Imagining and Creating a Sustainable Future

Review of *Sustainable technology development*, by Paul Weaver, Leo Jansen, Geert van Grootveld, Egbert van Spiegel, and Philip Vergragt. 2000. Sheffield, UK: Greenleaf Publishing.

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When the *Limits to Growth* study (Meadows et al. 1972) found that humankind was on a trajectory towards overshoot of carrying capacity and population collapse,, one of the most common reactions (e.g., Simon and Kahn 1984) was to dismiss the results of the computer model runs, on the theory that technology would be developed that would forever push all limits off into the future. These Cornucopians proclaimed that population growth was something to celebrate, as every birth represented two new hands and one new mind to work on building a better world. Most of these commentaries took it as an article of faith that political and economic systems would ensure that new generations would get the education they needed and the work assignments necessary to develop new technology to push back the limits.

The Brundtland Commission raised its own concerns about sustainability fifteen years later (World Commission on Environment and Development 1987). This time, the government of the Netherlands rolled up their collective sleeves and started working to find out how the conditions necessary for sustainability could come about. This book reports on part of that effort, the Sustainable Technology Development (STD) project. It is chiefly concerned with how to promote technological innovation in a direction that will help achieve greater sustainability.

Early work commissioned by the project (Weterings and Opschoor 1992, 1994) concluded that rich countries will exceed their share of the world's eco-capacity by 10-50 times in the year 2040, given today's technologies. Three methods of subverting this projection are suggested: 1) reducing the demand for goods and services, 2) increasing the world's eco-capacity, and 3) increasing the efficiency of use of eco-capacity per unit good or service in the economy.

The STD project decided that the latter two methods fall under their purview, and the search for ways to increase the efficiency of eco-capacity use by factors of 10-50 is the focus of the book's material.

The STD bases its approach to innovation on the main conclusion of the Dutch Commission for Long-Term Environmental Planning (CLTM), which this book summarizes: "the usual innovation practices offer no prospect of technology playing anything other than a peripheral role in achieving sustainable development" (CLTM (Dutch Committee on Long-Term Environmental Policy) 1990). Ten to fifty-fold improvements in eco-capacity efficiency can come about only through "path-breaking approaches to meeting needs that are radically different from the solutions we have in place today." (See also Box 1.)

Innovating the innovation process: The STD methodology

The STD project used a number of approaches to finding possible directions for technical innovation, evaluating those options, and starting actual innovation. These are briefly described here.

Creating new social networks. *Sustainable technology development* adopts the view of a body of theory called social network analysis, that technologies and innovation processes are characterized by social networks, and the networks are held together, in part, by their view of what

problems are to be solved. One way to start radical new directions of technology development, then, is to create new social networks, unencumbered by previous problem definitions.

Scenarios. Casting off the limitations on thinking produced by today's organization of technology and society can free the imagination to develop new problem definitions. By writing "future histories" to 2040, the STD project was not only able to think about long-term repercussions of today's technologies, but also to imagine drastic changes, like maintaining an industrial society without using fossil fuels.

Backcasting. Once some view of a possible and desirable future state of affairs is developed, "backcasting" is used to figure out how to get from now to then, by working from then back to now. There may be relatively few options for the last steps of fifty-year process of change, but relatively many for the first steps. Backcasting allows the participants to work from the easier end of the problem.

Constructive technology assessment. The STD team recognizes that technological innovation requires popular acceptance, and that society is shaped in many ways by the technology it uses. To improve the chances of investing in technology that will win acceptance, stakeholders are invited in for Constructive technology assessment (CTA). CTA is an open-ended method for evaluation, where the evaluation criteria are decided upon by the stakeholders themselves, in an open dialog, with the analyst playing "a neutral role." This gives considerably more latitude for participation than many types of technology assessment, where the analyst has determined the criteria ahead of time, and merely asks the participants to rate the criteria in terms of relative importance.

Life cycle assessment. Comparative life cycle assessment (LCA) is used throughout the project as the means of eliciting technologies' environmental impacts, and seeing what factor improvements in eco-efficiency are achieved.

Specially protected market niches. Initially, prototypes of the more sustainable technologies will be competing with much more mature technologies, which have distributed their development costs over many years of sales and which have achieved nearly optimal production strategies. The innovated technologies will generally not be able to compete head to head, it is thought, but need a special market niche to develop in. Present examples of such niches are the requirement by the US government that the paper they buy include a certain percentage of recycled fiber, and the requirement in California that a percentage of the car sales be "zero-emission vehicles" by 2005.

Case studies of sustainability

The STD project chose five case studies to apply this methodology to: food production and nutrition, transportation and mobility, buildings and urban spaces, water and wastewater, and materials and chemicals.

The main part of the book documents the way the STD methodology was applied to these case studies over the project's five-year life. An overview of the way all the parts of the methodology fit together is given for the food and nutrition case study. A chapter is then given to each of the individual components of the methodology, each in a specific case study. A final chapter sums up the conclusions of the project and assesses the assessment.

The project concludes that, in the cases studied, radical new approaches to providing goods and services can, in principle, improve eco-efficiency dramatically by 2040, and much more so than incremental innovation of present technologies. Transportation needs, for example, can be met by energy chains based entirely on renewable resources (although it is unclear to what extent their scenario uses nuclear energy, which the authors consider renewable). Another example is a

substantial reduction in the environmental impact of cleaning clothes and other textiles, first by a transition to more efficient water-based methods, and then by a transition to dry cleaning methods based on liquid carbon dioxide instead of the toxic chemicals used today.

And, the project concludes, it is possible to influence the innovation process, and nudge it in new directions, through a combination of public support, building new networks, and reconceiving problems. The authors point to the broad impact of the program on Dutch society, through the 500 professionals involved in developing STD activities and the 3000-4000 stakeholders who took part in workshops and symposia. Many of the 30 people on the project staff over its five year life are now pushing forward STD-related activities in some of the new networks created or in other contexts.

The potential of the STD approach is clear, the authors conclude, but very many similar and parallel efforts are necessary to produce the array of technologies necessary for sustainability.

Comments on the STD approach

Trying to see into the technological future is a daunting task, and it is prudent to be humble, both when doing so and when commenting on others' attempts to do so. Even industry leaders have been caught by surprise by the direction of technical innovation. Classic cases are those of IBM, who underestimated the market potential of personal computers and entered the field quite late, and Microsoft, who misjudged the importance of the internet and consequently was tardy in developing browser software.

The authors of *Sustainable Technology Development* might suggest that these industry leaders were caught by surprise by innovation precisely because they were industry leaders. Such patterns underscore the book's hypothesis from social network analysis, that radical innovation will only come from outside the established networks, which have a set conception of problem definitions and innovation trajectories. I have great respect for the way in which the participants in this project have pushed themselves and others, in many areas, to think outside the box and look for new, more sustainable ways of meeting needs.

This book demonstrates how important it is *who* creates the new networks. The authors, most of whom were deeply involved in the STD program, have technical positions, and the program produced a technophile's vision of sustainable technology. To some extent, this is an explicit choice to stick to the program mandate, with full awareness that other approaches to sustainability are useful and complementary. For example, the authors are well aware that there is much room for reducing resource use in transportation by structuring the pattern of homes, shops, and work places in a way that reduces the need for transportation. They choose to concentrate on the supply side of transportation, "in keeping with the STD objectives of stimulating technological innovation and evaluating the extent to which technology can contribute to sustainability."

I would be more comfortable with such a choice if the authors showed greater awareness of the side effects of focussing on technical fixes. Propping up the current transportation infrastructure of rich countries like those in Europe or North America with less polluting energy carriers and engines freezes in place the social and environmental effects of devoting enormous areas of cities to storing and moving around metal boxes. For example, kids are steadily more dependent on their parents to get to school and play, in part because schools and play areas are far from homes, in part because dangerously busy roads separate the kids from where they are going. Conversely, adults are slaves to their cars, with over 10 person trips each day per household in the US (Hu and Young 1999) and spending a daily average of one hour thirteen minutes per driver (Nationwide Personal Transportation Survey n.d.) to get to work, take the kids to school and soccer practice and swimming lessons, get groceries, etc. A vision more freed of constraints of existing technological and social arrangements than the authors present would at least include mention of this side of today's system.

Other case studies in the project did incorporate more thought about social change. STD's future vision of textile cleaning, for example, relies on centralized laundry facilities using liquid carbon dioxide or other cleaning agents too difficult or uneconomical to handle in the home. The authors realize that this represents a big change for people who like to wash clothes at home, and envision a plausible transition involving a period of small washing machines at home for personal clothes items and centralized washing of things like sheets and curtains. Meanwhile, technology like chips sewn into clothes to identify the owner is developed to make it easier for these to be collected for central cleaning and returned unerringly to their owners.

Furthermore, some of the technology these authors embrace as sustainable is rejected by large segments of the environmental movement. Environmental leaders in the US, as well as consumers in general in Europe, demand a go-slow (or don't-go) approach to genetically modified (GM) crops in general, and to human foods in particular. The authors blithely praise the potential of GM crops to meet needs more sustainably, with nary a care expressed for the substantive concerns which have been raised about them and only a short footnote (p. 122) to indicate awareness of popular rejection. Will incorporating insecticide genes into crop plants also harm those who eat the plants and accelerate the resistance of insects to those insecticides? You would never know that these were possibilities from reading this book's endorsement of the technology.

I've already mentioned that the book considers nuclear energy to be "renewable." There is no mention of any possible problems with safety of nuclear reactors, containing radioactive waste for 10,000 years, or terrorists capturing nuclear material to make bombs or spread poisons.

Overdependance on life cycle assessment probably reinforced the authors' technophilic inclinations in classifying GM foods and nuclear power as sustainable technologies. As LCA generally does not take risk and uncertainty into account, it treats GM plants and nuclear power as having no negative environmental effects.

A corporatized, alienating sustainability

Included in the new social networks the project stimulated were such huge industrial corporations as Akzo-Nobel, Shell, and DSM. It is easy to see the importance of helping these companies focus on sustainability. They are some of the largest users of resources and polluters, and also have a great deal of skill and resources that could be used to bring about sustainable technology. It should perhaps not be surprising, however, that many aspects of the STD future vision represent a further corporatization and disaggregation of the world, where easy manageability for profits comes before beauty or providing people with meaningful work.

For example, when considering how to use solar energy more efficiently for food production, one STD approach is to genetically engineer plants to have a higher efficiency of photosynthesis. This sounds like patented seeds and massive corporate profits. Another suggestion is that spaces capturing solar energy but not using it for crop production—like rooftops—be covered with collectors which transmit the solar radiation via fiber optics to "greenhouses" in cellars or PV arrays used to extend the day length in these cellar production facilities. Again, the emphasis is on controlled, centralizable environments dependent on large, technological investments.

How much different this world is from one envisioned by Nancy Jack and John Todd (Todd and Todd 1984), where the beauty of food-producing plants is displayed in rooftop and street-level greenhouses, and the level of technology is not much more than glass, transparent plastics, and deep awareness of greenhouse ecology.

When the authors do consider anything other than the technological sides of questions, they often seem to do so reluctantly, and in a stilted way. In discussing "novel protein foods," for example,

like those made from algae and fungi instead of pigs and cows, the authors assure us, "While foods fulfil nutritional needs, this is not their only function. The foods we eat provide satisfaction through their flavours, aromas and textures." This book will garner no prizes for food writing.

Wastewater: One-way flows from soil to glass

The chapter on using LCA to evaluate the municipal water system will probably interest many readers of this newsletter. Here the project looks at the consequences of extending sewers and centralized treatment of wastewater to all housing in the Netherlands, with the apparent assumption that anyone not connected to a sewer is dumping untreated wastewater directly into surface waters. Even with this remarkable assumption, the environmental consequences of a comprehensive sewer network are seen to be disastrous, with energy use doubled and more unusable sewage sludge produced.

The authors then proceed down a familiar path, looking at differentiating "the functions served by water in households and [cascading] water down a hierarchy of uses," beginning with drinking and bathing water and going to washing clothes and flushing toilets. Rainwater collection is suggested, also, and separation of storm water from domestic wastewater.

The end of the pipe surprised this reader, however. One main goal for wastewater treatment in the project is to reduce the amount of sewage sludge produced, by concentrating the wastewater and then using anaerobic digestion to treat it. This amount of sludge is so small, the authors speculate, that there are "options for final disposal not possible with aerobic treatment, like vitrification"! While separation of domestic wastewater from heavily contaminated industrial wastewater and surface water will do a lot to make the sludge produced cleaner and therefore more useful in agriculture, this thought does not, apparently, occur to the members of the project. Also, the book shows no awareness of the source sorting technologies for wastewater treatment developed in northern Europe the last ten years (Staudenmann et al. 1996; Etnier et al. 1997). If this accurately reflects the project's thinking on wastewater, it is a striking oversight of *current* technology.

The biological nonchalance of the authors is revealed most clearly in the way the occasional lip service to "closing the loops" for nutrients is contrasted with the agricultural systems proposed. Rather than the "inefficient" practice of plowing most of the plant biomass back into the soil, the STD advocates using the "non-food biomass" (as they affectionately refer to stems, leaves, and perhaps roots) as raw material for energy and chemicals. When even the end products of the food biomass, in the wastewater sludge, are to be vitrified and buried or dumped at sea, it looks like the soil will be endlessly mined, never replenished. Not what I would call sustainable.

Having struggled through many tomes in what I call "Continental English," I found the book's language to be technically better than expected from a Dutch study. The work of author Paul Weaver—apparently British—and perhaps of the editors at Greenleaf is clearly visible. Still, the book could have used another edit. Many oddly turned phrases, which I assume to be Dutchisms, remain, as well as simple grammatical errors and a few technical errors. The blue-green alga *Spirulina* and the fungus *Fusarium* are both identified as bacteria at one point (p. 104), and methanol is called "methane" in a figure caption. Even if the grammatical and technical errors were cleaned up, the pervasive ugliness of the prose would remain. The line quoted above, on the "functions" of food, is typical. Technology for sustainability is an exciting subject, but I found reading this book a chore, not a pleasure. I wish the authors could explain their ideas with the lucidity and beauty even of other technophile exponents of sustainability, e.g., (Weizsäcker et al. 1997; Hawken et al. 1999).

Still, I thought the book was worth the labor of getting through it. It reports on a substantial effort by a western European government to grapple with one aspect of sustainability, and shows itself to be part of what seems to be a more wide-reaching program. If nothing else, the book's vision

serves as a warning of how a massive investment in the name of sustainability can be made to produce a landscape more dominated by neon signs and highways, an economy and politics more dominated by large corporations, and more people working in specialized, meaningless jobs like flipping novel protein food burgers.

The book presents more than an eco-dystopia, however. Many of the methods the STD project uses, like backcasting, constructing new social networks, daring to think fifty years into the future, and consistently using LCA to evaluate options, can be used to help find a more palatable vision of sustainability. The STD project combines these at a scale and in a way that are impressive. I'd like to see fifty more projects like this one, and have the competing visions debated with the same fervor as is now given to releasing petroleum from the US strategic reserve to lower oil prices.

How much can the market do?

One reason the market will not provide sufficient incentive for technological innovation, the book explains, is that key shortages of eco-capacity lie in non-market goods, like the ability to assimilate pollution. For example, if the atmospheric CO_2 concentration is to be stabilized at 450 ppm (compared to 280 ppm in preindustrial times and 350 ppm today), then anthropogenic carbon emissions from 1990-2100 must be kept below 650 gigatonnes (GtC), which translates to an annual anthropogenic emission *less* than today's. At oil price equivalents of US$20-40 per barrel, world carbon-based fuel reserves are estimated to be 2000-7000 GtC. Clearly shortages of oil, coal, and natural gas will not prevent a significant overshoot of the 650 GtC emissions goal for the period 1990-2100. Supplements to the market, like taxes on carbon use or prohibitions on certain uses of carbon, are necessary.

The authors reason that there will not be the political will to impose the necessary controls on unsustainable activities that would stimulate more market-based innovation of technological alternatives, unless it is clear that those alternatives are there. It is this type of Catch 22 that the STD project wishes to circumvent, by showing another path for technology development.

Other scholars of markets and technology [Weizsäcker, 1997; Hawken, 1999] argue that the market is now developing technologies achieving very high increases in eco-efficiency, and would be capable of much more if present subsidies to fossil fuels, nuclear power, and other unsustainable technologies were eliminated (see also [Roodman, 1996]).

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