

# Overcoming Barriers to Implementing Environmentally Benign Manufacturing Practices: Strategic Tools for SMEs

This article describes the barriers faced by small and medium-sized enterprises (SMEs) in moving toward environmentally benign manufacturing. We discuss factors that can affect the uptake of environmentally benign manufacturing practices in SMEs, particularly where strong market and legislative drivers are just emerging.

We then introduce several strategic business tools that can be used to overcome some of these barriers and aid in establishing environmentally benign manufacturing practices among SMEs. The tools can be used to facilitate in voluntarily establishing a platform for the successful adoption of environmentally benign manufacturing practices.

We also discuss an in-depth case study of a furniture manufacturing company in New Zealand to illustrate the application of these business tools in an environmental context for SMEs.

## *Moving toward sustainability at small and medium-sized enterprises*

### **Background: Sustainability and Environmentally Benign Production**

Sustainable development is most commonly defined as “development that meets the

needs of the present, without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987). Today it is widely recognized that the responsibility for sustainable development needs to be shared among businesses, governments, and consumers (Jimenez & Lorente, 2001; Jordan, Wurzel, Zito, & Brückner, 2006; Shrivastava, 1995). Manufacturing businesses can contribute to this effort by designing products and production systems that have an

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insignificant or optimally low impact on the natural environment in terms of resource depletion, waste emissions, energy usage, and other impacts (Michaelis, 2003; Sarkis, 2001).

For the vast majority of manufacturing firms, achieving this level of environmentally benign production still requires much research and development, as well as organizational and cultural change (Michaelis, 2003). Over the past decade, however, an increasing number of manufacturing organizations have started to implement environmentally benign manufacturing initiatives (Sarkis, 2001).

This trend is particularly apparent in many countries in Europe, where it has been driven by the introduction of more stringent environmental legislation, a developing understanding in industry of the financial cost of waste, an increasing level of consumer awareness, and growing pressure with regard to environmental issues (Allen et al., 2002).

In Europe, environmentally benign manufacturing and care for the environment are fast becoming “order qualifying” factors. This means that customers are less inclined to consider purchasing products from manufacturing organizations that do not take an active role in improving and promoting the sustainability of their operations (Shahbazzpour & Seidel, 2006). Thus, environmentally benign manufacturing already ranks highly amongst the competitive objectives of most European companies.

By contrast, in other parts of the world (particularly Asia, South America, and Australasia), many firms are lagging behind, as the main external drivers toward sustainability are still relatively weak (Collins, Lawrence, Pavlovicha, & Ryan, 2007; Vives, 2005; Williamson, Lynch-Wood, &

Ramsay, 2006). In many of these economies, care for the environment does not yet carry enough weight in the market, and there is often an absence of effective environmental legislation. In addition, many companies operating in these areas fall into the category of small and medium-sized enterprises. Due to their intrinsic lack of investment capital and shortage of skill resources, SMEs find it particularly difficult to implement strategic improvement initiatives such as environmentally benign manufacturing.

### **Role of SMEs in Environmentally Benign Manufacturing**

There are different definitions of what constitutes an SME, and they vary around the world. The size component is usually determined by the number of people the enterprise employs. In the European Union, where SMEs are defined as having up to 250 employees, 80 million people are employed in almost 20 million SMEs (Biondi & Iraldo, 2002). In the United States, SMEs are defined as companies with fewer than 500 employees, and around half of that nation’s employment comes from SMEs, which make up 99.7 percent of all firms. In the context of this discussion, the term *SME* refers to the European definition.

In the past, environmental concerns about business have generally concentrated on large manufacturing organizations (Biondi & Iraldo, 2002). It has been said that this is because “small businesses are written off as a group that is too expensive to reach, while attention is concentrated on the easier to reach large businesses” (Rutherford, Blackburn, & Spence, 2000).

Another reason why more progress in this field has been achieved with larger companies is due to the public pressure that historically has been put on these large manufacturing enterprises, based on the belief that they are the major contributors to environmental degradation (Tilley, 1999). It is true that, individually, a typi-

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cal SME will most likely have a relatively small impact on the environment when compared with a large multinational company. However, the vast majority of enterprises operating around the world are SMEs. Thus, as a combined group, the cumulative impact of SMEs makes them very significant contributors to the world's environmental problems (Schaper, 2002).

While there are not many quantifiable figures available, it has been estimated that SMEs contribute up to 70 percent of pollution worldwide (Groundwork, 1995). It has also been claimed that SMEs are responsible for 60 percent of commercial waste and 60 percent of all carbon dioxide emissions in the United Kingdom (Marshall, 1998; Strokes & Rutherford, 2000). In order to make significant reductions in humankind's negative impact on the environment, it has thus become increasingly apparent that SMEs need to drastically improve their environmental performance.

### ***Growing Interest in SMEs Among Researchers***

Over the past decade or so, the scientific literature has recognized the important role that SMEs play in terms of environmental impact. While earlier research concentrated on large organizations, an increasing number of papers have now emerged that concentrate on the drivers, benefits, and barriers involved in the adoption of environmentally friendly practices among manufacturing SMEs (Biondi & Iraldo, 2002; Collins et al., 2007; Crowe & Brennan, 2007; Masurel, 2007; Simpson, Taylor, & Barker, 2004).

This particular article focuses on some of the practical business tools that have proved successful in helping overcome barriers to the implementation of environmentally benign manufacturing practices. It draws on research from the existing literature and on the extensive practical experience of the authors in establishing environ-

mentally friendly practices among manufacturing SMEs in New Zealand.

### ***ABC Ltd: Study of a Manufacturing SME***

The examples discussed in this article are drawn particularly from an in-depth longitudinal case study of a furniture manufacturing company in New Zealand (referred to in this article as ABC Ltd.). ABC manufactures high-quality panel furniture for the local and overseas markets. In recent years, a "project champion" from ABC's management team has led an internal movement toward improving the environmental sustainability of the company's operations.

ABC, like most other SMEs, has limited financial and staff resources available for this type of initiative. However, through application of the strategies and tools discussed later in this article, environmentally benign design and manufacturing initiatives have gradually gained momentum within the company.

### ***Special Features of SMEs***

When considering environmental issues with regard to manufacturing SMEs, it is important to understand the special features associated with these types of companies. SMEs cannot simply be seen as "smaller large companies." The specific characteristics of SMEs mean that the approaches they require for becoming environmentally responsible are different from those of larger organizations (Jenkins, 2004; Williamson et al., 2006).

### ***Management and Organizational Structure***

SMEs are often privately owned businesses that are managed by their owner/entrepreneur.

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In larger organizations, the “power base” tends to be more evenly distributed amongst the managers of various departments, whereas in SMEs the owner generally controls most strategic decisions. The background, character, values, beliefs, and education of an SME’s owner will thus have a significant impact on the strategic direction of the firm (Mandl & Dorr, 2007; Vives, 2005).

Another characteristic of SMEs that makes them different from larger companies is their general organizational structure. In SMEs, job descriptions are often not well defined. There can be a significant overlap in responsibilities, with staff members taking on a number of different

roles. The accountability of individuals is therefore often less clearly set out than in larger firms, and initiatives sometimes tend to “fizzle out.”

SMEs often have fewer, less structured procedures in place for strategic development. In addition, their communication and information flows are usually less formalized. This means that staff members sometimes fail to follow up on details regarding strategic initiatives, allowing such efforts to “fall through the cracks.”

### ***Focus on Local Markets***

Historically, SMEs have mainly served their local markets, as opposed to having significant international exports—although with increasing globalization, there is a trend toward more exports (Lefebvre, Lefebvre, & Talbot, 2001). SMEs are often less exposed to international pressures and trends when compared with larger multinational corporations, since local markets may not be representative of market expectations overseas in terms of legislation and public perception.

### ***Day-to-Day Orientation***

Another important characteristic of SMEs is their general focus on day-to-day activities. Because their financial and staff resources tend to be restricted, SMEs often concentrate on short-term problem solving and “making ends meet,” as opposed to taking a longer-term strategic approach (Epstein & Roy, 2000).

### **Barriers to Adopting Environmentally Friendly Practices at SMEs**

It is the combination of these SME characteristics that makes the implementation of strategic improvement projects (such as environmentally benign manufacturing) inherently complex. In addition to this, the process of moving toward environmentally benign manufacturing is often specific to each individual industry and company (Shrivastava, 1995). This means that, so far, there is no set path for companies to simply follow in order to become more environmentally friendly.

Previous research has identified the difficulties that SMEs typically face when aiming to implement environmentally friendly practices. The major impediments to environmentally benign manufacturing at SMEs are listed in **Exhibit 1** (with references from the relevant literature) and discussed in more detail below.

### ***Underdeveloped Organizational Environmental Culture***

An important barrier to improving environmental performance in SMEs is their underdeveloped organizational culture with regard to environmental issues (Biondi & Iraldo, 2002). This becomes a particular problem in economies that still have limited external drivers pushing SMEs toward making environmental improvements (such as legislation, competitive influence, public pressure, or market requirements).

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**Exhibit 1. Barriers to Adopting Environmentally Friendly Practices at SMEs**

Barrier Faced by SMEs	Examples of Literature References
Undeveloped organizational environmental culture	Petts, Herd, Gerrard, and Horne (1999) Biondi and Iraldo (2002) Kerr (2006)
Ignorance of own environmental impacts	Hillary (2000) Friedman and Miles (2001) NetRegs (2002) NetRegs (2005)
Lack of knowledge and experience with environmental issues	Groundwork (1995) Tilley (1999) Biondi and Iraldo (2002) Perez-Sanchez, Barton, and Bower (2003) Pimenova and van der Vorst (2004) Willard (2005)
Absence of effective environmental legislation	Rutherford et al. (2000) Biondi and Iraldo (2002)
Lack of awareness about environmental trends or not believing that sustainability will benefit the company	Groundwork (1995) Shearlock, Hooper, and Millington (2001) Schaper (2002)
Limited financial and staff resources available for environmental projects	Tilley (1999) Shearlock et al. (2001) Biondi and Iraldo (2002) Pimenova and van der Vorst (2004) Willard (2005) Collins et al. (2007)
Perceived conflicts between environmentally friendly practices and other business objectives	Gerstenfeld and Roberts (2000) Shahbazzpour and Seidel (2006)

In this situation, companies are effectively forced to develop their own internal drive toward environmentally friendlier manufacturing. Without an organization-wide affinity for environmental issues (originating in particular from top management), companies will most likely make very limited progress in this area (Petts, Herd, Gerrard, & Horne, 1999).

***Ignorance of Their Own Environmental Impacts***

As mentioned earlier, manufacturing SMEs as a group play a significant role in the degradation of our environment. However, a survey into the environmental practices of SMEs in the United Kingdom has revealed that the vast majority of these organizations are ignorant of their own environmental impacts (NetRegs, 2002). For ex-

ample, in 2002, 86 percent of SMEs questioned thought that their activities did not have a harmful impact on the environment.

Past surveys by the U.K. organization Envirowise actually highlight an increasing level of “head in the sand” attitudes by SMEs: 22 percent, 33 percent, and 48 percent of the businesses questioned in 1995, 1998, and 2000, respectively, felt that they did not have a negative impact on the environment (Envirowise, 2000). A similar trend is evident from a follow-up survey to the 2002 NetRegs study, which revealed that in 2005, only 7 percent of the surveyed U.K. businesses thought they performed activities that could cause harm to the environment (NetRegs, 2005). It is obvious that this misjudgment by SMEs of their environmental impact does not bode well as a driver for increasing their level of environmental performance.

### ***Lack of Knowledge and Experience With Environmental Issues***

Owner-managers of SMEs typically have very limited “ecoliteracy”—that is, little knowledge and understanding of environmental issues and how they relate to their companies (Tilley, 1999). This is a major concern because, as noted above, owner-managers in small firms generally have significant power and influence, and thus are the source of most strategic initiatives and decisions. In cases where this lack of knowledge in relation to environmental issues exists, owner-managers are unlikely to put into place systems or initiatives to make improvements.

In addition, environmental information is some-

times provided to companies by government officials or nongovernmental organizations that do not have in-depth experience with small business management. They therefore lack appreciation of the problems faced by these companies in interpret-

ing environmental information, guidelines, and tools. Small firms have expressed a need for information that is specifically targeted at them so that it can be more easily applied (Tilley, 1999).

### ***Absence of Effective Environmental Legislation***

Past studies have shown that environmental legislation serves as one of the most important factors motivating SMEs to invest in environmental improvements (Bansal & Roth, 2000; Masurel, 2007). SMEs often state that they will not invest in such improvements unless they are forced to do so by law (Masurel, 2007; Williamson & Lynch-Wood, 2001). A European Commission study involving six EU member states suggests

that there are few specific allowances made for SMEs in terms of environmental legislation (Berends, Morère, Smith, Jensen, & Hilton, 2000).

### ***Lack of Awareness About Environmental Trends***

Another major barrier for SMEs is their apparent lack of awareness regarding international trends in legislation and markets with regard to the importance of environmental aspects to business (Schaper, 2002). It is true that with the growth of information technology and globalization, SMEs now have increased access and exposure to international business influences, opportunities, threats, and imperatives (Rodríguez, 2003). However, it seems that even in the twenty-first century, many SMEs (especially in less-developed economies) struggle to use the available information to respond quickly to the competitive pressures from abroad (Hitchens, Clausen, Trainor, Keil, & Thankappan, 2004).

### ***Limited Financial and Staff Resources***

The inability of SMEs to be flexible and their failure to adapt to the increased importance of environmental issues in the marketplace are likely caused by their general lack of financial and staff resources. SMEs will usually not consider an investment that does not offer a significant short-term financial benefit (Biondi & Iraldo, 2002). This presents a particular problem in countries that do not have stringent environmental legislation, since they effectively must rely on manufacturing companies to voluntarily adopt environmental practices.

### ***Perceived Conflicts Between Environmentally Friendly Practices and Other Business Objectives***

While cost is often seen as a barrier to the adoption of more environmentally friendly practices in SMEs, some manufacturers are also wor-

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ried about trade-offs with other manufacturing performance objectives (Shahbazzpour & Seidel, 2006). Environmentally benign manufacturing can have impacts on other important manufacturing issues (such as quality, cost, and product delivery) in terms of resources, energy usage, materials, and waste emissions.

## **Overcoming Barriers to Environmentally Benign Manufacturing at SMEs**

### ***Perception Versus Reality***

With an appreciation of the barriers that are faced by SMEs in voluntarily adopting environmentally benign practices, it can perhaps be understood why these organizations are often reluctant to make significant strides in the “green” direction. However, in the authors’ experience, many of the problems that SMEs have in getting started with environmentally benign manufacturing are due to initial perceptions rather than insurmountable hurdles.

This finding is in line with the results of a 2002 research project by the U.K. Department of Trade and Industry, which established that most of the barriers to the uptake of environmentally and socially responsible practices by SMEs were built on perceptions of unmanageable time and cost requirements (Department of Trade and Industry, 2002). In fact, however, SMEs that have actually implemented environmentally friendly manufacturing practices do not consider these issues as major barriers (Castka, Balzarova, Bamber, & Sharp, 2004).

Many of the apparent barriers to environmentally benign manufacturing can, therefore, be attributed to misunderstandings and preconceptions of decision makers in SMEs. While the investment capital problems related to environmental projects cannot always be dealt with easily, there are opportunities to widen the horizons of decision makers in SMEs.

### ***Laying the Foundation for Environmentally Benign Manufacturing: A Practical Approach***

By using the tools and practical ideas discussed in the following sections of this article, SMEs can lay a foundation for environmentally benign manufacturing practices and be in a much better position to make worthwhile improvements. The tools and advice presented here have been found to aid in:

- identifying internal and external stakeholders and increasing their involvement in environmental initiatives,
- accumulating and disseminating company-specific environmental information,
- quantifying operational and strategic impacts of environmental projects and programs,
- identifying and prioritizing projects that will lead to early financial successes, and
- applying a longer-term strategic vision.

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### ***Tools for Overcoming Barriers***

Over the past several years, the authors of this article have been involved in implementing environmentally benign manufacturing practices in New Zealand SMEs. Over this period, a range of approaches and tools have been trialed in order to aid in the facilitation of this complex process (Seidel, Shahbazzpour, & Oudshoorn, 2006; Seidel, Shahbazzpour, & Tedford, 2007; Seidel, Seidel, Tedford, Cross, & Wait, 2008; Seidel, Seidel, Tedford, Shahbazzpour, & Haemmerle, 2008). The tools highlighted in this article are:

- stakeholder analysis,
- SWOT (strengths, weaknesses, opportunities, threats) analysis,

- basic life-cycle inventory, and
- prioritization of environmental aspects.

These tools have been effectively applied in business-analysis processes around the world, but as yet are not widely used in the environmental context. These basic tools can be used in sequence as a “road map” for overcoming some of the initial hurdles faced by SMEs in improving environmental performance (see **Exhibit 2**). These specific tools have been chosen because they:

- are fast and easy to apply;
- require little sustainability-specialist background knowledge;
- address specific SME barriers;
- express information in usable business terms;
- require few financial resources;
- are complementary, build on each other, and provide multiple perspectives; and
- quantify the impacts of likely future requirements.

Each of these four tools is discussed in more detail in the sections that follow.

### Stakeholder Analysis

Stakeholder analysis is a technique used to identify and assess the importance of key people, groups of people, or institutions that may significantly influence the success of a particular initiative or project. A stakeholder is any group, individual, or organization who can affect or is

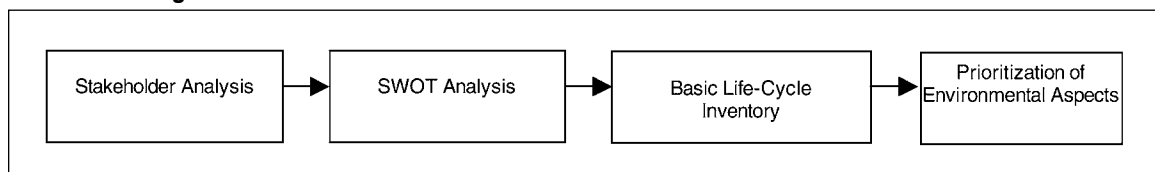
affected by the achievement of an organization’s objectives (Freeman, 1984). Stakeholder analysis is beneficial in the environmental context for SMEs because:

- It can be used to identify stakeholders that can be involved, affected, or have an interest in the firm’s environmental performance.
- One of the most important means of overcoming a lack of adequate knowledge and experience with environmentally benign manufacturing is networking. Stakeholder analysis identifies the parties that should be involved in this network.

It is clear that the environmental impact of a manufactured product needs to be considered throughout its entire life cycle. This means that an SME manufacturing company, given its generally central position in the product life cycle, needs to deal with a range of stakeholders up and down the value chain. By developing sustainability partnership networks with external organizations, the SME can gain invaluable knowledge, transfer its own experiences, pool resources, and develop mutually beneficial environmental projects.

Research on sustainability performance among SMEs in Europe has concluded that the wider the stakeholder network of a company, the more likely the company is to overcome the barriers and constraints that it faces in adopting environmentally benign manufacturing practices (Biondi & Iraldo, 2002; Friedman & Miles, 2002).

**Exhibit 2. SME “Road Map” for Overcoming Barriers to the Adoption of Environmentally Benign Manufacturing Processes**



This is mainly because knowledge can be shared among the members of a network, and companies with extensive networks thus do not need to “reinvent the wheel” every time they encounter a knowledge barrier.

**A Simplified Approach to Stakeholder Analysis**

The stakeholder analysis tool can be adapted to the needs of the company using it. In the SME context, it is best to use a low-cost, fast analysis. A simplified stakeholder analysis can take the following approach:

- Develop a working group of around three to five people to carry out interviews and analysis. The working group should ideally include members both from inside and outside the organization.
- Develop a list of all possible internal and external stakeholders.

- Identify the impact and role of each stakeholder with respect to environmentally benign manufacturing.
- Categorize the stakeholders and develop a contact list.

Once the relevant stakeholders have been identified, an SME can work with the various parties on environmental initiatives. They can give and receive important information that can lead to the development of innovative environmental solutions.

**Stakeholder Analysis at ABC**

**Exhibit 3** summarizes the stakeholders identified in the case study of ABC (the specific names of suppliers and customers have been omitted in this article).

ABC’s supplier of board material was identified as an important potential partner. ABC found that it could send material waste from its manu-

**Exhibit 3. Stakeholders Identified by ABC in Connection with the Sustainability Project**

Internal Stakeholders	Stakeholders Along the Value Chain	Stakeholders in the Local Community	Societal Stakeholders
Employees (production)	Customers (Australia and New Zealand)	Local government	Nongovernmental organizations
Employees (office, management, and administration)	International electronics manufacturers (customers)	Neighborhood companies	New Zealand government departments (e.g., Ministry for the Environment)
Marketing	Customers (Asia, the United States, and Europe)	Neighborhood civilian communities	International governments
	Retailers	Natural environment	Landcare Research—Enviro-Mark®
	Suppliers		National and international competitors
	Recyclers		Customer organizations (e.g., Consumers Institute New Zealand)
			Local university
			Sustainable Business Network
			New Zealand Eco-Labeling Trust (Environmental Choice)
			Banks and other lending institutions

facturing processes back to the supplier to reuse in its processes. In addition, ABC is investigating the possibility of partnering with a company that creates compost from bio-waste. Through these types of initiatives, significant savings in landfilling costs and transport can be achieved, in addition to the obvious positive impact of diverting waste from landfill.

ABC has established a close relationship with several of its external stakeholders, and is currently working with its suppliers to reduce the environmental burden of the raw materials that it receives. This will help the company become eligible for the Environmental Choice NZ eco-label certification, which is supported by the New Zealand government.

**SWOT analysis will help to identify important strategic considerations with respect to improving the environmental performance of an SME.**

### **SWOT Analysis**

SWOT (strengths, weaknesses, opportunities, threats) analysis is a strategic business tool that is commonly used to assess an organization's relative strengths and weaknesses, which can affect its ability to carry out projects. SWOT analysis also identifies opportunities and threats to the company associated with implementation of a particular project or business venture.

As mentioned previously, SMEs generally are concerned with the short-term financial implications when they consider investing in environmental projects for their companies. However, the short-term payback period of a particular project should not be the only factor involved in the capital investment decision-making process (Epstein & Roy, 2000).

Strategic and technical factors are also very important, although these are sometimes difficult to quantify. For example, the strategic signifi-

cance of improved vendor reputation obtained as a result of environmental improvements is substantial in the long term, but difficult to quantify. SWOT analysis helps SMEs identify strategic performance variables related to environmental projects.

Having identified the relevant internal and external stakeholders using the stakeholder analysis tool, SMEs should establish contact with key stakeholders, develop relationships with them, and begin to accumulate information. During SWOT analysis, the company can collect and evaluate data from a series of interviews, group discussions, and brainstorming sessions with stakeholders. Organizations can also find it helpful to analyze recent relevant literature and case studies of similar companies with regard to their environmental programs.

### ***Defining the Analysis Objective***

The first step in a SWOT analysis is to define clearly the objective of the analysis. In the context of this discussion, SWOT analysis will help to identify important strategic considerations with respect to improving the environmental performance of an SME. To help achieve this, data is collected from the organization's internal and external stakeholders.

### ***Evaluating and Categorizing Data***

The organization then evaluates and categorizes data in the following four areas (see **Exhibit 4** for the ABC case study example):

- Strengths: The attributes of the SME that will likely contribute to a positive outcome with regard to the company's environmental aspirations. For example, a company employee may have experience in environmental issues.
- Weaknesses: The attributes of the SME that will likely have a negative effect on the suc-

**Exhibit 4. Outcome of the SWOT Analysis Performed for ABC in Connection With the Sustainability Project**

Strengths	<ul style="list-style-type: none"> <li>• High standard of production and information technology, quality management, and health and safety management</li> <li>• Availability of internationally accepted and locally proven cleaner production methodology</li> <li>• Proven benefits of cleaner production and waste minimization in both financial and environmental terms</li> </ul>
Weaknesses	<ul style="list-style-type: none"> <li>• Lack of experience and resources</li> <li>• No strong drivers for sustainability within the company (other than from the project champion)</li> <li>• No quantified short- and long-term benefits as yet</li> </ul>
Opportunities	<ul style="list-style-type: none"> <li>• High degree of support from representatives of territorial authorities, regional councils, central government, business groups, and industry associations</li> <li>• Cost reduction (in areas such as energy, waste disposal, and raw materials)</li> <li>• Increased market shares in New Zealand, Australia, and the United States</li> <li>• New market opportunities in Europe and Asia</li> <li>• New product ranges for environmentally conscious customers</li> <li>• Early alignment with future environmental legislation, avoiding costly ad hoc initiatives</li> <li>• Powerful branding and marketing tool</li> </ul>
Threats	<ul style="list-style-type: none"> <li>• Growing low-cost competition from Asia, reducing margins and opportunities for sustainable production</li> <li>• Long-term benefits hard to quantify</li> <li>• Loss of market share if no progress on sustainability</li> <li>• Competitors faster in development of sustainable brand</li> <li>• Global economic crisis could stifle demand for sustainable products</li> <li>• Upcoming local legislation with unforeseen impacts (e.g., New Zealand Packaging Accord)</li> <li>• New international trade boundaries based on new environmental legislation</li> </ul>

cess of an environmental project. For example, lack of organizational resources in any area would be identified here.

- Opportunities: External factors that will likely result in a positive or value-creating effect on or from the success of the project. These are usually trends or changes of some kind or overlooked needs that increase demand for a product or service and permit the firm to enhance its position by supplying it. For example, there may be a developing market in a particular country for environmentally friendly products.
- Threats: External factors that will likely have a negative effect on the success of the project. A threat may be a barrier, a constraint, or

anything external that might cause problems. For example, the local government may be planning to introduce stricter environmental legislation.

***Benefits of SWOT Analysis***

Having completed the SWOT analysis, the SME will have a more strategic understanding of the business environment in which it is planning to implement its environmentally benign manufacturing program. An effective strategy for environmental manufacturing is one that takes advantage of the organization's opportunities by employing its strengths and mitigating threats through avoiding them or correcting or compensating for weaknesses.

## Basic Life-Cycle Inventory

The stakeholder and SWOT analysis tools introduced in the previous sections provide the SME with information relating to its business environment and potential partners, as well as insights into factors such as the drivers, benefits, and opportunities involved in implementing environmentally benign manufacturing practices. After using these tools, the SME will have developed an improved understanding of its situation and will be in a good position to begin developing its environmental strategies and initiatives. The next step is to develop an understanding of the specific environmental aspects that the SME needs to consider.

## Life-Cycle Assessment

Life-cycle assessment (LCA)—also known as life-cycle analysis, cradle-to-grave analysis, or eco-balance—is a well-established tool that is used to investigate and evaluate the environmental impacts of a given product or process. ISO 14040 and ISO 14044 describe, respectively, the principles and framework and the requirements and guidelines applicable to LCA (ISO 14040, 2006; ISO 14044, 2006). According to these standards, there are four phases involved in LCA:

1. Goal and scope: This stage involves establishing the objectives, system boundaries, required accuracy, and extent of the LCA.
2. Life-cycle inventory (LCI): This is the data-collection stage. It involves analyzing the inputs and outputs of processes within the defined system boundaries.
3. Life-cycle impact assessment (LCIA): This stage involves evaluating the data collected

in the life-cycle inventory for its contribution to environmental impact categories (such as global warming, climate change, and acid rain production).

4. Interpretation: This final stage involves interpreting what conclusions can be drawn and whether the goals of the LCA have been met.

## Using LCA at SME Manufacturing Companies

Undoubtedly, a complete LCA is the most effective means for environmental assessment (Epstein & Roy, 2000). It is therefore an indispensable starting point for sustainability initiatives in business organizations. However, the tool has mainly been applied in larger organizations. Manufacturing SMEs generally find an extensive LCA to be too complex, time-consuming, or irrelevant (Le Pochat, Bertoluci, & Froelich, 2007).

Given the lower level of resources available to SMEs, their product life-cycle initiatives are usually partial, limited, or incomplete in scope (Lefebvre et al., 2001). In the context of SME manufacturing firms, it is not usually feasible (at least in the early stages of the company's environmental program) to define the system boundaries for the environmental assessment beyond those of its own internal production processes.

This being said, it should also be noted that stakeholder analysis can provide the SME with contacts up and down its value chain. By using the stakeholder analysis tool, an SME can create a foundation for extending its environmental program so that it incorporates the entire life cycle of the company's products. In the authors' experience, such an expansion of the environmental program is most likely to occur at a stage when the SME has seen the environmental and economic benefits of environmentally conscious practices within its own operations.

At the early stages of environmental program development, most manufacturing SMEs will not practically be able to progress past the life-cycle

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inventory stage of a complete LCA. By conducting a basic LCI, however, the manufacturing SME can access a relatively cost- and time-efficient means for developing a solid understanding of its environmental aspects (even though a basic LCI will not provide the company with detailed information on how much those environmental aspects contribute to phenomena such as global warming).

### **LCI Phases**

An LCI usually consists of four phases:

1. Development of a flow diagram for the processes being evaluated: A flow diagram is a tool for mapping the inputs and outputs to a process or system. Having previously defined the system boundary as the SME's own production system, this phase of the LCI involves developing a flow diagram of the processes within the manufacturing system.
2. Development of a data-collection plan: This phase involves selecting sources of data for completing the LCI. Creating an LCI data-collection plan helps ensure that the quality and accuracy of the data gathered will meet the expectations of the company's decision makers. In the SME context, sources of data may include suppliers, production floor analysis, procurement staff, waste invoices, and energy meters.
3. Collection of data: This phase involves collecting data as per the data-collection plan.
4. Evaluation and reporting of results: This final phase involves evaluating and reporting on the data collected during the LCI.

### **LCI Conducted at ABC Ltd.**

As part of our case study, we conducted a basic LCI at ABC Ltd., giving the organization a qualitative overview of its environmental aspects. The system boundary was defined as starting

when raw wooden panels of medium-density fiberboard (MDF) arrived at the manufacturing facility and ending when packaged ready-to-assemble furniture products left the factory.

Complete details of the LCI carried out at ABC Ltd. cannot be included in this article. However, **Exhibit 5** provides an overview of the company's environmental aspects as identified by the LCI.

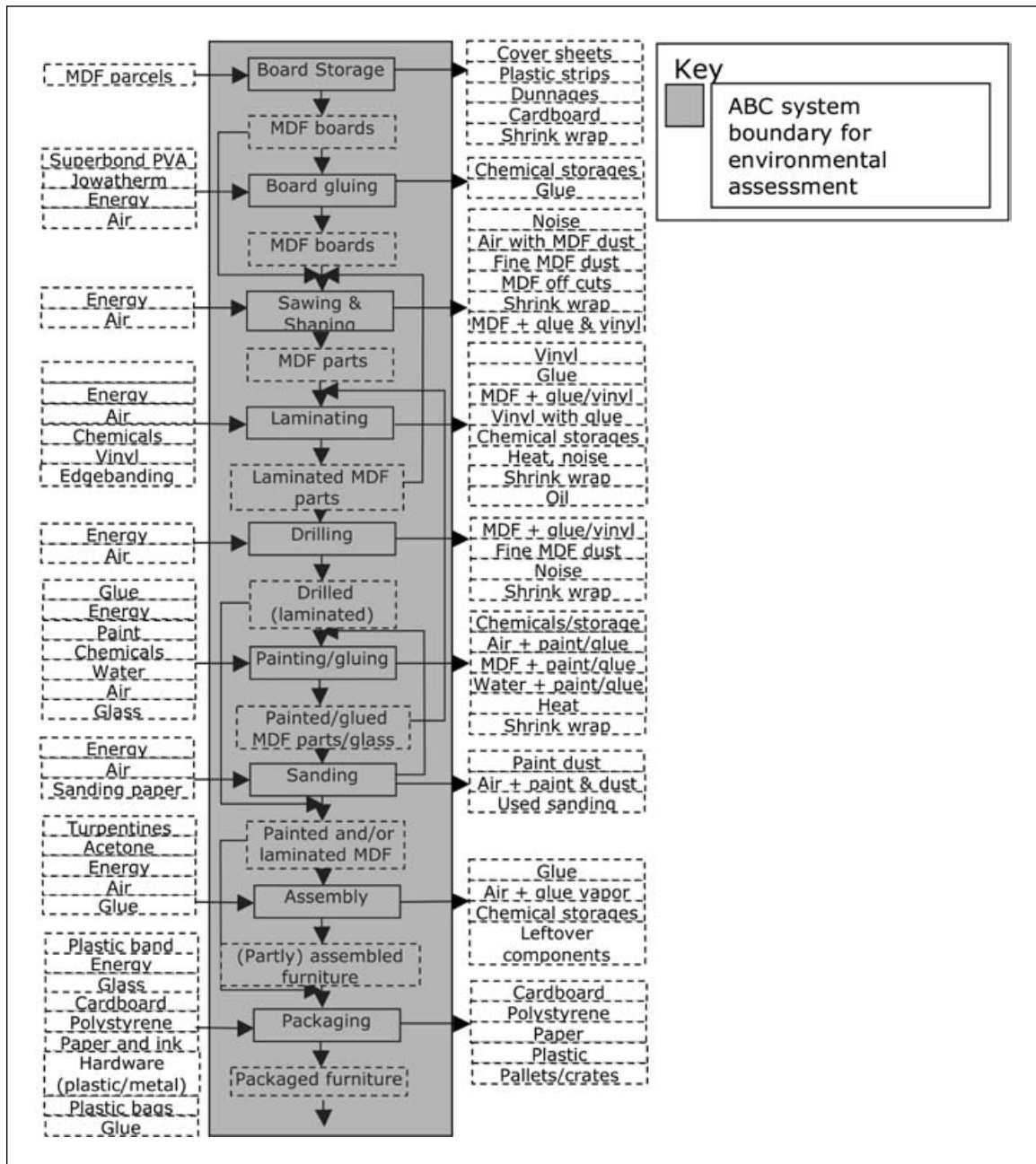
### **Prioritization (Evaluation and Ranking) of Environmental Aspects**

The LCI can identify the environmental aspects of the manufacturing SME. The next step is to undertake a basic evaluation of those environmental aspects in order to prioritize areas that are most suitable for the start of the environmentally benign manufacturing program. To achieve this, the identified environmental aspects should be assessed against four weighted criteria (discussed below).

It should be noted that this approach is not intended to determine the exact environmental impact of each activity or type of waste. To do this, it would be necessary to complete the LCIA stage of the LCA (as discussed above). The LCIA, which is very time-consuming and resource-intensive, thoroughly considers the environmental aspects identified in the LCI. The LCIA is used to determine, for example, which of the company's manufacturing processes has a greater impact on global warming or climate change. While this may be very important information for a large multinational manufacturing company that is seeking to market itself using this extensive research and analysis, it is comparatively less important (and less feasible to conduct) for an SME.

**The LCIA, which is very time-consuming and resource-intensive, thoroughly considers the environmental aspects identified in the LCI.**

**Exhibit 5. Basic LCI Flow Diagram of ABC's Production Process**



The evaluation and ranking approach presented in this section helps ensure that, during the critical start-up phase of the environmental program at an SME, the company's limited resources are applied as effectively as possible—thus maximizing the probability of achieving visible and commercially relevant improvements. This

approach assumes that the company's products and processes already meet the relevant requirements of all applicable environmental legislation.

**Weighted Criteria**

For evaluating waste types produced at a manufacturing facility, the four weighted criteria

used in this ranking approach (and shown in **Exhibit 6**) are:

- possible financial benefits,
- quantity of waste,
- severity of consequence, and
- future developments.

Most SMEs operate under constant economic pressure (Seidel, Seidel, Tedford, Wait, Cross, & Hämmerle, 2008; Seidel, Shahbazpour, & Seidel, 2007). For this reason, “possible financial benefits” have the highest-ranking score. In order to develop early momentum for environmental projects at SMEs, it is important that early financial successes be achieved. Accordingly, a higher weighting is allocated to the “possible financial benefits” criterion. In line with the literature, ABC management (and management at other SMEs that the authors have been involved with in recent years) considered that the early economic achievements of environmental initiatives were critical factors in the success of their environmental program.

The “quantity of waste” criterion is relative. It expresses how much waste is created compared to the highest observed quantity of particular waste types.

“Severity of consequence” indicates the impact that the particular waste has on the environment, and is based on duration and range of

impacts. Without extensive research, this may be seen as a relatively subjective comparison. However, by using some common sense and developing a basic background understanding of materials with significant environmental impacts, SMEs should be in a position to make relatively sound judgments for this criterion.

“Future developments” is intended to give an indication regarding expected future changes with respect to legislation affecting the particular waste type, as well as the costs and impacts that may be associated with it. An understanding of these issues can be developed through reviewing government Web sites, researching overseas market trends (as part of SWOT analysis), and holding discussions with environmental groups (as part of stakeholder analysis). In this category, the SME might consider, for example, upcoming export barriers for a particular material or waste type. In the case of ABC, evaluation for this last criterion was based on literature review and overseas market research (in particular a study of the situation in Europe), along with review of information obtained from the New Zealand Ministry for the Environment and Landcare Research, a government-owned entity in New Zealand that focuses on research in sustainability and natural resources.

***Evaluation of Waste Types at ABC***

In this article, the waste types generated by ABC are used as an example to illustrate how the

**Exhibit 6. Weighted Criteria for Waste Types**

	Possible Financial Benefits	Quantity	Severity of Consequence	Future Developments
Very high	10	5	5	5
High	8	4	4	4
Moderate	6	3	3	3
Low	4	2	2	2
Very Low	2	1	1	1
None	0	0	0	0

evaluation method works. **Exhibit 7** summarizes the rankings of waste streams at ABC, normalized to a maximum score of 100. The final scores were grouped into four categories (0–25, 26–50, 51–75, and 76–100).

As can be seen from this exhibit, the LCI and the ranking process identified two particular types of waste (polystyrene in furniture packaging and board off-cuts) as contributing most significantly to the company's environmental footprint. Importantly, changes in these areas would provide significant environmental improvements and relatively rapid economic benefits for a comparatively low initial investment. It was thus decided that a project to reduce the environmental impacts of packaging would be a strategically sound way to begin ABC's environmentally benign manufacturing program.

### Discussion and Conclusions

During the past few years, drives toward environmentally sound practices have been getting stronger in most areas of business and society. In Europe in particular, sustainability has become a major competitive factor for many manufacturing organizations. In New Zealand and many other countries in the Asia-Pacific region, market forces and social and environmental factors have

also started to make manufacturing companies consider sustainability more seriously.

However, the change toward environmentally benign manufacturing poses significant challenges for small and medium-sized enterprises, which generally have relatively little experience in this area and few resources available for the task. This is particularly true if SMEs operate in a business environment (and within a legislative framework) where sustainability is only now emerging as a new business paradigm.

This article has illustrated a number of effective, cost-efficient, and simple-to-use business tools that can be utilized by SMEs in the early stages of implementing environmentally benign manufacturing initiatives.

In working with SMEs, the authors have learned that many companies perceive the barriers to adopting environmentally benign manufacturing practices as being very difficult to overcome. As a result, many SMEs do not even attempt to adopt such practices. By using the tools presented in this article, however, manufacturing SMEs can develop significant environmental achievements and strong platforms for future improvement. Companies can progress toward sustainability by developing stakeholder relationships, achieving enhanced understanding of the organizational

**Exhibit 7. Ranking of Waste Types at ABC**

	Possible financial benefits	Quantity	Severity of consequence	Future Developments	Total	Total (x4)
Polystyrene	9	5	3	4	21	84
Off-cuts	10	5	3	3	21	84
MDF dust	8	4	3	5	20	80
Vinyl	6	3	4	3	16	64
Chemicals	2	3	5	3	13	52
Rest waste	2	3	3	3	11	44
Crates/wood	4	2	1	1	8	32
Plastics	2	1	3	1	7	28
Waste air	0	3	3	1	7	28
Water	0	2	3	1	6	24
Cardboard	2	2	1	1	6	24
Noise	0	3	2	0	5	20
Heat	0	1	1	0	2	8

requirements involved in the uptake of environmental initiatives, and creating momentum for their environmental programs through projects that enjoy early economic successes.

### Additional Ongoing Research

Further research is being carried out in this area using an “action research” methodology. The researchers are directly involved in SME manufacturing organizations and are working as part of their environmental management teams. The aim of this research is to develop a model of the complex dynamics involved in the adoption of environmental innovations and initiatives within manufacturing SMEs.

After developing this theoretical model, the researchers will create a practical, strategic framework to provide guidance for practitioners who seek to effectively implement environmentally benign manufacturing practices using cost-efficient tools, techniques, and organizational strategies.

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