Barriers and Opportunities for Delivery of Sustainable Solutions:

Lessons from the Field

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The paper which follows was the keynote address to the Organization for Economic Cooperation and Development Conference on Potential Environmental Benefits of Nanotechnology: Fostering Safe Innovation-led Growth, Paris France, July 15-17, 2009. The rapid growth of nanotechnology has brought issues of its introduction and control to the forefront. Early research shows that many materials can be made which have entirely altered properties, and a great range of potential uses. Thousands of products now contain nano-materials; these include building materials, electronic components, cosmetics, food products and monitoring systems. Some nano-products seem to have properties not unlike those of asbestos fibres which are similar in size to nano-tubes. For most, both the range of applications and risks has yet to be determined. The Challenge is to find ways to make the best use of this suite of new technologies in support of human goals, while making certain that undue risks are controlled and undesirable outcomes prevented. The Paris Conference marked one of the first times that the scientists, policy makers, entrepreneurs and potential users came together to address these issues and seek sustainable solutions.

The global challenge of our age is to find ways that human civilization can sustain itself. This challenge occurs at all scales, and is related directly to the human footprint on the planet, collectively and individually. Any model defining potentially sustainable solutions involves a combination of actions – which involve new human behaviours, new approaches to governance and improved technologies. The challenges and potential solutions addressed in this paper are based on the experiences and observations of over 30 years of work associated with the delivery of environmental management and sustainable development. Over that period I have had the opportunity to visit more than 120 countries and undertake projects in more than 50 of them. The content in this paper is based on how different people define problems and what factors influence the success of solutions to sustainability issues. I speak to you not as a specialist in technology, but rather as someone who has worked to see that the most suitable and successful approaches and technologies are used where they can make the greatest difference. Over the years I have come to understand that communication is a core element in the delivery of solutions, and that nearly everything we try to accomplish can be cast as a form of problem definition and risk management.

As Dennis Meadows, one of the original authors of the report to the Club of Rome on the Limits to Growth (1972) noted in his speech earlier this year to the Japan Foundation while receiving the 2009 Japan Prize, (Tokyo, Japan; April 21, 2009.) "*So you may reasonably ask whether technological advance has the potential for changing our forecasts. The answer is, 'No.' Technological advance alone does not eliminate any of the three reasons that predispose global society to overshoot or to collapse. It is urgently important to develop many new technologies. But they will only give us time for the important changes: reducing desired family size, altering consumption goals, raising the concern for equity, enhancing respect for nature" http://www.clubofrome.at/news/sup2009/dl_jul_dm_text.pdf)*. This is the context within which nanotechnology falls, as a promising suite of solutions beyond imagination, but which will be delivered by a range of humans and institutions, not all of whom understand or will accept these technologies.

"Sustainable development "is the term now used to refer to development which is sound socially, economically, environmentally and organizationally at all scales. (Superseding former approaches called e.g., integrated development, environment/economy integration, holistic development etc) . It involves the clear understanding of real problems at all scales – from global to local to individual to the smallest measurable, and the crafting and delivery of effective solutions which respect all of the factors listed in the definition. While there is an immense need for better technologies, human and Institutional factors are as important as scientific and technical ones if sustainable solutions are to be actually implemented.

What has become very apparent from my work with enterprises and communities on all inhabited continents is that the problems encountered tend to be unique, due primarily to the social, economic and environmental context. A small coastal village in West Africa may have very limited access to energy, yet it needs potable water. While we have many techniques available to provide water, most require a reliable energy source. Yet the village is off grid, tens of kilometres from a reasonable surface water source, and its ground water may be contaminated. As well, the distant water source is owned by another village who may not want to share. How do we provide them with the water they require? Water in this case may be the single most strategic input to stimulate any form of sustainable economy. Can we provide a self-contained solar desalinization facility, and at what cost? Can they establish sufficient local capacity to keep it going and maintained? Who will control the distribution of power or water? All these are factors which will directly affect the success of whatever technical solutions we are able to provide. How will it play out when it reaches the workers, peasants, end users?

From 1995 to 2005 I participated with the Foundation for International Training and the Canadian International Development Agency in a project with Jiangsu China to clean up thousands of factories in the lower Yangtze. These ranged from tiny village operations mixing industrial chemicals for export to immense metals factories producing engine blocks for trucks or anvils for American hardware stores. In most cases, the managers were not experts, and many factories had no professional staff. Yet all required technical solutions – from new cleaner production processes and equipment to methods to effectively clean the waste stream. As well, nearly all needed management and worker training. As one factory manager noted, only the person who carries out the bucket knows what happened to the toxics. This pattern was replicated in similar industrial and institutional audit projects which we carried out in Romania, Pakistan, Argentina, Sri Lanka and Mexico.

Key barriers to implementation of sustainability

Defining Problems

While managers and officials may be aware from the symptoms of an environmental problem that the problem exists, many have little capacity for problem identification and problem solving. This is not limited to developing countries. Many consultants like me make a good living helping government officials and private sector managers to scope problems. Some are blind to key problems - if the enterprise has habitual procedures, and the contamination of the site has been common practice, they may not even realize that it is a problem until identified by outsiders. For decades, a major Canadian railroad overfilled all locomotives with diesel because once, an engine ran out of fuel on a main line and blocked all traffic. The new operating rule was to not stop pumping fuel until it overflowed. It took us twenty years to clean up most of the contaminated sites through a major government led revolving fund. In some of our factory clean-up work in Asia we use video "walk- throughs" of contaminated factories to train managers of similar properties how to spot the risks (contamination, health and safety, product loss) in the expectation that it will sensitize them to finding similar problems in their own facilities. We have used the same approach with managers in government departments in Canada and Argentina for the same reason.

Knowledge of potential solutions

Because so much of the actual implementation of solutions occurs at the enterprise or community scale a key barrier is access to information and advice. In many cases, the only access to technical advice comes from the seller of the technology. The seller of a specific bio-reactor is not very likely to recommend a competitor, much less an alternative technology. There is a general problem of access to independent competent advice regarding available technologies and their applications or potential benefits. Now that the internet is nearly universally accessible it may be easier to provide knowledge of the range of potential solutions but this has not solved the problem of how to choose among them and how to get good independent technically sound advice at the local level.

Tradition

"We have always done it that way. Tradition can be a strong barrier. In China, water has always been dirty, and food traditions have evolved with the assumption that everything must be boiled and no-one (until the recent advent of bottled water) would ever consider drinking water. In Bermuda, the tradition of white roofs on houses has evolved over many centuries – a reasonable adaptation to the climate and a visual delight. Roofs also collect rainwater and, if white, are easier to clean if needed. Hence there are no solar collectors. These traditions factor directly into decisions at all levels regarding where investments are made.

Institutional and regulatory barriers

The Bermuda tradition is now law – white roofs are compulsory. Until solar collectors come in white, they will not likely be used in Bermuda. In my own city of Ottawa Canada it took 20 years to get solar collectors approved for link to the grid, although passive use for swimming pool heating was outside the regulatory framework and was allowed. In many cases, laws are written which are prescriptive – and only that which is specified is permitted. For new technologies, there may be long review processes, or even the need to change laws (e.g. the National Parks Act in Canada specifies the materials which can be used in buildings in Parks and park communities, and any alteration will require an amendment to the Act, not just the rewriting of a regulation). Many nations or municipalities have lists of approved building methods or materials which exclude any others until added.

Understanding of risks and benefits

Any sufficiently advanced technology is indistinguishable from magic - (Arthur C Clarke `Profiles of the Future 1961.) Clarke's Third Law, quoted above, illustrates the understanding gap which accompanies new technologies. How can you be accountable for something you don't understand? Who will be your guru when you need to adopt, allow, or approve a new technique? How can you weigh the arguments of proponents and opponents? Some additional factors affecting this are covered in the section on risks and decisions below.

Resources

As with all investment, resources are a critical factor. Often new technologies have higher costs. Particularly for those who invest in the first applications, costs can be prohibitive. In the broader context, it may take a specific and rich user to pay for the first application (See hotel solar desalinization example below) . Where there is a specific demand it may be easier to get venture capital.

What technology? How to Choose
A simple case will illustrate how difficult it can be for a manager of a small enterprise to deal with technical solutions. A small dye factory in Jiangsu China had a problem with contamination of a watercourse with its by-products. The levels of contamination from heavy metals, petroleum based dyestuffs and animal based dyes resulted in the factory being given six months to clean up or close. The manager wanted "the very best most modern technology". A firm from Shanghai was pressuring the factory to install a bigger bio-reactor and they already had put one in which was not working. Our assessment showed that the mix of contaminants was quickly killing the biota. The solution lay in changing the production system so that contaminants could be separated earlier in the process and only those suitable put into the biotic system. Due to political upheaval in the past, local experts had totally missed membrane technology which might have been a better solution. With some help through a technology transfer and support project a cleaner production solution was provided and the factory is still in operation. (For more information on this project see the Foundation for International Training website at http://www.ffit.org/SMEEP/Default.htm). Without the external support, access to a practical solution was nearly impossible for the factory manager who had no technical credentials. This situation was replicated in nearly all of the several thousand factories involved in the project.

Risk and Decisions
Nanotechnology is likely to receive the same kind of attention from the public as earlier technological advances; a mixture of hope and fear. While there is likely to be great interest in the solutions which the new technology may bring, for new technologies like nanotechnology there is always suspicion. Where there is insufficient understanding, risks are often exaggerated. Longer term benefits are often discounted. Fear of what you cannot see (like radiation or biotechnologies) may be the predominant reaction. In our public consultations on a national program for monitoring sustainable tourism in Cyprus, there was a significant public lobby to make the banning of genetically modified foods part of the policy solution, even though the public meetings were on a totally separate subject with minimal if any links to GM foods. There often are large gaps between the empirically documentable risks and the public perception. These have halted national programs for safe disposal and storage of high and low level nuclear waste in many countries, even where there are solutions which are clearly much safer than current temporary storage.

In my country, Canada, we have been unable to agree on a permanent site for high level nuclear, despite scientific agreement on several sites where risk is agreed to be near zero. Even low level nuclear causes major logistic issues because the public focuses on their perception of the words "nuclear" or "radioactive", not on the science. Politicians and their constituencies have problems dealing with differences between "all" and "some": if any example of a technology is "bad" then all is assumed to be. A case in point is the public reaction related to disposal of a small quantity low level radioactive waste left from a decommissioned aviation instrument manufacturing plant near Vancouver airport. Local municipalities refused to let a truck carrying the contaminated dirt go through their territory to a safe disposal site in an abandoned uranium mine about 300Km away. Eventually the truckload of earth was taken out to sea and dumped surrounded by protesters who were afraid of impact on the ocean and on the whales. The total level of radioactive material was about the same as that in a truckload of watches en route to Wal-Mart. This incident reinforces the conclusion that good knowledge will be critical to the ability to use new technologies and to not engender ill informed opposition.

Government and private decision-makers often have difficulty dealing with uncertainties and anything expressed in stochastic terms. If there is any disagreement, it is very difficult for public decision-makers to act. Certainty and consensus is preferred. The public wants their leaders to guarantee safety, success and benefit. This is not easy. Regulatory regimes are often crafted to convey certainty; that is why so many regulatory regimes are prescriptive, not permissive. Further, approving or supporting an action or technique may incur liability. Taking chances is not likely to receive public favour. Politicians who do not concur with public perceptions of risk, right or wrong, may lose their office.

What they think they know

Even when information is carefully stated and positioned, the message may not be received as sent. In the 1970's the Club of Rome publicized the famous work on "Limits to Growth". What it said, based on a complex model, was that if we proceeded on the same path, and did nothing to change the world would reach a point where resources would be insufficient to support the global population. A more sophisticated version of the same model has been rerun many times and it still works. But that is not what most of the public thinks. When the model was made public, few actually read the book. Instead, the press took notice of the model by projecting doomsday scenarios. .. "We will starve, world to end..."etc.. When this did not come true, many observers have concluded that the Club of Rome was wrong; we didn't all perish so there must be no limits. Like this example, there is often a significant difference between what was said and what was publicized. , and the public only has access to the latter. What is clear is that the public perception of scientific information is based on what they think they "know"; that they don't know what they don't know, but that their reactions are based on their current perceptions. Any dissent among scientists is read as uncertainty (e.g. climate change) and for decision-makers a strong reason to postpone decisions or actions.

Nanotech and the Public

What does the public currently think about nanotechnology? First, most have not heard of it, or if they have heard of it have little direct knowledge of what it means. The word "nano" has been used to advertise some goods, and positioning has been fairly positive to date. At the same time, there is a great fear of "unnatural resources" (a term devised by Saskatchewan ecologist Stan Rowe to describe any material, mix or concentration not normally found in nature). Most of the public is unaware of the lengthy list of current uses, from fabrics to cosmetics to electronics to ………. At the same time, most have not been told the "Grey Goo" fable which could raise the fear factor. There is some opposition emerging such as the call for a moratorium on nanotechnology applications until risks clearly addressed (ETC and others) , and growing interest in the establishment of standards and review procedures. Given the range of applications, this will not be easily satisfied. Like biotech or any major branch of technology, each application will be unique, and there appear to be few limits. Past history shows us that almost any technology can be misused, and mistakes can happen. When it comes to assuring safety and security it will be difficult to reach consensus on how much evidence is "enough".

Communication

Poor communication between specialists and others is an impediment to cooperation on development and implementation of solutions. For many years, my own focus has been on the integration of science and decision-making, having a foot in academia, another in the bureaucracy and my right arm in the private sector. Many of the providers of new technical or behavioural solutions have a reductionist focus; this makes it difficult for many to communicate their results effectively to the public and to decision makers. The jargon itself is a barrier. Little of the scientific language makes it through the process to create a briefing note for an official or a sales flyer for a potential purchaser. And much is often lost in transition. In our work with developing communities we have often created forums where we bring the public the officials the companies and the experts together in a problem identification and solution scoping session involving all stakeholders. The *Guidebook: Indicators of Sustainable Development for Tourism Destinations* (UNWTO 2004) contains both a methodology and results. The use of a focus on identification of key indicators in actual workplaces and communities has proven to be a powerful catalyst for dialogue between all, and a means to bridge gaps in problem identification and problem solving.

How do we get the best information across the institutional gaps?

In most countries our institutions have difficulty establishing creative forums where the decision makers and scientists get to communicate with each other. Even when the science is sponsored by or managed by governments, the lines of vertical communication can be long. The specialist will seldom get to meet the political official or even the person who briefs him or her. Despite this general issue there are some good models. In Scandinavia the interchange of experts from industry, academia, government and special projects, including foreign ones is a normal process, particularly in the environmental area. A senior specialist is expected to have a career path which includes government service, university research and teaching and private sector or integrated project experience. The system helps in orchestrating the exchanges; administrative barriers which impede exchanges in other nations, such as portability of pensions or seniority are not an issue. Integrated working groups can be easily formed to address new issues and the results tend to feed effectively into the policy process.

Another approach which works is applied placements and exchanges (out of the lab and into the fray). Once in a forum on relevance in research which I was moderating, a desk scientist stated that he was a “pure” researcher and none of this meant anything to him. My reply was that in my experience there were no “pure” researchers, only virgin ones. Creating on site problem-solving workshops which bring the lab scientists and the field operators together can be of great benefit to both. When the specialists and those with the empirical problems put their minds together on a real problem, both gain immensely.

The above approach also can lead to forms of distance mentoring and the creation of formal and informal support networks. For several years our Yangtze cleanup project set up a liaison process through our Nanjing office where factory owners with a problem could contact the office and receive support - initially from in-China experts but wherever the solution could benefit from overseas expertise, it was quickly available – usually with a 48 hour turnaround from experts linked to the project. (Sometimes longer when technical factsheets had to be translated). This approach works best if the experts have been in the field and have had some practical experience with the factory or similar ones and understand the context.

Conferences, particularly ones like this one which bring technical and non-technical specialists together to focus on common problems are of great value. Too often single-disciplinary conferences feed a reductionist approach, which can seldom create full solutions to complex problems.

Institutional Barriers

New approaches or technologies often meet regulatory or even legal barriers. As noted earlier, the way in which regulations are cast can be critical: do we ban everything which is not explicitly allowed, or allow everything which is not specifically banned? The precautionary principle remains problematic for many –it can be seen a reason to stop everything until it is proven safe, but what constitutes sufficient proof? And as already noted, some of the public expects zero risk, which is not normally possible under any circumstances. These factors will challenge policy-makers seeking optimal means to deal with risks.

Accountability and Control

Increased focus on accountability (public and private) makes decision-makers in both the private and public sector even more risk- averse than they have been in the past. Besides the public expectation of "zero risk" there is an increased interest in holding managers and officials personally responsible for any adverse outcomes. In one seminar which we held in a high level training program for senior government officials, the head of one ministry asked, "how do we punish those who do not meet their environmental goals?" Class action lawsuits in North America increasingly target not just the firm or government agency but individual managers. This has bred both a demand for iron-clad review procedures and more intensive and extensive monitoring of impacts.

In this context, what is expected of managers of new technologies?

- Taking intelligent risks – working to advance acceptance and adoption of appropriate technologies in support of their mission or mandate but with comprehensive review procedures in place.
- Anticipating impacts – use of independent third party review procedures which are project - specific and which include environmental and social impact assessments
- Preventing unacceptable outcomes – no matter what review and control procedures are in place, accepting responsibility for the actual outcomes - this is where approaches such as cradle-to- grave assessment, regular monitoring procedures, and acceptance of some responsibility for what partners and users may do with the product or process.
- Respecting "limits of acceptable change" - this is a social science concept of what individuals and societies will accept and what is not negotiable. It involves greater work to understand how a new approach or technology will affect the society where it is used, and whether or not it will violate expectations and norms.

The litany of issues of sustainability is also a list of opportunities

Is nanotechnology to be supply driven – based on the evolving discoveries, or is it responsive to what is needed or wanted? R. Buckminster Fuller alleged that "*Humanity is acquiring all the right technology for all the wrong reasons.* " It would be good if we can prove him wrong when it comes to nanotechnology, but how do we keep all the "buckyballs" in the air? While new discoveries will open new possibilities, ultimately realization of the potential will also have to be demand driven: that is – how can the new technology help solve the real problems? In our work to help enterprises and communities achieve more sustainable forms of development, and to reduce the negative environmental impacts of their activities, we have encountered what can be seen as a menu of demands. A key challenge will be to look at the menu of needs – from global to local – and ask how nanotechnology can help. In the remainder of this paper I will review some cases which illustrate a number of challenges from the perspective of implementing sustainable development. From the problems encountered in many nations, it is possible to create a wish list. This is a start and I would encourage all of you to help build the list and to share it. The menu of needs for technological solutions in the delivery of more sustainable solutions is vast. As with nanotechnology, there is great variety –often each demand is unique. Nanotechnology will not have all the answers – but may be a significant part of the solution to many – at a very wide range of scales. What follows are a few of the challenges which have been encountered in my own work on delivery of sustainable solutions where there may to be a role for applications of nanotechnology.

Priority Sustainability Issues

Over the past 20 years my work has involved participatory consultations on sustainable development in more than 40 communities in Africa, Asia, Europe and the Americas. What has become clear is that many problems emerge as common priorities in nearly all cases. While some involve needs to modify human behaviour and improve access to information, most will need improved technologies for resolution.

Most pressing are water supply, energy supply, solid waste management, liquid waste disposal, remediation of toxic sites, protection of health (notably food purity) improvement of air quality; noise reduction (from transportation and industrial processes), protection of fragile systems and endangered species, and provision of suitable health services . Many companies are working on this genre of problems and good practical solutions are eagerly awaited.

If you can't measure it you can't manage it, and many of the challenges lie in provision of improved information to those who make decisions which affect sustainability. How do we get key information into the decision process in real time – when it is needed? One area of need is for better environmental remote sensing, as much of the information critical to issues such as climate change, species health, and biomass is dispersed widely and can be inaccessible. – For example, how do we make remote sensing equipment more durable and longer lasting, particularly those left in place to continuously transmit information such as water quality, radiation airborne contaminants or temperature? Can you drop it from a plane and will it continue to provide information?

How can we get better information on indicator species (many of which are very small)? How can we trace the migration paths? Can we improve monitoring transmitters; make them smaller, more durable, biodegradable, and easily recoverable?

Monitoring Key Indicators

Technology is dominated by two types of people: those who understand what they do not manage, and those who manage what they do not understand. **- Putt's Law (**Archibald Putt (pseud.) (1981). *Putt's Law and the Successful Technocrat: How to Win in the Information Age*. Smithtown, NY: Exposition Press**.** Decision-makers seldom have the key information they need to make good decisions – the right level, at the right time in an understandable form. For this reason, many have tried to develop sets of indicators ideally associated with programs which provide the right information in an understandable form at the right time. Because such indicators are designed to measure what is important, initiatives such as the UN social indicators program (http://unstats.un.org/unsd/Demographic/Products/socind/) , the UN Millennium Goals (http://www.endpoverty2015.org/goals , the EU Sustainable Development Strategy (http://ec.europa.eu/sustainable/welcome/index_en.htm) , or the UNWTO program on Indicators of Sustainable Development for Tourism Destinations with which I have been principal consultant, all contain lists of key issues of sustainability. One could do worse than scan these issues lists and attempt to suggest where nanotechnology could contribute and how.

Selected Issues

Clean water supply

Clean water supply is a universal issue. From the above sources the key indicators: are quantity, purity, and cost. Much of the world lacks sufficient clean water and seeks means to supply it. Water is usually managed locally and desired solutions need to be at a suitable scale, easy to manage, and low maintenance. System integrity and high quality monitoring are critical. Some recent technologies such as irradiation are promising but do not control any contamination entering distribution systems beyond the point of treatment. Can we provide end of system solutions such as individual filtration systems which are inexpensive, reliable and nearly failure proof? What mix of contaminants can they handle? Can we customize them for different sizes of communities and will nanotechnology be able to provide a wider range of durable solutions? Note that water reticulation tends to multiply domestic use levels many fold, and that tourists will consume up to ten times as much water per capita as local residents.

Solar Energy

Many small communities have no accessible energy sources except the sun. For small island communities and many tropical coastal communities solar energy seems to provide the only potential for them to pursue development options. But we are not quite there yet. In 2005 I was part of a team evaluating new proposals for resort development on 13 islands of the Maldives. Each tiny island had no fresh water or terrestrial energy sources and solar appeared to be a good option given the availability of sun most days of the year. But resort operators make their living providing experiences, and none were prepared to deface their resort image by roofing their cottages with solar panels. The means to get them to change, and to stop having to transfer oil regularly across fragile reefs to power generators, and desalinate water will be to make solar panels which look like thatch or roofing tiles. There is potential to harness the need of the resort industry, with its many properties located far away from the grid on islands, in deserts or on mountaintops to help fund solar and water treatment solutions. Coincidentally, the size of desalinization unit which would serve a typical 100-200 room resort is about the same as one to serve the needs of a rural village of 2000. Perhaps the tourism industry can be convinced to fund the initial development which can then become a solution to energy and water problems much more widely. And better storage batteries to ensure power on rainy days would also help make the solar technology more useful where the community does not have sunshine nearly every day.

Energy Efficiency and Design

A recent project for a major international hotelier aimed at reducing greenhouse gas emissions has revealed an interesting barrier to many solutions which would make economic and environmental sense. For heritage buildings (many of the hotels) it is important to maintain many of the architectural characteristics of the building. Where a building has a traditional log façade and/or interior, or is faced in a specific type of tile or stone, it may not be permitted to change the aesthetics. In these cases, a new material is needed – one which visually emulates the traditional material but which provides insulation, and is also ideally durable and affordable. For example, the traditional Chateau Montebello in Canada is one of the world's largest log buildings – with most walls made of huge logs – inside and out. Can nanotechnology be employed to help; can you make an R40 log?

Liquid waste disposal

Worldwide, sewage flows across beaches, into watercourses and aquifers. Most treatment is costly and requires continuous maintenance. Even where there are treatment systems, overflows happen. Can nanotechnology help make treatment systems more effective and fail safe? Can nanotechnology help with improved real time monitoring systems to support managers?

Solid waste management

At a community in Sri Lanka, we asked where the garbage went. The official said "away". We followed the truck a couple of kilometres upriver to where it was dumped into the river, arriving back on the town beach a few hours later. Solid waste is an immense issue for all parts of the world. While there are advances in incineration methods, even so there is great opposition to incinerators from most communities. How do we make them safe? Can we assure the public that when a toxic (for example a few Kg of mercury) is accidentally put in the incinerator that it will shut down without releasing a vapour cloud? Can nanotechnology help in either eliminating the risk (how about real time scanning of all that enters the incinerator) or instantaneously monitoring outputs and creating fast shut-down capability?

Are there other means to digest the normal mix which is domestic waste, and can these be improved? How about recovery and re-use? And how can we alter our behaviour regarding creation of waste? How do we deal with a legacy of unsustainable activities?

The Legacy of Contamination

Most developed and developing nations have extensive areas which have been contaminated by past industrial activities. Reclamation is very costly. While there are a number of new bio-remediation methods for industrial sites and contaminated rivers, for many sites the mix of contaminants creates a toxic soup which defeats most current biotechnologies . New methods are needed to return these lands to productive use. Many such sites are in or near urban centres meaning that there may be a rich market for the land once cleaned, and the risks are also higher due to the populations potentially adversely affected.

There are other important local or firm level issues in sustainable development which are commonly identified in local consultations. These include the following: which may benefit from certain applications of nanotechnology:

- Protection of health (notably food purity)
- Improvement of air quality – indoor and outdoor
- Noise reduction (mainly from transportation and industrial processes),
- Protection of fragile systems and endangered species,
- Provision of suitable health services.

There are also a range of "soft "issues which round out the common wish list for sustainable solutions: These primarily involve human behaviours which lead to unsustainable situations. They include crowding and situations where human activity exceeds natural or design carrying capacities, issues regarding levels of participation in planning and control and governance, and means to alter consumption patterns. With regard to these issues, the potential impact of nanotechnology is less clear although improvements in monitoring devices and communications products could contribute to solutions.

Communication and Problem (opportunity) identification

If a tree falls in a forest and no-one hears it was there a sound? If I have a great technological solution and no-one who needs it has heard about it, does it really exist? Or at least, can we call it a solution? For all of the issues above a key concern is that the potential users of the technologies often do not know enough to understand how to ask for help or even where to go. We have found that environmental audit or risk audit approaches at very local levels can help a factory manager, a hotel owner or a local environmental officer both in providing clarity to their problems and knowledge of the menu of solutions.

Corporate reluctance

When you have them by their wallets, their hearts and minds will soon follow…. For industry decision-makers the economics will always be the core focus. Cost effective technologies which respond to known problems will be the most attractive. Increasingly, major firms are making very public commitment s to environmental and social objectives. While the previously noted concerns with accountability and broad risk reduction may be a barrier to adoption, those who are able to demonstrate that they are good environmental citizens may achieve marketplace advantage. Corporate risk perception can both assist in adoption and be a barrier to it. Where new technologies can advance monitoring capacity or replace more damaging processes the investment and insurance industries may provide incentives to use. But if the new technology is perceived as risky, venture capital and insurance may be hard to obtain. Nanotechnology appears to have nearly unlimited opportunity to design new solutions. It appears to have few limits but also a short track record.

Another issue may be one of property. As with all technologies, it is essentially intellectual capital. When we were discussing with some international firms the possibility of providing baghouse systems to some Asian factories to help control emissions, many were very reluctant. The question was asked – "what if we provide one to China or India – won't they just copy it and make millions of them". The answer is likely yes; there is a strong chance that the techniques will be copied. From a corporate perspective that is a problem, but from a social perspective the rapid proliferation of use of some technologies (such as use of membranes, better air and water pollution cleaning technologies clean coal, safe nuclear, advanced solar etc) does contribute significantly to the global good. The conflict is between global and corporate ethics – fodder for another conference in the future; how to think global and act at the local or firm level. In our work for UNWTO we give away our indicators methodology because we want it to be used. If we sold it commercially, most of the small communities and small to medium sized enterprises that need it most could not afford it.

Positioning scientific and technical advice

"Follow them, see what they eat" - from a friend who works in the New York advertising world.

"For a successful technology, reality must take precedence over public relations. For Nature cannot be fooled". (Richard Feynman, Rogers' Commission Report into the Challenger Crash Appendix F - *Personal Observations on Reliability of Shuttle* (June 1986)*).* The world of public relations can provide some ideas about how to get technological advances accepted and used. But as Feynman notes, the truth is essential. Advertising acts to help people to want something. It often uses association to position a product so it is seen to provide what we think we want. As well, the advertising world can try to create new needs we didn't know we had. Where nanotechnology can truly help to solve environmental or social problems, it can be legitimately positioned as a boon and worth having. To support sustainable development, the capacity to provide cleaner, more efficient, green products is a positive. The common advertising terms "new, improved, powerful, and advanced" also come to mind. But at the same time, any branding also sets a product up for a fall if it does not come through. The current uses of the term Nano in public – small cars, small and powerful electronics, super processors – is a very positive image by association to start with.

Visible Progress

There is growing evidence of progress in addressing many of the issues associated with introduction of nanotechnology. A number of methods can be used to better scope risks. Iterative audits and monitoring of results and impacts will build the empirical data on actual risks and benefits associated with implementation. Like all technologies, a life cycle approach to management will be of great value to all parties. Because of the varied nature of technologies which fall under the rubric of nanotechnologies, and the infinite variety of potential applications a case by case review process will be essential. As with all new technologies, all assumptions will need to be challenged as there is a limited history on which to base any conclusions on real risks. And with respect to many materials and processes this new technology itself may change all assumptions regarding what exists, what is possible, and what can be changed.

The importance of accepted standards in which governments, entrepreneurs and the public can have confidence cannot be overstated. China is now a world leader in development and implementation of standards for nanotechnology. (*D. Liu, Nanotechnology in China: Regulations and Patents,* *Nanotechnology Law & Business, (Winter 2008).* Others are moving to catch up. In my own country, Canada, much work has taken place but final approval of review procedures is still pending. http://www.nanolawreport.com/2009/01/articles/national-nanotechnology-regulation-in-canada/ Globally agreed standards will have to come, such as those which ISO is in the process of developing, because technologies are global. Where a plethora of competing standards exist, (think ecotourism, organic foods, clothing sizes) confusion results. As I have noted earlier, new technologies are global solutions which are applied to normally local problems, even though the cumulative result can be significant at the regional or global scale. The overall challenge of future sustainability lies in reducing the human footprint in many ways - and nanotechnology needs to be a positive building block.

Strategic Wish List for Sustainable Solutions

Which applications are most likely to make a difference? I will end with my own short list of some of the specific areas where, from my experience, new technologically based solutions, possibly employing nanotechnologies are most critical. I encourage others to create their own wish lists, as a means to focus some of the future developments in nanotechnology. Creative dialogue with those who need the solutions will undoubtedly expand this list, and provide a menu of new challenges for those who work with nanotechnologies.

My top ten

- Durable solar collectors which can be used in construction (roofs, walls, parking lots)
- Ambient temperature superconductors for long distance energy transport - link this to solar at a regional scale or to allow efficient load sharing between time zones
- Inexpensive storage media for energy at dwelling or village scale – these need not be light, only inexpensive, reliable and simple to run and maintain
- Simpler filtration systems for water purification and waste management – particularly those capable of filtering complex mixes of contaminants
- Real time remote monitoring systems
- New toxic site and watercourse cleanup methods particularly for mixes of contaminants
- More robust crops which will survive a wider range of water regimes and temperatures– given climate change potential
- Light weight , portable, high capacity energy storage systems for vehicles
- Insect repellents which are medically safe and which will last for 24 hours or more without having to be replaced
- Safer methods to allow foodstuffs to last longer in storage without degradation

Sustainable development is an optimistic concept. It implies that we can develop and effectively use new technologies, that we can alter human behaviours to be more in concert with natural capacities and limits and that we can construct systems of governance which will make this work. It will be important for those involved in the development of nanotechnology to be part of the broader dialogue to make certain than nanotechnology and all its applications contribute optimally to a sustainable future for us all.

May you all enjoy a long, productive and sustainable future.

Selected references:

Electronic references are noted in the body of the paper where first referenced.

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Note that further detail on many of the projects and cases cited in this paper can be found in the Tourisk Inc. website www.tourisk.com and the references and publications noted on that site.

Note: pictures showing most of the case studies noted are contained in the PowerPoint presentation which parallels this paper.

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