Sustainability and Energy

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The words "sustainable" and "sustainability" have become fashionable. Investments are called "sustainable" if profit is guaranteed for a number of years. Paper mills receive "sustainability" awards for recycling waste water and natural gas is claimed to become "sustainable" when it is converted to hydrogen by steam reforming. These examples show that the true meaning of the word is not properly understood. "Sustainability" needs to be defined. *Things* as such cannot be sustainable. Only *processes* can be organized in a sustainable way.

In simple terms, sustainability is living forever from nature without hurting it. Long-term, our chosen energy options must be sustainable, because energy is essential for services such as warmth (in buildings), mobility (for transport) and mechanical power, lighting and electronics (from electricity). It is also essential for obtaining materials, by mining and refining, synthesis, and recycling.

Sustainability has two requirements. The first concerns the harvesting of energy and materials from nature. The concept of sustainability (German: "Nachhaltigkeit") was first postulated in 1713 by Hans Carl von Carlowitz, the Supervisor of Mining for Saxony (see below). He stated that avoiding future shortages of timber and firewood requires harvesting only the natural growth of wood, not the tree stock itself. His rule has since been adopted by prudent forest managers in Europe and elsewhere. It amounts simply to living on the interest from an investment, not on the capital itself.

The second concerns the return to nature of products and wastes arising from the use of energy and materials. These can arise anywhere in the chain between the source and the sink. For example, power plants lie between coal mines and electricity users. However, the carbon dioxide they emit is harmful for nature. Hence the second sustainability criterion is violated in this case.

The reserves of coal, oil, natural gas and uranium are limited. In our time scale, they do not regenerate. Hence we can use them only as long as they last. In addition, their emissions -- carbon dioxide and radioactive waste -- cannot be absorbed by nature. Consequently, none of these energy sources can satisfy both sustainability criteria. In fact, sustainable energy solutions cannot be based on any of the "below-ground" energy deposits.

Another feature of "below-ground" energy is often overlooked. More and more energy is needed for recovering energy from sources of deteriorating quality, for transporting the crude materials over longer distances and for refining lower-grade crude to obtain high-grade fuels for market needs. Even for a constant net energy demand, the gross primary energy requirement must increase exponentially. The price of energy from such sources, and their carbon dioxide emissions, follow this exponential trend. Eventually, the "energy

cost of energy" exceeds the "energy return" -- and what was an energy source becomes an energy sink. At some point, neither increased prices nor increased energy conversion efficiency can overcome this unavoidable development.

Therefore, sustainable energy can never be achieved with "below-ground" fossil or uranium sources. The character of the original coal fuel does not change if it is converted to hydrogen. Even "clean coal" can never be a sustainable energy option because of the dwindling coal supplies. In the event CCS (carbon capture and sequestration) becomes commercially feasible, it is likely to suffer from similar exponential increases in the parasitic energy fraction used as all easily accessible locations to store CO_2 become filled.

In contrast, renewable energy sources exhibit no such exponential increase, because no energy is required to make the sun shine or the wind blow. After the initial energy investment in a renewable energy plant, the "energy return" is always positive and, averaged over time, remains the same. The fuels generate no harmful emissions; the only emissions come from constructing the generating, storage and distribution facilities.

For energy supply, only renewable sources can satisfy the sustainability criteria. However, even some renewables are not always harvested sustainably. Ethanol from corn is not sustainable as the total fossil energy input from plowing the fields to distilling the mash may exceed that of the end-product, and large quantities of water are required. Silt deposits in water reservoirs may gradually reduce the hydroelectric power production. Arable land may be spoiled by intensive farming. Geothermal wells may be exhausted as they are cooled by heat extraction.

The sustainability criteria are best satisfied by solar, wind, wave and most hydropower options. This renewable energy is available "above ground" in our biosphere. Thus installations for harvesting renewables from sun, wind, and waves are all visible. Land for energy production is occupied, but not consumed by installations. Although there may be some visual impacts, most "above-ground" renewable energy facilities satisfy the sustainability criteria.

Other options that can help to meet the sustainability goals are energy savings and increased energy efficiency. The first reduces the energy consumption by responsible use of energy – e.g., turn off lights when leaving a room. The second reduces energy losses of energy conversion processes – e.g. use more efficient lamps for the conversion of electricity to light. Together, energy saving and energy efficiency can reduce the demand for fuels and harmful emissions.

Today, significant losses result when "below-ground" energy resources are converted to motion and electricity. This also applies to hydrogen produced inefficiently by electrolysis, or with CO_2 emissions from natural gas. In a sustainable future, energy services will be supplied at the highest efficiency by electricity from renewable sources. Except for biofuels and solar heat, most natural energy is harvested as electricity. This may be obtained from wind turbines, photo-voltaic arrays, and thermal power plants driven by concentrated solar, municipal waste, biomass and geothermal heat. Clean electricity will become the "lead currency" of a sustainably organized "electron economy." It can produce warmth via heat pumps and motion in electric cars with high efficiency. For long distance land, sea and air transport, requiring high-density portable fuels, the remaining oil and biofuels will be preferred.

The difference between "below-ground" and "above-ground" sources is not just a matter of definition, or a reflection of ideology or wishful thinking. Only the "below-ground" sources are subject to the exponential growth of primary energy requirements, carbon dioxide emissions and energy prices. Mankind must escape from these exponentially increasing constraints, the sooner the better. Achieving a sustainable energy future should become a common political goal, with all regions, countries and continents implementing the necessary transitions. Some countries have already accepted this obligation while others hesitate even to recognize the problem. A swift and determined switch to energy savings, increased energy efficiency and renewable energy supplies would increase the level of sustainable energy services for the benefit of mankind. Why are we so reluctant to start the transition?

Mit GOtt!

SYLVICVLTVRA OECONOMICA,

Oder

Haußwirthliche Nachricht und Naturmäßige

Anweisung

Zur

Wilden Baum-Zucht,

Nebst

Gründlicher Darstellung/

Wie zu förderst durch Göttliches Benedeyen dem allenthalben und insgemein einreissenden

Grossen Holtz-Mangel/

Vermittelst Säe- Pflantz- und Versetzung vielerhand Bäume zu prospiciren/ auch also durch Anflug und Wiederwachs des so wohl guten und schleunig anwachsend- als andern gewächsigen und nützlichen Holtzes, ganz öde und abgetriebene Holtz-Oerter, Plätze und Orte widerum Holtzreich, nütz und brauchbar zu machen; Benebenst von Saam-Bäumen und wie der wilde Baum-Saamen zu sammlen, der Grund und Boden zum Säen zuzurichten, solche Saat zu bewerckstelligen, auch der junge Anflug und Wiederwachs zu beobachten. Daneben das sogenannte lebendige, oder Schlagen Ober- und Unter-Holtz aufzubringen und zu vermehren, welchen beygefüget die Arten des Tannen- und Laub-Holtzgewächs theils deren Eigenschaffen und was dasselbige Holtz für Saamen trage, auch wie man mit fremden Baum-Gewächsen sich zu verhalten, ferner wie das Holtz zu fällen, zu verkohlen, zu äschern und sonst zu nutzen.

Alles zu nothdürfftiger Versorgung des Hauß- Bau- Brau- Berg- und Schmeltz-Wesens/ und wie eine immerwährende Holtz-Nutzung Land und Leuten/ auch jedem Hauß-Wirthe zu unschätzbaren großen Aufnehmen/ pfleglich und füglich zu erziehlen und einzuführen.

Worbey zugleich eine gründliche Nachricht von den in Churfl. Sächß. Landen

Gefundenen Turff

Dessen Natürliche Beschaffenheit/ grossen Nutzen/ Gebrauch und nützlichen Verkohlung.

Aus Liebe zu Beförderung des algemeinen Bestens beschrieben

Von

Hannß Carl von Carlowitz/

Königl. Pohl. und Churfl. Sächß. Cammer-Rath/ und Ober-Berg-Hauptmann.

Mit Königl. Pohl. und Churfürstl. Sächß. allergnädigsten PRIVILEGIO.

LEIPZIG/

verlegts Johann Friedrich Braun 1713.

Cover page of the original presentation of the sustainability concept

"Anweisungen zur Wilden Baum-Zucht"

(Instructions for a Natural Tree Growth)
by Hannβ Carl von Carlowitz
published 1713 in SYLVICULTURA OECONOMICA
by Johann Friedrich Braun