D. Baird, A. Nordmann & J. Schummer (eds.), *Discovering the Nanoscale*, Amsterdam: IOS Press, 2004.

ISBN: 1-58603-467-7

Shrinking the Ecological Footprint with NanoTechnoScience?

Astrid E. SCHWARZ
Institut für Philosophie, TU Darmstadt
schwarz@phil.tu-darmstadt.de

Abstract. Nanotalk has provoked expectations just as high as fears: On the one hand NanoTechnoScience is expected to solve problems in almost every area of our daily lives; on the other hand there serious objections are being raised against the promises of a "brave new world". Nanorhetorics and nanovisions, the fictitious and factitious, the seemingly rational and irrational in this debate coalesce with peculiar sharpness in the "environmental argument". Here, in turn, the ambiguous concept of sustainability is important. The variety of meanings of this concept, its pluralistic use and at the same time problematic and attractive character is discussed with respect to nanodiscourse. The concept of the ecological footprint will be used to show the inconsistencies in the nanodebate. The discussion ends up noting that the concept of sustainability may at least be conceived to serve as a sort of information campaign or boundary concept that allows the debate of issues like growth and environment in the nanodiscourse. As such it could eventually help to place the whole debate in a more political and less ethical or economical context and to prevent the "nanotechnification" of nature and society.

Introduction

Talking about the future potential of "Nano" seems to be no less than proclaiming the next Industrial Revolution. Both supporters and critics of NanoTechnoScience alike agree that the new TechnoScience[1] will radically change all areas of life and concern all branches of industry: medical and pharmaceutical systems, agricultural and food production, transportation as well as building trade, and last but not least the military. In January 2003 a prediction was published, saying that "(b)y 2005, Atomtech will attract more interest (and controversy) than biotech. By 2010, Atomtechnologies will be the determining factor to profitability in virtually every sector of industrial economies. By 2015, the controllers of Atomtech will be the ruling force in the world economy."[2]

Looking a bit closer at this nanotalk, one might suspect that it fits perfectly into the sustainability discourse on revisiting the boundaries between science and society, nature and culture, as well as respecting the limitations of natural resources and the scarcity of environmental goods. As Roald Hoffmann, Nobel Laureate in Chemistry, pointed out already in 1981: "Nanotechnology is the way of ingeniously controlling the building of small and large structures, … it is the way of the future, a way of precise, controlled building, with *environmental benignness* built in by design."[3] Nano promises to eradicate poverty by providing material goods (of course pollution free) to all the world's people, cure diseases, even reverse global warming, and finally solve the energy crisis. This meets quite well the general objectives of the sustainability discourse represented (for example) in the just emerging discipline of "Sustainability Science" that claims "to understand the fundamental character of interactions between nature and society. Such an understanding must encompass the interaction of global processes with the ecological and social characteristics of Science".[4]

On the other hand, one can clearly find properties of conventional economic development: nano, techno and science as a dream team of the classical model of economic growth and prosperity as it is criticized by most of the economic conceptions inspired by the principle of sustainability. It seems that the investment community has decided that nanotechnology is "the next big thing"; business investment in nanotechnology start-ups is on the rise.[5] This is well documented by the following numbers: U.S. venture capital investment has grown from a modest 100 million dollars per annum in 1999 to 780 million in 2001 and was expected to pass 1 billion in 2003. Of the 710 million dollars in funding for the US NNI (National Nanotechnology Initiative) in 2003, less than 500,000 (that is 0.1%) is devoted to the study of environmental impact.[6]

The pros and cons in the debate and the ambitious forecasts, above all, echo the arguments of the biotechnology-debate of the early 1980s. In the following I will focus on a rhetorical phenomenon in nanodiscourse and bring it together with a certain concept developed in the context of the sustainability debate, namely that of the "ecological footprint". The phenomenon is the seeming ease with which nanotalk embraces the concept of sustainability – *e.g.* in the promise "to reverse global warming and to resolve the energy crisis". This will be discussed not with respect to the consequences for nanotechnoscience but rather to the concept of sustainability.

1. Ambiguity of the Concept of Sustainability

The use of "sustainability" is quite malleable in respect to the problems and challenges of such concepts. It is used in innumerable contexts and with various meanings without taking into consideration differences due to language as in the German "Nachhaltigkeit" or the French "devélopment durable". One of the early critics commented already in 1987 – the same year when the famous Brundtland-report *Our common future* was published: "The balance between fruitful ambiguity and outright contradiction is a delicate one, and ultimately the idea of sustainable development could not bear the weight of competing interpretations."[7] In spite of such skeptical objections, the idea of sustainability experienced an outstanding success story, and nowadays it is well known and established in society and, of course, science.

Why, then, should we not acknowledge this as a victory for environmentalists? Because it is – as the environmental philosopher Dale Jamieson stresses – just the surface.[8] In reality it reflects the lack of interest in further environmental protections by postindustrial nations and it represents the colonization of the sustainability discourse by economists. Consequently, disciplines such as 'ecological economy' could grow up in the 1990s.[9]

The ambiguities described go back to the earliest English use of "sustain" and its cognates. One family of meanings is related to the idea of sustenance; a second one centers on maintaining something in existence and leads naturally to a focus on preservation. The former pushes in the direction of "meeting the needs of the present", while the latter leans towards concern for the interests of the future. This semantic ambiguity forms the background to the whole discourse on sustainability. Another important and certainly more visible feature structuring the discourse is the distinction of human versus natural capital. Based on this distinction are the two probably most important conceptions of sustainability which have been developed over the last decade. Strong sustainability asserts that what should be preserved is "natural capital", while weak sustainability is centered on well-being and makes no essential reference to environmental goods. Both conceptions have their problems.[10] Furthermore, it is important to note that between the meanings of sustainability in professional discourse and in everyday understanding is a remarkably wide gap. What at least the majority of these meanings share is an anthropocentric outlook. While strong sustainability is very complex and technical, weak sustainability refers to simple and grand

ideas, which can be characterized in short as follows: sustainability is a good thing; it is about human survival and the avoidance of ecological disaster. According to this, the values most evident among the arguments advanced for sustainability are justice, well-being, and the value of nature "in its own right".

Most authors participating in nanodiscourse refer by and large to those simple and grand ideas, that is, to the colloquial use of the term "sustainability". In the following I will analyze some excerpts from various texts, stemming from fairly distant contexts.

2. The Setting: NanoTechnoScience and the Environment

The influential brochure *Nanotechnology: Shaping the World Atom by Atom* was published in 1999 by the U.S. National Science and Technology Council (NSTC) and worked out by the Interagency Working Group on Nanoscience, Engineering and Technology (IWGN), chaired by M.C. Roco. Under the slightly threatening title *Nanotechnologists project that their work will leave no stone unturned*, several aspects of everyday life are listed that will be subject to change. The aspects concerning the environment are the *Smokeless Industry* and *But, wait, there's more!*[11] The projected "smokeless industry" promises that nanotechnological bottom-up manufacturing "should require less material and pollute less". Engineers are believed to be able to embed life-like functions into materials, finally resulting in self-maintaining materials. "Even concrete will get smart enough to internally detect signs of weakness and life-like enough to respond by, say, releasing chemicals that combat corrosive conditions. In effect, the constructed world itself would become sensitive to damaging conditions and automatically take corrective or evasive action". In other words: the nano-constructed bottom-up world would be more sustainable than the traditionally constructed bottom-down world ever could be. This takes up exactly the vision of the "environmental benignness built in by design" already raised by Roald Hoffmann in 1981.

Interestingly, the environmental argument does not occur at all in the plea for "the small world" in the nano-founding paper by Feynman, which dates back another 20 years to 1959. His promises for the projected technoscience clearly point out the possible economic applications and particularly the intellectual adventure: "What are the possibilities of small but movable machines? They may or may not be useful, but they surely would be fun to make. How many times when you are working on something frustratingly tiny like your wife's wrist watch, have you said to yourself, 'If I could only train an ant to do this!' What I would like to suggest is the possibility of training an ant to train a mite to do this."[12] It would certainly be interesting – especially with respect to the assumptions and consequences of technology assessment and the shaping of technology – to figure out in detail at which time the environmental argument entered nanodiscourse and how this was linked to the emerging sustainability debate of the 1980s.

The surprises under the heading *But wait there's more* of the NSTC-brochure come in a list of further techniques to improve techniques in the field of "green business" that are partly existing already. These include molecular layer-by-layer crystal growth to make new generations of more efficient solar cells and selective membranes that can fish out specific toxic or valuable particles from industrial waste. Even more ambitious (and of course fictitious) are scenarios envisioning nanotechnoscience as the "only hope" for preventing natural catastrophes resulting from earthquakes, climate change, or asteroid collisions. "To survive a giant plume of volcanic dust in the atmosphere, for example, we could unleash 'sky bots' that would consume dust particles as feedstock and self-replicate into the trillions."[13] Other more moderate and apparently more realistic positions lean obviously towards the sustainability discourse. Lester Milbrath from the State University of New York claims for example: "Nanotechnologies have the potential to produce consumer goods with much lower throughput of materials and much less production of waste, thus reducing carbon

dioxide build up and reducing global warming. They also have the potential to reduce waste, converting it to natural materials which do not threaten life."[14] Environmentalists object to the general claim of nanoproduction requiring less material and polluting less. Even if this is true, there may be counteractive effects in the more costly process engineering. Even more serious objections are raised against the speculations to "seed" the oceans to better absorb pollutants or "seed" the stratosphere to patch up holes in the ozone layer. These hold that the implications of such experimentation are unknown, "but profoundly troubling". These seeding scenarios have raised the most persistent environmental fear concerning nanotechnology that are discussed under the heading "grey and green goo". There is a huge and heated debate behind this, but the most important point here is that it is argued that industry might see nanotechnology just as a means to "medicate" environmental problems, rather than confront the underlying problems that are over-consumption and waste – these obviously important objections also draw upon the sustainability concept.[15]

The inconsistencies in the nanodebate concerning the meaning of sustainability are surfacing in the confrontation of different social and political groups. But the suspicion that sustainability and environmental discourse may be of merely strategic use – and the malleability of the sustainability concept invites us to do so – can be strengthened even further by quoting the NSTC-brochure again. Reflecting on the viability of nanotechnology's promises it proposes the following: "consider the claim that nanobiology will enable people to live longer, healthier lives" and "longer average lifetimes will mean more people on earth" – but "how many more people can the Earth sustain?" Translated into arguments of the sustainability discourse, the NSTC-brochure begins with the well-being argument, seeks justification with the justice-argument and ends up conflicting with nature in its own right. The longevity-dilemma is in the end due to a problem with the sustainability concept itself. Both, the interest in human well-being and the conservation of nature are central to the sustainability discourse and correspond to the distinction between human and natural capital. Their different evaluations mark the difference between the two conceptions of weak and strong sustainability. The claims made in the nanodebate are mostly much more demanding than suggested by weak sustainability. Rhetorically, at least, it is more oriented to strong sustainability and will be discussed here under the heading "shrinking the ecological footprint". But before going into the details of the footprint, I would like to insert a note. The example from the brochure that led to the general dilemma of sustainability is a fictitious dilemma; according to the Greenpeace report published in July 2003, only a small part of the world population will benefit from the nano-world (predicted are 8.6% by 2025) – and they are the least likely to suffer the effects of the overpopulation problem.[16]

3. Tracing the Ecological Footprint

The Ecological Footprint is defined as "the land (and water) area that would be required to support a defined human population and material standard indefinitely".[17] The concept has not just been inspired but refers directly to the ecological concept of "Carrying Capacity"[18] that is based, overall, on economic assumptions. In general it seeks to express the continuing material dependence of human beings on nature. But the concept's most important critical implication is that limits to growth are invisible to static monetary analyses, because monetary expansion itself is not bound by physical limits. The authors point out that "The ecological perspective … challenges (the) money-based view. Clearly the physical consumption of natural income by one person pre-empts any other person from using those same income flows." Now, what Mathis Wackernagel and William Rees propose is to translate the total of social and economic activities carried out by the people of a city or single persons into land areas – of course, the ecologically productive land areas. They have developed a sophisticated system to calculate the footprint of cities, newspapers, cars, and

so on. The footprint of a typical North American measures 98000 m^2, an average Canadian leaves one of 78000 m^2, and a European has a footprint of about 48000 m^2.[19]

The strength of the concept is surely its ability to communicate that humanity is materially dependent on nature, and that nature's productive capacity is limited. Why not represent the environmental nano-promises and visions in terms of the ecological footprint? From a sustainability perspective, this could certainly contribute to the shift of social consciousness and to the development of suitable policy responses.

At the same time, this cannot deflect the critical objections that were raised even against the concept of strong sustainability. It may be true that the invention of "natural capital" enhances the reference to environmental goods, but it does not escape the economic notion in the concept. Instead, it incorporates the natural world into economic thought. The idea of natural capital implicitly involves the idea of human transformation and use; thus it is quite difficult to distinguish natural from human capital. Renewable resources, for example wood or drinking water, are not given to us by brute nature. Nature produces trees; humans act on trees in such a way so as to utilize the wood. What turns water into drinking water is that it is fit for humans to drink. Another important question to be raised is what exactly it means to maintain natural capital or "ecologically productive land". While ecologists can agree that a terrestrial ecosystem can be productive, most of them would object against the notion of ecologically productive land: Of course, the ecosystem *high mountains* is productive in an ecological sense, but it is not according to Wackernagel and Rees.

There seems to be little hope for the ability of the concept of sustainability to structure nanodiscourse. At most it could serve as a sort of information campaign or boundary concept that allows the debate of issues like growth and environment. As such, it could provoke us to reassess our notions of quality of life and environment and eventually to help us place the debate in a more political and less ethical or economical context.

Though I discussed in a rather critical sense nanorhetoric and nanovisions, I do not want to claim that visions are *per se* something bad or have to be avoided. On the contrary, I think it is most important to develop a richer set of positive visions regarding the proper human relationship to nature. But – as the environmental philosopher Dale Jamieson points out, "(t)hese visions must go beyond the bloodless futures of scientific forecasters".[20] I agree with Jamieson when he points to the necessity of simple and compelling stories that show us how to participate practically in creating the future in our daily lives. What we need is a discourse that permits deeper discussion of aesthetic, religious, cultural, political, and moral values; hopefully preventing the "nanotechnification" of nature and society.

Notes

1 I am using the term in the sense of Haraway 1997.
2 ETC 2003, p. 43. The "etcetera-group" is talking of "atomtech" instead of "nanotech" to point out the political connotations of the technology.
3 NSTC-report 1999, p. 4 (emphasis added).
4 Kates *et al.* 2001.
5 Arnall (ed.) 2003, p. 32.
6 Arnall (ed.) 2003, p. 40.
7 Redclift in Jamieson 1998, p. 184.
8 Jamieson 1998, p. 184.
9 One of the first and most prominent publications in the field is the book *Ecological Economics: The Science and Management of Sustainability*, edited by Robert Costanza in 1991 (Columbia University Press).
10 See extended discussions in Hinterberger, Luks & Schmidt-Bleek 1997 and Holland 2002.
11 NSTC-report 1999, p. 8.
12 Feynman 1960, p. 26.
13 NSTC-report 1999, p. 8.

[14] The Ecologist 2003, p. 38.
[15] ETC 2003, p. 30.
[16] "Those who participate in the nano revolution stand to become very wealthy. Those who do not may find it increasingly difficult to afford the technological wonders that it engenders" (NSTC/CT 2001).
[17] Wackernagel *et al.* 1996, p. 11.
[18] For more details see in Höhler 2004 the comparison of different concepts that rely on the idea of the carrying capacity.
[19] Schomberg 2002, p. 21; the European research program FP6 lists under priority 6 and 7 "Research mapping our footprint on national, regional and global scale to increase eco-efficiency".
[20] Jamieson 1998, p. 191.

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