

Sustainable Development: The Technology Management Implications and Opportunities

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To the Chief Technology Officer (CTO) and the technology management group in your company, sustainable development may appear to be someone else's challenge. But appearances can be deceiving.

Leading companies are finding that dealing effectively with sustainable development requires significant innovation in technology visioning and execution – because sustainable development is fundamentally new territory. For your company and many others, traditional planning may not pick up the sustainable development issues on the horizon – issues that could significantly affect your business's basic technologies and competitive framework.

The experience of British Petroleum (BP), DuPont, Interface, Monsanto, and others shows that innovative technology management is the common denominator of successful sustainable development initiatives. This puts the onus on the CTO and the technology management team to take the lead in scanning the horizon and developing the appropriate sustainable development vision and action plan for the company. The way things are shaping up, even a „waiting and watching“ sustainable development strategy will require an innovative scanning system to ensure that your company does not get blind-sided by unexpected threats – or miss critical opportunities – in terms of either technology or business. Traditional scanning and planning methods ignore many of the realities of sustainable development, such as the need for discontinuous technology development and the opportunity to recast the business by adding key service delivery technologies to the traditional product offering. The CTO should lead the development of the process and ultimately own the responsibility for monitoring these unconventional opportunities and threats.

In addition to developing a new vision, the CTO and the technology management group will need smarter, faster, better, and cheaper ways of developing innovative sustainable development technology and getting it to market. Traditional technology management approaches are geared toward incremental improvements in established technology arenas. However, sustainable development often requires simultaneous development of both incrementally improved and breakthrough technologies. Incremental improvement provides the basics, such as improved energy efficiency and the reuse of materials in manufacturing. Breakthrough technology innovations provide entirely new ways of meeting customers' needs, such as developing disease-resistant crops to replace traditional chemical sprays. Traditional approaches may be too slow, costly, or limited for this dual innovation requirement.

In addition, sustainable development requires broad interdisciplinary approaches to innovation and technology management, and traditional approaches often bog down in interdisciplinary efforts.

The bottom line is that eventually your company will have to translate the requirements of sustainable development into the rough-and-tumble world of developing products and services and getting them to customers at prices that are competitive. And while this process is essentially familiar, sustainable development creates the opportunity to rewrite the equation by creating significantly different solutions to established customer needs. The companies that address sustainable development most successfully will be those that recognize the potential new solutions and innovate, altering their technology management to fit the new, more demanding external conditions.

In this article, we first take a look at what some leading companies are doing in this area and then offer suggestions about ways that companies can develop new vision and renew their approaches to technology management.

Lessons from Leaders

Make no mistake, technology management will be the common currency of sustainable development. Leaders in science and technology around the world are gearing up to address the interdisciplinary realities of sustainable development and to take the lead position for change. For example, in her Presidential Address to the American Association for the Advancement of Science, Jane Lubchenco stated, „Urgent and unprecedented environmental and social changes challenge scientists to define a new social contract. The new and unmet needs of society include more comprehensive information, understanding, and technologies for society to move toward a more sustainable biosphere – one which is ecologically sound, economically feasible, and socially just.“¹

Around the world, scientists, engineers, and technologists from all disciplines are wrestling with the emerging challenges of sustainable development. In many leading companies, the challenges are dictating new roles and responsibilities for technology managers. The following are some recent examples of leadership at the confluence of sustainable development and technology innovation.

Monsanto. Monsanto, with its long history in the chemicals industry, may seem an unlikely candidate to lead the way toward new technologies for sustainable development. But the company has made a firm commitment to sustainable development and is making some remarkable changes. In seeking growth through sustainability, it is betting that the technical and strategic discontinuity will create significant competitive advantages that few companies will be able to match.

As part of its sustainable development initiative, Monsanto bioengineered the NewLeaf potato to protect itself against the destructive Colorado potato beetle and to resist leaf virus, another common scourge. Traditional potatoes often require massive amounts of insecticides and packaging to achieve the same level of protection and crop yield. By developing a sustainable development technology vision, Monsanto has dramatically changed the traditional business of potato farming and created a new basis for a dominant competitive position in an otherwise unchanging market.

Monsanto has used similar technological visioning and innovation with B.t. Cotton, a genetically reengineered cotton plant. Whereas traditional cotton requires dusting with chemicals to hold the harmful budworm at bay, B.t. Cotton produces its own protective proteins, giving farmers a better and cheaper way to produce cotton – and giving Monsanto new momentum in a highly competitive arena.

Monsanto continues to explore new opportunities in the biotechnology area. It has launched major innovation efforts with universities and labs. It is also buying up assets, such as Cargill's foreign seed unit, and forming joint ventures, e.g., Seminis, to bolster its competitive strength. For Monsanto, the sustainable development technology vision for agriculture is driving new deals and investment in competitive assets.

At the same time, Monsanto is looking beyond innovation in plants and seeds and has rethought the problem of top-soil erosion. It designed Roundup Herbicide to stay where sprayed, limit topsoil erosion, and biodegrade naturally via soil microbes. By building the right information into the product, Monsanto has created a more sustainable and cost-effective approach that farmers prefer over traditional methods. The company has demonstrated again that sustainable development and technology innovation go hand-in-hand.

Not all of Monsanto's businesses are so ripe for sustainable development-related changes, but for the agricultural business, it has become critical to rethink how to provide the best results and to reconsider the technological approaches. For businesses like agriculture that face significant sustainable development opportunities and threats, Monsanto's CEO, Robert B. Shapiro, says, „I am not one of those techno-utopians who just assume that technology is going to take care of everyone. But I don't see an alternative to giving it our best shot.“²

British Petroleum. BP is another company that has rethought its business along sustainable development lines and found some new technologies in its future. A few years ago, BP asked itself some hard questions regarding sustainable development and its historic petroleum-based business. BP noted that the world has moved from solid (e.g., wood, coal) to liquid fuels (i.e., petroleum-related) over the past several hundred years, and that the next fuel transition will be from liquids to gas, as liquids become more expensive and gas remains plentiful and relatively inexpensive. Eventually, BP sees the energy business moving toward renewable energy in order to become sustainable. For BP, the sustainable development vision has identified the need to change from an oil company (with a primary focus on petroleum-related technologies) to an energy company with a portfolio of alternative technologies.

Rest assured, BP has no illusions regarding the importance of oil, especially in the short term. However, on the basis of BP's sustainable development vision, the company has begun the shift from petroleum and natural gas to a broader energy portfolio, including development and commercialization of advanced solar technologies. It is striving to be the first company to make this transition and to become the leader in energy technologies of today and the future.

DuPont. This mega-firm has three business units that have made major changes related to sustainable development. The first, DuPont Agricultural Products, has launched major initiatives in the biotechnology arena (similar to Monsanto) because it sees clear competitive advantage in the new sustainable-development-related technologies. These advantages include replacing traditional high-cost chemical reactors used in the production of polymers and intermediates with biological plants that produce the desired chemicals in their cells.

DuPont's film unit has undergone an even more stunning change. Seven years ago the unit – which produces food packaging, audio tape, and substrates for circuit boards – was in such bad shape that DuPont planned to sell it. Its reversal of this decision was due in large part to a bold sustainable development technology vision and excellent execution. The film business unit developed a regeneration process, Petretec, for polyester (80 percent of its business) that can infinitely regenerate polyester film into virgin-quality product. The process literally „unzips“ the recycled polymer and provides fresh starting materials. This process rejuvenated sales and changed the cost structure of the mature industry. DuPont and others are looking for similar technical approaches for other polymers, such as nylon, in the hopes of working the same sort of magic.

Most recently, DuPont has challenged conventional operating procedures in the car paint arena. Historically, DuPont and Ford had a classic supplier/customer relationship in which they dickered over quality and costs, each trying to optimize its own position. DuPont supplies automobile paints for Ford and wants to maximize sales volume. Ford uses the product to paint its cars and tries to minimize costs and wastes. DuPont rethought the relationship in terms of what would be more sustainable and still provide a good business for DuPont. The answer was for DuPont to provide Ford with not just the product but the entire auto paint service. DuPont and Ford are now working together to produce the best possible paints and painting approaches, to minimize wastes and maximize finished product. DuPont shares in the cost savings to Ford – a business opportunity that was not possible with the traditional „sell the product“ approach.

Interface. This carpet and textile company has 7,300 employees in 26 factories on 4 continents. It produces a million pounds of synthetic carpet and fabric every day, using petroleum products for its raw materials. Driven by the CEO's vision of not using any virgin nylon to stitch its fabrics, the company has reconceived its business and its technologies and is changing the rules of the game in the industry. In effect, Interface is becoming a service provider rather than a product supplier. Interface has stopped selling carpet and has begun to lease carpet and take it back at the end of its life. The company then reuses the carpet, reducing the net use of petroleum products, in the process of changing, Interface has created different relationships with and different ways of thinking about its suppliers and customers, as well as its products and raw materials. Today the company is driving to:

- Eliminate wastes
- Make emissions benign
- Fully close the manufacturing-use-recycle loop by making nylon a truly recyclable material
- Use recycled polyester whenever possible
- Find new raw materials that are not petroleum-based

Many other companies are rethinking their approaches and are launching new technology initiatives. Volvo is striving to solve transportation problems, not just sell cars. „Ultimately,“ says one Volvo executive, „we will be not product suppliers, but solution suppliers who ‘by the way’ sell some products.“

Another Scandinavian leader, Electrolux, has carefully assessed its role in sustainable development and undertaken new technologies in its broad line of consumer appliances. Electrolux reports that not only is it more sustainable as a result, but that products with the best environmental performance accounted for 5 percent of its sales and 8 percent of its 1996 profits. In 1997 these numbers grew to 10 percent of sales and 15 percent of profits. (These products have a 3.5 percentage points higher margin than the average margin.)³

These leading companies have demonstrated the two critical activities required for sustainable development. First, they have assessed their business opportunities with a different approach and created a new vision and technology road map based on fresh insights and out-of-the-box thinking. Second, they have converted the vision via innovations in the technology management process, working in new technology arenas and launching interdisciplinary efforts that were new to their companies and industries.

The companies that have been successful have created new technology management systems that are:

- *Fault tolerant* – use of an imperfect development system that has sufficient room and flexibility to find and use the most robust resources. This overcomes the problem of knowing everything you have to know before you start the development process.
- *Resource rich* – a system that has a wealth of different types of resources that have a high degree of connectivity and interact to provide strong ideas and powerful results.
- *Learning oriented regarding the new business and technology interactions* – a process that forces technology and business folks to deal with the sustainable development threats and opportunities as integrated business/technology deals, not as separate business or technology entities. This is important because sustainable development opportunities do not closely resemble traditional approaches, and business managers and product/service developers need new models that simultaneously capture the opportunities and risk.

Traditional approaches do not provide enough of those ingredients – fault tolerance, richness of resources, and learning – to be successful in seizing sustainable development opportunities.

Developing a New Vision

The first step is understanding what sustainable development could mean to your company (or your competitors) in terms of the technologies you use to meet your customers' needs. This requires new approaches and out-of-the-box thinking. DuPont's and Monsanto's shift to biotechnology in their agriculture businesses was not based

on conventional thinking. In fact, one could argue that their competitive advantage in the agrobiotechnology business is based as much on their innovative way of approaching the issues as on their innovative technology. For them the question was, „What is the best way to meet the customers’ needs in a sustainable fashion?“ not „How do we improve our products?“ They threw aside what they had learned about giving customers what they traditionally want. Instead they probed their understanding of the root causes of the customers’ needs and the emerging technologies that could be harnessed to meet those needs. The mental models and planning systems that worked so well in meeting traditional needs in the traditional manner would have been too hidebound to create the biotechnologies that meet the fundamentally different business requirements of sustainable development.

If you have been successful at a given business, your team has probably developed strong mindsets and biases that will initially limit its assessment of sustainable development. Initial responses to sustainable development on the part of both technologists and others will range from „Sustainable development won’t affect our business one iota“ at one extreme to „This is urgent; we must act now to overhaul our business“ at the other. These reactions are not much use in making business decisions, because they are short on insight and facts.

Discussing sustainable development brings out strong emotions but little innovation if left unchanneled. Creating an innovative vision requires a structured approach. While each business is different, and there is no off-the-shelf formula that will yield the perfect assessment for your company, you don’t have to start from scratch. We recommend that the assessment and visioning process include the following elements:

- *New decisions* – try to push your decision-making to the „no trespassing“ zones that have previously been (explicitly and implicitly) declared out of bounds.
- *New people and voices* – introduce fresh, relevant material into thinking and planning to stimulate innovation and out-of-the-box thinking.
- *New conversations* – incorporate cross-fertilization and inquiry that cuts across traditional operational boundaries to provide crucial understanding.
- *New excitement* – use shared vision to help participants get genuinely excited about sustainable development; excitement fuels inquiry and the pursuit of new technology and business deals.
- *New perspectives* – seek fresh views of existing and potential business opportunities that promote out-of-the-box thinking and honest assessment.
- *New prototypes* – use trial-and-error experimentation with prototypes and models to stimulate valuable learning, especially in pursuit of breakthrough technologies or new business approaches.
- *New knowledge networks* – establish linkages among thought leaders to provide a flow of knowledge and insight that goes well beyond the one-shot planning meeting.⁴

The new vision will emerge over time, rather than be created in a single flash of insight. Once the company has identified threats and opportunities and their timing and has developed a vision, it must create the necessary technologies. This brings us to the second element of sustainable development innovation: an innovative technology management process.

Renewing Technology Management

The experience of leading companies demonstrates that sustainable development initiatives usually require technology expertise from new arenas, as well as new levels of interdisciplinary collaboration. Think of DuPont or Monsanto forging into biotechnology from their historic chemicals technology platform. Achieving these new levels of expertise and collaboration with available resources can be challenging. Usually, the companies’ R&D staffs are already stretched too thin. In addition, product development cycles today are being compressed to the breaking point. Finally, there may already be a lot of products in the technology development pipeline and no room for more to be added. All these factors spell trouble for the CTO and the technology management team that try to tackle sustainable development innovation in the traditional manner with existing systems.

Traditional technology management approaches and current resources may not provide sufficient technology „bandwidth“ (a term commonly used in Silicon Valley companies to describe the breadth of performance capability of a technology, system, person, or organization) or interdisciplinary capabilities to fully realize the vision (e.g., a breakthrough technology). For example, DuPont’s and Monsanto’s moves into sustainable development agriculture required significant new capabilities in bioengineering that had to be merged with existing technology and scientific know-how to achieve breakthrough products.

To understand how to overcome this dilemma, you only have to look at some of the leaders in sustainable development and some of the fastest-growing and most innovative companies (e.g., Boeing, Cisco, Microsoft). These companies are getting more yield out of existing technical resources, speeding product development, and

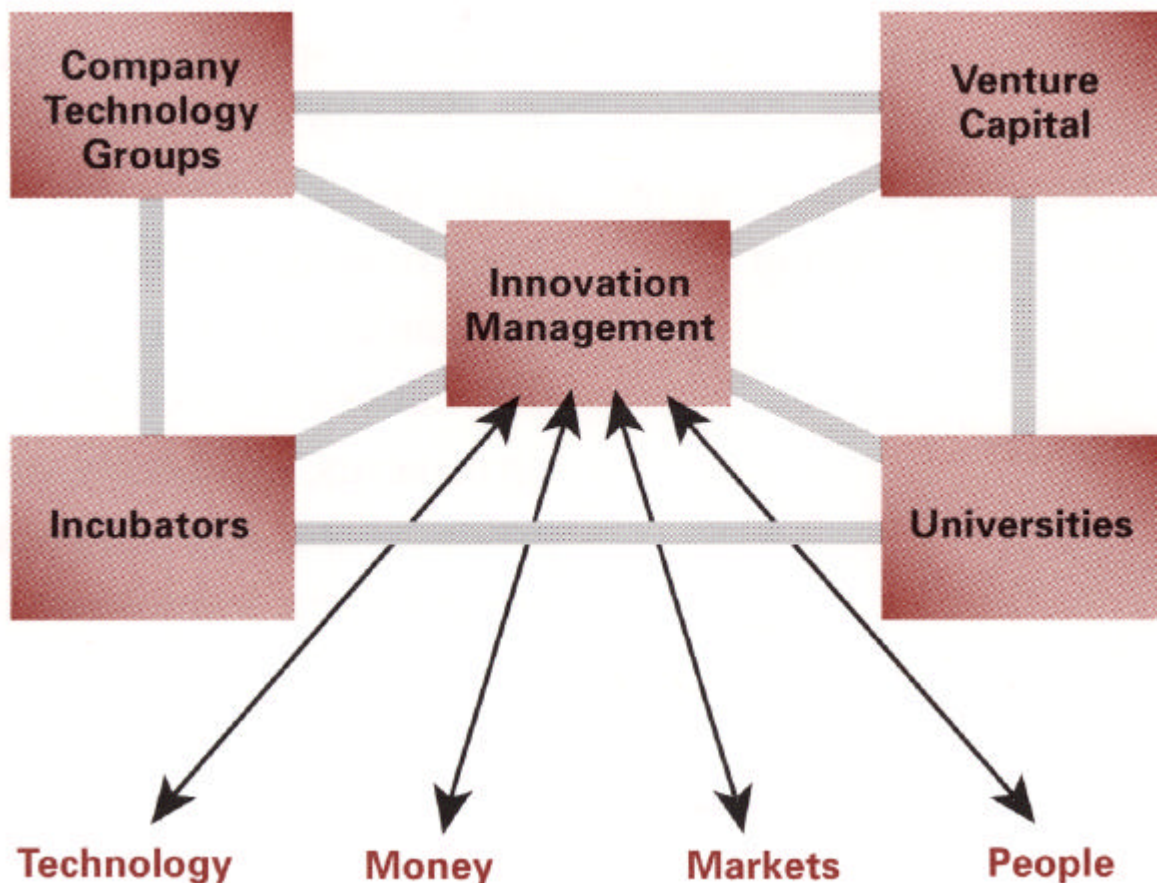
harnessing new resources to address new areas of concern to their industries and their companies' competitive advantage. They have harnessed external resources to form broad-bandwidth innovation (BBI) networks (Exhibit 1). These BBI networks leverage resources via partnerships, license agreements, and equity venturing to systematically develop products and innovate outside their internal technology management framework and resource base.

The BBI networks include some nontraditional players:

- *Incubators* – small, inexpensive breeding grounds for start-up companies that provide new technologies and business approaches. They operate independently and provide continuous streams of new ideas and technologies.
- *Universities* – university-based R&D centers provide excellent intellectual capital.
- *Internal technology management at other companies* – other companies can provide allied R&D, marketing, and other innovation resources that work with the BBI network in selected areas to capture value, direct programs, and cross-fertilize.
- *Venture capital* – technology innovation also requires dealmakers that look far and wide (inside and outside the formal BBI) and that can pull together the best deals. Equity partnerships are an excellent way to gain access to technology without applying internal resources.

Exhibit 1

Broad-Bandwidth Innovation Networks



Typically the BBI relationship is focused on agreements in narrowly defined areas. They provide low-cost, high-yield innovation as well as valuable personnel that can be seconded to manage technology development and spearhead new projects and ventures.

Participation in BBIs gives companies a range of valuable benefits beyond the obvious expansion of resources. As they shift from traditional practices of managing R&D internal projects to managing technology deals that develop and flow from the network, their new focus on „deal flow“ provides several important innovation assets:

- A focus on the business opportunities related to technology improvements, not just the technology per se
- Increased technical and scientific capabilities, far beyond each participant's internal resource pool, and the ability to cross-fertilize thinking from the various parts of the network
- Better understanding of the market and customer needs, based on additional inputs from the BBI network and the use of prototypes, experiments, and models
- Greater risk sharing and significantly improved access to investment funds during all stages of innovation, development, and commercialization
- A significantly increased technology deal flow without the cost and bureaucracies associated with traditional internal development; this translates into more technology innovation with less cost and more speed than traditional approaches

To achieve low-cost, high-volume technology development and deal flow through a BBI requires the use of dynamic models or prototypes. The prototypes provide a simulation of the emerging new technology and provide the link for the BBI network participants who are often spread out over wide areas and unable to meet in the same room on a regular basis. While prototypes are not new, their use in the multi-user, dynamic test-and-revise world of BBI networks has transformed them into something different from their predecessors. The prototypes add the new dimension of a dynamic but shared vision among the network participants in the innovation process. For example, Boeing radically improved its development of the 777 aircraft using an electronic prototype that allowed suppliers, multiple engineering project teams, and customers to work concurrently on integrating and improving the design. This resulted in significant innovation and improvement and dramatically reduced commercialization times.

Application of BBIs is not limited to sustainable development initiatives of course. Current BBI users, in addition to those mentioned above, include Cisco Systems, Motorola, and Thermo Electron (see description of Multi-Modal Innovation in „Innovation in the Fast Lane,“ *Prism*, third quarter 1998). These companies have proved that interdisciplinary, breakthrough technology innovation can be accomplished with fewer internal resources, less cost, and less time via the BBI.

Conclusions

By reassessing their businesses in the light of the opportunities and threats of sustainable development, BP, DuPont, Interface, Monsanto, and others have arrived at valuable new strategic visions, leading to the development of new technologies and business approaches, new competitive advantages, and, sometimes, new rules of the game in their industries.

Envisioning and developing the discontinuous technologies for sustainable development is not easy. The key to success for sustainable development is innovative technology management based on fresh perspectives, out-of-the-box thinking to spur innovation, and an innovative technology management approach, BBI, that leverages internal and external resources and fosters breakthrough product development.

¹ *Science*, volume 279, January 23, 1998, pp. 491-497.

² Joan Magretta, „Growth Through Global Sustainability: An Interview with Monsanto 's CEO, Robert B. Shapiro,“ *Harvard Business Review*, January-February 1997.

³ *Electrolux Environmental Report*, 1997.

⁴ Gary Hamel, „Strategy Innovation and the Quest for Value,“ *Sloan Management Review*, Winter 1998.

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