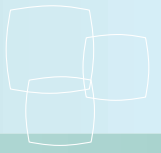


# DESIGN FOR ENVIRONMENT:



## *Innovating to Compete*

## **DESIGN FOR ENVIRONMENT: Innovating to Compete**

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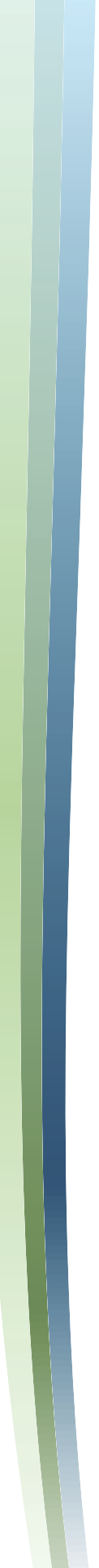
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Design for Environment:

*Innovating to Compete*





## *Highlights*

Sustainable development is becoming a guiding objective of economic and technological advancement as individuals and firms grow more aware of and concerned about their impacts on the environment. Design for Environment (DfE) is one aspect of this overarching objective of sustainable development. DfE focuses on improving environmental impacts over a product life cycle by incorporating environmental considerations into product design. In today's complex business environment, the extent to which firms use DfE practices is a key determinant of their competitiveness.

Industry Canada has partnered with the Design Exchange (DX) and Canadian Manufacturers and Exporters (CME) to review this valuable service business function. Drawing from a survey and intelligence from industry, and using economic analysis from Industry Canada, this industry-government partnership has produced the first assessment of DfE usage by Canadian design service providers and their business partners. This unique analysis is intended to help Canadian product design and development executives as well as decision makers understand current trends and recognize the advantages of adopting DfE practices to improve business competitiveness.

Design for Environment is a valuable activity that enables Canadian firms to improve their business competitiveness on many levels.

## *Key findings:*

- **Best-in-Class (BiC)\* firms are able to better differentiate their products, increase sales, and access foreign markets.**
- **Main DfE business drivers include corporate responsibility, need for product differentiation, customer demand for environmentally friendly and energy efficient products, and regulatory compliance.**
- **Firms are using several DfE strategies including: design for resource and emission efficiency; design for recyclability, disassembly, and environmentally friendly disposal; and design for reduced packaging.**
- **Small- and medium-scale businesses have difficulty financing DfE related investment, lack the knowledge to implement DfE practices, and are less aware of the business benefits.**

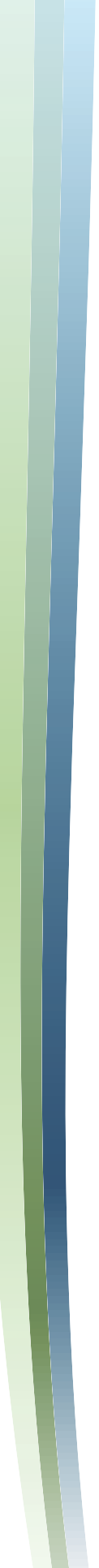
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## *Approach and methodology*

This report is based on a collaborative undertaking between the DX research committee, the CME, and Industry Canada's Service Industries and Consumer Products Branch. The DX research committee and the CME defined industry needs, drivers, and metrics and offered valuable insights from an industry perspective. By using information from industry partners and international market research organizations, and by applying unique economic models developed in-house, Industry Canada provided the overall analysis and brought together all the components needed to produce Canada's first Design for Environment report with competitive performance parameters.

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\* Best-in-Class (BiC) firms are defined as businesses who achieve positive results in two of the main environmentally specific activities: improved product environmental impact and energy efficient distribution practices.



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## Background

It is estimated that over 80% of all product-related environmental impacts are determined during the design phase of a product.<sup>1</sup> Businesses that design environmentally friendly (i.e. highly recyclable or energy efficient) products for their customers are successfully differentiating themselves. This trend emphasizes the importance of using Design for Environment (DfE) practices to help Canadian product design and development service providers and their supply chain partners introduce new and innovative product concepts and compete both domestically and internationally.

DfE integrates environmental considerations into the product design and development process. Firms use DfE practices to improve the environmental performance of products while reducing cost, boosting their competitive advantage, and stimulating innovation.<sup>2</sup> The DfE process can involve designing products that use environmentally friendly materials, fewer resources, and/or less packaging. DfE can also focus on designing products that are more easily recycled, reused, or upgraded.

Goals of DfE<sup>3</sup> can include:

- Reducing or eliminating waste throughout the product life cycle;
- Meeting or exceeding regulatory goals;
- Reducing energy consumption throughout the product life cycle;
- Improving logistics to minimize transportation throughout the product life cycle; and
- Maximizing the use of recovered materials and energy throughout the product life cycle.

In general, investment in a new business process such as DfE should be supported by a business plan that outlines a demonstrable return on investment. For this reason, Industry Canada has partnered with the Design Exchange (DX) and Canadian Manufacturers and Exporters (CME) to initiate research on DfE practices and their business benefits. Specific business benefits include greater product differentiation, successful compliance, increased sales, new access to foreign markets, better customer retention, and improved cost reduction.

It is expected that this research will help inform policy makers of current and future industry needs by identifying industry perspectives, issues, and drivers related to DfE practices.

In particular, this report assesses the:

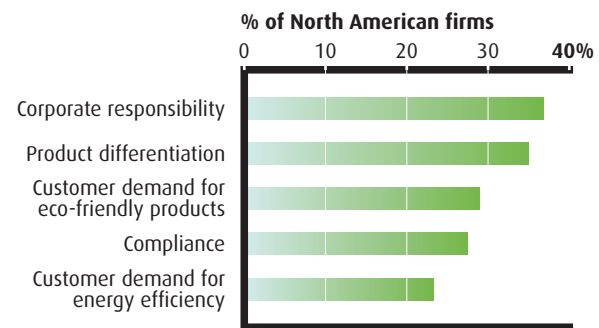
- Use of DfE practices by industry;
- Internal and external pressures involved in adopting DfE practices;
- Specific DfE strategies that businesses use; and
- Business benefits that Best-in-Class (BiC) businesses gain.

## DfE Practices: Drivers and Adoption

### Drivers

A wide range of pressures are driving North American firms to adopt DfE practices, including increased corporate responsibility, greater product differentiation, growing customer demand for environmentally friendly and energy efficient products, and improved compliance processes. Compliance refers to their conformity to regulations as well as to how firms meet and respond to corporate objectives (*Figure 1*).

**FIGURE 1**  
Drivers for the adoption of DfE practices<sup>4</sup>



For example, the most common DfE driver for North American automotive and consumer product goods (CPG) firms<sup>†</sup> is corporate responsibility, as these companies strive to be viewed as proactive and environmentally friendly by their customers. The most prevalent DfE driver for North American aerospace and industrial electronics firms is compliance with environmental

<sup>†</sup> CPG firms are companies that design, manufacture, and market apparel, food, cleaning products, hand and power tools, home furniture, housewares, sporting goods, linens, and consumer electronics and appliances.



regulations on both regional and global levels, with the aim to improve access to foreign markets.<sup>4</sup>

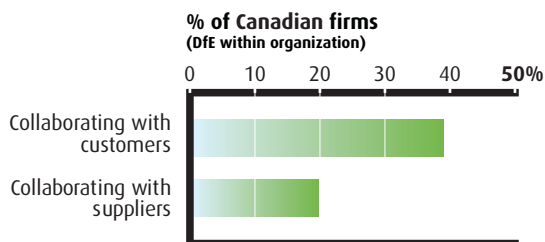
Many regions have regulatory bodies in place to implement environmental regulations on products. To increase their export capability, firms should design products to meet the environmental regulations in each potential export market. One example is the European Union's Restriction of Hazardous Substances Directive (RoHS). The goal of the RoHS is to reduce the use of hazardous substances such as lead, cadmium, and mercury in the production of new electric and electronic equipment sold in the European Union.<sup>5</sup> Canadian businesses that wish to access the European market should design new products that comply with such hazardous substance restrictions.

To sell domestically, Canadian firms should also design products to meet Canadian environmental regulations.<sup>6</sup> In addition, some provinces have extended producer responsibility (EPR) concepts that include DfE elements and/or set out product reuse and refurbish targets.

## Adoption

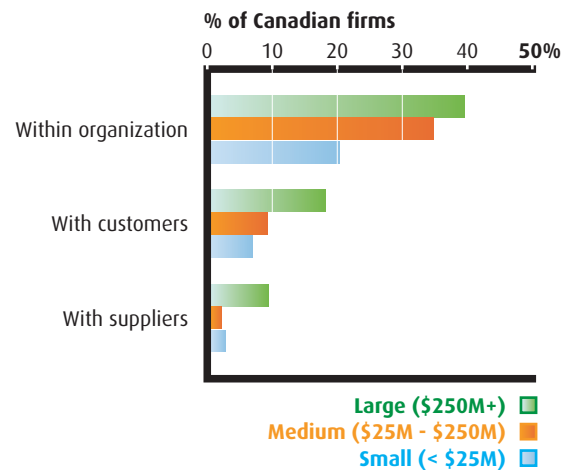
DfE practices can be implemented exclusively within organizations or in collaboration with customers and/or suppliers. Currently, 30% of Canadian manufacturers implement DfE practices within their organizations. Of these, 39% are doing so in collaboration with their customers and 19% are doing so in collaboration with their suppliers (Figure 2).

**FIGURE 2**  
Collaboration in DfE practices<sup>7</sup>



Compared to large-scale businesses, fewer small- and medium-scale Canadian businesses are adopting DfE practices. Within organizations, 40% of large businesses are implementing DfE practices, whereas only 20% of small-scale businesses are doing so in-house (Figure 3).

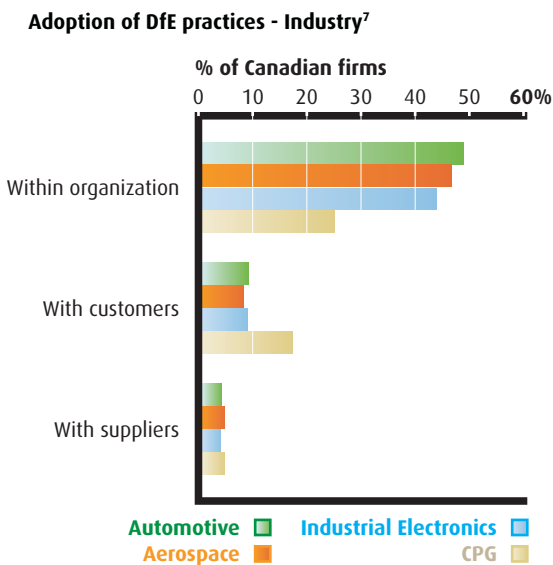
**FIGURE 3**  
Adoption of DfE practices - Business size<sup>7</sup>



Often this difference is due, in part, to the substantial capital investment required and the high cost of technology needed to implement DfE practices. Small- and medium-scale businesses have difficulty financing the investment required to implement DfE practices. In addition, some small- and medium-scale firms are less aware of the business benefits related to DfE and lack the knowledge to implement DfE in their product design and development process.<sup>8</sup>

The adoption of DfE practices also varies by industry. For example, nearly 50% of Canadian automotive, aerospace, and industrial electronics firms are currently adopting DfE practices compared to only 20% of CPG firms (Figure 4). One reason for this difference is that automotive and aerospace firms are using processes and concepts that ease DfE adoption. For some time now, Canadian automotive firms have embraced lean concepts in their operations that focus on increasing efficiency and reducing waste. Taking a long-term view allows firms that adopt lean processes to transition to making more environmentally friendly products with greater ease.<sup>8</sup>

**FIGURE 4**



For Canadian aerospace firms, DfE practices are highly interrelated with Six Sigma<sup>8</sup> design processes. For a number of years, Six Sigma methodology has been used by aerospace businesses to design products to be as flawless as possible. Frequently, this focus on increased design quality leads to other DfE-related advancements, such as parts and materials that have a longer useful life.<sup>3</sup> Industrial electronics firms have been adopting DfE practices due to the high level of environmental compliance required to access foreign markets.<sup>8</sup>

For CPG firms, the shift to DfE is relatively new, but a niche environmental market is emerging. Currently, some CPG firms are targeting sub-groups of the population that are more sensitive to environmental considerations in their lifestyles. In the medium to long term, this

market is expected to expand.<sup>8</sup> Relatively more CPG firms do, however, have DfE practices in place with their customers due to the fact that some of these CPG firms supply private label products\*\* to retail chains that have environmental product mandates.

Even though DfE adoption is currently limited in Canada, DfE practices are expected to become more common in industry as the cost of raw materials and energy increases and as consumer concern of environmental impact heightens.<sup>2</sup>

### DfE Strategies

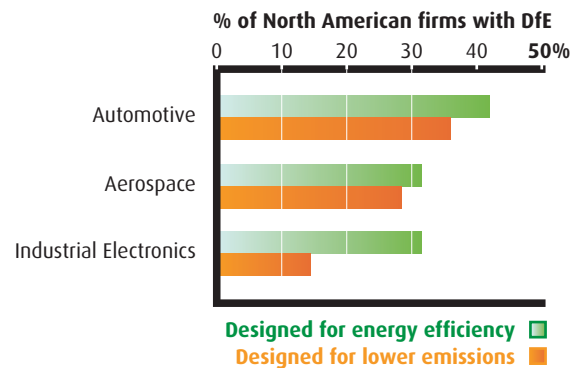
Canadian firms implement different DfE strategies according to the environmental goals associated with each newly designed product. DfE strategies can be broken down into three general categories: design for energy and emission efficiency; design for recyclability and environmentally friendly disposal; and design for reduced packaging.

#### Design for energy and emission efficiency

Manufacturers, in partnership with their design service providers, are using DfE practices to achieve greater energy and emission efficiency in their products. For example, approximately 40% of North American automotive and automotive parts firms with DfE practices in place are designing products that are more energy efficient and produce fewer emissions (Figure 5).

**FIGURE 5**

**DfE practices for energy and emissions efficiency<sup>4</sup>**



<sup>8</sup> Six Sigma Total Quality Management is a term used to indicate that a process is well controlled. This means, for example, that its tolerance limits are  $\pm 6$  sigma (3.4 defects per million events) from the centre line in a control chart.

\*\* Private label products are manufactured by one company for offer under another company's brand. Private label goods are available in a wide range of industries from food to cosmetics.

Using DfE practices, automotive and automotive parts companies are developing solutions for hybrid and electric vehicles and creating green technologies such as hydrogen fuel cells.

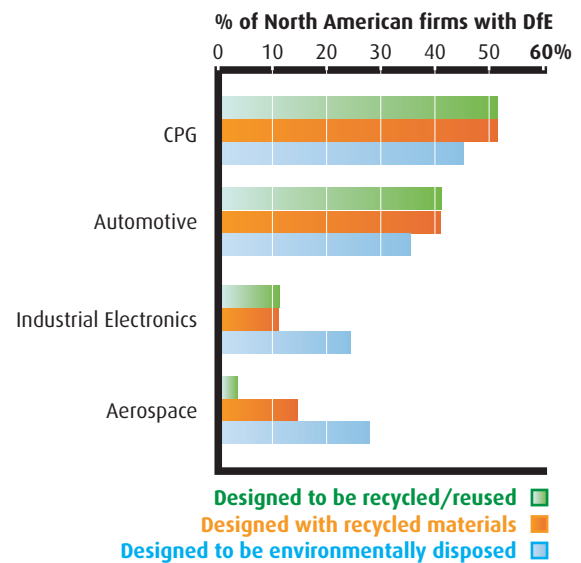
Aerospace firms, meanwhile, are focusing on energy and emission efficiency in aircraft design. Aircraft engines are now being designed to emit less carbon dioxide and nitrogen oxide while burning less fuel. In addition, aircraft are being designed to emit less noise pollution, which enables them to land at inner-city airports and thereby decreases the need for long-distance passenger commuting. Aerospace businesses are also integrating advanced materials such as carbon fibre and Kevlar into their aircraft to reduce aircraft weight and increase fuel economy.<sup>8</sup>

Industrial electronics and CPG firms are also focusing on designing more energy efficient products. For example, many electronics items are now designed with power management features such as low-power standby modes, and some CPG products, such as household appliances, are being designed to meet energy efficiency standards.<sup>77</sup>

### Design for recyclability and environmentally friendly disposal

Since North American CPG firms view consumer demand for environmentally friendly products as an important DfE driver, it is not surprising that approximately half of CPG firms focus on designing products that use more recycled materials and/or can be disposed of in an environmentally friendly manner (Figure 6).

**FIGURE 6**  
DfE practices for recycling and environmentally friendly disposal<sup>4</sup>



Cleaning product firms, for example, are creating products that contain minimal amounts of harmful compounds (such as ozone-depleting compounds and volatile organic compounds that contribute to smog, tropospheric ozone, and poor air quality). Other CPG businesses (such as in the beverage sector) are using DfE practices to produce low-cost, recyclable containers to reduce waste. A large proportion of CPG firms also focus on design for recycling because many CPG products have a short product life cycle.<sup>8</sup>

Design for recycling is also important for automotive companies; it involves designing parts that are made with recycled materials that can be recovered and reused from end-of-life vehicles. For example, some vehicle seats are designed to be manufactured with fabric made from 100% post-industrial materials. Aerospace firms are relatively less focused on DfE for recycling, which is related to the 30-plus year lifespan of their products. With such a long product lifespan, aerospace companies realize the benefits of DfE for recycling much later than companies in other sectors.<sup>9</sup>

Optimal disassembly is an important aspect of DfE to consider when designing a recyclable/reusable product. Design for Disassembly (DfD) is a concept embedded

<sup>77</sup> One example is ENERGY STAR. ENERGY STAR-designated products must meet and/or exceed minimum Canadian federal energy efficiency standards in accordance with a prescribed performance level applicable for each product area.

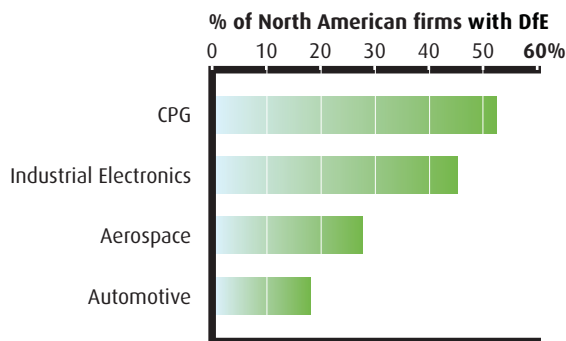
in the larger DfE framework that considers product assembly configurations that allow for economically efficient separation of recyclable components.<sup>10</sup>

Successful DfD includes applying three disciplines: the selection and use of materials; the design of components and the product architecture; and the selection and use of joints, connectors and fasteners. An example of DfD is the use of fasteners made from shape memory polymers or alloys in a product. These types of fasteners change shape when exposed to a temperature threshold, allowing them to be easily removed from a product and reducing the time for disassembly.<sup>11</sup>

### Design for reduced packaging

Design for the purpose of reducing packaging is a strategy often used by CPG firms; in fact, 52% of North American CPG firms with DfE practices in place focus on reducing packaging (Figure 7). An added benefit of implementing DfE practices in this sub-sector is that it often results in newly designed products that can be packaged in less space, thus helping companies also save on logistics costs. This process allows industry players to better comply with retail chains' green supply chain management mandates.<sup>##</sup>

**FIGURE 7**  
DfE practices for reduced packaging<sup>4</sup>



North American CPG firms are reducing their packaging footprint by implementing DfE in several ways. Some examples include: designing packaging that can be reclaimed; integrating biodegradable, reclaimed, or recycled materials into packaging; and integrating packaging into the product itself.<sup>12</sup>

### Business Context and Benefits of DfE Practices

Many firms still face challenges in the implementation of DfE practices, such as the high financial costs of the technologies involved and the complex task of integrating DfE processes into existing product design and development frameworks. Nevertheless, not only are some Canadian firms using DfE, but they are also gaining significant business benefits as a result.

Making the shift to DfE requires consideration and adoption of new approaches. Since the design process often uses advanced technologies such as computer-aided design, virtual product development, and rapid prototyping, making complex changes and adjustments to both the design process and its related technologies costly. In addition, the benefits of designing environmentally friendly products can be difficult to quantify, hindering a business' ability to justify the large investment needed. The International Organization for Standardization has a technical report (ISO/TR 14062) that provides a process model to help guide firms to integrate environmental thinking into the product design and development process.<sup>13</sup>

### Best-in-Class Analysis

With the increasing implementation of sustainable development concepts, DfE is being put into place as part of a firm's global environmental framework that includes green supply chain management practices.<sup>\*\*\*</sup>

BiC firms are defined as businesses that achieve positive results in the two main environmentally specific activities: improved product environmental impact and energy efficient distribution practices. BiC firms are often leaders in their respective industries. Currently, 10% of Canadian manufacturers meet these criteria while gaining significant business benefits such as:

- Increased product differentiation;
- Successful compliance;
- Increased sales;
- Improved access to foreign markets;

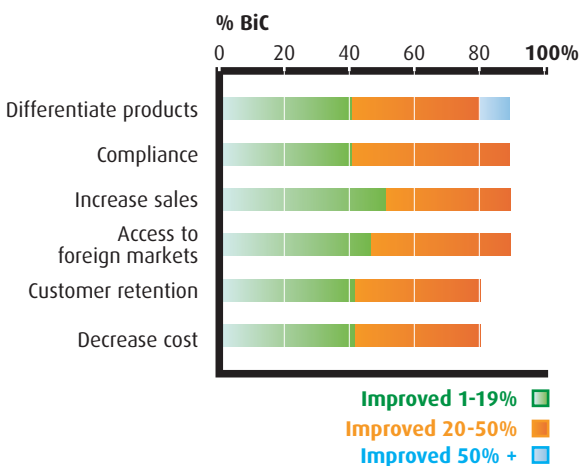
<sup>##</sup> See Industry Canada's "Green Supply Chain Management: A Retail Chain and Consumer Product Perspective"

<sup>\*\*\*</sup> Green supply chain management processes integrate environmentally friendly thinking into supply chain management (SCM). This includes implementing technical and innovative processes within material sourcing and selection, in the delivery of the final product to the consumers, and in end-of-life management.

- Increased customer retention; and
- Decreased cost.

Nearly 90% of BiC businesses are seeing improvements in successful compliance processes, product differentiation, foreign market access, and increased sales. In addition, these businesses are making significant gains in customer retention and cost reduction as a result of adopting such practices. Specifically, at least 40% of BiC firms have reported a 20–50% improvement in the six aforementioned business achievements, and 10% of BiC firms have noted an improvement of over 50% in product differentiation (*Figure 8*).

**FIGURE 8**  
**Business benefits - BiC businesses<sup>7</sup>**



By developing designs for products free of hazardous materials, a firm can reduce the time and resources required to obtain regulatory approvals and meet existing regulations. Simultaneously, a firm can realize cost savings by reducing the use of materials that have high disposal costs.<sup>14</sup>

Furthermore, by developing environmentally friendly products, a company can strengthen its reputation of corporate responsibility, which can improve customer retention and help further differentiate a product from other market alternatives.<sup>13</sup> Moreover, firms may be able to increase their market share and access new foreign and domestic markets by using DfE to add environmentally friendly features to their products. For example, as private and public organizations develop procurement

guidelines for environmentally preferable products, Canadian firms with established DfE capabilities will be able to take advantage of such “green” procurement policies and increase their market share.<sup>8</sup>

These associated business benefits differ for each specific industry (see Annex 1 for detailed BiC sectoral analysis). For example, all Canadian BiC automotive businesses report some improvement in foreign market access and increased sales. BiC aerospace businesses are seeing the greatest gains in foreign market access, increased sales, and decreased cost. Furthermore, 80% of BiC aerospace businesses have reported some improvements in product differentiation, successful compliance and customer retention. All Canadian BiC industrial electronics businesses have reported gains in all six business achievements. Approximately 75% of BiC industrial electronics businesses have seen an improvement of 20–50% in successful compliance, product differentiation, customer retention, and foreign market access.

## *Final Remarks*

To benefit from DfE, both product design and development service providers and manufacturers should develop their own business cases. Canadian companies should not only make the business benefits of DfE clear to their supply chain partners, shareholders, employees and senior management, but they should also make the environmental benefits of DfE clear by developing metrics that are universally understood — for example, expressing the CO<sub>2</sub> emission reduction of a newly designed product as equivalent to “x” number of cars taken off the road or “y” number of trees saved. Each business case should include recommendations and a roadmap for implementing the proposed DfE action plan. The roadmap exercise consists of documenting a long-term vision and classifying its components into specific actions linked to deliverables, performance indicators, objectives, return on investment, and the project time frame.

Below are some useful and wide-ranging DfE guidelines that businesses can follow when designing an environmentally friendly product once their action plans have been developed:<sup>15</sup>

- Analyze the product life cycle to understand where negative environmental impacts will occur;
- Identify which environmental impacts can be addressed during the design process;
- Select the DfE strategies that will reduce or eliminate the main negative environmental impacts;
- Discuss trade-offs with other departments within the organization; and
- Investigate and create design concepts that meet environmental goals by using selected DfE strategies.

For policy makers, the findings presented in this report draw important linkages between the drivers for adopting DfE practices, firm activities and resulting business benefits. These connections can help inform a continued dialogue across government and with stakeholders. This report also sets the stage for those interested in DfE trends to pursue new research opportunities and projects.

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## *Annex F: Best-in-Class Analysis*

### *I. Adoption of DfE Practices – % of firms*

	<b>Within Organization</b>	<b>With Customers</b>	<b>With Suppliers</b>
Manufacturing	25%	15%	10%
Large-scale business	40%	15%	10%
Medium-scale business	35%	10%	5%
Small-scale business	15%	5%	–
Automotive	50%	10%	5%
Aerospace	50%	10%	5%
Industrial Electronics	45%	10%	5%
CPG	20%	15%	10%

### *II. BiC Business Benefits – % of BiC*

	<b>Automotive</b>		<b>Aerospace</b>		<b>Industrial Electronics</b>	
	<b>Improved 1–19%</b>	<b>Improved 20–50%</b>	<b>Improved 1–19%</b>	<b>Improved 20–50%</b>	<b>Improved 1–19%</b>	<b>Improved 20–50%</b>
Product Differentiation	40%	40%	40%	40%	25%	75%
Successful Compliance	40%	40%	40%	40%	25%	75%
Customer Retention	40%	40%	40%	40%	25%	75%
Costs	40%	40%	60%	40%	75%	25%
Access to Foreign Markets	50%	50%	50%	50%	25%	75%
Increased Sales	60%	40%	60%	40%	50%	50%

‡ Supply Chain & Logistics Association Canada: Green Survey, 2008  
(-) = No result