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The Path to Sustainability-Driven Innovation

Environmental sustainability can be the foundation for increasing competitive advantage and the basis for effective innovation.

Phil Metz, Susan Burek, Tawnya R. Hultgren, Sam Kogan, and Lawrence Schwartz

OVERVIEW: Many companies see environmental sustainability as a cost—a legal and social obligation requiring investments that may never be recovered—rather than as an opportunity. However, environmental sustainability can be the foundation for increasing competitive advantage and creating business value, and it can be the basis for effective innovation. This is sustainability-driven innovation, an innovation approach that leverages environmental sustainability to drive superior business results. A study of leaders in sustainability-driven innovation suggests some best practices: inculcate a sustainability mindset, set high standards for sustainability performance, deliberately search for sustainability-based opportunities.

KEYWORDS: Environmental, sustainability, Sustainability-driven innovation, IRI Research

As consumer and regulatory pressures in support of "greener" products and practices grow, businesses are increasingly finding that environmental sustainability is a necessary consideration in their innovation processes. In this context, many companies view environmental sustainability as a cost—a legal and social obligation requiring investments that may never be recovered. However, the drive toward environmental sustainability can represent much more than a necessary cost—innovation that incorporates sustainability as a core element can offer opportunities to increase competitive advantage, create business value, and build stronger customer relationships. This is sustainability-driven innovation.

Sustainability-driven innovation may be defined as innovation that leverages environmental sustainability to drive superior business results through more effective innovation. It can include innovation to develop new products or services, new businesses and business models, or new processes.[1] A few companies are already capturing significant value by systematically pursuing the opportunities that environmental sustainability can create, as a 2011 McKinsey study shows (Bonini and Görner 2011). The Sustainability-Driven Innovation IRI Research working group, chartered in February

[1]While we recognize the importance of the triple-bottom-line triad of "people, profits, and planet" in a comprehensive approach to sustainability, the work reported here focuses exclusively on environmental sustainability.

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ROR Profile

Sustainability-Driven Innovation

Targeting environmental sustainability to drive superior business results through more effective innovation.

Goal: To identify best practices among companies that have excelled at integrating sustainability into product development to create innovation success and business growth by creating superior products or processes, carving out new product spaces to beat competitors, or successfully entering new markets.

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2013, sought to understand how these companies are building innovation success by leveraging a focus on sustainability.

Working from the hypothesis that companies adopting sustainability as a mindset—rather than treating it as a cost—saw valuable gains in both sustainability performance and innovation success, the group pursued its work in three ways: through a review of the existing research on sustainability and innovation; through a set of case studies of leaders in sustainability-driven innovation, each focused on a specific major initiative in which environmental sustainability was employed to drive more effective innovation; and through a survey of IRI member companies to examine the role of environmental sustainability in driving innovation goals, practices, and challenges at typical companies.

The Literature on Sustainability and Innovation

Our understanding of the relationship between business success and environmental sustainability emerges from Stuart Hart's (1995) theory of competitive advantage. Hart proposed replacing the then-prevailing resource-based view of competitiveness, which saw a firm's competitive advantage as based on its internal capabilities and resources, with a natural resource–based view. Working from his belief that "strategy and competitive advantage in the coming years will be rooted in capabilities that facilitate environmentally sustainable economic activity" (p. 991), Hart argued that competitive advantage is based on a firm's relationship to the natural environment along three vectors: pollution reduction, product stewardship, and sustainable development. In doing so, he flipped the perception of natural resource management and sustainability, suggesting that businesses should see them not as constraints and problems to be overcome but as potential sources of advantage and business opportunity.

A 2005 study by Arthur D. Little extended this discussion to innovation, coining the term *sustainability-driven innovation*, defined as "the creation of new market space, products & services or processes driven by social, environmental or sustainability issues" (Keeble et al. 2005, p. 3; see also Baue 2005). For the Arthur D. Little team, sustainable innovation is a process in which considerations of environmental, social, and financial sustainability—the triple bottom line—are integrated into the innovation process from idea generation to commercialization. In a survey of 40 companies around the world, the study found that 95 percent of respondents felt that sustainability-driven innovation had the potential to bring business value but that benefits were still intangible and the barriers to success were significant. The study also found that a small minority of leading companies had successfully integrated sustainability into both their business strategies and their product and process designs and were exploring breakthrough sustainability-based opportunities. In other words, although many companies agreed that sustainability could have major business impacts, only a few had figured out how to access those opportunities.

Subsequent researchers have affirmed that sustainability can have a major effect on both innovation and business success. For example, Bos-Brouweers (2010) postulated that many sustainable innovations are incremental, directed at improving technological processes and reducing the costs of production, but she also found cases in which sustainability-driven innovation created value through the development of new-to-market products. Business leaders are recognizing the potential. Accenture (2012), in a survey of 250 top executives, found that 78 percent of respondents viewed sustainability—defined to include economic, social, and environmental impacts—as vital to future growth, not just in areas sensitive to environmental issues but also as a key driver of future revenue. While this was most true for emerging market executives (91 percent of respondents from emerging markets agreed versus 78 percent of all participants), it was very important in traditional markets as well. Likewise, an executive survey by Kiron, Kruschwitz, Reeves, and Goh (2013) found that companies increasingly viewed sustainability as both a business necessity and an opportunity.

Accessing that opportunity, though, requires organizational and business model realignments. A number of studies have found that the companies most successful at sustainability-driven innovation have implemented substantive organizational and business model changes in order to make sustainability a business driver (Nidumolu, Prahalad, and Rangaswami 2009; Haanaes et al. 2011; Albino, Balice, and Dangelico 2009; Kiron et al. 2013; Wandiga 2014). Comparing the results of MIT and Boston Consulting Group's 2010 and 2011 global surveys of over 2,600 executives, managers, and thought leaders, Kiron et al. (2013) found that of the 37 percent of participating companies that reported undertaking profitable sustainability initiatives, 59 percent had changed three or four elements of their business model by focusing on "target segments" and "value chain processes."

Sustainability-driven innovation offers opportunities to capture significant value, but each company's path to capturing that value is unique.

The literature also suggests that the ability of sustainability to positively affect innovation draws on a powerful innovation lever: efficiency. To realize the opportunity offered by sustainability, successful companies focus on increasing efficiency by reducing consumption of nonrenewable resources (Nidumolu, Prahalad, and Rangaswami 2009) or focus on environmental sustainability to reduce waste (Kiron et al. 2013). However, in spite of a number of academic studies and examples of increased efficiency by companies that have adopted sustainability as a business practice, sustainability is still believed by many to be an additional cost that will not deliver financial results (Nidumolu, Prahalad, and Rangaswami 2009).

Situations analogous to the advent of sustainability-driven innovation have arisen in the past. For example, many companies viewed the implementation of safety regulations in the 1960s (US Congress, Office of Technology Assessment 1995) and quality standards in the 1970s (Corbett et al. 2002) as costs. As a result, they were slow to recognize that these new rules and regulations offered opportunities to gain competitive advantage. The results, we now know, were quite different: data show that companies that embraced the safety and quality challenges early found new sources of revenue, improved operating economics, and achieved overall better business results. These seeming costs, it turned out, were actually untapped operating efficiencies and opportunities to create new business and new value.

The key takeaway is this: sustainability-driven innovation offers opportunities to capture significant value, but each company's path to capturing that value is unique (Bonini and Görner 2011). Building on this foundation, the research group identified specific examples of companies that have captured value in this way and conducted in-depth case studies to investigate how these companies leveraged sustainability for innovation and business success: What did they accomplish? What practices, organizational changes, and new business models did they employ to leverage sustainability for competitive advantage? And especially, what can typical companies learn from the experiences of these leaders?

Leading the Way in Sustainability-Driven Innovation: Case Studies

To explore these principles in action, we conducted in-depth studies of six successful sustainability-driven innovation initiatives; cases were identified through literature search, networking polling of participants at group sessions, and conversations with sustainability experts. We defined successful initiatives as those that represented an improvement of 20 percent or more in both sustainability and key product, process, or business performance measures (such as margin improvement, cost reduction, product functionality, or new business creation). Each initiative we examined represented a specific major product or process development effort.

We collected case data by conducting interviews with key participants in each initiative, with questions based on a structured interview guide. The questions asked about the initiative's focus and objectives and the innovation and business results actually achieved, the sustainability capabilities utilized in realizing the initiative, and the functions and individuals involved in the initiative. For each case, we determined the degree of satisfaction with the business and innovation outcomes the initiative achieved, as reported by interviewees, as well as the challenges and barriers the initiative encountered. Beyond case specifics, we also asked about a range of company-wide practices and attitudes related to sustainability-driven innovation, including the role of sustainability at each company; the top challenges to sustainability innovation that each company faced; and the scope, organization, and measurement of sustainability innovation in the company. The interviews were summarized and analyzed by each interview team (one notetaker and one interviewer) and examined by the group as a whole and by IRI members who participated in our sessions. Where it was available, we also reviewed public company financial and product information.

The six cases come from a spectrum of companies, from startup to midsize to giant, in multiple industries, including chemicals, manufacturing, consumer products, and services (Table 1). Each of the initiatives represented a major technical effort for the company involved, requiring extensive R&D effort and organizational realignment, and each resulted in a significant innovation achievement—a substantially new commercial product or service that delivered significantly improved performance and environmental sustainability over existing options, as well as major economic value. In several cases, the innovation that resulted from the initiative we studied formed the foundation for future product generations.

The initiatives captured in the case studies shared a number of objectives, processes, and organizational approaches (Table 2). In each of the six cases, the company had set company-wide sustainability goals and established strong top management commitment to sustainability. Most (5 of 6) set explicit objectives for developing sustainable products and deliberately searched for sustainability-based opportunities. All implemented new innovation practices such as green chemistry (the development of safer, nontoxic chemical products and processes) and, in most cases, open innovation, and sought contact with

TABLE 1. Leading cases

Company	Co. Size/Type	Goal	Results
Consumer Co.	$10 billion+ public company	More sustainable fabric softener with improved cost/performance	25 % + increased sustainability profile, significantly lower cost, 30% increased performance vs. existing products
Large Mfg. Co.	$10 billion+ public company	More sustainable product coating	Greener coating that met performance requirements at equal or lower cost
Material Co.	$1 billion public company	More sustainable, high-efficiency solvent-based recycling process for printed wiring boards	99 % + efficient process (vs. 70% for conventional smelting) with no toxic effluents
Large Chemical 1	$10 billion public company	Bio-based chemicals	Cost-competitive bio-based eco nylon and cellulosic ethanol
Large Chemical 2	$10 billion public company	More sustainable Bisphenol A (BPA)–free polyesters as alternative to polycarbonate	BPA-free polyesters with superior clarity, chemical resistance, and durability vs. polycarbonate
Small Chemical Co.	Private venture-backed startup	Profitable sustainable chemicals business	First to market with a bio-based material that is more sustainable and less costly than existing oil-based product; knowledge base for next-generation bio-based materials; successful IPO

TABLE 2. Objectives priorities, practices, and outcomes for case initiatives

	Consumer	Large Mfg.	Material	Large Chemical 1	Large Chemical 2	Small Chemical
Objectives, Priorities, Strategies						
Explicit objective for sustainable products	✓		✓	✓	✓	✓
Deliberate search for sustainability opportunities	✓		✓	✓	✓	✓
Customer-driven need		✓	✓		✓	✓
Company-wide sustainability goals, scorecard	✓	✓	✓	✓	✓	✓
Top management commitment	✓	✓	✓	✓	✓	✓
Innovation Process						
Introduction of open innovation and partnering			✓	✓	✓	✓
Emphasis on internal visibility and awards	✓	✓	✓		✓	
Implementation of green chemistry	✓	✓	✓	✓	✓	✓
Intensive communications with customers	✓	✓	✓		✓	✓
Organization and Resources						
Major technical effort	✓		✓	✓	✓	✓
Skunkworks		✓	✓			
External partnerships				✓	✓	✓
Outcomes						
Major product performance impact	✓	✓	✓	✓	✓	✓
Major product cost impact	✓		✓		✓	✓

customers to identify needs. Case companies also pursued organizational strategies, such as creating skunkworks-type units and engaging in external partnerships specifically to support sustainability-driven innovation.

The leaders we studied all reported very strong success with sustainability-driven innovation efforts. All six case companies reported that their initiatives delivered major product performance impact and most reported a major product cost impact. In several cases, the innovation that resulted also formed the foundation for future product generations.

Sustainability-Driven Innovation in the Mainstream: The Survey

The case studies gave us a good understanding of how leaders are integrating sustainability into their innovation approaches and processes. To understand how more mainstream companies were faring with sustainability and innovation, the group conducted an in-depth survey of a sample of industrial companies drawn from IRI's membership.

The survey consisted of 21 multipart multiple-choice questions that asked about top management commitment

TABLE 3. Survey respondent demographics

Characteristic	Respondents (%)
Respondent role	
CEO or CTO	13
VP-level	36
Director, manager, or individual contributor	52
Industry	
Chemicals & materials	27
Consumer products	27
Industrial products, equipment, & machinery	13
Automotive & transportation	7
Construction	7
Services	7
Electronics	3
Other	9
Company size	
<$1 billion	13
$1 billion–$50 billion	77
>$50 billion	10

to sustainability and to goals and strategy for sustainability-driven innovation, as well as processes, organization, resources, metrics, and incentives around sustainability-driven innovation. We also asked about drivers of sustainability efforts and barriers to delivering results. Additional items captured company demographics. The survey, which was administered online between October 2013 and August 2014, yielded 35 complete responses from a broad range of roles, company types, and industries (Table 3).

By and large, we found that sustainability-driven innovation has not yet reached the mainstream. Responses to an item asking respondents to rate specific sustainability objectives on a scale of 1 (not important at all) to 5 (extremely important) showed that most companies have not yet focused their sustainability efforts on driving innovation success. Rather, a large proportion of participants were focused on compliance with laws and regulations (62 percent), cost reduction (46 percent), and achieving internal performance goals (37 percent) (Table 4). Some innovation-related sustainability goals were designated as "extremely important" by a solid minority of respondents—"Achieve competitive advantage" was seen as important by 49 percent and "Engage with customers to help them address their sustainability issues" by 37 percent. But more radical innovation goals attracted "extremely important" or "important" responses from a much smaller subset of respondents: "Enter new markets or engage with new customers" was seen as important by 26 percent, and "Use sustainability to enhance innovation success"—the core of sustainability-driven innovation—by only 20 percent.

We also asked respondents to identify from a list those sustainability-related business outcomes they saw as most important, using the same five-point scale. We then asked respondents to rate their satisfaction with their organization's performance against that same list, with 1 = "not satisfied at all" and 5 = "extremely satisfied."

We identified as top gaps those business outcomes that a majority of respondents rated as important (4 or 5) for which fewer than 50 percent rated their satisfaction with company performance in that domain as 4 or 5. Using this approach, the top four gaps (outcomes with high importance ratings and low satisfaction ratings) all concerned innovation outcomes:

- Obtaining competitive advantage and differentiation vs. competitors
- Using the sustainability of our products (services) to reach new customers or markets
- Obtaining higher prices and margins
- Getting products (services) to market faster

By contrast, respondents reported relatively high satisfaction with other high-importance outcomes, including:

- Complying with regulatory requirements
- Satisfying customers
- Cutting costs (energy, transportation, packaging, etc.)
- Improving corporate image and brand
- Appearing as innovators

Clearly, achieving innovation outcomes through sustainability remains a challenge for many companies, even those who are thinking about sustainability in those terms.

The survey also asked respondents to identify top barriers to delivering sustainability innovation results (Table 5). Short-term financial pressure was by far the most commonly cited barrier; other key limitations included lack of resources, lack of accountability for results, and other challenges relating to demand, strategy, incentives, and know-how.

Our survey results show that the mainstream of industrial companies has not yet achieved sustainability-driven innovation success. Although sustainability-driven innovation is recognized as important by a solid minority, achieving sustainability-related

TABLE 4. Survey results: Importance of specific sustainability objectives

Objective	Respondents Ranking Goal "Extremely Important"
Reduce incidence of noncompliance with environmental laws.	62%
Achieve competitive advantage.	49%
Reduce costs.	46%
Engage with customers to help them address their sustainability issues.	37%
Achieve internal sustainable performance goals.	37%
Improve brand and image.	31%
Enter new markets or engage with new customers.	26%
Increase corporate sustainability ranking.	24%
Use sustainability to enhance innovation success.	20%

TABLE 5. Survey results: Barriers to delivering sustainability-driven innovation results

Business Challenge	Respondents Rating Challenge "Important" or "Extremely Important"
Short-term financial pressure	50%
Lack of resources to deliver sustainable innovation results	25%
Lack of accountability to deliver sustainable innovation results	21%
Lack of customer demand/drive	17%
Lack of incentives tied to sustainable innovation results	17%
Lack of a systematic strategy and process that link business objectives to sustainable innovation results	17%
Lack of training, education, and know-how in sustainable innovation	14%

innovation outcomes remains a challenge even for these companies. The top barriers are short-term financial pressure and lack of resources and accountability to deliver results.

Comparing the Leaders to the Rest

The case examples demonstrate the value of effective sustainability-driven innovation. Yet our IRI member survey shows that it is not being implemented effectively at a majority of industrial companies. How, then, do the practices of the leaders, as exemplified by our six cases, differ from those of the survey participants? We identified three key differences between the leaders in our case studies and the typical companies we surveyed:

1. **Focus.** The sustainability-driven innovation leaders we examined in our case studies focused their sustainability efforts on innovation success and competitive advantage; five of the six companies conducted major sustainability-based technical efforts, and six of six achieved major breakthroughs in both sustainability and product performance. Survey participants, by contrast, typically focused sustainability efforts on regulatory compliance, brand and image, and internal performance goals—even though a large proportion (49 percent) recognized achieving competitive advantage (an innovation-focused function) as an "extremely important" goal for sustainability efforts.
2. **Accountability.** The leaders also provided an environment characterized by the accountability needed to nurture sustainability-driven innovation efforts. These companies implemented company-wide sustainability goals and scorecards (six of six), defined explicit objectives for sustainable products (five of six), and expressed explicit top-management commitment to sustainability-driven innovation (six of six). For our survey participants, by contrast, sustainability innovation was typically not named as a top three objective for top management.
3. **Commitment.** Likewise, leaders in sustainability-driven innovation make the investments needed to achieve innovation success—six of six set company-wide sustainability goals and had clearly expressed top management commitment for these. More typical companies lack top management commitment to sustainability innovation. Consequently, short-term financial pressure, lack of resources, and lack of incentives to deliver sustainability innovation results become barriers for those companies.

These differences are expressed in a number of practices and approaches that drive the development of sustainability-driven innovation competencies.

1. *Develop a sustainability mindset, driven by management commitment and captured by clear, quantitative objectives.* The case data supports the idea that a sustainability mindset, driven by a management commitment to sustainability results, is important for delivering sustainability-driven innovation success. Most of the case companies (five out of six) began with an explicit objective, openly supported by management, to develop sustainable products and a deliberate search for sustainability-based opportunities. All six cases reported having company-wide, quantitative sustainability goals with progress captured on scorecards.
2. *Support the sustainability initiative with appropriate organizational structures.* The structure of the initiative and its leadership can both signal management commitment and ensure the work receives the attention and resources it needs. In the larger enterprises we studied, while company-wide sustainability goals provided the impetus for action, specific responsibility for leading the initiative and delivering business results was assigned to business units. In a few cases, innovation was led by a mid-level manager. For example, at Material Co., the development of a recycling process for solvent-based printed wiring boards was led initially by a director-level manager who had a strong commitment to sustainability via a skunkworks-type unit supported by the CTO. Only when the process achieved success at the pilot scale was it moved to a business unit for commercialization.
3. *Sustainability-driven innovation can support a range of competitive strategies across diverse business environments, not just those based on sustainability itself.* In fact, in most of our cases (four of six), the initiatives were driven primarily by commercial self-interest and not by customer demand for increased environmental sustainability. For example, the solvent-based recycling system for printed wiring boards developed by Material Co. supports an

optimization strategy in a highly cost-driven business environment: vendors have adopted Material Co.'s process not only because it is more environmentally sustainable but primarily because it offers the potential for far higher metal recovery rates—and hence better economics—than traditional smelting. Consumer Co.'s fabric softener was part of a company-wide drive to increase sustainability, but the business unit–level innovation work that went into the product resulted in a fabric softener that offered both 30 percent increased performance and lower cost, as well as sustainability improvements. And both Small Chemical Co. and Large Chemical 1 have developed bio-based products that compete with existing offerings based on cost.

4. *Integrate sustainability-based practices into existing innovation practices.* Investment in and implementation of sustainability-derived innovation practices—approaches to innovation, such as green chemistry or biomimicry, that owe their origins to the environmental sustainability mindset—and integration of those practices into existing innovation processes were found in most of the cases we studied, along with new innovation ecosystem practices, such as open innovation and partnering. Open innovation was also a factor in four of the six cases; even the largest firms rarely have all of the capabilities required for innovation success at this level (see "Leaders in Sustainability-Driven Innovation: The Role of Open Innovation," p. 55).

Thus our cases exhibit a pattern of behavior representing organizational commitment to sustainability and sustainability-driven innovation: company-wide sustainability goals and metrics, supported by strong top management commitment, driving a deliberate search for sustainability-centered opportunities and explicit objectives for sustainable products. These efforts are manifested in major technical efforts that harness sustainability-based innovation approaches, such as green chemistry, and result in major new commercial products or processes.

Implementing Sustainability-Driven Innovation—a Leadership Model

The patterns revealed in our analysis suggest an approach other companies can take to develop a solid foundation in sustainability-driven innovation (Figure 1). That approach begins with self-assessment, to establish where you are in engaging with sustainability-driven innovation, then moves through identifying opportunities to develop expertise, considering strategic options and identifying relevant business objectives, and building needed capabilities.

Calibrate where you are. A good starting point for a company to implement sustainability-driven innovation is to understand its current level of environmental sustainability. All six of the leading companies we investigated began by establishing company-wide sustainability goals and defining metrics to assess their performance against those goals. Benchmarking current sustainability performance, perhaps by using a tool such as the Sustainability Maturity Model (see "The Sustainability Maturity Model," on p. 56), creates a basis for assessing progress later. Consistent with the practices of the leaders we studied, such a benchmarking exercise offers an opportunity to take stock and identify gaps.

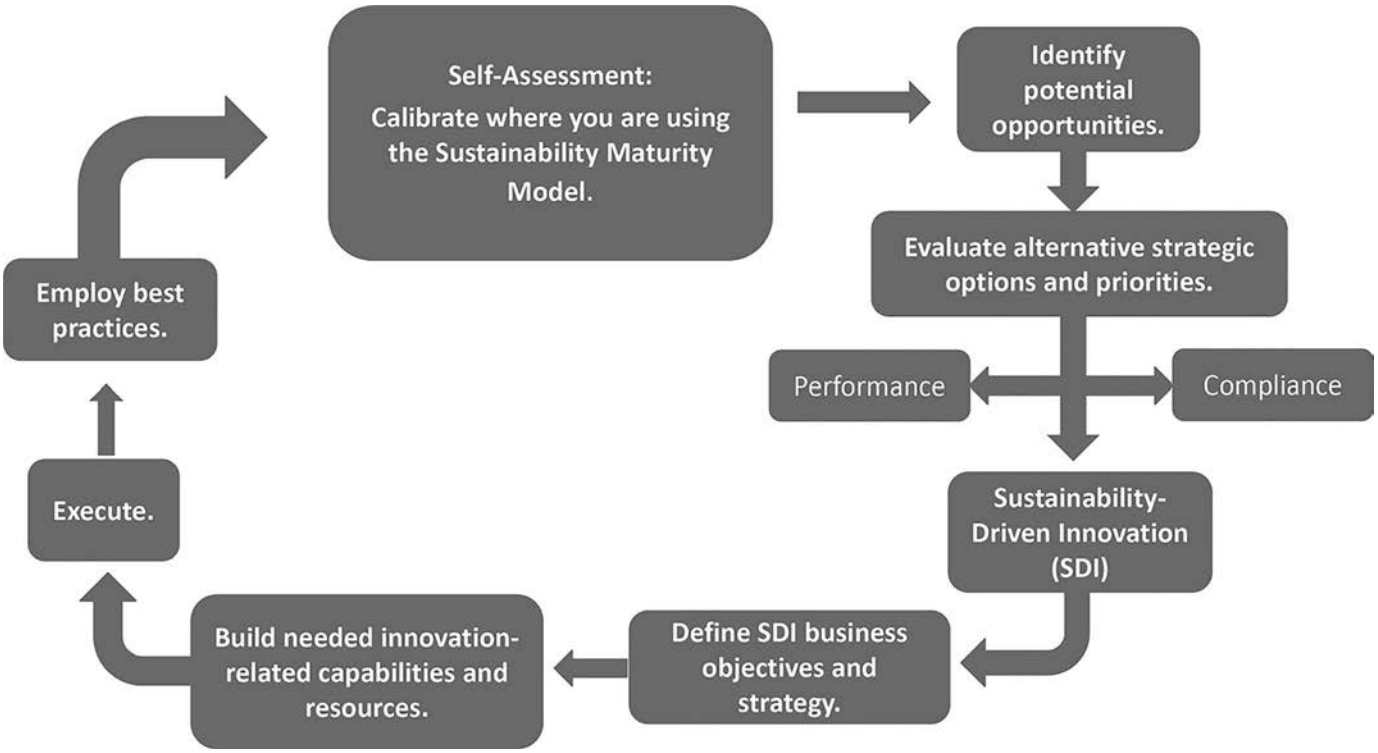


FIGURE 1. The sustainability-driven innovation implementation model

Leaders in Sustainability-Driven Innovation: The Role of Open Innovation

Two companies, Large Chemical 1 and Material Co., saw particularly striking success from the combination of open innovation and sustainability-driven innovation; each leveraged external partnerships to deliver expertise or market access they did not have. The results are more striking because the two companies are very different (one a $10 billion Europe-based global giant, and the other a US-based mid-size company valued at around $1 billion), and they undertook very different initiatives in very different markets (new chemical products vs. an electronics recycling process).

Large Chemical 1: Cellulosic Ethanol from Corn Stalks

DSM, identified in our study as Large Chemical 1, is a large, global, science-based company, headquartered in Europe, that is active in health, nutrition, and materials. In addition to a substantial number of products made through fermentation and other biotechnological processes, DSM also makes and sells a wide variety of oil-based polymers and chemicals. Environmental sustainability is a key pillar of the company's core values, and compensation for officers and managing board members is tied to performance on sustainability metrics. Historically, the company's sustainability efforts have focused on sourcing, design, construction, and manufacturing, but it is increasingly leveraging sustainability as a key source of competitive advantage and differentiation.

The Challenge

DSM sought to develop cellulosic ethanol from corn stover—the stalks and stems of corn plants—at a price competitive with corn-based ethanol. Such a development represents a huge commercial opportunity because corn ethanol has reached its mandated maximum production volume in the United States, defined by the Renewable Fuel Standard as updated by the US Congress in 2010. Ample room for growth remains in cellulosic ethanol. Cellulosic ethanol made from corn stover, though much more sustainable than traditional corn-based ethanol because it uses waste rather than diverting corn from the food supply, was very expensive, and several companies that attempted to develop a cost-competitive product had already failed.

The company leveraged its well-developed expertise in enzymes to develop an enzyme-based process for the hydrolysis of cellulose and hemi-cellulose and to create advanced yeasts that provide fermentation to produce ethanol. However, the company lacked large-scale biorefinery capabilities, which would have taken years to develop; it resolved this challenge by partnering with a leading biorefinery company, one of the largest producers of corn-based ethanol. The partner, which had previously manufactured traditional corn-based ethanol, built on its existing connections with growers and existing expertise in stover removal and collection, plus its existing routes to the market, to bring DSM's product to market.

Results

In September 2014, DSM and its partner announced the opening of the first commercial-scale cellulosic ethanol plant in the United States. This facility is a commercial-scale demonstration plant intended to prove the process so that the partner can license the technology to other producers and diffuse the process internationally. The combination of the company's enzyme technology with the partner's biorefining expertise led to successful development of the product over a significantly reduced cycle time over what DSM would have been able to achieve itself.

Material Co.: Solvent-Based Recycling Process for Printed Wiring Boards

Material Co. is a global supplier of specialty semiconductor materials and handling and delivery solutions for materials requiring a very high level of purity. Until 2007, the company had no real sustainability program. The company began to invest in its green chemistry capability after customers complained about a surface preparation for recycling semiconductor test wafers that created unacceptably high chemical oxygen demand in waste streams. This experience spurred deeper exploration of the potential of green chemistry to address other business problems and pursue new opportunities.

The Challenge

Driven by customer requests, Material Co. sought to develop an environmentally sustainable and economically efficient alternative to smelting for recycling printed wiring boards. Less than 20 percent of e-waste disposed of in 2009 was recycled, and, although it represents a small fraction of US landfill mass, this waste accounted for 70 percent of the heavy metals in the waste stream. Smelter-based recycling typically recovers about 70 percent of these metals; given that the recycled metal value of mobile phones, for example, is estimated at $28,000 per ton, a high-efficiency recycling process could have huge economic value.

Building on its 25-year knowledge base in semiconductor fabrication chemistries, Material Co. developed a proprietary low-temperature, closed-loop, aqueous chemistry–based process to extract maximum value from waste printed wiring boards and integrated circuits. To do so, the company supplemented its existing competencies in selective aqueous chemistry with external expertise in green chemistry. Initially, development was led by a director-level manager in a skunkworks-type unit under the wing of the company's CTO. As development matured, the process was shifted from an R&D-based innovation unit to a cross-functional business development team charged with driving market entry and fueling growth.

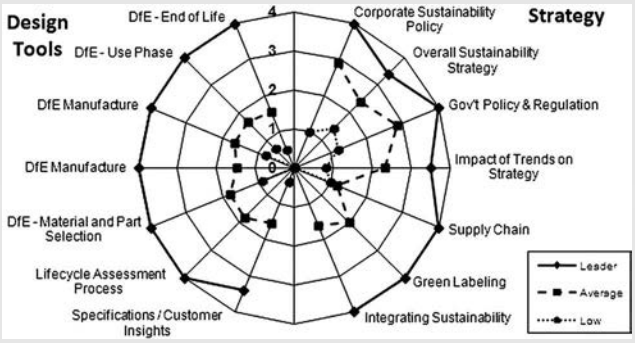
Results

Material Co. has created a pilot-scale system capable of processing up to 400 pounds of printed wiring boards per hour and extracting more than 99 percent of the metals from them at 99 percent purity. The system is portable and sufficiently low-polluting to be used in the United States. Because the process is outside the company's core business, Material Co. selected a licensing-oriented business model for commercialization and is investigating market opportunities with licensees in the United States, China, and Japan.

The Sustainability Maturity Model

The Sustainability Maturity Model was developed by the Sustainability Maturity Model IRI Research group (Hynds et al. 2014), whose work built on that of the Sustainability in R&D group (Chapas et al. 2010) and provided the foundation for the current work. The current group, in developing its sustainability-driven innovation implementation model, found that evaluating a company's current practices against the Sustainability Maturity Model could be a valuable first step, allowing a company to understand its maturity level with regard to sustainability as an initial step toward developing more advanced capabilities.

The Sustainability Maturity Model, which focuses specifically on new product development, was developed to provide a tool that is readily and freely available and is straightforward to administer. The model addresses 14 dimensions of sustainability activities, organized into two categories: Strategy and Design Tools. Each dimension identifies key activities and elements that are important to developing new technologies and products in a sustainable manner. It is possible to create value by focusing efforts on any of the 14 different dimensions, but achieving the highest maturity levels requires some attention to all of the dimensions.



The Sustainability Maturity Model can be a valuable guide for a company initiating a sustainability-driven innovation effort, suggesting where the organization may start to look for suitable opportunities. Typically, companies with higher sustainability maturity ratings will explore more advanced and more comprehensive opportunities and strategic options. For example, a manufacturer with a maturity model score of 1 (Beginning) might begin by working with supply-chain partners to conduct a systematic lifecycle assessment to identify opportunities to cut manufacturing costs and better meet customer sustainability requirements. An advanced practitioner with a score of 4 (Leading), on the other hand, will likely already have comprehensive lifecycle assessments in place; that company might use a sustainability value analysis to develop a comprehensive sustainability-driven innovation strategy; such an analysis would help the company identify new business opportunities and discover how sustainability can build competitive advantage.

As our case examples illustrate, Leaders are capable of ambitious, complex, and, for large enterprises, crosscutting sustainability innovation initiatives. These companies have a strong management commitment to sustainability and sophisticated sustainability capabilities that are well integrated into the innovation process. Companies with scores of 2 (Improving) or 3 (Succeeding) can certainly succeed at sustainability-driven innovation, but their initiatives will likely tend to have a narrower scope and require extensive capability building.

Indeed, even the leaders we studied, all of which had experience with successful sustainability-driven innovation, found gaps to shore up as they pursued their ambitious initiatives. They had to build new capabilities—in green chemistry, for instance—and develop new approaches. In fact, only one of the six case companies scores a 4 (Leading) on the Sustainability Maturity Model (Table 6). Two earn a rating of 2 (Improving), and three are rated as 3 (Succeeding). This assessment demonstrates that sustainability maturity is not a prerequisite for effective sustainability-driven innovation, although it is a factor in determining the scope of what a company can do, and how fast it can do it.

Identify potential opportunities and evaluate alternative strategic options and priorities. Clearly, the pursuit of sustainability-driven innovation opens a wide range of value-creating possibilities. As our cases illustrate, sustainability-driven innovation can result in new products with superior performance, lower cost, and greater process efficiency, as well as improved sustainability and reduced toxicity—one case company even disrupted an established commodity market. However, explicitly seeking out potential business opportunities and quantifying the value of sustainability-driven options for addressing them is critical for success. Five of the six case companies deliberately searched for sustainability-derived opportunities and explicitly sought to develop sustainable products.

TABLE 6. Maturity model scores of case companies

Company	Initiative	Sustainability Maturity Model Rating
Consumer Co.	Fabric softener with 30% increased performance vs. existing products	3 Succeeding
Large Mfg. Co.	Greener product coating	2 Improving
Material Co.	High-efficiency solvent-based printed wiring board recycling process	2 Improving
Large Chemical Co. 1	Cost-competitive bio-based chemicals—eco nylon and cellulosic ethanol	4 Leading
Large Chemical Co. 2	Sustainable BPA-free polyesters as polycarbonate replacement	3 Succeeding
Small Chemical Co.	Bio-based material more sustainable and less costly than existing oil-based product	3 Succeeding

Define business objectives and strategy, build needed innovation-related capabilities and resources, and execute. With specific opportunities and the options for exploiting them identified, the next steps are to zero in on sustainability-focused business objectives, build needed capabilities and resources, and execute to deliver results. Our leaders excelled in each of these steps. Five of the six case companies set explicit objectives for sustainable products, five of six undertook major sustainability-based technical efforts, and all set high bars for results, focusing on performance in terms of innovation success (rather than on compliance or cost reduction, as survey respondents tended to do).

The leaders we studied tended to start small, typically with a single project, and build upon initial success. Consumer Co., for example, selected one major new business opportunity—a superior-performing fabric softener—that required challenging reformulation, enhanced green chemistry capability, supply chain alterations, and new packaging. Large Chemical 1, on the other hand, already had a solid base of capabilities for sustainability-driven innovation; therefore, this company explored three major opportunities simultaneously as part of an overarching sustainability strategy. Ultimately, the company selected two opportunities as business growth targets to be pursued via joint ventures with partners and out-licensed the third.

The sustainability-driven innovation process is an iterative loop of developing maturation. Almost all of the leaders we studied ultimately made sustainability-driven innovation a central feature of their innovation practices. As a company builds sustainability innovation capabilities and its sustainability maturity grows, it is able to undertake increasingly challenging and far-reaching sustainability-driven initiatives.

Conclusion

Our results show that sustainability can be a powerful lever to drive innovation and create business value. Nevertheless, sustainability-driven innovation has not reached the mainstream—most industrial companies are not thinking about sustainability in terms of innovation outcomes. Rather, they are focused on regulatory compliance, cost reductions, and brand image issues.

How can these companies make the transition to sustainability-driven innovation? We recommend pursuing the stepwise approach employed by the leading companies in our case studies: establish a sustainability mindset, start with a specific initiative or even a single project, identify specific sustainability-based innovation opportunities that promise concrete business results, and use the sustainability implementation model to drive the process. Use these pilot projects to put a stake in the ground, identifying needed capabilities and establishing metrics and incentives.

Our research shows that industrial companies that adopt a sustainability mindset can use environmental sustainability to drive more effective innovation and deliver superior business results, including improved product performance, reduced costs, and more efficient processes. From this perspective, sustainability-driven innovation represents an untapped business opportunity for many industrial companies. It also highlights an important risk for companies not embracing sustainability as a core part of innovation—as more companies do go this direction, competitive advantage will increasingly depend on environmentally sustainable practices and initiatives.

The sustainability-driven innovation process is an iterative loop of developing maturation.

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