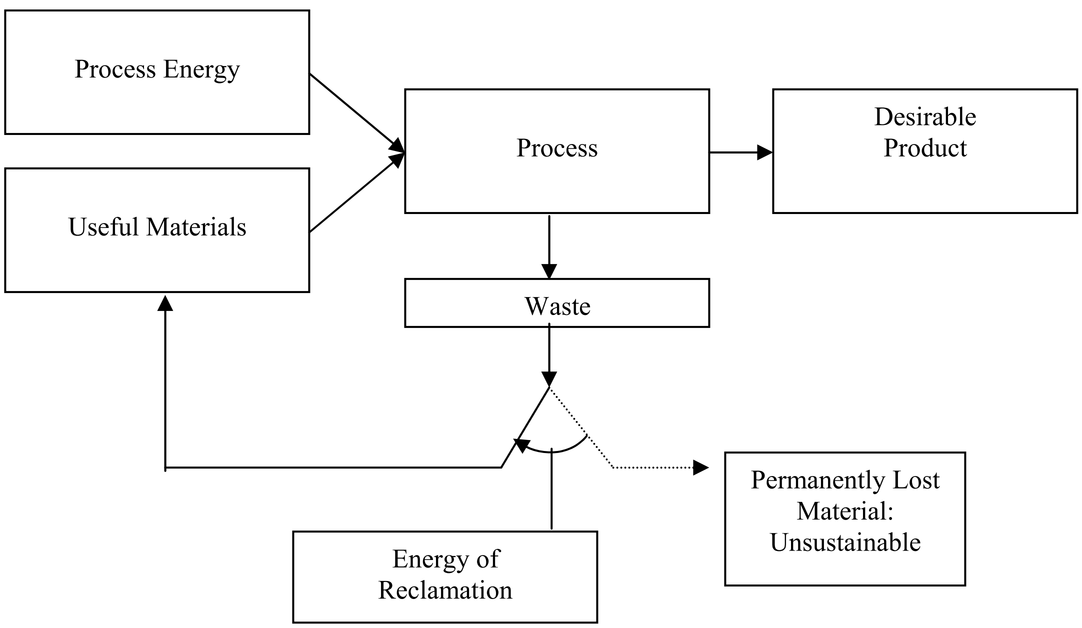

Figure 1. Sustainablity is a function of the energy of reclamation needed to make the percentage of Permanently Lost Material smaller than some specified value.

There are many problems to solve in achieving any state which could be called sustainable. Some are technological, some are socio-political and some organizational [5]. However, because all these domains encompass variables which tend to be incommensurable [6], there is a problem in finding a single driver which can naturally point decision makers in the right direction [7]. This paper proposes the adoption of the energy of reclamation of all outputs of an anthropogenic process as a metric for its sustainability; it is scientifically derived, has known dimensions, and can be evaluated numerically often via different pathways thus providing additional confidence in any one calculation.

There are some surprising corollaries from this proposition, the most challenging being that companies' profitability is irrelevant to their sustainability. This is such paradoxical statement that it should be closely examined, for if profit is a poor indicator of sustainability, it may be a poor indicator of other factors. This also implies that companies may be able to become highly sustainable while not impacting their profitability. Nevertheless, it will be impossible overnight to change accounting practice so that a company's health is calculated by more than its profits. Here it is noteworthy that the concept of the Global Reporting Index (GRI) may be a more useful measure of overall corporate health, and it is suggested that the concept of the energy of reclamation might one day be incorporated into the international GRI metrics. It is the hope of the author that this can be a topic for further fruitful research.

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