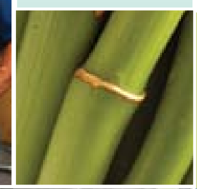
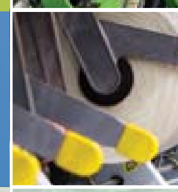
BEST PRACTICES IN GREEN MANUFACTURING AND TECHNICAL TEXTILES





Key skills for a changing industry

Textiles Human Resources Council
Conseil des ressources humaines de l'industrie du textile

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An electronic copy of this report and the executive summary are available online at www.thrc-crhit.org/en/gtt.

Canada

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The opinions and interpretations in this publication are those of the author and do not necessarily reflect those of the Government of Canada.

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EXECUTIVE SUMMARY

The Textiles Human Resources Council's (THRC) *Green Manufacturing and Technical Textiles* initiative was conceived in response to a need identified in the *Technology Roadmap for the Canadian Textile Industry* (2008) and THRC's recent *Labour Market Information and HR Needs Assessment* (2010) reports, which together captured the face of today's Canadian textile industry and charted its future course and global positioning.

Green Manufacturing and Technical Textiles Focus Group (April 2011, Québec)

The reports reveal a broad industry belief that textile production in Canada would be enhanced with the movement to the manufacturing of specialized products (technical and other value-added textiles) in response to the various forces driving demand in the sector, specifically global production and market demands, environmental concerns, changing demographics, and international trade agreements.

The *Green Manufacturing and Technical Textiles* initiative has as its ultimate goal the development of a skills framework and inventory enabling the Canadian textiles industry to respond to key opportunities and challenges by (1) generating awareness of requirements for skills upgrading, (2) identifying new human resources and recruitment needs, and (3) allowing companies to assess the impact of new production methods and technologies on key occupational groups.

Research and Industry Validation Process

This report and attendant *Green Manufacturing and Technical Textiles Skills Inventories* were developed with secondary research contribution from CTT Group, ellipsos inc., l'École de technologie supérieure (ETS), the Institute for Product Development (IDP), and the University of Manitoba, and represent the culmination of the first phase of this initiative.

Following an examination of available literature on best practices in technical textiles production and green manufacturing both domestically and internationally, an industry consultation and validation process was undertaken with more than 150 industry participants.

Key Findings

The transition to technical textiles production for specialized end-use markets and the adoption of green manufacturing processes requires companies to review products and markets, change processes and machinery, and upgrade and develop workforce skills in order to ensure the continued survival and global competitiveness of the Canadian textiles manufacturing industry.

The research and industry validation process revealed that the global and domestic trend is towards collaborative manufacturing environments in which multidisciplinary teams work together and with clients and/or users on new product design and development.

Further, it was found that not only are the vast majority of existing occupational skills and competency profiles within the textile industry outdated and no longer representative of the realities of the workplace, but also that new key occupations have emerged for which there are currently no industry competency standards. 80% of occupations in the textile industry will see significant changes to their job roles and responsibilities as a result of the move to technical textiles production and green manufacturing. Of the eight key industry occupational groups identified in the 2010 *Labour Market Information and HR Needs Assessment* survey,[1] fully 100% of occupations will need to be reviewed and re-developed in order to reflect current and anticipated industry changes resulting from the move to technical and sustainable textiles production.

> *Fully **80%** of occupations in the textile industry will see significant changes to their job roles and responsibilities as a result of the move to technical textiles production and green manufacturing.*
>
> – THRC *Best Practices in Green Manufacturing and Technical Textiles* (2011)

Employees must acquire new knowledge and skills to process or create materials and develop and use new production methods and technologies.

In today's textile industry, the acquisition of new skills and the sharing of existing skills between workers are equally important to the success of the sector, directly affecting the recruitment and retention, talent management, and day-to-day operations and performance of all those involved in an organization.

Recommendations

The findings of this report confirm the urgency with which the industry must respond to changing occupational needs at all levels resulting from the gradual move towards technical textiles production and the adoption of sustainable manufacturing practices.

The following key recommendations are presented to assist the Canadian textile industry in adopting and integrating sustainable manufacturing processes and transitioning to production of technical textiles:

1. Existing occupational profiles and skills and competency standards for key existing occupations should be revised and adapted to reflect the realities of the changing industry and respond to evolving global demands. Specifically, attention should be paid to reviewing profiles and standards for the top key affected occupations as identified by the industry, namely: R&D Specialists, Senior Managers, Marketing & Sales occupations, and Procurement occupations. Profiles and standards should be established for new and emerging key occupations as they are identified within the industry.

> *There is a **pressing need** to redefine the industry's HR approach in response to changing occupational needs.*
>
> – THRC *Best Practices in Green Manufacturing and Technical Textiles* (2011)

2. The textile industry is rapidly changing, and a range of new and specialized skills is required to ensure its ability to meet the needs of the various specialized end-use sectors it now increasingly serves, such as: hygiene and medical (medtech), building and construction (buildtech), transportation (mobiltech), and protection (protech).

[1] Senior/Specialist Managers, Supervisors, Engineers, Technicians, R&D Specialists, Mechanics, Machine Operators, and Sales and Business Development Personnel.

The existing and broadening occupational skills gap resulting from the move to technical textiles production and the adoption and integration of green manufacturing practices should be further examined, and potential avenues of redress explored. These avenues could include employee upskilling and knowledge acquisition through formal (e.g.: certification and diploma programs, etc.) and informal (e.g.: virtual knowledge-sharing and problem-solving networks, in-person and online workshops, etc.) training and learning.

3. Identified best practices in green manufacturing and technical textiles should be communicated broadly and a benchmarking strategy developed and implemented to establish a means of continuously and accurately positioning the Canadian textiles industry within the domestic and global manufacturing context. This benchmarking strategy should address various key industry facets and performance indicators (e.g. technological, commercial, educational, etc.) and be evaluated regularly to ensure alignment with industry progression. Central to this strategy should be a plan for the continuous collection and evaluation of labour market intelligence.

Next Steps

The THRC is working with industry, educational, provincial and federal government, and related stakeholders on the development and implementation of potential solutions to guide the next phase of the *Green Manufacturing and Technical Textiles* initiative. In response to industry feedback solicited over the course of the first phase of this initiative and attendant recommendations captured in this report, options will be explored for evaluating and where necessary revising the profiles of affected textile occupations to reflect changes occurring in the industry.

TECHNICAL TEXTILES
Key Competencies and Knowledge

Occupations

ENGINEERING	HUMAN RESOURCES	PROCUREMENT	R&D SPECIALISTS
FINANCE	MARKETING AND SALES	PRODUCTION	SENIOR MANAGEMENT

SKILLS

- Adaptation to new distribution channels
- Adaptation to new marketing and communication strategies
- Flexibility and adaptation to customer special requests
- Innovation and creativity
- Polymer science
- Characterization of yarns and fibres
- Ability to work with non-textile sectors
- Chemical, mechanical and electronic engineering
- Adaptation to new technology, machinery, and equipment
- Ability to work as a team with people from other disciplines

KNOWLEDGE

- Regulations and clients' needs
- Technical textiles applications and processes
- New markets and new end-use clients' needs
- Hazardous materials
- New technologies and equipment
- Technical fibres reinforcement
- Textile chemistry
- International purchasing

Benefits of TECHNICAL TEXTILES PRODUCTION

Improved Corporate Image	Competitive Advantage	Product Development
Innovation	Market Development	New Technology Development

Source: Textiles Human Resources Council (THRC) *Best Practices in Green Manufacturing and Technical Textiles* (2011). Industry validation with more than 45 Canadian textile manufacturing firms.

GREEN MANUFACTURING
Key Competencies and Knowledge

Occupations

ENGINEERING	HUMAN RESOURCES	PROCUREMENT	R&D SPECIALISTS
FINANCE	MARKETING AND SALES	PRODUCTION	SENIOR MANAGEMENT

SKILLS

- Strategic and long term planning
- Mobilizing employees to integrate steps to sustainable development
- High level of ethic, integrity and social justice
- Change management
- Creativity – innovation
- Life cycle analysis
- Responsible procurement
- Ability to adapt to change – flexibility
- Principles of responsible marketing
- Skills in engineering – scientific expertise – technology solutions

KNOWLEDGE

- Sustainable development principles
- Standards, trends, financial programs
- Stakeholders' roles
- Environmental regulations
- Products prohibited for production
- Sourcing policies
- Regulations on chemical substances in foreign countries
- Green labels
- Customer trends
- Environmental hazards

FACTORS

- Environmental regulations
- Certifications
- Ecolabels
- Stakeholder expectations
- Hazardous material restrictions

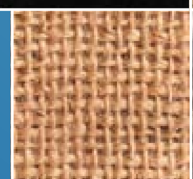
Benefits of GREEN MANUFACTURING

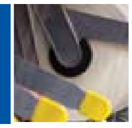
Improved Corporate Image	Competitive Advantage	Eco-innovation
Cost Savings	Product Development	Market Development

Source: Textiles Human Resources Council (THRC) *Best Practices in Green Manufacturing and Technical Textiles* (2011). Industry validation with more than 45 Canadian textile manufacturing firms.

BEST PRACTICES IN TECHNICAL TEXTILES



Contents

1 Introduction

This study was undertaken in order to:

1. Present the current state of technical textile developments in Canada, the United States, and Europe;
2. Identify the developments in thirteen (13) applications of technical textiles in Canada and internationally;
3. Identify the technical skills required for various technical textile subsectors;
4. Identify best practices; and,
5. Make recommendations.

1.1 What are Technical Textiles?

Technical textiles are "textile materials and products manufactured primarily for their technical and performance properties rather than their aesthetic or decorative characteristics".[1] Technical textile materials are developed for specific end-uses, the twelve primary end-use applications, as identified by Messe Frankfurt,[2] being:

Agrotech — Agriculture, horticulture, forestry, and landscaping

Clothtech — Technical components of footwear and clothing

Hometech — Technical components of furniture, household textiles

Medtech — Hygiene and medical

Oekotech — Environmental protection, waste disposal, and recycling

Protech — Personal and property protection

Buildtech — Building and construction

Geotech — Geotextiles and civil engineering

Indutech — Filtration, conveying, cleaning and other industrial applications

Mobiltech — Automobiles, rail, maritime, and aeronautics

Packtech — Packaging, covering, transportation

Sporttech — Sport and leisure

In this report, a new end-use application is added to Messe Frankfurt's list:

- **Smarttech:** intelligent textiles

[1] The Textile Institute, *Technical Textiles Terms and Definitions*, (Manchester, England: Textile Institute, 1975).
[2] Messe Frankfurt, *Techtextil Application Areas* (2011), techtextil.messefrankfurt.com/frankfurt/en/besucher/messeprofil/anwendungsbereiche.html

Technical textiles are most commonly produced for use in the manufacturing of goods for the Protection, Medical (Hygiene and Health), Sport & Leisure, Construction, Industrial, and Environmental sectors, where specialization and functionality of materials are key. The following table provides examples of the primary functions and properties applicable to technical textiles used for the above-mentioned applications:

Table 1: Examples of primary functions and properties applicable to technical textiles produced for Protection, Medical, Sport & Leisure, Construction, Industrial, and Environmental sectors

FUNCTIONS	PROPERTIES*	USUAL TEXTILE MATERIAL
Mechanical	• Count • Tenacity • Breaking strength • Elastic modulus • Breaking elongation • Tensile force • Compression and bending strength	• Inorganic fibre (steel, carbon, glass, silica) • Organic fibre • High Tenacity or High Modulus (polyamide (PA), polyethylene terephthalate (PET), polysulfone (PES), polypropylene (PP), aramid)
Thermal	• Flame resistance (flammability, velocity, persistence, LOI) • Heat and Thermal resistance (melting and degradation temperature) • Dilatation properties	• Thermostable fibre • Inherently flame retardant fibre • Blend of fibre or treated fibre • Aramid, glass, organic fibre
Electrical	• Conductivity and resistivity • Dielectrical properties and electromagnetism • Static electricity	• Coated yarns • Hybrid or gimped yarn • Textile surface functionalized (e.g. metalized) • Materials capable of electromagnetic interference (EMI) shielding • Heat treatment by high frequency on dielectric materials
Chemical	• Chemical resistance properties • pH sensibility • Humidity (moisture regain)	• Solvent, base and acid resistant fibres (para-aramid, chlorofibre and fluorofibre, polyetheretherketone (PEEK), polyphenylene sulfide (PPS), ultra-high-molecular-weight polyethylene (UHMwPE), PP)

* These properties can, in most cases, be determined and tested in fibres, yarns and fabrics.

2 Textile Industry Overview

2.1 The Canadian Textile Industry and the Move Toward Technical Textiles

Today's textile industry remains a major employer in Canada, accounting for approximately 43,526 jobs in 2010,[3] and in the year 2000 the industry posted one of the highest innovation intensity rates at 85.8% (compared to 80.2% for industries as a whole). Canadian research and development (R&D) activities significantly outstripped those of the United States, measuring in at 1.3 against 0.5 for the United States.[4]

In 2006, total textile production in Canada was placed at an estimated $5.7 billion. The value of Canadian textile exports for the same year amounted to approximately $2.7 billion — establishing it as Canada's sixth-largest export industry. Nearly 82% of exports were destined for the United States, with the majority of the remainder being exported to Asia, Europe and South America. From 1996 to 2005, textile manufacturers contributed over $4 billion to the Canadian economy.[5]

With the economic downturn in 2004, several Canadian firms experiencing low profitability in the traditional textiles industry began taking steps toward a strategic move into the technical textiles markets, recognizing the significant growth potential offered by this competitive market. High costs associated with product development, lack of information about potential new target markets, and a lack of R&D activities in the field all posed significant challenges to the firms initiating a transition to technical textile production.

In 2008, however, firms initiating or continuing a move to this newly identified market found support and guidance with the release of the *Technology Roadmap and Action Plan for the Canadian Textile Industry* (herein referred to as the *Textile Technology Roadmap*). The *Textile Technology Roadmap* calls for the adoption of a new industry strategy focused on the design and production of specialized products — specifically technical and other value-added textiles — for specialized markets, and identifies four Technical Usage Textiles (TUT) application sectors with high growth potential for the industry, namely: Protech, Mobiltech, Buildtech and Medtech.[6]

R&D activities are crucial to the successful design and development of new textile-based products to meet the demands of these four identified TUT application sectors. Commitment to, and investment in, R&D is used as a major indicator when evaluating the Canadian textile industry's entrance into the technical textiles market.

In 2007, the most recent year for which personnel counts are available, 147,599 full-time equivalents (FTE) were performing tasks related to industrial R&D across Canadian industries — a 16% increase in research efforts over 2003 (127,205) — with an estimated 702 of these FTEs working within the textile industry. Between 2005 and 2009, the textile industry spent an estimated total of approximately $231 Million on R&D, the majority of which went towards paying salaries and wages.[7]

3 Textiles Human Resources Council, *Canadian Textile Industry Labour Market Information and HR Needs Assessment: a report on the changing face of Canada's textile industry* (Ottawa: Textiles Human Resources Council, 2011) p. 1.
4 Lee, Po-Chih and Steven Tzeferakos, *Innovation Performance in Canadian Manufacturing Industries* (Ottawa: Industry Canada, 2001), p. 34.
5 Canadian Textiles Institute, *The Canadian Textiles Industry… at a glance (Ottawa: Canadian Textiles Institute, 2006).*
6 CTT Group, *Technology Roadmap for the Canadian Textile Industry* (Québec: The CTT Group, 2008) pp. 7–8.
7 Statistics Canada, *Industrial Research and Development: Intentions 2009* (catalogue no. 88-202-X) p. 15.

2.1.1 Why Technical Textiles are Essential to the Canadian Textile Industry's Future Success

The worldwide growth in demand for technical and value-added textiles has been broadly acknowledged,[8] and in 2008 the Canadian textile industry committed in the *Textile Technology Roadmap* to a long-term plan to position itself as excelling in technical textiles production. In an increasingly intense competitive environment which has rendered the production of commodity textiles not viable, this strategy is critical to the continuous evolution of the industry.

Although the Canadian textile industry has been shrinking, a number of textile subsectors have seen positive trade balances consecutively from 2000 to 2009. The export performance of these subsectors lends additional evidence to support the *Textile Technology Roadmap*'s conclusion to further develop the technical textiles sectors.

Table 2: Canadian textile industry subsectors reporting consecutive trade balances from 2000 to 2009[9]

HS CODE**	DESCRIPTION
5402	Synthetic filament yarn
5903	Textile fabrics impregnated, coated, covered or laminated with plastics***
5906	Rubberized textiles
5909	Textile hosepiping and similar textile tubing
5911	Other textile products and articles for technical uses

** Harmonized System Code (HS Code)

*** HS 5903 shows consecutive trade balance from 2001 to 2009.

The establishment of textile technology platforms is not unique to Canada — in 2004, Europe launched its textile technology platform which identifies industrial sectors as one of its targets.[10] More recently, in 2010 the Government of India released a five-year plan to develop its technical textiles industry, a strategy which involves establishing four centers of excellence to focus on nonwovens and composite textiles for industrial and sports end-uses.[11] As other regions of the world work toward achieving growth in technical textiles R&D, Canada must not be a bystander to the ever-evolving developments in the international textiles sector.

2.1.2 New Product Development — Implications

The pursuit of technical textile manufacturing as a strategic industry path has profound implications for human resources management. New Product Development (NPD) is defined as "the overall process of strategy, organization, concept generation, product and marketing plan creation and evaluation, and commercialization of a new product."[12] The amount of adaptation and transformation required of a firm or sector moving from the traditional textile industry towards technical textile manufacturing is significant, and includes not only the adoption of new technical skills and processes but also restructuring of working relationships — both internal and external/client-facing — and revisiting of established priorities, outlooks, and approaches.

8 David Rigby Associates, *Technical textiles and nonwovens: World market forecasts to 2010* (2002), www.davidrigbyassociates.co.uk/DRA%20WEBSITE%2003/assets/TTandN.pdf
Van Delden, H. H., *International Textile Manufacturers Federation, Annual Conference Report* (2009) pp. 1–16.
9 Industry Canada, *Trade Data Online* (2011), www.ic.gc.ca/eic/site/tdo-dcd.nsf/eng/Home
10 European Apparel and Textile Organization (EURATEX), *European Technology Platform for the Future of Textile and Clothing — A Vision for 2020* (Belgium: EURATEX, 2004).
11 Government of India, Ministry of Textiles, Office of the Textile Commission, *Technology Mission on Technical Textiles* (Government of India, 2011).
12 Product Development Management Association, *NPD glossary* (2011), www.pdma.org/npd_glossary.cfm.

Whereas the markets for standardized products demand from their suppliers the capacity to produce large volumes of textiles at the lowest per unit cost, the markets for technical textiles demand that their suppliers treat textiles or textile-based materials as solutions to highly specific problems. In some cases, a textile firm may not have a known technology to respond to a client's demands. To arrive at a solution, textile firms have to engineer one. This new product engineering, as explains Gernot H. Gessinger, is a multi-skill task.

> "When it comes to starting from a really new material that is still in the research stage (e.g. nanotechnology), we are faced with an abundance of unanswered questions, which never will be answered by any theory or tool. So, to use Peter Drucker's expression of *convergence*, a range of skills has to be handled by either one person or a team of specialists who know how to communicate and exchange views and opinions."[13]

The level of customization and specialization required when serving technical textiles markets for specific end-uses is markedly higher than that required in production for standardized product markets. As such, technical textile product development teams are likely to be comprised of material scientists, technicians, engineers, and marketing and logistics personnel.

Furthermore, to be able to produce technical textiles that meet the performance criteria specified by the client, the client's knowledge of the end-users and the use environment must be incorporated into the development and design process. The product development process therefore involves input from two major parties — the product development team and the client.

For their solutions to be effective, the knowledge and skills held by each team member must be shared. In order to create a vibrant technical textiles sector, the learning of new skills is just as important as preparing scientists, engineers, technicians, sales and marketing personnel to purposefully seek and consider each other's input as valid contributions to the design, process, management, and marketing dimensions of new product development. This mutual sharing of knowledge and skills requires the effective development and management of knowledge networks.

[13] Gessinger, G. H., *Materials and Innovative Product Development: Using common sense* (Burlington, MA : Butterworth-Heinemann, 2009), pp. 3–4.

2.2 Overview of the American and European Textile Industries

2.2.1 The U.S. Textile Industry

As the third largest global exporter of textile products and one of the largest manufacturing sectors in the United States, the American textile industry remains a significant player both domestically and internationally. In 2010, according to the National Council of Textile Organizations, the U.S. textile industry counted over 560,000 employees — with 255,000 of these workers employed in textile mills and textile product mills. In 2008, the U.S. spent $811 million on R&D for textile, apparel and allied leather products,[14] and between 2001 and 2008 the industry invested nearly $14.5 billion in new plants and equipment.[15]

In 2008, the United States spent $811 million on R&D for textile, apparel, and leather and allied products.

Figure 1: 2009 U.S. textile and apparel trade[16]

IMPORTS

- $81 billion total textile and apparel imports
- 40% of imports originated in China ($31.8 billion)
- 65% of imports originated in India, Vietnam, China and CAFTA-DR (Central American – Dominican Republic – United States Free Trade Agreement) and NAFTA (North American Free Trade Agreement) countries
- $1.31 billion in imports originated in Canada

EXPORTS

- $13.6 billion total textile and apparel exports
- 70% of textile and apparel exports destined for NAFTA and CAFTA-DR countries

From 2000 to 2009, U.S. importation of textiles and apparel from Canada dropped from $3.35 billion to $1.31 billion — a 60.8% decrease.

[14] National Science Foundation (NSF), *U.S. Businesses Report 2008: Findings from New NSF Study*, InfoBrief Science Resource Statistics (NSF 10–322, May 2010) p.2., www.nsf.gov/statistics/infbrief/nsf10322/nsf10322.pdf

[15] National Council of Textile Organizations (NCTO), *U.S. Textile Industry* (2010), www.ncto.org/ustextiles/index.asp

[16] National Science Foundation (NSF), 2010. Botero, S., *Overview of U.S. Textile and Apparel Trade and the Importance of Advanced Textiles*, Delivered at Expo-Hightex 2010 (Montreal, October 6–7, 2010).

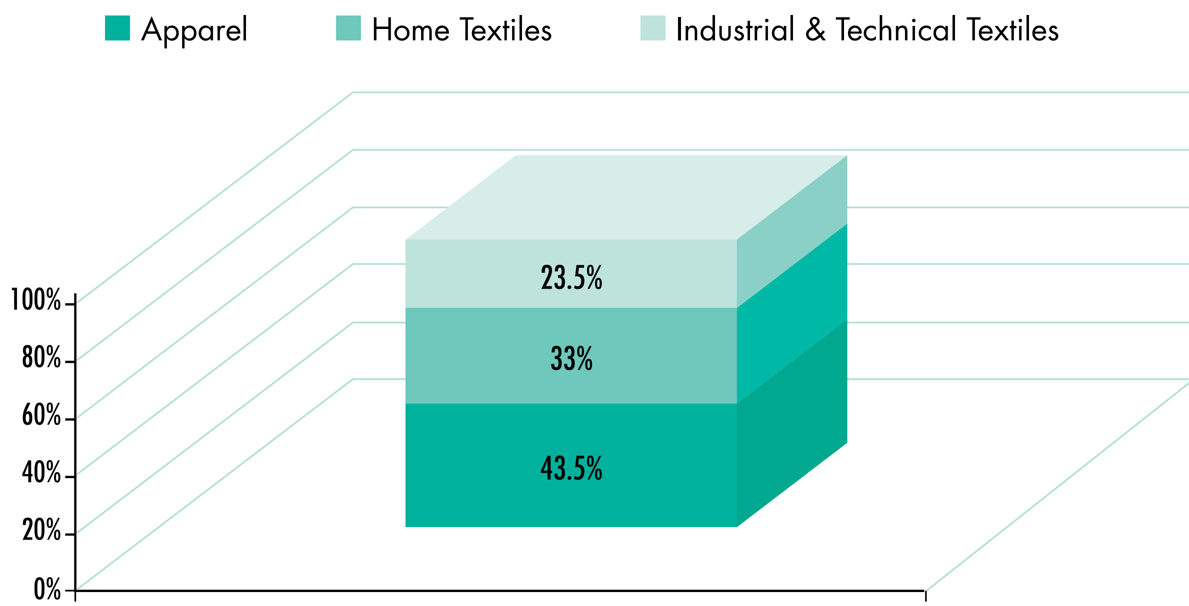
2.2.2 The European Textile and Apparel Industry

Textiles and apparel manufacturing constitutes one of Europe's major industries, with approximately 200,000 firms employing more than 2.3 million individuals, and turnover of just under €2 billion (2007, the most recent year for which data is available).[17]

In 2004, the European Apparel and Textile Organization (EURATEX) published its *European Technology Platform for the Future of Textile and Clothing — A Vision for 2020*, calling for an increase in R&D and innovation commitments and initiatives, and identifying three primary "pillars" to support the future success of the industry. These three pillars commit the industry to:

> "(1) Move from commodity fibres, filaments & fabrics, towards specialty products from flexible high-tech processes; (2) [Establish] textiles as the raw material of choice in many industrial sectors and new application fields; and (3) End the era of mass manufacture of textile products, and move towards a new era of customisation, personalisation, intelligent production, logistics and distribution."[18]

Figure 2: European Textile Production, 2003[19]



[17] EuroStat European Commission, *European Business Facts and Figures: 2009 Edition* (Luxembourg: Office for Official Publications of the European Communities, 2009).
[18] EURATEX 2004, p. 3.
[19] EURATEX 2004, p. 3.

For further information about the European textile sector and selected European technical textiles initiatives, please explore the websites below.

LEAPFROG IP

www.leapfrog-eu.org

Leadership for European Apparel Productions from Research along Original Guidelines.

AVALON

www.avalon-eu.org/cms

Multifunctional textile structures driving new production and organizational paradigms by textile SME interoperation across high-added-value sectors for knowledge-based product/service creation.

CLEVERTEX

www.clevertex.net

European Commission-funded program, aiming at developing a master plan and a framework for future actions in research, education and technology transfer in the European textiles sector.

SPACE2TEX Report

www.euratex.eu/content/space2tex-waste-water-recycling-textile-finishing-through-application-and-further-developmen

Wastewater recycling in textile finishing through the application and further development of membrane bio-reactors used in space life-support systems.

TEX-MAP Report

www.euratex.eu/content/tex-map-new-organization-and-e-business-solutions-conventional-and-non-conventional-textiles

New organization and e-business solutions for conventional and non-conventional textile applications: a roadmap.

3 Motivation for Moving to Technical Textile Production

3.1 Competitive Advantage

Canada's involvement in the U.S.–Canada Free Trade Agreement (FTA) (1989), the North American Free Trade Agreement (NAFTA) (1994), and the Agreement on Textiles and Clothing (ATC) (1995) has both furnished opportunities for, and presented threats to, the Canadian textile industry. The FTA and NAFTA offered the Canadian textile industry the opportunity to establish export relationships with the United States — Table 4 (below) shows that the 10-year period from 1990 to 2000 saw Canada's share of world textile exports grow from 0.7% to 1.4%. However since then, and especially after the termination of the ATC on January 1, 2005, Canada's share of world exports of textiles has been declining. From 2000 to 2009, textile exports constituted an increasingly smaller share of Canada's total merchandise export. Table 3 (below) shows that as Canada's textile exports waxed and waned, the United States continues to be the major market.

Table 3: Share of Canadian textile exports destined for the U.S.[20]

Year	Share (%) of Canadian Exports Destined for the U.S.
1992	78
2000	92
2001	93
2002	93
2003	90
2004	90
2005	90
2006	88
2007	86
2008	86
2009	85

Table 4: Share of Canadian textile exports — global and national perspectives[21]

Year	Share of World Exports (%)	Share of Canada's Total Merchandise Export (%)
1980	0.6	Data not available
1990	0.7	Data not available
2000	1.4	0.8
2006	1.1	0.6
2007	1.0	0.6
2008	0.8	0.4
2009	0.8	0.5

20 Industry Canada, 2011.
21 World Trade Organization, *International Trade Statistics 2001, 2007, 2008, 2009, 2010*, www.wto.org/english/res_e/statis_e/statis_e.htm.

With an overall decline in textile exports from Canada, the subsector "Coated, Impregnated, Covered or Laminated Fabrics and Industrial Textiles" is the only one that recorded positive trade balances for six consecutive years, from 2004 to 2009, as can be seen in Table 5 (below).

Table 5: HS 59 Coated, Impregnated, Covered or Laminated Fabrics and industrial textiles trade balance 2000–2009 (in millions $CDN)[22]

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
-155	-134	-80	-44	50	68	74	116	115	94

The export performance of industrial textiles shows that Canada enjoys competitive advantage in this subsector, which also embraces some of the textile end-uses identified as growth areas in the *Textile Technology Roadmap* (Medtech, Buildtech, Protech, Mobiltech). Furthermore, the R&D inventory shows that universities and research organizations in Canada are engaging in research in textiles or textile-based materials in these areas.

Although the Canadian textile industry is small in comparison to others, the small size of the textile community may yield benefits. For example:

1. Small or medium sized firms are more flexible in their ability to respond to changes in the market.
2. The communication channel between the scientific community and the industry is relatively direct and manageable.
3. Opportunities for collaboration between the scientific community and the industry will be more readily identified.

22 Industry Canada, 2011.

3.2 New Opportunities

Five (5) major categories of opportunities for Canadian textile manufacturers were identified in the *Textile Technology Roadmap*, specifically: new markets, product development, new technologies, new demand factors, and collaborative work.

Table 6: The five major categories of opportunities for Canadian textile manufacturers, as identified in the *Textile Technology Roadmap*

<table>
<tr><th>New Markets</th><th>Product Development</th><th>New Technologies</th></tr>
<tr>
<td>• New niche markets
• High value-added markets
• Markets corresponding to new needs/market-generated needs
• New markets emerging as a result of industry-driven innovations</td>
<td>• Development of entirely new products
• Improvement of existing products (i.e. through the addition of new functionalities)
• Transfer of existing technological innovations to new applications</td>
<td rowspan="3">• Intelligent textiles (e.g. sensors, light sources, actuators) for energy transfer and as reactive, adaptive, responsive components
• Nanotechnologies (e.g. surface treatments, finishing treatments, nanofibres, nanowebs, nanocomposite fibres)
• Nonwovens — increased applications (e.g. with hybrid structures combining several processes and improved mechanical performance)
• Polymer-based composites — increased demand (will benefit from 3D textiles, net-shape performs, and energy absorbing/dissipative structures)
• High-performance fibres and fabrics — leading to improved durability (e.g. through combination of different materials)
• Biomaterials/natural fibres — recyclability, biodegradability, increased energy efficiency, less chemically-intensive processes
• Surface treatments (e.g. plasma treatments) for water-proofing, oil-proofing, surface functionalization, etc.
• Other technologies</td>
</tr>
<tr><th>New Demand Factors</th><th>Collaborative Work</th></tr>
<tr>
<td>• Collaborative work is seen as a major contributor to success in technical textiles production
• Collaboration can occur between industry and R&D centre researchers, as evidenced by the scientific support available in Canada on subjects of interest for the textiles industry
• Collaboration should also result from partnerships and networking through the value chain</td>
<td>• Population growth and aging
• Environmental concerns
• Geopolitics and world conflicts
• Regulations and trade agreements
• Purchases by government channels
• Changing availability of natural resources
• Increased purchasing power
• Industrialization/de-industrialization
• Ease of transportation
• Increased expectations in terms of quality of life</td>
</tr>
</table>

These new opportunities give technical textiles manufacturers a strong advantage in overcoming the challenges currently faced by the Canadian textile industry.

4 Key Developments, Challenges, and Trends in Technical Textiles

Recent advancements in coating, functional finishing and composite techniques allow textile-based materials to offer new benefits — such as unique lighting effects, superior environmental (weather, flame and fungus) resistance and self-cleaning properties — in addition to their intrinsic advantages (e.g.: light weight, low cost, flexibility and recyclability). For example in Buildtech — one of the five industry-dominant textile application sectors as identified in the *Textile Technology Roadmap* — there is a general trend toward adopting natural fibres (e.g.: coir, hemp) over synthetic fibres for enhanced sustainability, and using advanced technology to mitigate inherent limitations.

The table below provides an overview of the current key products and technologies, primary challenges, and main trends of the thirteen (13) TUT application sectors, as introduced in Section 1.1 of this report.

Table 7: Key products, technologies, and primary challenges and trends of the thirteen (13) primary TUT application sectors

Key Products/Technologies	Primary Challenges	Main Trends
MOBILTECH		
• 1D and 2D reinforcement-based composites • Warp knitted fabrics • Nonwoven • PU foam as a filler material • 3D knitted fabrics or spacer fabrics as seat covers and fillers at the same time (used but very new) • Circular knitted fabric • Polyester and nylon webbing used for seatbelts • Woven nylon 6.6 for airbags • Polyester and polypropylene backing for carpet • Tufted carpets • Needlepunched carpets • Nonwoven (spunbond, meltblown) • Activated carbon filters • Microfibres • Nonwoven (wetlaid, meltblown, airlaid, needled composite technologies) • Foam made of polyurethane (PU) • PET flexible, semi-rigid and rigid thermoformable foams • Natural fibres • Synthetic fibres • Water jet stabilized microfibre nonwovens	• Reduction in weight and fuel consumption • Cost efficiency • Competitivity • Recyclability • Aesthetic • Safety • Reduction in flammability • Durability • Performance monitoring • Higher requirements • Lean manufacturing • Green manufacturing • Reduction in variability • Sustainability	• Customization of textiles for interiors • Composites for structural parts • 3D textiles for net-shape preforms • Spacer fabrics • Integration of end-of-life indicators • Self-healing materials • Multifunctional textiles and materials (functionalization of textile surfaces or 3D structures) • Coating of airbag fabrics with new silicone based nanomaterials • Anti-bacterial/stain-resistant/self-cleaning (nano) coatings • Nanocomposites (carbon nanotubes, nanoclay) • Sensors or smart materials embedded into textiles • Use of natural fibres • High performance fibres • Nanofibres, nanomesh, nanotextiles • Life cycle analysis

Table 7 (continued)

Key Products/Technologies	Primary Challenges	Main Trends
BUILDTECH		
• Fibrous web insulation formed by mechanically laying and horizontally cross-lapping, followed by bonding (mechanical, thermal, or chemical) • Sheet insulation formed by aerodynamically laying followed by bonding • A variety of lighter, stronger, rot-, sunlight- and weatherproof (also often fireproof) synthetic materials • Glass, polypropylene and acrylic fibres-reinforced composites • Architectural non-woven membranes • Net made from high-tenacity, nylon mesh • Rope made from low density and high strength HMPE (high modulus polyethylene)	• High logistical cost for construction materials made from natural fibres	• Use of natural fibres for better sustainability • "Greener" composites: e.g. replacement of harmful materials such as copper chrome arsenic treated wood by wood plastic
CLOTHTECH		
• Knitted and woven fabric • Synthetic (polyester; polypropylene; nylon; viscose) and natural fibres (cotton and wool) • Fleece fabrics • Full-fashion knitting technique • Whole garment knitting technique • Stretchable fabric (even woven fabrics) • Elastane • Crease-resistant fabric (resin finishes) • Heat-setting for shrinkage control • High-heat-sensitive fibres • Moisture management material or treatment • Microfibres • Denim woven fabric • Waterproof and breathable (membrane coating or laminating) • Windproof materials (woven fabric-laminated membrane) • UV-resistant material (nylon coated with urethane) • Cut resistant fabric: high-performance fibres (para-aramid fibres) • Reflective materials (labels) • Waterproof sewing • Ultrasonic sealed sewing • Inkjet printing for labels	• Comfort • Cleansing • Odours • Toxicity • Sizing • Cost • Durability • Colourfastness	• Integration of smart materials for active thermoregulation functions • Antibacterial functions onto garments • Stain repellent finishing treatment • Ultra absorbent material (sweat absorbent) • Use of natural fibres such as bamboo for garments • Integration of smart materials (heating and cooling purposes) • Integration of nanomineral materials • Eco-friendly finishing processes • Anti-cell phone radiation fabrics • Non-abrasive fabric • Plasma dyeing • Microencapsulation of active components (smell, hydration, etc.)

Table 7 (continued)

Key Products/Technologies	Primary Challenges	Main Trends
	GEOTECH*	
• Polyethylene (PE) fibres • Polypropylene (PP) fibres • Polyethylene terephthalate (PET/PETE) fibres • Nylon fibres • Needlepunching • Woven • Nonwoven • Warp-knit	• Cost • Recyclability/reusability of materials • Product recyclability/ environmentally friendly disposal	• Development of geocomposites (combinations of two or more separate materials in one product) • Development of multi-functional geotextiles • A trend towards "green" materials from renewable resources**
	HOMETECH	
• Woven polyester fabrics • Jacquard fabrics • Warp knitted fabrics • Narrow knitted fabrics • Narrow woven fabrics/tapes • Tufted material • Circular knitted fabric • Cotton fibres (Supima®, etc.) • Quilted textile • Coated fabric • Microfibres • Microdenier suede • Printed fabrics • Laminated material • Metallized fabrics	• Colourfastness to wet and dry crocking • Colourfastness to light • Physical properties • Abrasion • Odour control • Flame resistance • Pilling • Cost of natural fibres • Cost of synthetic fibres • Acoustic insulation (offices, panel, etc.) • Aesthetic aspect (fashion trends)	• Eco-friendly materials • Life cycle assessment • Recycled materials used to make new home textiles • Natural materials • Antibacterial properties/hypoallergenic fibres • Stain resistance • Odour control • Home textiles preventing humans from EMI damage • Electroluminescent component embedded onto home textiles (curtains, etc.) • Photovoltaic cells on curtain • Neutral colours (earth colours for eco-friendly feeling) • Orthopaedic pillows
	INDUTECH	
• Polysulfone (PES) fibres • Polyamide (PA) fibres • Polypropylene (PP) fibres • Polytetrafluoroethylene (PTFE) fibres • Polyimide (PI) fibres • Metallic fibres • Glass fibres • Aramide fibres • Carbon fibres • Alumine fibres • Natural fibres (cotton, bamboo, etc.) • Lyocell • Microfibres • Silicone impregnation	• Lightweight • Fast and easy maintenance • Environmentally friendly/ reduced environmental impact • Large surface area • Impermeable sealing • Seamless • Extended life • Flame-resistant properties • Abrasion resistance • Machine washable • Quick drying • Durable antibacterial functionalization	• Increase and optimize the surface and the performance relative to the surface • Decrease the frequency of change (extended life product) • Produce no by-products • Reduce pressure drop • Elimination of biological contaminants • Plasma treatment • Microfibre (thermowelded) • Nanofibres, nanotextiles, nanocomposites • Non-carcinogenic coatings • Plasma treatment • Natural and organic fibres • Reusable and recyclable fibres

* Geotextiles are any permeable textile used with foundation, soil, rock, earth or any other geotechnical engineering-related material as an integral part of a human-made project, structure, or system. In terms of fabric structure, geo-textiles can be grouped into five categories — woven, heat-bonded nonwoven, needlepunched nonwoven, knitted and by fibre/soil mixing. Around 75% of geotextiles are made from various nonwoven fabrics.

** Regulatory pressure and likely continued rise in the price of petroleum mean natural fibres (jute, coir, flax and hemp) provide good growth potential for this application.

Table 7 (continued)

Key Products/Technologies	Primary Challenges	Main Trends
INDUTECH (cont'd)		
• Ignifugeant • PTFE, acrylic coating • Oleo-phobic • Antistatic • Mechanical finishing (glazing, singeing, etc.) • Micro- or nano-encapsulation • Technical fibres or yarns with mechanical properties for reinforcement • Coated yarns • Technical narrow weaving (webbing) • Technical and 3D braiding • Pull-winding • Rubber manufacturing	• Compatibility with polymer • Increase mechanical performance • Compatibility between components • High strength properties • Flexibility	• Increase durability (abrasion resistance, PU coating, microfilament) • Increase absorptive performance relative to the surface (micro-fibres, hydrophilic treatment) • 3D nonwoven and knitting • Non-carcinogenic coatings • Flexible conductive printing • Improved conductive yarn and fibres • Smart textiles • Improved mechanical properties • Metallic stainless yarn (thin, flexible, etc.)
MEDTECH		
• Self-assembly of silver nanoparticles (antibacterial activity) on textile substrates • Silver nanocrystal coating on textiles using a physical vapour deposition technique • Microencapsulation of drugs (growth factor for their controlled delivery) • Hollow fibre or membranes for hemodialysis, hemofiltration, plasmapheresis, and hemoperfusion • Knitted-to-shaping (3D knitting) • Tissue engineering using electrospun nanofibrous scaffolds • Braided composites containing carbon and polyester filaments • Low density polyethylene for cartilage replacement • Antibacterial modification of textile substrates achieved by micro-encapsulation, radical graft polymerization and coating techniques such as sol-gel coating • Superabsorbent polymers and fibres • Smart and intelligent fabrics	• Required legislative approvals • Safety and side effects (for implantable medical textiles) • Comfort, durability, washability, reliability, self-sufficiency, ease of use and maintenance	• Further development of biodegradable fibrous materials for implantation • Development of textile materials with multiple and responsive bio-functions • Further development of smart fabrics and intelligent textiles for infant monitoring and critical patient care

Table 7 (continued)

Key Products/Technologies	Primary Challenges	Main Trends
	OEKOTECH/ECOTECH	
• Eco-friendly bleaching (peroxide bleaching) • Enzymatic desizing • Enzymatic scouring • Enzymatic bleaching • Bio-polishing • Phthalates-free printing • Enzyme-based softeners • Pre-treatment agents for cellulose with cationic • Polylactide (PLA) • Lyocell • Lycra® • Tencel®	• Reducing the potential for toxic products leaching into the environment (e.g.: toxic dyes, heavy metals, toxic chemicals, chemical-bound solids) • Respecting regulations on the use and presence of prohibited, restricted, and worrying substances in textile materials	• Life cycle assessment (assessing the environmental impacts of a textile product from its creation to its disposal) • Use of natural, eco-friendly, or organic fibres (wool, silk, cotton, bamboo, banana leaf, hemp, PLA, Lyocell, Lycra®, Tencel®) • Use of recyclable and reusable fibres, fabrics, and materials (e.g.: cotton, PES, PET) • Use of formaldehyde-free fabric softeners • Use of bio-processing methods that use less energy, less water and less effluent (e.g.: enzymatic desizing, enzymatic scouring, enzymatic bleaching, enzyme-based softeners, etc.) • Eco-friendly dyeing and printing (e.g.: utilizing low impact dyes, natural dyes, azo-free dyes, phthalates-free printing)
	AGROTECH	
• Windbreak fences and shading/privacy screens and light weight, knitted tape, nets for shade and frost protection • Bird nets: open, knitted, nets for crop protection • Insect meshes: fine, woven, meshes which resist insect penetration • Ground cover: breathable, nutrient- and water-permeable cover providing weed suppression and ground moisture conservation • Lawn cover: to protect lawn (residential/golf) from frost, snow and winter damage • Capillary pads/growth mats (irrigation) • Filters (drainage tiles) • Root control products (e.g.: in-pot plant growth, tree production bags, root control barriers) • Composting tarps (optimize humidity and heat for efficient composting, provide odour control)	• Meeting market demands surrounding product lifecycle sustainability, recyclability, green production	• New polymers • Increase durability • Add functions such as control and monitoring • Sustainability (recyclability, reusability, green production)

Table 7 (continued)

Key Products/Technologies	Primary Challenges	Main Trends
PACKTECH		
• Nonwoven technologies (wetlaid, airlaid) • Braiding (twine and string) • Knitting (net) • Weaving (jute bags) • Use of synthetic materials for increased strength and durability (e.g.: tenacity of PP, PVC coating, etc.) • Including a small percentage of anti-static yarn, which prevents explosions when carrying combustible materials by dissipating electrostatic charges which accumulate on the walls of the fabric after filling and emptying • Adding leak-proof seams or lining/coating with aluminium • Biodegradable tea bags (composed of a wet laid nonwoven made primarily from abaca or hemp fibre) • Twine: increased use of polypropylene instead of sisal in the twine market, because of its superior performance and low cost	• Lightweight • Environmentally friendly • Bio-compatibility and management of air and moisture permeability (good penetration of airlaid non-woven food soaker pads and good wet strength) • Calibrate the lifetime of the product (extended life for some applications and rapid biodegradability for others) • Control of costs and supply (decreasing costs with specifically products, management of the fabrication and printing, ease of transport and recycling) • Minimize the risks of contamination	• Eliminate harmful materials (natural and bio fibres) • Maximize recovery and recycling (reusable and recyclable fibres and materials/ replace PES by PP for recycling easier) • Minimize landfill • Abrasion resistance • PU coating • Microfilament (for example replace metal bands and wires by narrow woven polypropylene strapping, in heavier duty applications) • Reduction of toxic treatments used in conventional treatments to improve the durability and strength of bags and packaging • Intelligent packaging: provides functions such as temperature indication, freshness monitoring, traceability markers and security detectors
PROTECH		
• High-performance fibres • Weaving and knitting of stainless steel tread • Micro-encapsulation • Nonwovens • Elastomers coated textiles • Composite with 2D textiles • Viscoelastic materials and air-pockets against vibrations	• Cost • Impact on wearer (weight, movement) • Reduction of properties over time • Better fitting • Impact on environment/ health • Reduction of dependence on oil-based products • Lower tolerance to risks • Higher diversity of risks • Compatibility between components • Increased comfort • Increased acceptability	• Smart textiles (vital signs, localization, external conditions) • More attention to aesthetics and comfort • Lean manufacturing • Increasing role of integrators • Multifunctional materials • Increased use of nonwovens • Nanofibres, nanotextiles, nanocomposites • Non-carcinogenic coatings • Biomimetics • Autoadaptable materials • Phase change materials • More customization to shape and needs • Shape memory polymers • Natural fibres and organic fibres • Recycling/reuse of fibres • Avoidance of disposable PPE • 3D textiles for composites and energy absorption

Table 7 (continued)

Key Products/Technologies	Primary Challenges	Main Trends
SPORTTECH		
• Technical weaving • Microporous membrane • Variable moisture permeability membranes made of shape memory alloys • Biomimetics (Stomatex®) • Textile composite structure • Auxetic material for energy absorption and impact resistance • D3O (a new material for different types of impact protection) • UV absorption (photoactive dye chemical (trichromatic), cellulose, finishing (coldblack®) • Metalized and oxidized metallic fabrics • Micro and nano-pigment metallic • Clear material (white, grey, pastel) • Microencapsulation • Natural fibres (e.g. cellulose) • Metallic treatment (micro or nano) • Extruded fibre with metallic treatment inside • Melt spun sheath/core fibre (zirconium carbide core) • Fibre containing ceramic micro-particles • Fabric containing phase change materials • Bi-layer laminated film containing a layer of shape memory polymer • Three layer evaporative cooling system • Scotchlite™ reflective material transfer film comprised of thousands of powder-like beads • Smart textiles (vital signs, localization, external conditions) • Conductive fibres	• Cost • Performance • Reduction of dependence on oil-based products • Increased acceptability • Lightness, flexibility, comfort • Increased comfort • Impact on environment/health • Durability • Efficiency/price • Better fitting	• Better physiological comfort • Multifunctional materials • Biomimetics • Stimuli-responsive materials to better protect athletes • Natural fibres and organic fibres • Recycling/reuse of fibres • Niche market for new extreme sports to provide optimal protection to athletes • Improving phase-change materials • Highly technical materials to enhance athletes' performance • Physical stimuli control (heartbeat, muscular frequency) • Indication (T°, humidity, pressure, geo-localization) • Signalization (LED) • Conductive textile printing

Table 7 (continued)

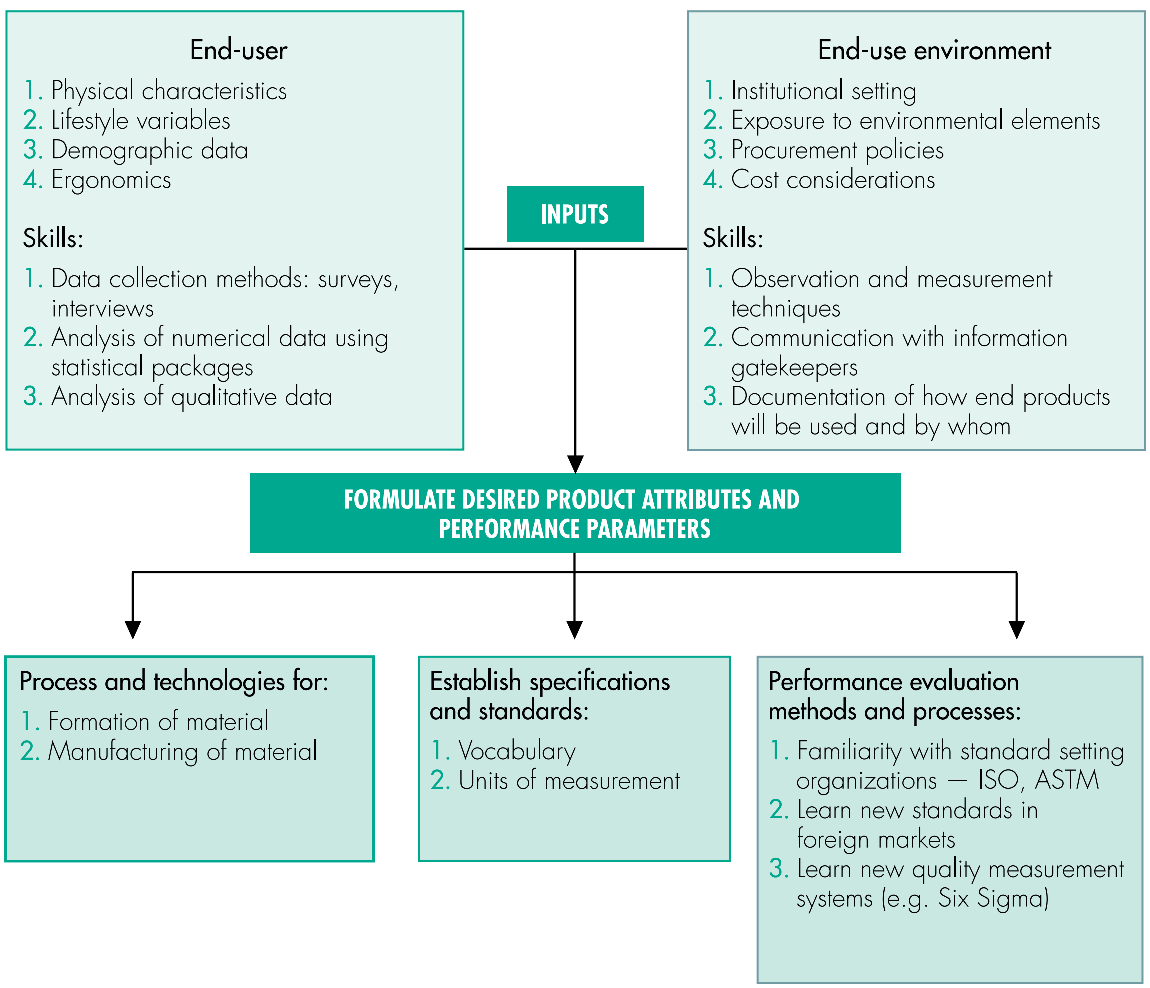
Key Products/Technologies	Primary Challenges	Main Trends
	SMARTTECH	
• Conductive fibres and yarns • Conductive polymers • Piezoelectric material • Phase change material • Aerogel-insulated clothing • Shape memory alloy/materials • Shape memory materials • Electroactive polymers • Mechanically active materials/textile structures • Conductive materials • Fibre optics • Embroidering for the interconnections between electronic components • Photovoltaic material/fabric	• Durability • Washability • Connection • Lack of standards for testing • Flexibility • Comfort for wearers • Reliability • Commercialization • Invasiveness • Efficiency • Cost • Multidisciplinarity	• Integration of fibre optics for monitoring (ECG and breath rate) • Integration of sensors into hometextiles, for "home monitoring" • Integration of nanomaterials (e.g. carbon nanotubes) to increase conductivity • A lot of work is being done around the toxicity of microcapsules • Development of fire-retardant material • Chemically bondable microcapsules on fibres • Development of stretchable technologies (STELLA Project) • Development of Platform for Large Area Conformable Electronics by Integration (Place-it project led by Philips (Germany)) • Integration of sensors into concrete or composite materials to prevent structures from irreversible mechanical damages • Controlled drug releasing • Integrated textile keypad (Intelligent Textiles Ltd. (UK)) • Textile antenna for wireless communication (Ghent University, Belgium) • Development of flexible OLED textile system for data communication • Development of fibre transistors (ENSAIT, in France) • Development of Photovoltaic Textiles based on novel fabrics (DEPHOTEX Project) • Printed photovoltaic material on textile substrate • Integration of piezoelectric material into carpets • Wind power harvesting through sensors embedded in textiles (curtain, flags, etc.)

5 Essential Skills and Best Practices in Technical Textiles Production

5.1 Textile Processes Influencing Future Skills

As the design and development of technical textiles entail understanding the end-user and the end-use environment(s), a range of skills will be required to arrive at a product that satisfies the market's demand. The design and development process must begin with gathering and analysing detailed information about the end-user and end-use environment.

Figure 3: Design and development process in relation to the end-user and end-use environment



Source: Dr. Lena Home, University of Manitoba

Gathering valid data on user and end-use environment(s) requires the possession of a number of research skills, including the ability to make disciplined observations and develop and administer questionnaires and/or interview questions. The data gathered via these methods are essential inputs into the choice of materials, which is itself a task that requires an entirely different suite of skills.

Following the above-mentioned information gathering process, one must formulate desired product attributes and performance parameters and then proceed with the production and testing of technical textiles. All of which require different expertises in polymer science, material science and mechanical/electric/chemical engineering. The multidisciplinary nature of technical textiles production makes it a challenging field for education/training of students and recruitment of the technical workforce. The tables found in the following subsection summarize key competencies required for the production and testing of technical textiles.

5.1.1 General Key Competencies Required for the Production and Testing of Technical Textiles

Table 8: General key competencies required for the production of technical textiles

	Processes	Machineries	Key Competencies	Applications (in Protech, Mobiltech, Builtech and Medtech)
Technical Fibre	• Spinning — Electrospinning • Extrusion — Sea-island extrusion, reactive extrusion	• Electrospinning apparatus • Twin screw extruder • Spinneret for multi-components fibres and hollow fibres	• Polymer science • Chemical engineering	• Filtration • Tissue engineering • Antibacterial fabrics • UV fabrics • Technical yarn: multi-component yarn, hollow fibres
Staple Technical Yarns Spinning	• Ring spinning • Rotor spinning • Friction spinning • Wrap spinning • Air-jet spinning • Twistless spinning	• Ring, rotor and friction spinning machines • Hollow spindle machine (wrap spinning) • Murata jet spinner • TNO twistless system	• Mechanical engineering • Electronic engineering	• Functional yarn used for Protech and Medtech (e.g. flame-retardant and antistatic yarns can be made by incorporating flame-retardant and electricity conductive fibres)
Fabrication of Technical Fabrics	• 3D weaving • 3D knitting • 3D nonwoven • Technical weft and warp knitting • Technical nonwoven • Technical weaving • Embroidery (E-broidery) • Braiding	• Modified weaving machine • New design of each components of a loom • Double bed knitting machine (warp and weft) • Modified creel for weaving and warp knitting • Laying head on embroidery machine, for fibre deposition and positioning on various textile or non-textile substrate	• Computer-aided design • Mechanical engineering • Electronic engineering (to be able to modify existing equipment, to provide new options) • Characterization of yarn, fibres	• 3D knitting or spacer knitted fabric for PU foam substitution (Mobiltech application) • 3D woven fabric or braiding structure (made with high performances fibres such as carbon, glass, etc.) as composite reinforcement • Electronic embroidery, conductive fibres positioning to develop heating textile elements • Development of flexible connections • Braiding for stent and various prosthetics (medical application)

Table 8 (continued)

	Processes	Machineries	Key Competencies	Applications (in Protech, Mobiltech, Builtech and Medtech)
Finishing of Technical Textiles	• Mechanical processes • Heat setting • Chemical processes • Biocatalytic processes • Surface coating • Coating • Lamination	• Calender, raising machine • Shearing or cropping machine • Wringer, steamer, plasma finishing machine • Calender coating machine, rotary screen coating machine	• Polymer physics • Polymer chemistry • Organic chemistry • Chemical engineering	• Protective clothing • Automotive textiles • Construction textiles
Textiles in Composite	• Moulding (manual, vacuum and pressure) • Resin transfer moulding (RTM) • Reinforced thermoplastic injection • Pultrusion • Filament winding • Centrifugation	• Moulding: by contact, by vacuum bag, by pressure bag, by autoclave • RTM • Compression of pre-impregnated (sheet and bulk moulding compound) • Pultrusion machine • Injection moulding machine • Centrifugation machine • Pull-winding machine	• Knowledge of technical fibres reinforcement (size, shape, composition and rate) • Knowledge of fabrics reinforcement (technical weaving and knitting) • Knowledge of 3D reinforcement (multilayer, multiaxial, honeycomb, laminate) • Knowledge of mechanical and thermal properties of fibres and fabrics • Knowledge of compatibility with resin	• Automotive • Aeronautics • Aerospace • Sport and leisure

Table 9: General key competencies required for the testing of technical textiles

Field	Properties	Key Competencies	Applications
Physical, Chemical, and Durability Testing Analyses: • Composition and architectural construction • Mechanical properties • Flammability properties • Liquid and vapour properties • Chemical resistance properties • Stability • Optical • Colourfastness • UV resistance • Chemical resistance • Micro-organism resistance	• Fibre count, mass per unit area, specific gravity, construction, breaking, tearing and bursting strength; puncture, cut, pilling and abrasion resistance • Shrinkage resistance • Flame resistance, heat and thermal resistance, and insulation properties • Permeability, absorption, repellence, moisture regain, wetability, dyeability • Laundering, acid, bleaching, chlorinated water, gas fading action • Solvent, acid, base resistance	• Knowledge of materials (fibres, yarns, fabrics, knits) and of architecture • Knowledge of metrology • Knowledge of textile chemistry	• Characterization • Standardization • Classification

Depending on the novelty of the product, manufacturers could choose from a range of intermediate inputs that are already commercially available. However, if the appropriate intermediate inputs and the technologies for materializing them do not exist, an organization will have to embark on research and development. Depending on the end product, the processes and technologies may precipitate changes in training or education of current employees or necessitate sourcing new workers with different skill sets.

5.1.2 Key Industry Occupations Affected by the Move to Technical Textiles Production

The following tables provide an overview of the potential changes in training and education for a selection of key industry occupations affected by the move to technical textiles production. For a comprehensive list of occupations affected and attendant processes and applications driving change, please see the appendix.

Table 10a: Overview of potential changes in training and education for a selection of key industry occupations affected by the move to technical textiles production

Key Occupations Affected by the Move to Technical Textiles Production	Processes and Applications Driving Change
Human Resources Managers	The product development process will involve interdisciplinary teams. • Employee relations will change because the organization will have to learn how to create a harmonious environment where the scientists, the technicians, the engineers, the marketing and sales people, and the production managers can feel their inputs are equally valued. • Those who supervise will have to know what they will be supervising. Otherwise, their evaluation may be invalid. The employees' rewards may be affected. • Recruiting will have to involve additional, non-traditional areas as well as more multidisciplinary backgrounds.
Sales, Marketing and Advertising Managers	Technical textile clients are likely to demand highly specialized solutions from the organization, meaning that the sales force will have to be able to accurately identify and capture the client's needs and demands and work with the product development team to arrive at a customized solution. The sales force must have knowledge of technical textiles. Technical textiles will also mean new markets and new end-use clients, with different languages and needs. The marketing department cannot serve the market effectively without knowing the client's needs: • Communications strategies (e.g.: hospitals versus aerospace) • Distribution channels (e.g.: hospitals versus aerospace) All these will change when serving specialized end-use market and clients/customers.
Production Managers	The production of technical textiles may create new categories here because in some cases the traditional spinning technologies may not apply. For example, this category does not include polymeric materials or composite materials, which require very different production processes. Technical textile production will involve new machines and new technologies. It will also require being more flexible and adaptable to special requests, e.g. small production volume.
Chemists	The chemists will be part of the product development team, offering his or her expertise in creating the new product. Must be able to work with others. In addition the technologies, products and even the chemistry itself will be different.

Table 10a (continued)

Key Occupations Affected by the Move to Technical Textiles Production	Processes and Applications Driving Change
Industrial and Manufacturing Engineers	Depending on the type of technical textiles being manufactured, the engineers may have to learn new systems for assessing safety or environmental compliance, and will be required to work with non-textile sectors (e.g. Six Sigma). They will also need to understand the needs and regulations of clients from other, non-traditional sectors and other countries. Finally, they may need to adapt existing technologies/systems/machines to fit to new requirements.
Technologists and Laboratory Technicians	New occupation categories may appear.
Technologists and Technicians in Industrial and Manufacturing Engineering	These occupations will change but additional data is required in order to develop a clear picture of where specifically the changes will occur. In fact, some people employed in these positions may need to be completely re-trained.
Technologists and Technicians in Electronics and Electrical Engineering	Will have to learn to get new equipment working, in addition to modifying existing equipment to fit new needs. Will need to work as a team with people from other disciplines.
Industrial Instruments Technologists and Technicians	Will have to learn to get new equipment working.
Industrial Electricians	New machines may have different demands on energy use.
Mechanics and Textile Machinery Fitters	Some of these occupations may disappear. Those that remain will need to be adapted to the requirements of new technologies and machines.
Electrical Mechanics	May have to work with new and customized equipment.
Supervisors in Textile Products Transformation	New materials and new technologies will require new skills and knowledge.
Machine Operators for Textile Fibres and Yarn Preparation	New materials and new machines will require new and different skill set and knowledge.

Two additional occupations not currently possessing National Occupational Classification (NOC) Codes identified as a result of this study that are significantly impacted by, and play a large role in making possible, the move to technical textile production are R&D Engineers and Researchers.

Table 10b: New textile industry occupations resulting from, and key to, the move to technical textile production

Occupation	Key Responsibilities
R&D Engineers	Responsible for providing engineering direction for a product line, including new product development and modification to existing products. Must communicate with people from other disciplines, and must be willing to collaborate and share their knowledge and expertise.
Researchers	Responsible for designing, developing, building and evaluating products, services or technologies. Must communicate with, and be willing to learn from, people in other disciplines and people on the floor in order to form an effective collaborative team.

5.2 Sample Technical Textiles Development Tasks and Implications for Skills Development

The development of several types of innovative materials falling within the key areas of growth identified in the *Textile Technology Roadmap* is well within the capability of Canadian textile firms. Listed below are specific technical skills required to develop these types of innovative materials.

5.2.1 Natural Fibres

Natural fibres are made from plant fibres (Lenpur® from white pine, bamboo and banana fibres, and also fibre form jute, sisal, linen, hemp, etc.), or from other natural resources — Ingeo®, for example, is made from corn. All these fibres are increasingly used in various technical applications, such as composite reinforcements, and advantages of use include commercial availability (natural resource, price etc.) and facilitation of production of highly-valued "green textiles" (due to the fibres' organic origins and biodegradability). Some of these fibres are improved by functionalization processes (e.g.: the functionalization of cotton fibres to improve drying properties), which are generally chemical.

5.2.2 Engineering High Value-Added Fibres

The number of applications involving high value-added fibres, for example high performance fibres like Spectra®, Dyneema® and Kevlar® and fibres based on nanotechnologies, is increasing gradually due to their exceptional performances, in particular their mechanical properties and their resistance to heat and flames. However, working with these fibres, both at the development and production stages, requires a brand new set of tools, methods and expertise. For instance, the measurement of nanosized objects is in itself a major challenge, yet has profound implications on the final performance of the product. In addition, knowledge about the behaviour of these materials, for example during processing operations and throughout service life, is still very limited and is currently largely restricted to the scientific community.

5.2.3 New Single Layer Structures

In order to reduce costs and limit manipulation during manufacturing operations, there is a growing trend towards the production of final-shape, single layer textile structures. One example is the production of net-shape 3D textile preforms for composites. The efficient production of multifunctional textiles, like smart textiles, also involves the integration of all components during the weaving, knitting or braiding process. Such practices are also aimed at decreasing final product variability. However, success in that enterprise is only achievable by rethinking the entire production process through a final-product oriented lens, as opposed to the component-based step-by-step method. It requires involving the whole value chain as well as all staff levels in the discussion leading to the new design. It also calls for the development of new production methods and new manufacturing machines. Finally, it translates into new skills acquired at the production level. This revolution fits very well with the low volume, flexible production style characterizing the Canadian textile industry.[23]

5.2.4 Lamination and Surface Treatment of All Types of Textile Structures

Surfaced treated (e.g. coated) and laminated textiles form an important sector within the textile industry,[24] and are used extensively in most, if not all, of the 13 technical textile application areas. Textile surface treatment and lamination processes are themselves quite technology-intensive, and rely on production teams knowledgeable in textile technology, organic/polymer chemistry and mechanic/electric engineering for successful implementation.

[23] CTT Group, 2008
[24] Fung, W., *Coated and Laminated Textiles* (Cambridge: Woodhead Publishing Ltd., 2002).

The general trend towards "greener" products and processes provides further challenges. For example, 100% solid hot-melt materials must be developed to replace both solvent- and water-based adhesives in order to create a process that requires less energy and produces less emissions overall. The production of laminated textiles using "just enough" adhesion, allowing for easier separation of chemically dissimilar materials and facilitating recycling of end-of-life articles, is another challenging proposal for "greening" textile production processes. Some of these challenges can be met through the application of new developments in surface treatment techniques. Adhesion in polyurethane fabric coating, for example, has been greatly improved by implementing plasma pre-treatments of the base fabric, allowing for stable coating at a lower temperature and a faster speed.

Overall, industry trends are moving towards the development of textile lamination and surface treatment processes that are:

1. Increasingly automated, flawless and cost effective;
2. More environmentally benign (i.e. low emission, non-toxic and enabling easy recycling of the treated product); and,
3. Capable of producing responsive or "intelligent" textiles.

To adapt to these trends, it is essential that researchers, product development teams and production teams further develop effective communication and research skills to promote critical thinking, lateral thinking and problem solving.

5.2.5 Development of "Intelligent" Textile Materials Using Sensors and Electronics

Intelligent textiles are often defined as structures capable of reacting/adjusting themselves to external demands and communicating with their environment. In order to functionalize these textile structures, they can be coupled with electronic components, chemical components, or material possessing particular properties (conductive or piezoelectric materials, etc.).

Advanced e-Textile systems integrate a range of features — including sensors, connections, transmission systems, power management, etc. — resulting in the production of e-Textile systems capable of gathering, presenting, and transmitting information about the user and her/his immediate environment in response to specialized demands from end-use markets (generally Medical, Military, Sport and Leisure, Entertainment, and First Responders markets).

A growing interest in cooperation between electronic, medical, chemical and textiles manufacturers has been noticed around the world. Textiles engineering and technology have demonstrated that electronic components, sensors, and actuators can be integrated into the fabric and then be completely embedded in finished textile products. The successful production and implementation of this "new generation" of textiles is reliant on multidisciplinary cooperation. Indeed, without the close collaboration of multidisciplinary working teams, it may be difficult to respond to challenges — such as connection, testing methods, comfort and reliability — which are presenting themselves in this new growing market.

5.2.6 Employment of Multiple Technologies to Create Multifunctional Flexible Materials

Multifunctionality in textiles can be arrived at in different ways, the first being during the extrusion or manufacturing of bi- or multi-material yarns, or via surface treatment of fibres (micro-encapsulation, for example). The availability of a wide variety of fabric surface treatments also allows for the multifunctionalization of textile products. Finally, multifunctionalilty can be achieved by combining products with different properties during the making of a final product (multilayer fabrics, for example).

5.2.6.1 Multifunctional Flexible Materials — Textile Composites

Flexible multifunctional materials are materials (here technical fibres or fabrics) made entirely or partly using textile technology. Textiles can possess many properties — for example mechanical, chemical, thermal, electrical — and are often combined to increase functionality. Textiles, or more precisely textile fibres, offer flexibility to the final product made with them, and can complement and/or enhance the properties of other materials with which they're paired (e.g.: when textiles are coupled with rubber or plastic resin to increase mechanical strength properties in a composite product).

5.2.7 Development of New Measurements and Standards

With the introduction of new materials and the development of new manufacturing techniques and new applications, new characterization tools and new standards are needed. For example, working with nanomaterials involves probing their properties at a scale 1000 times smaller than the microscale generally considered as the lower limit in the textile industry — tensile properties of a carbon nanotube are not measured with the same equipment as those of a polyester yarn. In addition, as new levels of performance emerge, current methods have to be expanded or replaced. The exceptional resistance of high performance fibres made of Spectra®, Dyneema®, Kevlar® and carbon nanotubes is far beyond that of technical polymers like nylon and polyester. New requirements also arise in relation to green practices and sustainable development. The necessary implementation of these new measurements and standards has a significant impact on the textile industry taskforce at many levels, from R&D departments to quality control services to production operations and points in between. In addition, since most of these new measurements and standards deal with completely new and generally multidisciplinary concepts, there is a need for affected workers to develop new skills in different domains.

5.2.8 Implementation of Stringent Quality Measurement Methods (e.g.: Six Sigma)

Since innovative technical textiles tend to be high value-added materials that serve a variety of highly specialized markets, the organization's ability to meet the quality standards imposed by the end user markets is essential to its success. Adopting a process such as Six Sigma that tolerates very few defects in many aspects of an organization's operation may enable small- and medium-sized textile companies to achieve lean manufacturing. According to Six Sigma, "The objective of Six Sigma Quality is to reduce process output variation so that on a long term basis, which is the customer's aggregate experience with our process over time, this will result in no more than 3.4 defects Parts Per Million opportunities".[25]

Six Sigma is used here as an example, and of course may not be the optimal quality system for all organizations. Selecting a quality system that is compatible with the firm's operation and the client's demands is fundamental to the success of an organization. Depending on the quality system, an organization may have a large pool of qualified workers at its disposal or it may have to re-train its current personnel. Adoption of a new stringent quality assurance process will necessitate the identification of existing staff requiring process training.

5.2.9 Use of New Technical Textile Technologies by End-Users

Use of new technical textiles technologies requires the development of new promotions and sales approaches. In general, end-users are currently not accustomed to the terms of new technical textile technologies, and therefore not prepared for adoption. For example, if we look to nanotechnologies, the majority of end-users are not used to thinking and working in micro- and nano-scale dimensions when discussing textiles and their capabilities and applications. New techno-commercial skills need to be developed to introduce technically new products, which in turn necessitate an understanding of languages belonging to different technical domains.

[25] iSixSigma, *Statistical Six Sigma Definition* (July 2010), www.isixsigma.com/index.php?option=com_k2&view=item&layout=item&id=1254&Itemid=110.

5.3 Best Practices in Technical Textiles Manufacturing

A trends analysis of the four priority TUT application sectors identified during the *Textile Technology Roadmap* project reveals the following four main trends in best practices:

1. Multidisciplinary work;
2. Working closely with users;
3. Active technology forecasting; and
4. Setting action plans incorporating findings resulting from active technology forecasting.

The following tables provide an overview of these trends in areas of development and best practices applied to them. It should be noted that in many cases more than one best practice trend is applicable.

Table 11a: Overview of best practices trends in Mobiltech

MOBILTECH	
Area of Development	Best Practice
Customization of textiles for interiors	Working closely with user
Composites for structural parts	Multidisciplinary work
3D textiles for net-shape preforms	Active technology forecasting
Spacer fabrics	Active technology forecasting
Integration of end-of-life indicators	Working closely with user
Self-healing materials	Multidisciplinary work
Multifunctional textiles and materials (functionalization of textile surfaces or 3D structures)	Multidisciplinary work
Coating of airbag fabrics with new silicone based nanomaterials	Multidisciplinary work; Active technology forecasting
Anti-bacterial/stain-resistant/self-cleaning (nano) coatings	Multidisciplinary work
Nanocomposites (carbon nanotubes, nanoclay)	Multidisciplinary work
Sensors or smart materials embedded into textiles	Multidisciplinary work; Active technology forecasting
Use of natural fibres	Active technology forecasting
High performance fibres	Multidisciplinary work; Active technology forecasting
Life-cycle analysis	Working closely with user
Nanofibres, nanomesh, nanotextiles	Active technology forecasting

Table 11b: Overview of best practices trends in Buildtech

BUILDTECH	
Area of Development	Best Practice
Use of natural fibres for better sustainability	Active technology forecasting
Use of "greener" composites: e.g. replacement of harmful materials such as copper, chrome, and arsenic-treated wood by wood plastic	Multidisciplinary work

Table 11c: Overview of best practices trends in Medtech

MEDTECH	
Area of Development	**Best Practice**
Further development of biodegradable fibrous materials for implantation	Multidisciplinary work; Active technology forecasting
Development of textile materials with multiple and responsive bio-functions	Multidisciplinary work; Active technology forecasting
Further development of smart fabrics and intelligent textiles for infant monitoring and critical patient care	Multidisciplinary work; Active technology forecasting

Table 11d: Overview of best practices trends in Protech

PROTECH	
Area of Development	**Best Practice**
Smart textiles (vital signs, localization, external conditions)	Multidisciplinary work; Active technology forecasting
More attention to aesthetics and comfort	Working closely with users
Lean manufacturing	Working closely with users
Increasing role of integrators	Working closely with users
Multifunctional materials	Multidisciplinary work
Increased use of nonwovens	Result of active technology forecasting
Nanofibres, nanotextiles, nanocomposites	Multidisciplinary work
Non-carcinogenic coatings	Result of active technology forecasting
Biomimetics	Multidisciplinary work
Auto-adaptable materials	Multidisciplinary work; Active technology forecasting
Phase-change materials	Multidisciplinary work; Active technology forecasting
More customization to shape and needs	Working closely with users
Shape memory polymers	Multidisciplinary work
Natural and organic fibres	Result of active technology forecasting
Recycling/reuse of fibres	Result of active technology forecasting
Avoidance of disposable PPE	Result of active technology forecasting
3D textiles for composites and energy absorption	Result of active technology forecasting

5.4 Industry Validation

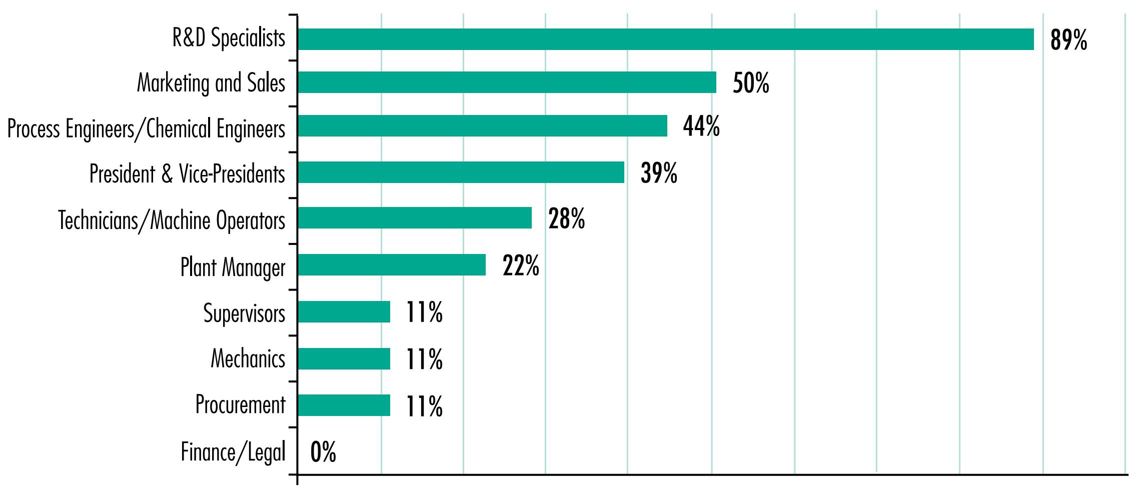
Between February and August 2011, an industry consultation and validation process was undertaken to validate the findings of secondary research conducted during the development of this report. This process included the review of best practices findings in green manufacturing and technical textiles production.

Green Manufacturing and Technical Textiles Focus Group (April 2011, Québec)

As part of this consultation, five focus groups and seven webinars (with a combined total of more than 150 industry representatives) were held to review and validate identified occupations, key competencies and knowledge related to the production of technical textiles and the implementation of green manufacturing practices. With the results of the validation process, a skills inventory framework (see Section 5.4.1) was developed to inform the future development of new occupational standards and, eventually, programs to train new workers and up-skill existing employees.

When asked to identify the three (3) occupations which they believed to be key to technical textiles production, 89% of respondents placed R&D Specialists at the top of the list. Marketing & Sales placed second (identified by 50% of respondents) and Process Engineers/Chemical Engineers placed third (identified by 44% of respondents).

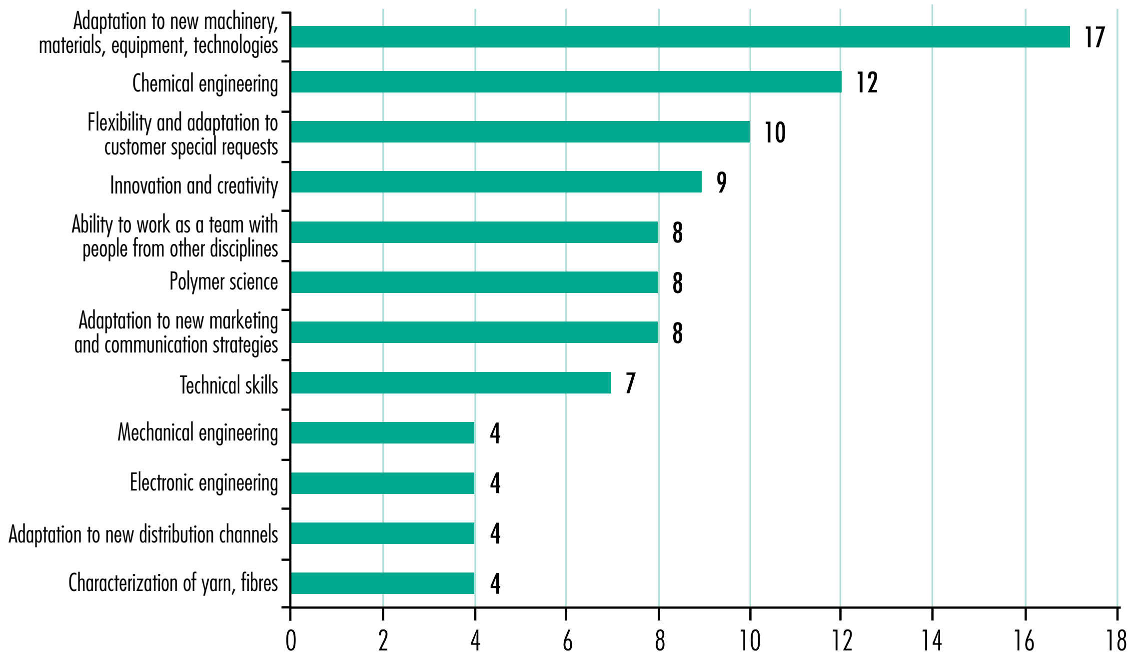
Figure 4: Key occupations — technical textiles production (industry consultation and validation)



Source: Industry validation with more than 45 Canadian textile manufacturing firms

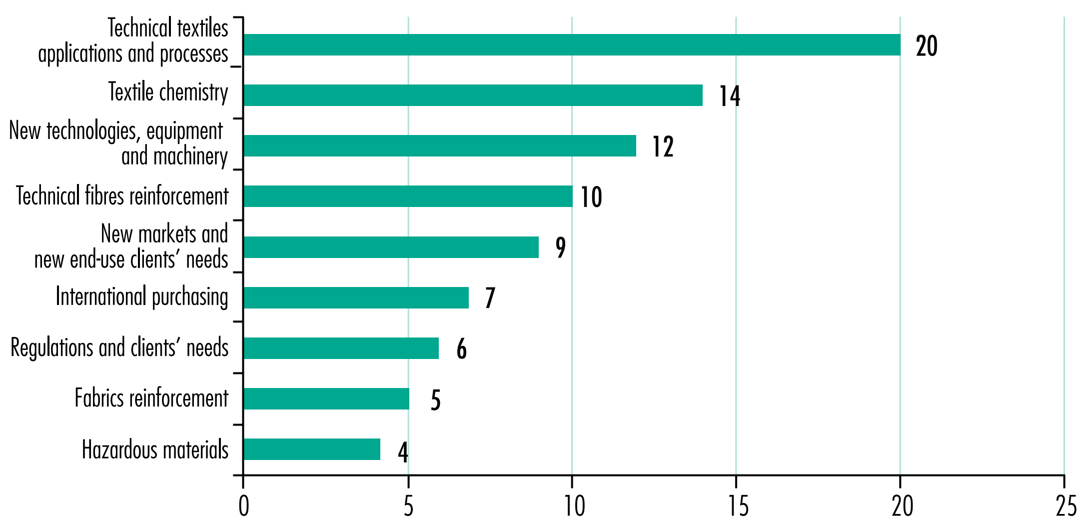
Respondents were then asked to identify up to three competencies and fields of knowledge which were in their opinion and experience most important to the successful production of technical textiles. Figures 5 and 6 below show the results of these polls.

Figure 5: Key competencies — technical textiles production (industry consultation and validation)



Source: Industry validation with more than 45 Canadian textile manufacturing firms

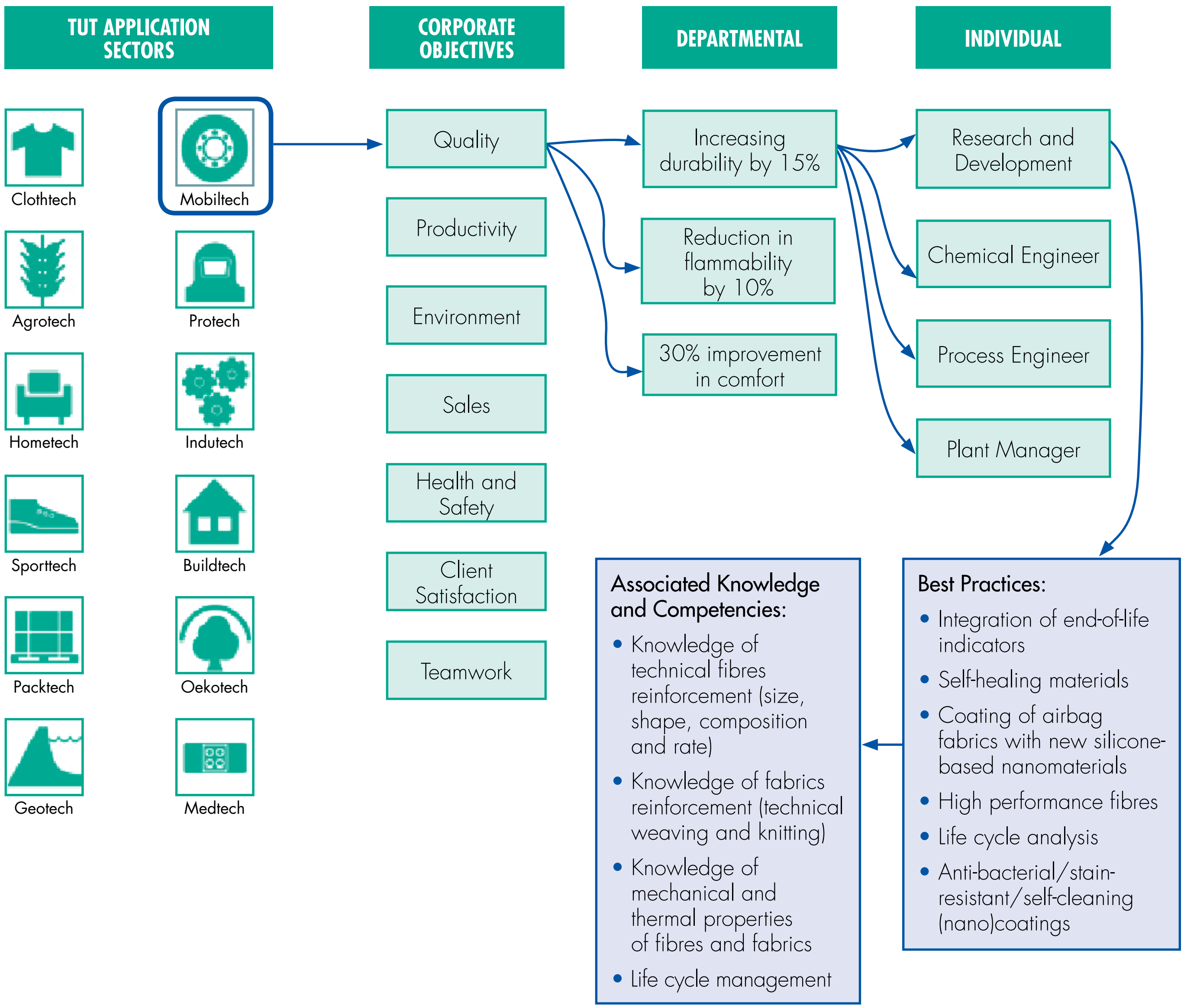
Figure 6: Knowledge key to the successful production of technical textiles (industry consultation and validation)



Source: Industry validation with more than 45 Canadian textile manufacturing firms

Knowledge, competencies, and best practices related to technical textile production are defined following the identification of corporate objectives and enabling objectives and responsibilities at the departmental and individual levels. Figure 7 below demonstrates this relationship using the example of a Research and Development Specialist developing technical textiles for the Mobiltech sector.

Figure 7: Application of key technical textiles best practices, knowledge and competencies in the furtherance of corporate objectives



5.4.1 Skills Inventory

TECHNICAL TEXTILES
Key Competencies and Knowledge

Occupations

ENGINEERING	HUMAN RESOURCES	PROCUREMENT	R&D SPECIALISTS
FINANCE	MARKETING AND SALES	PRODUCTION	SENIOR MANAGEMENT

SKILLS

- Adaptation to new distribution channels
- Adaptation to new marketing and communication strategies
- Flexibility and adaptation to customer special requests
- Innovation and creativity
- Polymer science
- Characterization of yarns and fibres
- Ability to work with non-textile sectors
- Chemical, mechanical and electronic engineering
- Adaptation to new technology, machinery, and equipment
- Ability to work as a team with people from other disciplines

KNOWLEDGE

- Regulations and clients' needs
- Technical textiles applications and processes
- New markets and new end-use clients' needs
- Hazardous materials
- New technologies and equipment
- Technical fibres reinforcement
- Textile chemistry
- International purchasing

Benefits of TECHNICAL TEXTILES PRODUCTION		
Improved Corporate Image	Competitive Advantage	Product Development
Innovation	Market Development	New Technology Development

Source: Textiles Human Resources Council (THRC) *Best Practices in Green Manufacturing and Technical Textiles* (2011). Industry validation with more than 45 Canadian textile manufacturing firms.

6 Recommendations and Baseline for Focus Group Discussions

The findings of this report confirm a pressing need to redefine the textile industry's human resources approach in order to respond to changing occupational needs at all levels resulting from the Canadian textile industry's strategic move towards technical textiles production. Thus, it is recommended that the industry undertake to:

Recommendation 1. Adapt current job profiles for key existing occupations affected by a move to technical textile production, identified in Section 5.1 of this report.

Recommendation 2. Define essential skills and develop occupational profiles for new occupations created as a result of the move toward technical textile manufacturing.

Recommendation 3. Further investigate key new job profiles for emerging technical textile occupations such as R&D Engineers, Researchers, Techno-commercial Representatives, etc.

Recommendation 4. Develop formal training opportunities such as internship programs through partnerships with educational institutions so that students can apply existing skills while developing new ones.

Recommendation 5. Make use of virtual networking platforms, such as *Knowledge Networks*, to connect key partners and technical contacts worldwide to support collaboration and innovation.

In addition, it is recommended that:

Recommendation 6. A comprehensive directory of Canadian degree and non-degree programs focusing on (a) textiles, and (b) textile-related materials be developed and maintained; and,

Recommendation 7. Benchmarking tools for different educational, technological and commercial aspects of the industry be developed and implemented.

Finally, because the industry must now be examined through a new, significantly different lens, it is recommended that the entire production process and value chain be revisited, and that:

Recommendation 8. An interdisciplinary lexicon of terms be developed in order to facilitate communication within interdisciplinary product design and development teams, and also between these teams and clients/end-users; and

Recommendation 9. A strategy be developed to provide education and training surrounding technical textiles (for example "Technical Textiles 101").

6.1 Benchmarking Recommendations

The diversity of processes in the textile industry makes the benchmarking process a complex undertaking, however it is extremely important to accurately position the Canadian textile industry in the global economy. It is recommended that a benchmarking strategy be developed as soon as possible by:

- Identifying types of technical textiles to benchmark;
- Identifying technological processes to benchmark;
- Identifying other industries that have similar involvements;
- Identifying organizations that are recognized as leaders in these areas; and,
- Visiting and surveying "best practice" firms to identify industry-leading measures and practices.

7 Conclusion

The successful design and development of new products for the technical textiles market clearly hinges on the effective collaboration of multidisciplinary teams of workers, and the range of occupational skills and competencies required of industry workers varies with the type of technical textiles being produced. From a human resources perspective, the collaborative nature of new product development will affect the recruitment and management of all those involved in an organization.

1. **Recruitment** — depending on the type of technical textiles, highly specialized expertise in core (textiles) and non-core areas may be needed. How does an organization allocate its resources to retain permanent core expertise and to attract compatible project-specific non-core expertise to respond to clients' demands?
2. **Management** — an organization will have to be able to create a culture of collaboration and respect among employees who have various levels of education and skills. This has further implications for incentive or reward issues. How does an organization encourage employees to learn from each other?

The identification of implications surrounding green and sustainable textiles design and production is complex, and requires detailed treatment as a separate topic. Unlike technical textiles where one's efforts are directed toward creating an end product that meets the market's demands, to be "green" or ecologically conscious is a commitment that an organization makes to develop processes that minimize emission of toxic substances, favour the use of renewable over non-renewable sources of energy, and significantly constrain the production and environmentally-unsustainable disposal of waste. Where an organization is not directly responsible for the production of products, a "green" organization is committed to ensuring the various players of the supply chain comply with "green" standards adopted by that organization.

The "green" mindset has a profound impact on skills development. In vertically-integrated organizations, the implementation of green manufacturing processes results in employees having to acquire new knowledge and learn new skills to process or create raw materials and to develop and use new technologies for the downstream transformation processes. Depending on the focus of an organization's "green" efforts, the bundle of skills and knowledge would vary. To provide evidence-based information on this, we must engage in research into the practices of successful Canadian (and/or other) firms.

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APPENDIX:

Key Occupations Affected by the Move to Technical Textiles Production

APPENDIX: Key Occupations Affected by the Move to Technical Textiles Production

<table>
<tr><th>NOC Code</th><th>Occupations in the textile industry according to the Comité sectoriel de main d'œuvre de l'industrie textile du Québec (CSMO Textile)</th><th>Change in Training or Education?</th><th>Reason(s)</th></tr>
<tr><td>0111</td><td>Finance Managers
• Chief Financial Officer
• Director – Financial Services</td><td>No</td><td></td></tr>
<tr><td>0112</td><td>Human Resources Managers
• Manager – Employee Relations
• Industrial Relations Manager
• Human Resources Supervisors</td><td>Yes</td><td>The product development process will involve interdisciplinary teams.
• Employee relations will change because the organization will have to learn how to create a harmonious environment where the scientists, the technicians, the engineers, the marketing and sales people, and the production managers can feel their inputs are equally valued.
• Those who supervise will have to know what they will be supervising. Otherwise, their evaluation may be invalid. The employees' rewards may be affected.
• Recruiting will have to involve additional, non-traditional areas as well as more multidisciplinary backgrounds.</td></tr>
<tr><td>0113</td><td>Purchasing Managers
• Director of Materials Management Services
• Purchasing Manager
• Equipment and Services Purchasing Manager</td><td>Yes</td><td>Some of the materials and equipment for technical textiles can be complex and non-traditional. The purchasing department may have to look for new suppliers within or outside Canada.</td></tr>
<tr><td>0123</td><td>Payroll Managers
• Director of Payroll Services</td><td>No</td><td></td></tr>
<tr><td>0611</td><td>Sales, Marketing and Advertising Managers
• Divisional Sales Director
• Regional Sales Manager
• Marketing Director
• Marketing Manager
• Communications — Sales and Marketing Director
• Sales Director
• Sales and Marketing Director
• National Sales Director
• Marketing Director</td><td>Yes</td><td>Technical textile clients are likely to have highly specific needs, meaning the sales force will have to be able to listen to the client's demands and work with the product development team to arrive at a customized solution. The sales force must have knowledge of technical textiles.
A move to technical textiles production will also bring new markets and new end-use clients, with different languages and needs.
For the marketing department, one cannot serve the market effectively without understanding the client's needs:
• Communications strategies
• Distribution channels. All these will change when one serves the technical textiles market.</td></tr>
</table>

NOC Code	Occupations in the textile industry according to the Comité sectoriel de main d'œuvre de l'industrie textile du Québec (CSMO Textile)	Change in Training or Education?	Reason(s)
0911	**Production Managers** • Textile Spinning-mill Manager • Textile Mill Manager	Yes	The production of technical textiles may create new categories here because in some cases, the traditional spinning technologies may not apply. For example, this category does not include polymeric materials or composite materials, which require very different production processes. Technical textile production will involve new machines and new technologies. It will also require being more flexible and adaptable to special requests, e.g. small volume.
1111	**Auditors and Accountants** • Chartered Accountant • Plant Accountant	No	
1121	**Human Resources Specialists** • Human Resources Management Consultant • Labour Relations Advisor • Industrial Relations Advisor • Labour Relations Coordinator • Human Resources Coordinator • Human Resource Generalist	Yes	Similar to 0112 May be required to help resolve communication difficulties between experts from different domains.
1222	**Executive Assistants** • Executive Assistant • Executive Secretary	No	
1241	**Secretaries (except legal and medical sectors)** • Secretary • Financial Secretary • Human Resources Secretary • Office Automation Technician	No	
1411	**General Clerical Employees** • Administrative Assistant • Clerical employee	No	
1414	**Receptionists and Switchboard Operators** • Admitting Clerk • Receptionist-clerk • Switchboard Operator • Receptionist • Reception Secretary	No	
1432	**Payroll Clerks** • Payroll Clerk	No	
1453	**Customer Service and Information Clerks, and similar** • Customer Service Clerk • Customer Service Advisor	Yes	Customer service desk will have to be able to respond to technical textile clients' inquiries.

NOC Code	Occupations in the textile industry according to the Comité sectoriel de main d'œuvre de l'industrie textile du Québec (CSMO Textile)	Change in Training or Education?	Reason(s)
1471	**Shippers and Receiving Clerks** • Shipping Clerk • Delivery Clerk	Yes	Some products may require special handling. Shifting to technical textile production will also involve different clients, a larger number of them, shipping smaller volumes and even a change in shipping techniques (for example faster ones).
1472	**Storekeepers and Parts Clerks** • Parts Counter Clerk • Parts Employee • Parts Technician • Storekeeper	Yes	The components of technical textiles will change. It is expected that there will be new parts and a larger number of them.
1473	**Production Clerks** • Laboratory Clerk • Production Clerk	Yes	They must be able to adapt to different modes of production. They may also have to adapt/modify existing methods to fit new needs.
1474	**Purchasing and Inventory Clerks** • Purchasing Clerk • Inventory Analyst	Yes	Sources of raw materials and supplies will change. Some technical textiles (e.g. medical or protective) may have standards that must be met. They will probably have to deal with a larger number of non-standard requests and be innovative in responding to them.
2112	**Chemists** • Laboratory Chemist • Industrial Chemist • Textile Chemist	Yes	Will be part of the product development team, offering expertise in creating new products. Must be able to work with others. In addition, the technologies, products, and even the chemistry itself will be different.
2141	**Industrial and Manufacturing Engineers** • Industrial Engineer • Manufacturing Systems Engineer • Quality Assurance Engineer • Time-study Engineer • Quality Control Engineer • Work Measurement Engineer	Yes	Depending on the type of technical textiles, the engineers may have to learn new systems of assessing safety or environmental compliance. They will also be able to work with non-textile sectors. e.g. Six Sigma They will also need to understand the regulations and needs of clients from other, non-traditional sectors and other countries. Finally, they may need to adapt existing technologies/systems/machines to fit to what they need.
2148	**Other Engineers n.o.c. (not otherwise classified)** • Textile Engineer	Yes	Ability to collaborate with others from other disciplines.

NOC Code	Occupations in the textile industry according to the Comité sectoriel de main d'œuvre de l'industrie textile du Québec (CSMO Textile)	Change in Training or Education?	Reason(s)
2211	**Technologists and Laboratory Technicians** • Chemical Laboratory Analyst • Laboratory Assistant — Applied Chemistry • Master Dyer — Textiles • Quality Control Technician— Chemical Processing • Chemical Laboratory Technician • Chemistry Research Technician • Textile Dyeing Technician • Dyeing and Finishing Technician • Synthetic Textiles Technician • Quality Control Technician — Chemical Processing • Technologist — Textile Dyes • Chemical Research Technologist • Chemical Laboratory Technologist • Dyeing and Finishing Technologist	Yes	New occupation categories may appear.
2233	**Technologists and Technicians in Industrial and Manufacturing Engineering** • Time Study Analyst • Quality Control Technician (except chemicals) • Textile Technician • Quality Control Technologist (except chemicals) • Textile Technologist • Quality Assurance Technologist • Fabric Design Technologist • Time Study Technologist • Technologist, Manufacturing • Industrial Engineering Technologist	Yes	Training requirements and skills profiles will have to be completely revised for some occupations.
2241	**Technologists and Technicians in Electronics and Electrical Engineering** • Electromechanical Technician • Electrical Technician • Electrical Engineering Technician • Electronics Engineering Technician • Electrical Engineering Technologist • Electronics Engineering Technologist	Yes	Will have to learn to use equipment and modify existing equipment to fit new needs. Will need to work as a team with people from other disciplines.
2243	**Industrial Instruments Technologists and Technicians** • Industrial Instrument Mechanic • Industrial Instrument Technician • Instrumentation and Electrical Technician	Yes	Will have to learn to use and repair new equipment.
2281	**Computer Operators, Network Operators and Web Technicians** • LAN (local area network) Administrator • LAN Technician • Internet Web Site Technician	No	

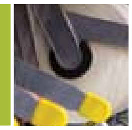
NOC Code	Occupations in the textile industry according to the Comité sectoriel de main d'œuvre de l'industrie textile du Québec (CSMO Textile)	Change in Training or Education?	Reason(s)
6221	Technical Sales Specialists — Wholesale • Technical Sales Specialist — Wholesale • Technical Sales Specialist, Exports • Technical Sales Specialist, Imports	Yes	Technical textiles serve very specific markets. Volumes are likely to be small. Practices that work with wholesale will not work equally well with small markets with highly specialized demands and customized products. They will need to know different technical languages corresponding to the numerous technical textiles markets.
6651	Security Guards and similar • Security Officer • Security Guard • Factory Security Guard	Yes	Some materials may require special handling. Some products and installations may have to be guarded. Intellectual property will be an issue under security. Need to direct and inform emergency response teams of the presence of hazardous materials in emergency situations.
6661	Cleaning Employees — light work • Cleaning man/woman	Yes	Need to know the presence of hazardous materials and sensitive products when cleaning.
6663	Janitors and Building Janitors • Janitor	Yes	Need to know the presence of hazardous materials and sensitive products when cleaning.
7231	Machinists and Machining and Tools Inspectors • Maintenance Machinist	Yes	New and customized machines will be used to produce technical textiles.
7242	Industrial Electricians • Plant Electrician • Apprentice Industrial Electrician	Yes	New machines may have different demands on energy use.
7251	Plumbers • Maintenance Plumber	Yes	More requests will be made to shift towards green solutions.
7261	Tinsmiths • Plant Tinsmith • Industrial Sheet Metal Worker	Yes	Need to be able to adapt to new products and processes. They will also need to adapt and modify existing machines to fit new needs.
7265	Welders and Operators of Welding and Brazing Machines • Industrial Welder	Yes	May have to respond to new and different requests.
7271	Maintenance Carpenters • Maintenance Carpenter • Repairman/woman, Electrical Instruments	No	

NOC Code	Occupations in the textile industry according to the Comité sectoriel de main d'œuvre de l'industrie textile du Québec (CSMO Textile)	Change in Training or Education?	Reason(s)
7317	**Mechanics and Textile Machinery Fitters** • Card Grinder • Knitting Machine Adjuster — Textile Manufacturing • Mechanic-Repairer, Looms — Textile Manufacturing • Textile Machinery Mechanic • Knitting Machine Mechanic — Textile Manufacturing • Loom Millwright — Textile Manufacturing • Loom Preparer • Quilter setter — Textile Manufacturing • Card Setter — Textile Manufacturing • Loom Setter — Textile Manufacturing • Winding Machine Fixer — Textile Manufacturing • Quilter Fixer — Textile Manufacturing • Card Fixer — Textile Manufacturing • Spinning Frame Fixer — Textile Manufacturing • Loom Fixer — Textile Manufacturing • Jacquard Loom Fixer — Textile Manufacturing • Shuttle Fixer — Textile Manufacturing • Comb Fixer — Textile Manufacturing • Mule Fixer — Textile Manufacturing	Yes	Some of these occupations may disappear. Remaining occupations will need to adapt to new technologies and machines.
7333	**Electrical Mechanics** • Electrical Mechanic • Electrical Instrument Mechanic	Yes	May have to work with new and customized equipment.
7334	**Motorcycle Mechanics and similar** • Forklifts Mechanic	No	
7351	**Stationary Engine Mechanics and Auxiliary Machinery Operators** • Maintenance Mechanic for Plant Stationary Engines • Heating and Ventilation Equipment Tender	Yes	Depending on the product, there may be safety or environmental regulations to meet. Materials may be more sensitive to environmental conditions.
7452	**Material Handlers** • Forklift Operator • Pallet Loader Operator • Material Handler — Manufacturing and Warehousing • Stock-keeper Helper	Yes	Volumes will be smaller and some types of materials could be more sensitive.

<table>
<tr><th>NOC Code</th><th>Occupations in the textile industry according to the Comité sectoriel de main d'œuvre de l'industrie textile du Québec (CSMO Textile)</th><th>Change in Training or Education?</th><th>Reason(s)</th></tr>
<tr><td>9216</td><td>Supervisors in Textile Products Transformation
Foreman, Inspection — Textiles
Foreman, Quality Control — Textile Processing
Twisting Foreman/woman
Textiles Foreman/woman
Knitting Foreman/woman — Textile Processing
Finishing Department Foreman/woman — Textile Processing
Finishing Department Foreman — Textile
Spinning Room Foreman/woman — Textiles
Dyehouse Foreman/woman — Textiles
Dye Room Foreman/woman
Weaving Room Foreman/woman — Textile Processing
Hosiery Foreman/woman
Finishing Department Supervisor — Textile Processing
Finishing Department Supervisor — Textile Processing
Dyehouse Supervisor — Textile Processing
Weaving Room Supervisor — Textile
Spinning Supervisor — Textiles</td><td>Yes</td><td>New materials and new technologies will require new skills and knowledge.</td></tr>
<tr><td>9441</td><td>Machine Operators for Textile Fibres and Yarn Preparation
Rover — Textile Manufacturing
Wool Opener and Duster
Winder Operator — Textile Manufacturing
Quiller — Textile Manufacturing
Card Tender — Textile Manufacturing
Sizing Machine Tender — Textiles
Beamer — Textile Manufacturing
Drawing Machine Tender — Textile Fibre
Warp Beamer — Textile Manufacturing
Spinning Frame Tender — Textile Manufacturing
Ring Spinner — Textile Manufacturing
Twisting Frame Operator — Textile Manufacturing
Opening and Blending Operator
Rewinder — Textile Manufacturing
Winder Tender — Textile Manufacturing</td><td>Yes</td><td>New materials and new machines will require new and different skill sets and knowledge.</td></tr>
</table>

NOC Code	Occupations in the textile industry according to the Comité sectoriel de main d'œuvre de l'industrie textile du Québec (CSMO Textile)	Change in Training or Education?	Reason(s)
9442	**Weavers, Knitters and Other Textile Machine Tenders** • Drawer-in Helper — Textiles • Hosiery Seamer • Threader — Textiles • Warp Tier-in — Textiles • Harness Tier — Textiles • Warp Tying Machine Tender — Textiles • Felt-making Machine Operator • Carpet-weaving Machine Operator • Drawer-in — Textiles • Cloth Weaver • Knitter — Textiles	Yes	New materials and new machines will require new and different skill sets and knowledge.
9443	**Dyers and Finishers of Textile Products** • Bleacher — Textile Manufacturing • Colourist — Textile Manufacturing • Centrifuge Operator — Textile Manufacturing • Finisher — Textile Manufacturing • Padding Machine Tender — Textile Manufacturing • Coating Machine Operator — Textile Manufacturing • Drying Machine Operator — Textile Manufacturing • Aging Machine Operator/Tender — Textile Manufacturing • Weft Straightener — Textile Manufacturing • Rinser — Textile Manufacturing • Dyer — Textile Manufacturing	Yes	New materials will require new and different skill sets and knowledge. Work with smaller volumes.
9444	**Quality Controllers, Classifiers and Samplers of Textile Products** • Quality Controller — Textiles • Sampler — Textiles • Finishing Inspector — Textiles • Quality Control Inspector — Textiles • Sample Checker — Textiles • Preshrinking Process Tester — Textiles • Textile Grader	Yes	New materials will necessitate new systems of testing or development of entirely new protocols. Quality control requirements may be more stringent.
9616	**Textile Products Helpers** • Helper — Textile Processing • Carding Machine Cleaner — Textile Processing • Creeler — Textile Processing • Textile Machine Cleaner • Spun Yarn Linker • Spool Carrier — Textile Processing • Cloth Carrier • Loom Cleaner	Yes	Will need to learn how to work with new materials.

BEST PRACTICES IN GREEN MANUFACTURING



Contents

1 Introduction

The historical flourishing of humanity throughout the 20th century was essentially related to the industrial revolution, in which the textile industry played a major role. At the start of the 21st century, the context has changed immensely for Canadian firms in this sector. The vanishing of tariff and trade barriers has triggered profound changes, including the relocation of several textile manufacturers to emerging countries such as China. Faced with global competition, the Canadian industry must not only react — it is now forced to review its practices, innovate and explore new markets.

This becomes increasingly apparent as in the 21st century we witness the dramatic results of the environmental impact of the industrial revolution: overexploitation of resources, biodiversity loss, threat of climatic changes, rising gap between the rich and the poor, end of affordable oil, etc. The impacts of these changes are sure to affect the development of textile firms and society as a whole in the medium and long run, though it remains unclear precisely how this will transpire.

How can these challenges be overcome? Would it be possible to simultaneously integrate innovation challenges (to face competition) and solutions to environmental problems and rising social gaps?

The authors of this report believe this to be possible; absolutely essential in fact. This idea is also gaining momentum in the international business community. In September 2009, in the midst of the global financial crisis, Adi Ignatius, publisher of the *Harvard Business Review*, wrote: "companies won't innovate successfully — and as a result won't grow — unless they throw themselves whole hog into green initiatives."[1] Many go as far as to claim that we have entered the next industrial revolution.[2] As readers will note via the examples that are quoted throughout this document, the textile industry is in possession of all the tools it requires to position itself, once again, as a leader of this new revolution.

In order to first understand the arguments in favour of sustainability and ecodesign, Section 2 of this report presents the "Business Case" of a sustainable development initiative, while laying out the major related issues.

Section 3 gives a general description of the best practices adopted by some forty cutting-edge firms from Canada and other countries.

Section 4 provides concrete examples of possible ways in which processes, technologies and strategy may be improved.

Section 5 identifies the core skills required for each type of position in order to succeed at integrating the concepts of sustainability in management practices.

Finally, Section 6 lays out a series of recommendations aiming to help the Canadian textile industry to reinvent itself, with the goal of positioning itself once again at the forefront of the local and global manufacturing sector.

[1] Ignatius, Adi, *Harvard Business Review* (September, 2009).

[2] McDonough, W. and Braungart, M., *Cradle-to-cradle: remaking the way we make things* (New York: North Point Press, 2003).
– Lovins, A. et al, *Natural Capitalism: Creating the next industrial revolution* (Back Bay Books, 2000).
– Trudel, J.S., *Arrêtons de pisser dans de l'eau embouteillée* (Les Éditions Transcontinental, 2007).

2 Sustainable Development: A Business Case

Is sustainable development really profitable? We are already recycling, what may we gain by doing more? When surveyed, many consumers claim that they are concerned with the environment, but do they favour more eco-friendly products when making purchases?

Leaders interested in sustainability raise many legitimate questions. Over the last 20 years, a growing number of organizations have integrated new management practices. Their experiences have shown, year after year, that there really is a *business case* for sustainable development. The following describes the main advantages generated by the adoption of sustainable practices in firms.

2.1 Image Enhancement

One potential advantage of a sustainable practices approach is a better reputation and image for firms.

Indeed, one study of consumer purchasing trends reveals that a majority (54%) of respondents claim that sustainability is a determining factor in decision-making when choosing a product or retailer. For 20% this is a dominant factor, and consumers most sensitive to the ecological footprint of products and manufacturers display a tendency to purchase more frequently and spend more than average consumers.[3]

Organizations with a reputation for being more socially engaged and responsible with respect to their environmental footprint are usually also more successful in attracting new consumers, increasing their market shares, and communicating with their stakeholders.[4]

2.2 Competitive Advantage

Many studies show that if offering eco-friendly products can indeed enhance corporate image, merely changing the colour of a logo (so-called "greenwashing") doesn't suffice to derive benefits.

In an article published in *Harvard Business Review*, Steve Bishop, Global Lead of Sustainability at IDEO design firm, argues that adopting an environmental positioning may in fact alienate a portion of a firm's existing consumers who are mainly concerned with quality and pricing. Further, he says, "[g]reen for green's sake products often don't meet the basic needs that most people require from their products. Take hemp clothing, for example. If green for green's sake products could go mainstream, we'd all be wearing hemp sweaters and be happy about it."[5]

In his view, one mistake firms make is to focus on one niche product — a market limited in itself. In contrast, they have every interest in promoting "green behaviours that everyone can aspire to."

When IDEO worked with bicycle parts manufacturer Shimano to create a competitive advantage, rather than turning to green consumers the designers focused on a "growth strategy with a 'green outcome' — more people riding bikes and enjoying it."

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3 Deloitte, *Finding the green in today's shoppers — Sustainability trends and new shopper insights* (2009), www.deloitte.com/assets/Dcom-Shared%20 Assets/Documents/US_CP_GMADeloitteGreenShopperStudy_2009.pdf

4 Industry Canada, *Responsabilité sociale des entreprises — Analyse de la rentabilisation de la RSE* (2011, consulted April 4, 2011), www.ic.gc.ca/eic/site/csr-rse.nsf/fra/h_rs00100.html

5 *Harvard Business Review, "Don't Bother with the "Green" Consumer"* (January 23, 2008), www.hbrgreen.org/2008/01/dont_bother_with_the_ green_con.html

This novel approach has enabled the firm to do what none of its competitors had been able to do yet: speak directly to 161 million potential consumers who don't have a bicycle.

A sustainable development approach should allow firms to develop competitive advantage "not by trying to appeal to green consumers by building green myths into the products they have, but rather by creating remarkable products that authentically integrate environmental and social values," argues Bishop.

2.3 Cost Reduction

Another benefit usually derived from a sustainability initiative is a reduction in operation costs. Improvements in energy efficiency or reductions in water consumption, waste, residue or greenhouse gas emissions are all moves that translate into greater environmental performance and cost reduction.

Firms that adopt more sustainable management practices are also known to be better managed. Therefore, they are considered by creditors and investors to be less at risk and, as a result, have greater access than their competitors to capital, preferential loans, and more favourable insurance premiums. Several studies have examined the relationship between social responsibility and the level of financial performance of firms, and the literature tends to demonstrate that this relationship is indeed positive.[6]

2.4 Mobilizing Staff and Recruiting Best Talents

Enhancing corporate reputation allows firms to attract more skilled employees and reduce their turnover rate. A proportion of workers will be motivated by an alignment of their values with those of the firm, which in turn will increase their commitment and level of productivity.

Because labour costs amount to a substantial portion of a firm's expenses, often exceeding 50%, mobilizing staff and improving recruitment of key employees through a serious sustainability approach turns out to be a major source of potential benefit for an organization.

2.5 Innovation and Ecodesign

By incorporating sustainability criteria into product design practices, a firm's innovative capabilities are stimulated. Developing a product with the aim of reducing its environmental footprint leads a firm's research and development (R&D), marketing, and production teams to find new assembly solutions, new materials, and new processes, and to meet customer needs in innovative ways.

More and more, design teams are required to integrate life cycle thinking into the design process, and increasingly seek to innovate by approaching their customers' needs systemically. In some cases, wanting to reduce a product's environmental impact may lead to reviewing a business model and ultimately offering the products to consumers through an alternate means — for example, rental or service instead of sale — which entails quite different design criteria, such as design for reuse or even reconditioning.[7]

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6 Industry Canada, 2011.
7 McDonough and Braungart.

A recent study[8] reveals the extent to which integrating environmental thinking into the product design process generates both positive economic impacts and a heightened capacity for innovation, by encouraging greater creativity. "In the majority of the products sampled (24 cases out of 30), the ecodesign process was said to have had an impact on creativity within the firm." It can also be noted that 26 of the 30 (87%) sustainably designed products that were examined presented additional functional attributes or improvements substantial enough to replace an existing product.

2.6 Consumer Requirements (Environmental and Social Labels)

In the latest TerraChoice study[9] on the marketing of environmental products, over 95% of the 4,744 products assessed displayed some sign of greenwashing. Simply put, almost all environmentally-friendly references on green-identified products were found to be exaggerated, incomplete, misleading, unreliable, invented or downright false. The study also reveals that between 2009 and 2010, the number of green products on the market increased by 75%.

Facing so much unreliable information, consumers are increasingly reluctant to trust manufacturers. For more credible information they rely on environmental labels, such as "green" certifications provided by independent parties signifying that products meet given standards, are free of certain hazardous substances, or that their manufacturing processes are less harmful for the environment. Environmental labels that apply to the textile industry are detailed in Section 3.

In addition to consumer requirements, a growing number of organizations (firms, municipalities, governments) are also adopting responsible procurement criteria. In another study published by TerraChoice (2009), carried out during the global financial crisis, it appears that some 80% of firms expect that they will "do more 'green' purchasing over the next two years."[10] The challenge will be, respondents say, to provide eco-friendly products at more competitive prices.

[8] Institut de développement de produits (IDP), *L'écoconception : quels retours économiques pour l'entreprise?* (2008): www.idp-ipd.com/images/pdf/etudes/idp_eco_etude.pdf

[9] TerraChoice, *Greenwashing Report* (2010), sinsofgreenwashing.org/findings/greenwashing-report-2010/

[10] TerraChoice, *EcoMarkets — summary report* (2009), www.terrachoice.com/files/EcoMarkets%202009%20Summary%20Report%20-%20Oct%202009.pdf

2.7 Non-tariff Barriers

In the last decades, there has been a strong tendency to eliminate tariff barriers and import quotas in the name of free trade. This opening of markets, however, has been hampered by a growing number of non-tariff barriers in the form of environmental requirements.[11]

Extended Producer Responsibility (EPR) is a regulatory approach now used by governments to impose a management fee on manufacturers for their end of life-cycle residual materials. In the province of Québec, for example, the organization Éco entreprises Québec bills manufacturers based on the weight of their packaging. Those manufacturers that reduce packaging can therefore limit their fees, while those that over-package pay higher fees than their competitors.[12]

Another example illustrating the use of non-tariff barriers: in 2008 the European Union (EU) adopted two regulatory directives known as the REACH (Registration, Evaluation, Authorization and Restriction of Chemical) and the WEEE (Waste Electrical and Electronic Equipment). The REACH restricts the use of certain hazardous substances in electronic equipment (including lead, cadmium and mercury) — firms that don't comply with these restrictions are denied access to the European market. The WEEE is an EPR strategy that imposes on firms an obligation to plan an infrastructure for the collection of electronic residual materials that they introduce into the European market.[13]

An emerging trend in non-tariff barriers, observed mainly in the OECD (Organisation for Economic Co-operation and Development) countries, is the requirement to provide a certified carbon balance, which has resulted in limiting access to the market. This information may be found on the product itself in the form of a carbon label affixed by the manufacturer, or it can be required by government to be presented elsewhere. Large retailers such as Wal-Mart, RONA, Tesco, Casino, and many others have launched similar initiatives aimed at quantifying the social and environmental performance of their suppliers for their entire product life-cycles.[14]

[11] National Foreign Trade Council (NFTC), *Enlightened Environmentalism or Disguised Protectionism?: Assessing the Impact of EU Precaution-Based Standards on Developing Countries* (2004, p. 89, consulted April 4, 2011), www.wto.org/english/forums_e/ngo_e/posp47_nftc_enlightened_e.pdf

[12] Éco entreprises Québec (ÉEQ), *Tarif 2009 pour les catégories « contenants et emballages » et « imprimés »: règles d'application et de contribution* (2011, p. 26, consulted April 4, 2011), www.ecoentreprises.qc.ca/_site/EEQ/documents/applications/pdf/tarif_2009_VFF_21_01_2011.pdf

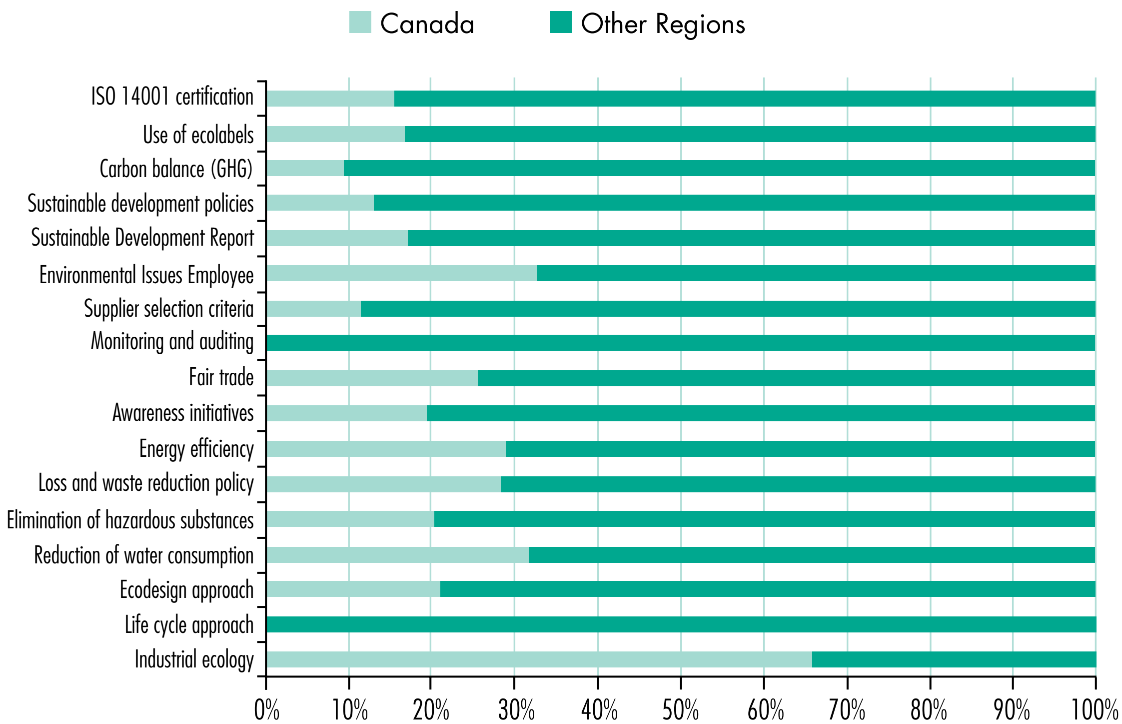
[13] European Commission — Environment, *Recast of the WEEE Directive* (2011, consulted April 4, 2011), http://ec.europa.eu/environment/waste/weee/index_en.htm

[14] Trudel, 2010.

3 Overview of Sustainable Development in the Textile Industry

In comparison to the United States, Europe, China, and other regions of the world, the Canadian textile industry appears to be lagging behind significantly in terms of the integration of practices associated with sustainable development. Yet, although the proportion of Canadian firms having adopted these practices is inferior to that recorded in other countries, data nonetheless indicates that they are catching up (Figure 1).

Figure 1: Proportion of identified leading firms in compliance with sustainability criteria — by geographic area

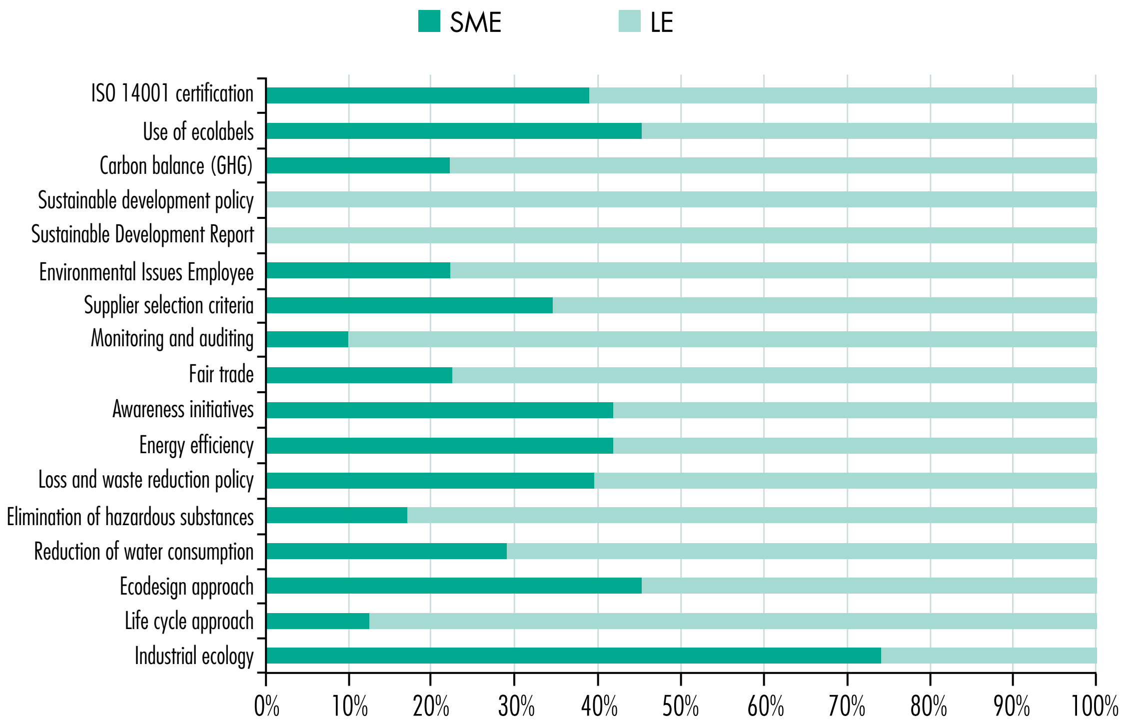


A literature review was carried out in order to establish an accurate picture of the best practices in use in the textile industry. A list of 17 indicators associated with a sustainability approach enabled the identification of leaders in the literature. To be retained for analysis, a firm had to meet a minimum of one out of 17 criteria. Three sources were consulted:

- Scientific databases;
- Corporate literature available online; and,
- Sector analyses (also available online).

In total, 44 firms in the textile industry were retained for analysis, geographically distributed as follows: 9 in Canada, 13 in the USA, and 22 in Europe, China, and elsewhere around the world. Figure 2 illustrates distribution among large enterprises (LE) and small and medium-size enterprises (SME) for each indicator, while the same sample is distributed by industry sector and geographic area in Figure 3.

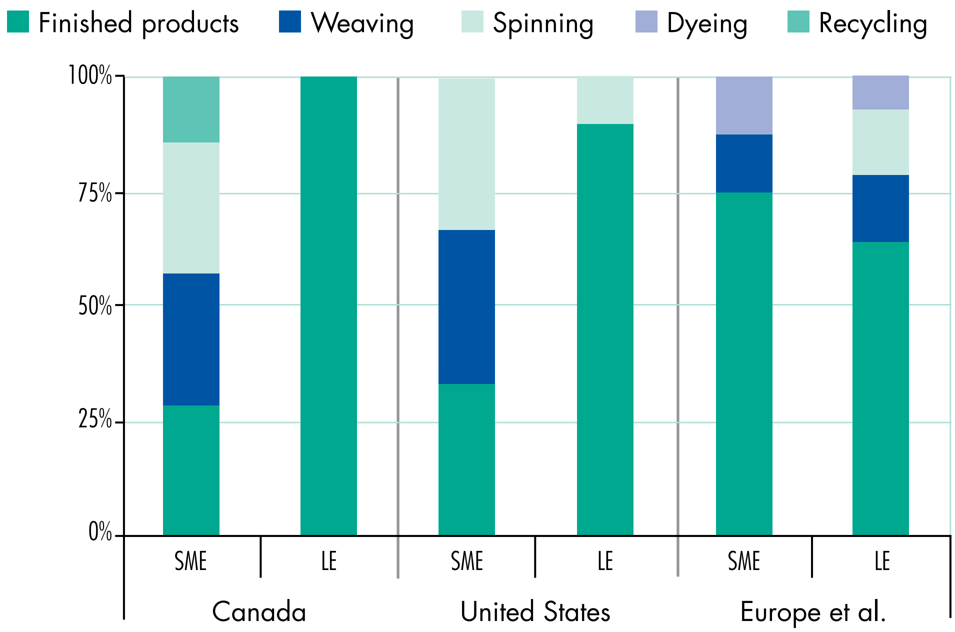
Figure 2: Proportion of identified leading firms in compliance with sustainability criteria — by firm size



Certain specific sectors tend to demonstrate a higher level of compliance to some indicators. For example, fair trade is more relevant to firms specializing in finished products than weaving or spinning mills, while industrial ecology is more relevant to vertically integrated firms.

In addition, in Canada, the proportion of leading firms producing finished products is lower than in the United States and other regions of the world. Because they are in direct contact with end-consumers, firms that manufacture finished products generally tend to perform better. This may explain, at least in part, why Canada is lagging so far behind. It should also be noted that our sample of leading firms includes 18 manufacturers specializing in outdoor apparel and accessories.

Figure 3: Proportion of identified leading firms in Canada, the United States and other countries — by firm size



These 17 indicators were selected because of their strong association with sustainable development in the literature. The following sections provide a more detailed definition of each indicator.

3.1 ISO 14001: for Firms and/or Suppliers

The firm is certified ISO 14001 (as opposed to firms that comply with the criteria yet are not certified or are on the way to certification). In the case of a firm specializing in sales of finished products, the criterion was considered to be met when its subcontractors were ISO 14001 certified.

3.2 Presence of Ecolabels

The firm, or one of its products, exhibits an ecolabel or an independent certification, or minimally a label deriving from an external organization presenting no affiliation with the firm (e.g.: Carpet and Rug Institute). The most common label encountered in the sample is Oeko-Tex 100.

3.3 GHG Balance of the Firm/Products

The firm, or one of its products, has undergone a greenhouse gas (GHG) balance. The criterion was met if the firm mentions its "GHG balance", "carbon balance", or "carbon footprint", or if the firm has demonstrated its awareness of the GHG emissions generated by all of its activities (gate-to-gate, cradle-to-gate or cradle-to-grave). Conformance to the ISO 14064 standard or other methodologies was not assessed.

3.4 Sustainable Development Policy/Corporate Social Responsibility

The firm meets this criterion if it explicitly refers to the firm's social responsibility or sustainable development policy. It was granted that a firm that publishes a report on sustainable development is endowed with such a policy (the contrary was not verified, however).

3.5 Sustainability Report

Preparation of a sustainability report has become a standard in large firms around the world since 2006. Within these reports, also called reports on corporate social responsibility (CSR), organizations publish information on their environmental, social, and financial performance. This report can sometimes be found in the traditional financial report of a firm. Although auditing of social and environmental information isn't as regulated as it is with financial statements, it does comply more and more with international standards, including those of the Global Reporting Initiative (GRI). A firm meets this criterion if it makes available online, through its corporate website, a report describing its sustainable development activities and its social responsibility.

3.6 Dedicated Employee to Environment or Sustainable Development

At least one person in the firm is clearly identified as the employee responsible full-time for the firm's environmental, ecodesign, sustainable development, and/or social responsibility component.

3.7 Selection of Suppliers

The firm has established a privileged relationship with its suppliers, which are small in number and show engagement (for example: signature of a Charter). The firm may require from its suppliers that they respect certain rules (for instance, regarding the working conditions of their workers), failing which they are in breach of contract and risk termination. It may also endow itself with a Responsible Procurement Policy (RPP) guiding the selection of its suppliers, or even of its sub-contractors. In addition to assessing a potential provider in accordance with traditional factors such as cost, quality and delivery capacity, an RPP adds environmental and social criteria to the assessment, which can cover either a given product or the providing firm. These criteria may be compulsory (entry criteria) or discriminatory (selection criteria).

3.8 Monitoring and Auditing

In order to control consistency with corporate rules of good governance, the firm performs social and/or environmental audits or monitoring of its various sites and/or sub-contractors and providers. These audits and site evaluations may be carried out by internal staff or by outsourced independent experts. Even if best practices require that firms make these reports public, this transparency criterion was not included because it was deemed too stringent in light of existing practices.

3.9 Fair Trade

The firm is a member of a fair trade association (for example: Fair Labor Association, World Fair Trade Organization, Rainforest Alliance) or a product it manufactures is certified with a fair trade label (for example: Max Havelaar certified).

3.10 Awareness Initiatives

The firm carries out awareness initiatives aiming to foster environmental awareness in clients (special labels supporting sustainability or social responsibility, conferences and talks, online information on website, etc.), in employees (training, setting environmental practices in the workplace, etc.), as well as in suppliers and competing providers. Among the awareness tools identified some are of particular interest, namely: green consumerism campaigns and sustainability campaigns, information about the impacts of its clients and, above and beyond, general and targeted training programs (e.g.: "Introduction to Sustainable Development", "Eco-driving").

3.11 Energy Efficiency

The firm is concerned with reducing its energy consumption (for example: improving process efficiency, heat recovery, new technologies). Alternatively, it favours renewable energy in place of fossil-based energy.

3.12 Loss and Waste Reduction Policy

The firm seeks to minimize its waste production at source (for example: optimization of processes to minimize losses).

3.13 Elimination of Hazardous Substances

The firm seeks to reduce or eliminate the hazardous components that make up its products (for example: heavy metals). It implements or doesn't implement a government directive (for example: the REACH directive).

3.14 Reduction of Water Consumption

The firm seeks to reduce its water consumption, either through optimization of existing processes or adoption of new processes and technologies.

3.15 Ecodesign Approach

The firm's products are, either wholly or in part, designed in such a way as to enhance their environmental profile in comparison to existing products on the market. Several ecodesign initiatives were retained: selection of organic materials, lengthening of life-cycles or improvement of product quality, use of recycled materials, product design (for example: creating modular carpet tiles, lowering number of components, eliminating most polluting stages), preferred use of environmentally low impact materials, etc.

As for the Monitoring and Auditing indicator, ecodesign best practices (integrating life-cycle analysis, performance assessment, including the social component) were not a criterion used to acknowledge an ecodesign approach. As a result, some ecodesign practices, presumably used in good faith, may unfortunately have adverse effects, increasing social and environmental impacts or causing a shift of impacts from one category of impacts to another, or from one stage of the life cycle to another. This may be the case when a designer resorts to selection criteria based on product features (recycled, organic, etc.).

3.16 Life Cycle Approach

The firm mentions the Life Cycle Assessment (LCA) methodology.

In our sample, LCA is mainly used by firms manufacturing finished products when communicating with their providers, and most often this is done internally, resulting in this information not being audited by an independent party, a stage required by the ISO 14044 standard for this information to be made public.

Yet, LCA may still be used at every stage of the production chain, as demonstrated by Germany's Lenzing group, which relies on LCA to ensure that the process it uses to create nonwovens from cellulose fibres performs better from an environmental standpoint,[15] and the Novozyme case, which compares, based on a life cycle approach, a manufacturing process using only enzyme processes and a traditional manufacturing process.[16]

3.17 Industrial Ecology

The firm values another firm's waste either for a portion of its production or its entire production, and/or ships its own wastes to another firm for recovery.

[15] Shen, L., Worrell, E. and Patel, M.K., *Environmental impact assessment of man-made cellulose fibres* (Conservation and Recycling, Volume: 55, Issue: 2, 2010b, 260–274).

[16] Nielsen, A. M. and Nielsen Henning, "Comparative Life Cycle Assessment cotton T-shirt produced with biotechnology and conventional technology" (2010).

4 Improvement Potential for the Industry

To illustrate how firms in the textile industry differentiate themselves in terms of incorporating sustainable development, this section provides concrete examples found in the literature review. Firstly, using the product life cycle approach, the principal environmental impacts will be described in order to give an outlook of the major "hotspots" in the textile industry. Secondly, a series of examples will highlight the potential for improvement of equipment, processes, supply and distribution chains, efficiency, and business models.

4.1 Life Cycle Assessment

Thanks to Life Cycle Assessment (LCA), it is now possible to target major environmental impacts with the goal of making better choices when designing products. LCA is a scientific methodology that is used to assess environmental impacts by taking into account all the stages in the life cycle of a product — i.e.: extraction of resources, transformation and manufacturing, distribution, usage, and end of life. It is embedded into ISO international standards (ISO 14040, 2006; ISO 14044, 2006).

Table 1 summarizes the main environmental impacts across the life cycle of clothing. It should be noted that, although wet processing (water), transportation (energy) and fabrication (wastes) display the most substantial environmental impacts, users also bear considerable responsibility for the environmental performance of a product due to its maintenance. In light of this, in cases where textile products need to be washed on a regular basis, designing the product in a way that minimizes maintenance may turn out to be more profitable and beneficial.

Table 1: Main environmental impacts across the clothing lifecycle (GEM DD, 2009)

	Water Consumption and Pollution	Air Pollution	Energy Consumption and GHG Emissions	Solid Waste
Fibre Production	High	Significant	High	Significant
Spinning			Significant	High
Weaving — Knitting			Significant	Significant
Wet Processing	Very high	High	High	Significant
Cutting & Manufacturing			Significant	Very high
Accessories	High	Significant	Significant	Significant
Packaging				Significant
Transportation & Logistics		High	Very high	Significant
Maintenance	Very high	Significant	Very high	
End of Life		Significant	Significant	Very high

A number of firms in the textile sector have turned to LCA to improve their performance. In one such case, InterfaceFLOR has innovated with modular carpet. This carpeting enables reduction of losses during installation, may contain more than 70% recycled materials, and is adhered using *TacTiles*® connectors (which adhere tiles together rather than using spread adhesives to glue carpet onto the floor, which results in emissions of volatile organic compounds (VOC)). InterfaceFLOR has also developed Cool Blue™ and ReEntry™ technologies, which are intended to separate carpet backings and recycle nylons 6 and 6/6, and enable the firm to buy raw materials from its clients and other products from its competitors.

Among fibre alternatives, new applications were developed for traditional fibres, such as using linen or hemp as reinforcement within a compound. Similarly, many biopolymers are being developed such as PLA (polyactic acid), which is made from cornstarch, opening the way to a new range of applications for renewable materials. Once again, LCA allows firms to gain better insight into the differences between materials, which in turn can lead to avoiding the solutions that simply cause impacts to shift or, worse, that increase the entire product's footprint.

Reduction in resource consumption is a performance indicator that is systematically factored into product development. However, when targeting reduction in environmental impacts, this factor must not be the only indicator. In some cases, as mentioned above, it may be more beneficial to focus on reduction in water or energy consumption during the usage stage in order to cause a net gain from an environmental standpoint.

Similarly, the use of recycled or recyclable materials may be relevant. In some domains, such as transportation, however, this must not be at the expense of the weight or energy performance of a vehicle. Once more, LCA takes these concerns into consideration.

4.2 Examples of New Technologies and Equipment Modification

Recycling of fibres: Textile fibres (cotton and polyester) can be recovered and recycled to produce new fibres — however, the question is whether the recycling process results in an environmental advantage. A study incorporating LCA methodology demonstrates that using recycled polyethylene terephthalate (PET) in the production of fibres allows savings ranging from 40% to 85% for non-renewable energy and from 25% to 75% for global warming in comparison to virgin PET.[17] Results for other categories of impact are unknown.

Organic Certification: When natural fibres are used, procurement of fibres from certified organic sources reduces considerably the impacts related to the production and use of fertilizers and pesticides.

Victor Innovatex: The spinning process involved in the production of Victor Innovatex's Eco Intelligent Polyester® is antinomy-free and the Cradle to Cradle® certification of these fabrics ensures infinite recyclability of the product as well as hazard-free product transformations. Victor Innovatex has also developed Agion® technology, which increases resistance of fabrics to microbes, as well as to wash cycles and light.[18]

[17] Shen, L., Worrell, E. and Patel, M.K., *Open-loop recycling: A LCA case study of PET bottle-to-fibre-recycling* (Resources, Conservation and Recycling, Volume: 55, Issue: 1, 2010a, pp. 34–52).
[18] Canadian Textile Journal, *Sustainable fabrics with Agion^MD antimicrobial protection* (June 2010, consulted January 20, 2011), findarticles.com/p/articles/mi_qa5422/is_201006/ai_n54717108/?tag=content;col1

Spintex: This firm has developed Greenspun yarns, made entirely from recycled materials: 80% recycled cotton and 20% polyester (derived from wastes such as bottles, industrial wastes, etc.). Integrating polyester allows Spintex to use cotton shreds that would otherwise be too short to produce fibres. In addition, Spintex utilizes software that is capable of determining the best combination of recycled threads in order to obtain a particular colour, which consequently allows them to eliminate the dyeing stage.[19]

Merrell: It's a known fact: the best waste is that which is not produced. Merrell has put this saying into practice for its white fabrics, which involve no dyeing whatsoever. The principle of Merrell's NADA program is simple: Not Any Dye Applied.[20]

Lenzing: This firm has developed Lyocell fibres for nonwovens. This process directly uses a cellulosic solution to create a nonwoven fabric, instead of other traditional oil-based products. An LCA has demonstrated that these new fibres provide higher levels of environmental performance than cotton and PET for all of the impact categories assessed (except for aquatic ecotoxicity, in which case PET performs better).[21] It also performs better than polypropylene in four out of eight categories.[22]

NanoSphere® Technologies: Textiles finished with NanoSphere® technologies require less frequent washing and need to be washed at lower temperatures. NanoSphere® meets the bluesign® standard.[23]

4.3 Examples of Process Changes

Teksajo: This is the first free ecodesign software for the textile industry. It is based on a life cycle approach and displays five indicators including water consumption, greenhouse gas (GHG) emissions or emissions of pollutants, for a variety of products and materials that enter the textile design stage. Development of the software, which was funded by the *Institut Français du Textile et de l'Habillement*, cost $690,000. It is expected to be available in 2012.[24]

AirDye®: This technology applies dye without the use of water. Rather, the process uses air to help the dye penetrate the fabric. In addition to managing the application of colour to textiles without water, it requires less energy. The technology presently works only for synthetic fibres.[25]

Fibroline: This process is employed for the printing of woven and nonwoven fabrics. Traditionally, the impregnation stage requires the use of solvents. Fibroline utilizes an electric field to help the powders penetrate into the fibres. It also results in a better distribution of the powder, which translates into savings.[26]

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19 Canadian Textile Journal, *Spinning a greener yarn with Spintex* (April 2007, consulted January 12, 2011), findarticles.com/p/articles/mi_qa5422/is_200704/ai_n21286228/?tag=content;col1

20 AirDye, *Much Ado about Nada*, (2009, consulted January 12, 2011), blog.airdye.com/goodforbusiness/2009/09/28/much-ado-about-nada/

21 Shen, et al. (2010b).

22 Canadian Textile Journal, *Lenzing and Weyerhaeuser will cooperate to develop sustainable nonwovens* (October 2008, consulted January 12, 2011), findarticles.com/p/articles/mi_qa5422/is_200810/ai_n31109804/?tag=content;col1.

23 Canadian Textile Journal, *Nanosphere[MD], a green finishing technology* (April 2009, consulted January 12, 2011), findarticles.com/p/articles/mi_qa5422/is_200904/ai_n31667467/?tag=content;col1

24 Technique de l'ingénieur, *Premier logiciel gratuit d'éco-conception pour la filière textile* (2010, consulted January 14, 2011), www.techniques-ingenieur.fr/actualite/environnement-securite-energie-thematique_191/premier-logiciel-gratuit-d-eco-conception-pour-la-filiere-textile-article_10968/

25 AirDye (2011), www.airdye.com

26 Usine nouvelle, *Fibroline : des textiles non tissés imprégnés à sec* (2004, consulted January 12, 2011), www.usinenouvelle.com/article/fibroline-des-textiles-non-tisses-impregnes-a-sec.N42386

Plasma: With the use of plasma, surface properties of fibres can be modified without causing deterioration, unlike traditional liquid processes. For example, with this process, fibre properties can be made hydrophilic or hydrophobic, or the binding properties of pigments for the colouring of fabrics can be strengthened. This process is low-polluting and consumes low energy.[27]

Elemental (Novozyme): Novozyme develops enzymes and organic solutions for industrial applications. The Elemental process utilizes enzymes as an alternative to chemical compounds throughout the entire textile production chain. By comparing the dyeing and the processing stages in the production of a T-shirt — first using the Elemental process and then the traditional process — an LCA has highlighted that Elemental can in fact reduce its climate change-causing impacts (more than 1 ton of CO_2/ton of fabric) because it uses less heat and electricity.[28]

4.4 Examples of Responsible Procurement

bluesign® standard: The bluesign® standard applies throughout the production chain, and ensures the consumer's safety while protecting the environment. The standard is in fact an assessment tool designed to measure durability, enabling analysis of every addition to a given process, and identification of the substances that are potentially hazardous with a view to eliminating them. This instrument can be used at all levels of the textile production chain, from spinning, to weaving or dyeing, and even at the retailer and consumer end.[29]

Examples of firms applying this standard:

- **Yarn producers:** HoYu Textile
- **Finished products:** Patagonia, REI and Mountainsmith select their suppliers in accordance with the bluesign® standard.

Sustainability Legislation in Québec: The *Loi sur le développement durable du Québec* is a provincial environmental law implemented in 2006 that has had far-reaching effects on the procurement criteria of the 150 ministries and government agencies in this province. For example, Hydro-Québec is preparing new selection criteria under which suppliers will have to qualify their products and firms, based on their environmental and social performance.[30]

To be consistent with its own sustainable development law, the Québec government in 2009 adopted a regulation on procurement contracts with public agencies, in which article 37 states that a public agency can resort to a quality insurance system — namely the ISO 9001:2000 standard — or another specification related to sustainable development and the environment when carrying out a contract. As such, a public agency that includes these requirements in a call for tenders now enjoys a 10% preferential margin with respect to the lowest bidder.[31]

[27] Le textile de demain, *Plasmatex : le plasma conquiert le textile* (2008), Textile Magazine (n 31, 2008b), p.31.
[28] Nielsen and Henning.
[29] bluesign® standard (2011, consulted January 28, 2011) www.bluesign.com/index.php?id=home
[30] L'espace québécois de concentration sur les pratiques d'approvisionnement responsable (ECPAR), *Rapport de recherche — pratiques d'approvisionnement responsable — Analyse des volets social, environnemental et économique* (2008), www.ciso.qc.ca/wordpress/wp-content/uploads/ecpar_rapport_avril09.pdf
[31] Gouvernement du Québec, Règlement sur les contrats d'approvisionnement des organismes publics -Loi sur les contrats des organismes publics (L.R.Q., c. C-65.1, a. 23) (1er mars 2011), www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=3&file=/C_65_1/C65_1R2.HTM

Selection of Providers: Lafuma is endowed with an ethical charter[32] included in its general purchasing terms and conditions and signed by 100% of its suppliers. The other members of Groupe Lafuma (e.g.: Millet) have adopted this charter as well, which is also signed by their own providers. Patagonia favours long term relationships with its providers and willingly partners with only a limited number.[33] Adidas, Columbia, Nike, Gildan, and Patagonia are members of the Fair Labor Association (FLA).[34]

Awareness Initiatives: Patagonia organizes educational trips for its competitors. In addition, the firm applies for a very small number of patents in order to make technologies available to all.

4.5 Example of Reduction of Resource Consumption (Ecoeffiency)

BASF: In collaboration with the United Nations Environment Programme (UNEP) and the United Nations, BASF has developed an ecoefficiency analysis software program to help dyeing firms optimize their processes.[35] The program integrates the LCA approach in addition to six indicators. A workshop was held to train 40 participants from the textile industry on how to use the software.

4.6 Examples Entailing a Review of Business Models, Design and Management Process

Shaw Industry: Post-consumption carpet recovery system for the production of new carpets (cradle-to-cradle products). For this purpose, the carpets are designed to be 100% recyclable (also called Design-for-Disassembly).[36]

Teijin Fibers: The ECO CIRCLE® system stems from a cooperative organization of apparel manufacturers that recovers polyester clothing in order to remanufacture new fibres. ECOPET® technology now allows for the manufacturing of recycled fibres from recovered PET plastic bottles.[37]

Victor Innovatex: Eco-Intelligent® fabrics contain no hazardous or carcinogenic chemical substances, and are infinitely recyclable (cradle-to-cradle).[38]

Patagonia and Millet: Offer after-sale repair services, with the goal of extending their products' life cycles for as long as possible.[39]

Klättermusen: Offers the rECOver program to recover Klättermusen products in exchange for purchasing rebates (some recovered products are repaired and donated to charity).[40]

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32 Lafuma, Sustainable Development Report (France: Groupe Lafuma, 2008).
33 Voyageons autrement, *Patagonia — Production et commercialisation de vêtements et accessoires outdoor — développement durable et Matos de Montagne* (2011, consulted January 12, 2011), www.voyageons-autrement.com/patagonia.html
34 Fair Labor Association, *FLA associates* (2011, consulted January 28, 2011), fairlabor.org/fla/go.asp?u=/pub/mp&Page=ParticipatingCompany1
35 BASF, *BASF's joint eco-efficiency project with UNIDO and UNEP* (2011), www.basf.com/group/corporate/en/sustainability/global-compact/unido-unep
36 Shaw Green Edge (2011), www.shawgreenedge.com
37 Teijin Fibers, *Environmentally-Friendly Materials* (2011), www.teijinfiber.com/english/environment/index.html
38 Victor Innovatex, *Eco-intelligence* (2008, consulted January 12, 2011), www.victor-innovatex.com/en/ecoIntelligence.php
39 Voyageons autrement, 2011.
40 Klättermusen, *Returned deposits on outdoor clothes and equipment!* (2011, consulted January 12, 2011), www.klattermusen.se/recover_EN.php?lang=EN&curr=

InterfaceFLOR: Has explored a new business model in selling its modular carpet installation and maintenance expertise rather than selling the product itself. This service approach enables the firm to remain the owner of the carpeting and, as a result, it can recover the materials at the end of their life cycle. The advantage with this approach is that the firm's inventory remains profitable while it is in the client's site, and then makes a full circle when optimized and reused. However, the program has encountered some difficulties, specifically with respect to tax rules. In this business model, carpet is not recognized as capital expenses but as operation expenses.[41]

Fibre Citoyenne® programme: This program offers help to firms that wish to pursue the path of social responsibility (counseling, guidance and independent auditing). In exchange, the firm commits to acting socially responsibly 100% of the time. About 85% of the firms in the professional garment sector in France have become members.[42]

[41] Anderson, R., *Confessions of a Radical Industrialist: Profit, People, Purpose — Doing Business by Respecting the Earth*, (McClelland & Stewart, 2009, p. 320).

[42] Fibre Citoyenne (2011, consulted January 12, 2011), www.fibrecitoyenne.org/index.php?id=3

5 Inventory of Core Skills in Sustainable Manufacturing

5.1 Definition of the New Set of Skills Related to Sustainable Manufacturing

In the last few years, sustainable development has led to the creation of several new jobs in textile businesses, and the adaptation of other existing jobs.[43] New positions and new skills go together. To shed some light on the implications of such changes, Table 2 outlines the core skills and specific knowledge required in key occupation categories (senior management, managers, sales & marketing, research & development, process engineers, chemical engineers, supervisors, operators, and technicians).

Table 2: Core skills and specific knowledge required in key occupation categories

Role	Business Goals and Application of Sustainable Development	Related Skills	Knowledge to be Acquired
President VP Marketing VP Finances VP Operations VP Human Resources	Corporate positioning on sustainability: definition of overall vision Reviewing business models (ecodesign, life cycle thinking, etc.)	Change management Systems thinking Strategic planning Long term planning Implementing a sustainability policy Ecodesign Mobilizing employees to integrate steps to sustainable development Project management Strong ethical convictions, integrity and commitment to social justice	Knowledge of stakeholders' roles Knowledge of sustainable design principles and understanding the need to integrate these principles Knowledge and understanding of geopolitical contexts Knowledge of role and functioning of global institutions (e.g. UN, World Bank, etc.) and NGOs Knowledge of standards, trends, financial programs
Procurement	Coordinating environmental and social audits of suppliers Formulating charters/codes of practice for providers/sub-contractors Establishing environmental and social criteria Implementing follow up and reporting tools for providers	Responsible procurement Life cycle thinking Strong ethical convictions, intergrity and commitment to social justice	Knowledge of fair trade principles Knowledge of sourcing policies Knowledge of regulations governing the use of chemical substances in foreign countries

[43] Eco Canada, *Defining the green economy* (Environmental Careers Organization, 2010), www.eco.ca/publications/default.aspx

Table 2 (continued)

Role	Business Goals and Application of Sustainable Development	Related Skills	Knowledge to be Acquired
Finance	Management of responsible investments, responsible sourcing Financial impacts assessment (savings in energy, time, etc.) Production of sustainability reports and triple bottom line Evaluating financial revenue associated with sustainability initiatives	Hazard analysis Eco-accounting Monitoring performance Transparency and ethical conduct Life cycle cost analysis (LCCA) Triple bottom line Internalization of costs	Knowledge of carbon market Knowledge of total costs of ownership Knowledge of government loans and conditions Knowledge of responsible investment practices Knowledge of costs associated with GHG emissions (penalties, etc.) Knowledge of responsible procurement
Legal	Obtaining certifications, complying with standards	Transparency and ethical conduct Standardization/certification processes	Heightened knowledge of new environmental requirements Knowledge of standards, trends, financial programs
Managers Plant Managers	Manufacturing environmentally-friendly products Developing competitive advantage	Strong ethical convictions, integrity and commitment to social justice Systems thinking Ability to adapt and integrate technological change Quality management Management of energy and water consumption Environmental hazard assessment	Knowledge of sustainable development principles Knowledge of environmental regulation Knowledge of life cycle analysis Knowledge of GHG accounting Skills in engineering — scientific expertise — technology solutions Knowledge of the supply chain — product systems

Table 2 (continued)

Role	Business Goals and Application of Sustainable Development	Related Skills	Knowledge to be Acquired
Marketing/Sales	Using ecolabels Green labelling New product development Improvement of brand image Considering consumer expectations	Creativity — innovation Ability to adapt to change — flexibility Responsible communication Strong ethical convictions, integrity and commitment to social justice Interdisciplinarity Principles of responsible marketing Using computer resources to stay informed, communicate, collaborate	Knowledge of sustainable development principles Knowledge of ecodesign Knowledge of ecolabels (e.g. Oeko Tex 100) Knowledge of green labels (e.g. carbon) Knowledge of eco-responsible events Knowledge of consumer trends and needs
R&D Experts Examples: Life Cycle Analyst Product Development	Life cycle analysis Integrating end of life cycle indicators Replacement of hazardous materials by more eco-friendly composites Using "green" materials from renewable resources (for home textiles, geotextiles, etc.) Using natural and organic fibres Production of reusable and recyclable fibres	Creativity — innovation Systems thinking Ability to formulate research questions or orient policies Life cycle analysis Scientific expertise — technology solutions Biomimicry Ecodesign	Knowledge of sustainable development principles Knowledge of biomaterials and "sustainable materials" Knowledge of the supply chain Knowledge of life cycle costing Knowledge of environmental regulation Knowledge of products prohibited for production

Table 2 (continued)

Role	Business Goals and Application of Sustainable Development	Related Skills	Knowledge to be Acquired
Process Engineers / Chemical Engineers	Creating competitive advantage Choosing environmentally sound processes (finishing, etc.) Life cycle analysis Reducing intensive chemical processes in textile wet processes (scouring, bleaching, mercerization, dyeing, printing, etc.) Selecting environmentally sound bleaching (e.g. peroxide bleaching) Selecting environmentally sound dyeing and printing processes (low-impact dyes, natural dyes, non-azo colours, etc.) Using organic processes (potential for new industrial processes that consume less energy and water, cause less problems related to waste water and produce better results)	Ability to formulate research questions or orient policies Chemical skills Treatment of waste water Waste and recycling management Optimization of processes Skills in engineering — scientific expertise — technology solutions	Knowledge of sustainable development principles Knowledge of environmental regulation Knowledge of GHG accounting Knowledge of renewable energy — energy efficiency
Mechanics	Resorting to best practices Controlling energy and water consumption	Ability to adapt to change — flexibility Ability to work well as part of a team/collaborate	Knowledge of sustainable development principles Knowledge of workplace health and safety regulations Knowledge of new technology mechanics
Supervisors	Controlling energy and water consumption Determining environmental objectives (waste reduction, etc.)	Ability to work well as part of a team/collaborate Ability to implement action plans and policies Ability to adapt to change — flexibility Ability to develop skills in a team	Knowledge of sustainable development principles Knowledge of workplace health and safety regulations Knowledge of environmental hazards
Technicians	Quality monitoring Chemical and biological analyses	Ability to work well as part of a team/collaborate Ability to adapt to change — flexibility Reporting on sustainability	Knowledge of gaseous and liquid discharge monitoring instruments for pollution control Knowledge of environmental hazards Knowledge of sustainable development principles Knowledge of workplace health and safety regulations

Interdisciplinarity: To integrate sustainable development, full collaboration is essential between the economic, social and environmental spheres. A person who works in the economic field must understand the social and environmental effects of her decisions, and vice versa. Hence, one way of integrating sustainable development is to allow these actors to gain knowledge in all three fields.

Aptitude for team work and collaboration: Applying the principles of sustainable development requires collaboration of all important spheres: economic, environmental, and social.

Life cycle thinking: Takes into account the environmental, social, and economic impacts of products throughout their entire life cycle stages: raw material extraction stages, fabrication, packaging, transportation, usage, and end of life.

Responsible communication: Clients are regarded as individuals responsible for their environmental impact, rather than simply consumers. Traditional business-oriented communication must be coupled with information on the impacts of the product on society and environment.

Responsible marketing: The firm endeavours to innovate sustainable practices in order to meet the demands of environmentally aware clients.

5.2 Taking the Steps to Skills Development

In terms of education, skills should not be developed separately through an individual "sustainability" program — a sustainable vision must be an integral part of the programs that already exist.[44] This philosophy can apply to a firm as a whole: sustainable development should not form a parallel industry; it must be adopted by all sectors.

In the same way, it is important to provide employees with the tools necessary to enable the different fields to work together. For this approach to be successful, employees must have integrated some notion of each of the three pillars of sustainable development: economy, society and environment.

Particular attention must be paid to values.[45] The skills associated with sustainable development are in general similar to traditional skills, albeit coloured by new values and knowledge. Therefore, it is important to revisit and, if needed, redefine corporate values upstream in the process.

[44] Parkin, S., Johnston, A., Buckland, H.,Brookes, F. and White, E., *Learning and Skills for Sustainable Development: Developing a sustainability literate society,* (London, UK: Higher Education Partnership for Sustainability, 2004): www.upc.edu/sostenible2015/documents/la-formacio/learningandskills.pdf

[45] Parkin, 2004.

Another key stage consists of defining the level of skills required depending on the function. This will in turn help to determine the type of training (knowledge development) that employees will need — whether they require a "basic level" of understanding that applies to all positions, or the ability to implement this knowledge, which is needed for key positions:

1. **Knowledge of sustainable development:** The aim is basically to gain a certain amount of "general culture" of the issues relating to sustainable development and existing practices in the scientific (e.g.: renewable energy, climate change), economic (e.g.: carbon market), and social fields (e.g.: ethical practices, fair trade).[46]
2. **Ability to implement the principles of sustainable development:** In addition to having knowledge in sustainability, employees have tools made available to them (assessment charts or grids, software programs, performance indicators, practical guides, technical trainings, etc.) to enable them to make concrete contributions.[47]

5.3 Which Occupational Categories are Affected and How

Because of its holistic character, sustainable development encompasses all occupational categories. However, some occupations are more directly concerned than others (see Table 2).

5.3.1 Adapting Existing Occupations

Literature shows that commitment to a sustainability approach translates mainly into adapting existing jobs and functions. "The effect [of a greening economy] is not entirely a net addition of new jobs, but a shift of workers in traditional jobs to green jobs," state the authors of a report on the movement towards greening the Canadian economy.[48]

According to another report: "Green Jobs will be a more specific version of the non-Green Jobs. Very rarely will an entirely new occupation need to be considered."[49]

Following are a few examples that illustrate how some existing occupations can potentially be adapted to take into account the new skills associated with a sustainability approach:

- **Energy engineers** apply their knowledge to renewable energy.
- **Civil engineers** apply their knowledge to green buildings.
- **Materials engineers** apply their knowledge to biomaterials.
- **Designers** integrate ecodesign into their techniques.
- **Managers** are accountable for the three pillars of sustainable development (financial, environmental, social).

46 Eco Canada, 2010.
47 Parkin, 2004.
48 Eco Canada, 2010.
49 CAEL, *Building Green Skills: A green job program for San Antonio* (2009): www.sanantonio.gov/oep/pdf/CAEL%20Jobs%20initiative%20Report%20Final.pdf (consulted January 16, 2011)

5.3.2 Creating New Occupations

In addition to adapting existing occupations, new occupations still need to be created,[50] as the following examples illustrate:

- Ethical Supply Chain Manager
- Director of Corporate Responsibility
- Global Sustainability Manager
- Climate Change and Energy Director
- Life Cycle Assessment Analyst

In general, these occupations are mostly relevant to larger organizations (employing at least 500 employees).

5.3.3 Skills Development

All employees of a given firm should subscribe to the same values, and certain skills must be common to all of a firm's employees while some other skills are more specific to decision makers. In purely technical positions, the knowledge and skills are simply reapplied in the field of sustainable development. An electrician, for example, continues to carry out the same tasks, but instead of connecting solar panels on the plant's roof, s/he will be connecting to an electricity distribution network.

Nonetheless, higher along the chain, the acquisition of some skills outlined above is needed.

[50] Cohen, E., *CSR for HR* (Greenleaf Publishing, 2010).

Table 3: Summary of the new skills, experience and knowledge required by job category in the next five years (Categories found in Eco Canada, 2010 — figure 12)

	Knowledge of Trends and New Problems in Social Development	Responsible Procurement	Communication with Consumer – Responsible Marketing	Innovating Green Product Development – Ecodesign	Life Cycle Management	Energy Conservation	Treatment of Pollution	Regulations and Standards
Purchasing	X	X			X	X	X	X
Marketing	X		X	X				X
Sales	X		X					X
Finance	X	X			X			
HR	X							
Legal	X	X						X
Production and Operations	X				X	X	X	X
R&D	X			X	X	X		X

5.4 Industry Validation

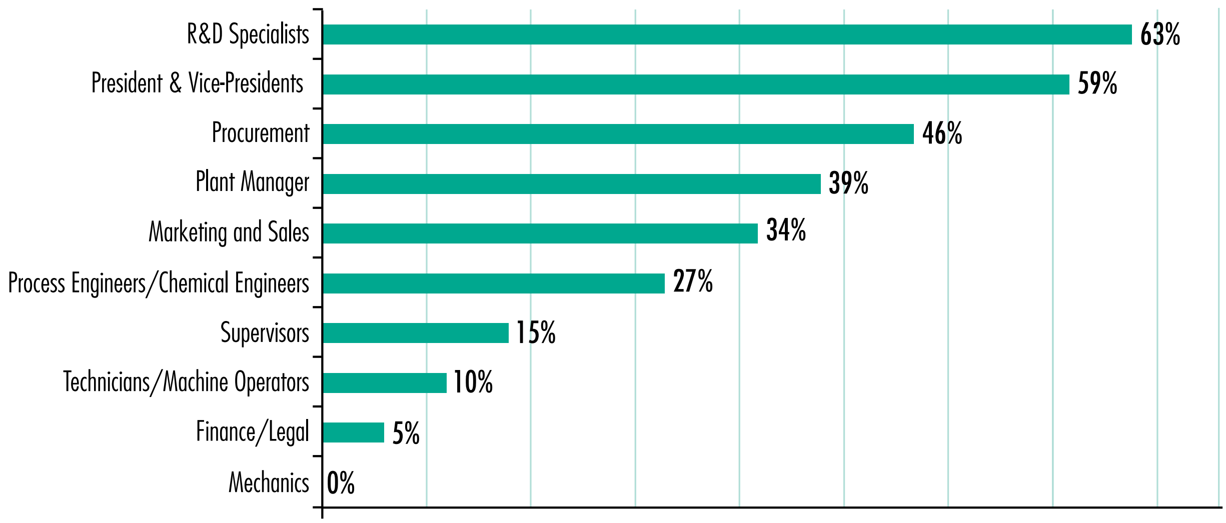
Between February and August 2011, an industry consultation and validation process was to validate the findings of secondary research conducted during the development of this report. This process included the review of best practices findings in green manufacturing and technical textiles production.

As part of this consultation, five focus groups and seven webinars (with a combined total of more than 150 industry representatives) were held to review and validate identified occupations, key competencies and knowledge related to the production of technical textiles and the implementation of green manufacturing practices. With the results of the validation process, a skills inventory framework (see Section 5.4.1) was developed to inform the future development of new occupational standards and, eventually, programs to train new workers and up-skill existing employees.

Members of the Club des leaders *at the first of three* Eco-innovation Workshops

When asked to identify the three (3) occupations which they believed to be key to sustainable/green manufacturing, 63% of respondents placed R&D Specialists at the top of the list. President & Vice-Presidents placed second (identified by 59% of respondents) and those occupations falling under the banner of "Procurement" placed third (identified by 46% of respondents).

Figure 4: Key occupations for green manufacturing (industry consultation and validation)



Respondents were then asked to identify the three competencies and fields of knowledge most important to the successful implementation of sustainable manufacturing processes. Figures 5 and 6 show the results of these polls.

Figure 5: Key competencies for green manufacturing (industry consultation and validation)

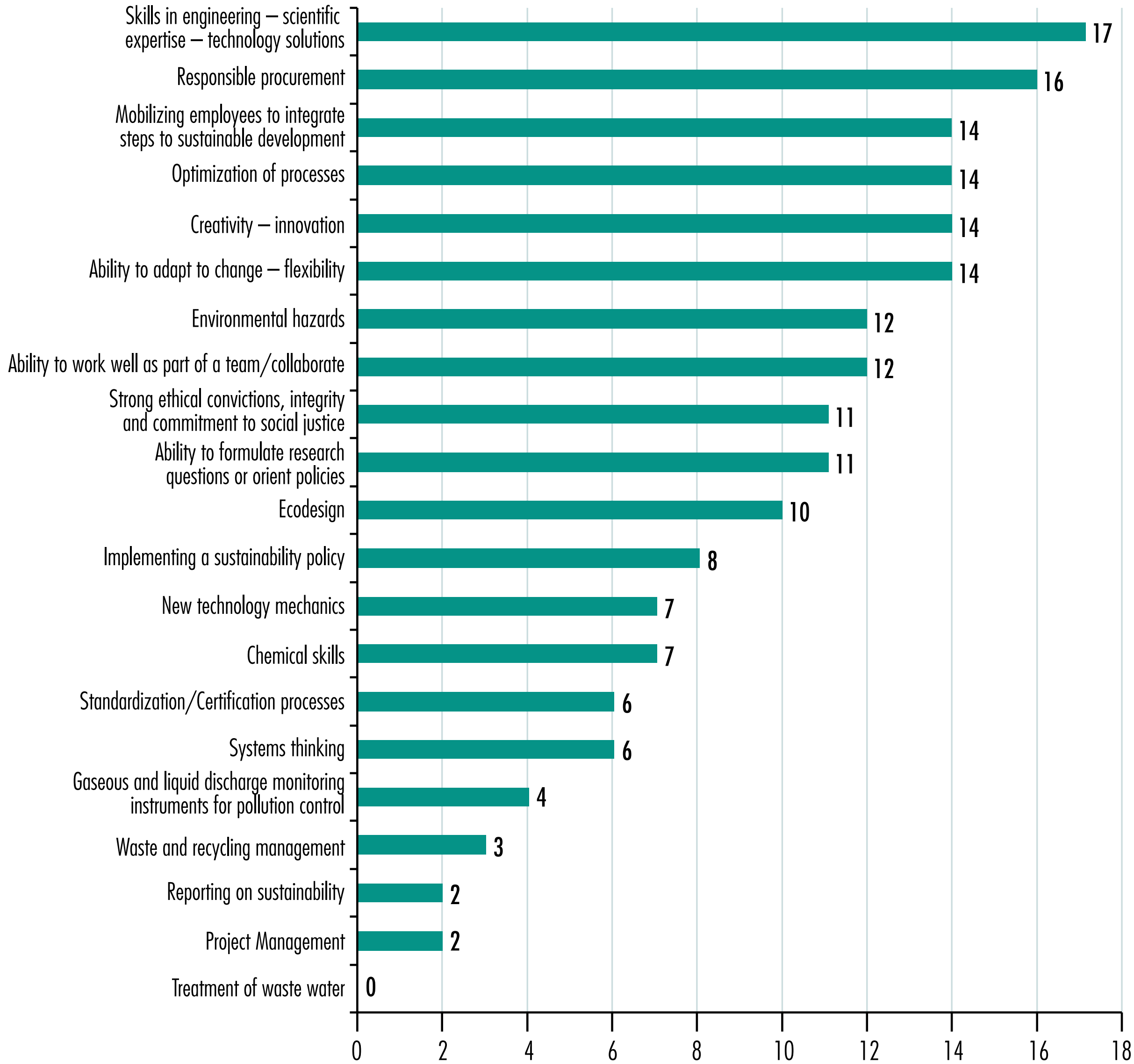
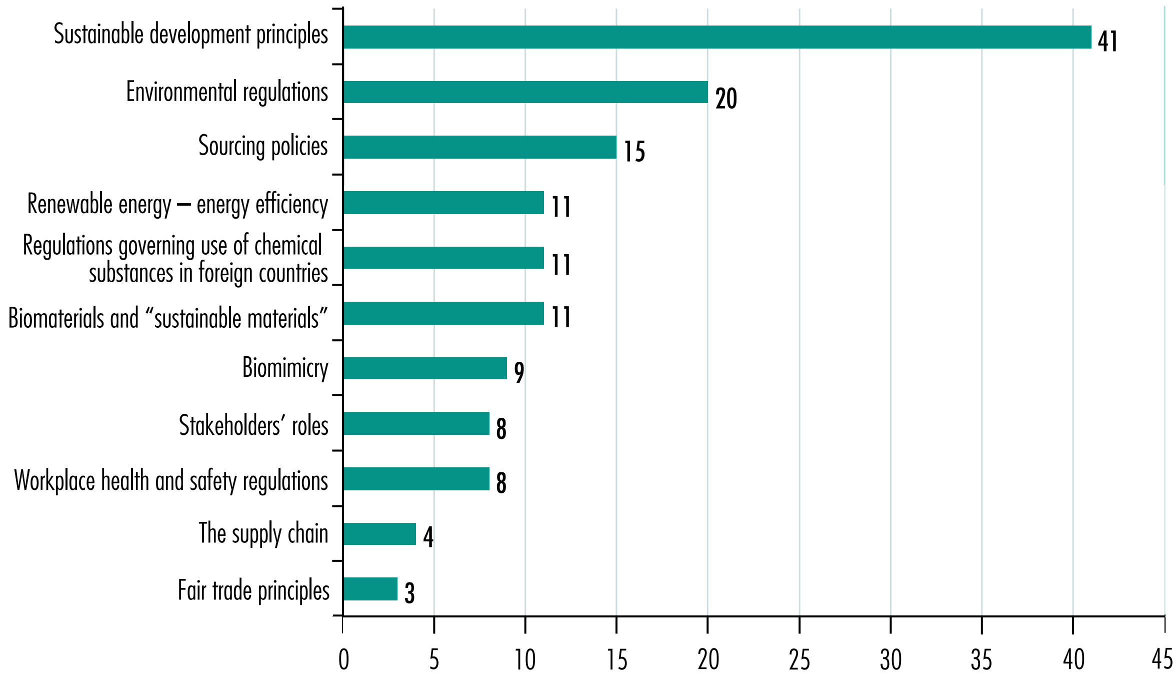


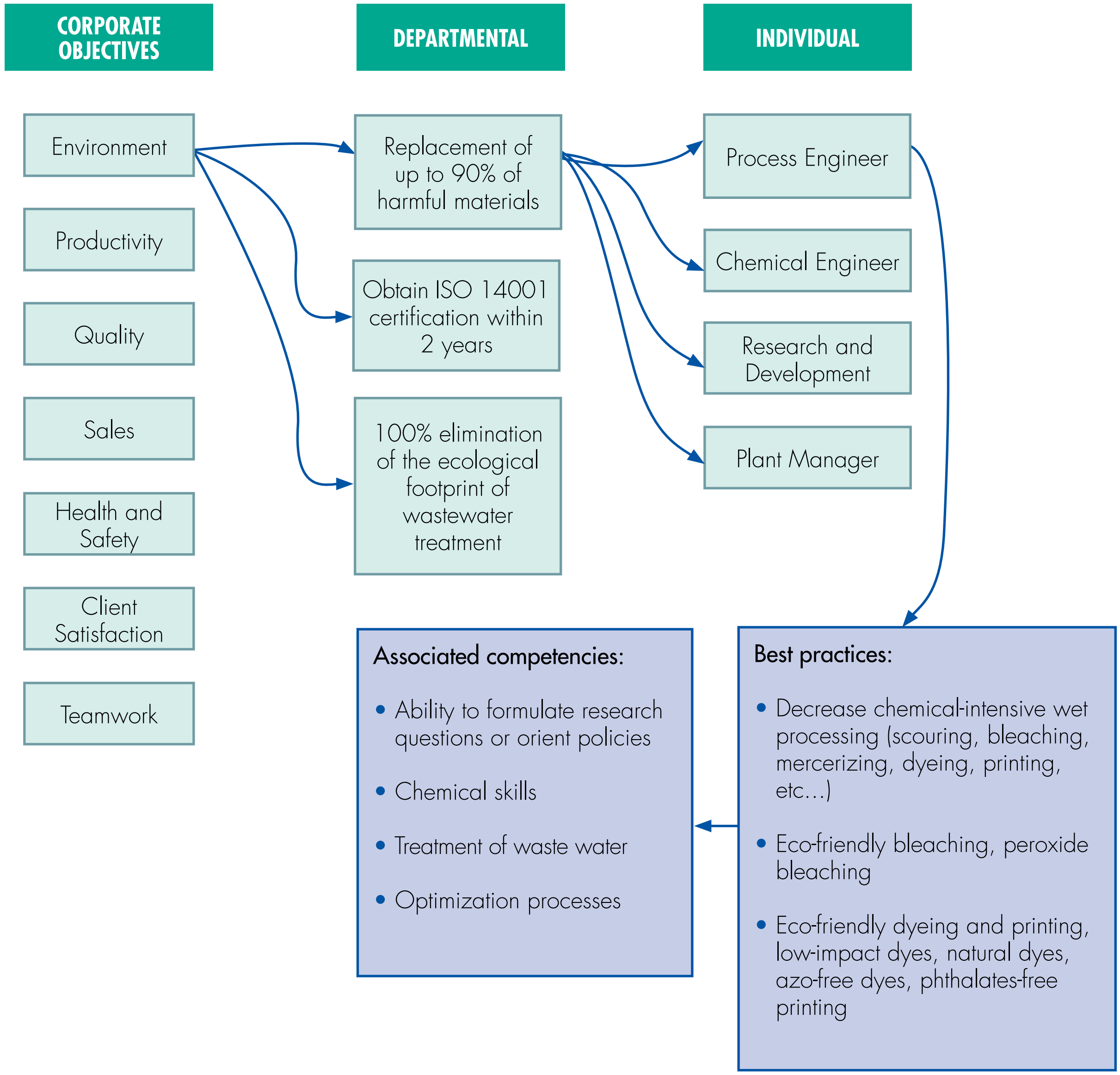
Figure 6: Knowledge key to the successful implementation of sustainable manufacturing processes (industry consultation and validation)



Source: Industry validation with more than 45 Canadian textile manufacturing firms

The implementation of a sustainable development approach within a manufacturing company requires integrated engagement and efforts across all levels of the organization. Competencies and best practices key to sustainable manufacturing are defined following the identification of corporate objectives and associated enabling objectives and responsibilities at the departmental and individual levels. Figure 7 (following page) demonstrates this relationship using the example of a textile manufacturer seeking to dramatically reduce reliance on environmentally harmful materials.

Figure 7: Application of key sustainable manufacturing best practices and competencies in the furtherance of corporate objectives



Source: Industry focus groups with 26 participants, May 2011

5.4.1 Skills Inventory

GREEN MANUFACTURING
Key Competencies and Knowledge

Occupations

ENGINEERING
FINANCE
HUMAN RESOURCES
MARKETING AND SALES
PROCUREMENT
PRODUCTION
R&D SPECIALISTS
SENIOR MANAGEMENT

SKILLS

- Strategic and long term planning
- Mobilizing employees to integrate steps to sustainable development
- High level of ethic, integrity and social justice
- Change management
- Creativity – innovation
- Life cycle analysis
- Responsible procurement
- Ability to adapt to change – flexibility
- Principles of responsible marketing
- Skills in engineering – scientific expertise – technology solutions

KNOWLEDGE

- Sustainable development principles
- Standards, trends, financial programs
- Stakeholders' roles
- Environmental regulations
- Products prohibited for production
- Sourcing policies
- Regulations on chemical substances in foreign countries
- Green labels
- Customer trends
- Environmental hazards

FACTORS

- Environmental regulations
- Certifications
- Ecolabels
- Stakeholder expectations
- Hazardous material restrictions

Benefits of GREEN MANUFACTURING		
Improved Corporate Image	Competitive Advantage	Eco-innovation
Cost Savings	Product Development	Market Development

Source: Textiles Human Resources Council (THRC) *Best Practices in Green Manufacturing and Technical Textiles* (2011). Industry validation with more than 45 Canadian textile manufacturing firms.

6 Recommendations

In light of the findings arrived at by analysis of the literature cited in this report, eight (8) recommendations are presented to help the textile industry remain competitive, if not improve its competitive edge, on the national and global scales, meet emerging eco-responsibility criteria demanded by clients, and increase profitability by making better use of resources:

6.1 Adapting the Profiles of Key Jobs

Finding: Commitment to a sustainability approach must become embedded in all levels of all the jobs in an organization.

Recommendation 1. Key positions and emerging positions should undergo adaptive adjustments in the textile industry (executives, sales and business development, research & development, engineers, product development, technicians, mechanics, machine operators, etc.), including roles and skills required in the sustainable approach.

6.2 Establishing Profiles for New Jobs

Finding: Analysis has shown that implementing a new approach for sustainable development in the textile industry may give rise to new positions.

Recommendation 2. A profile for each new position should be prepared. In particular, this is the case for life cycle analysts, employees in charge of ecodesign, ethical supply chain managers, directors of corporate responsibility, global sustainability managers and climate change and energy directors.

6.3 Upgrading Employee Skills Through Training

Finding: Moving toward sustainable development in organizations has contributed in recent years to new emerging occupations and professions in larger enterprises. In SMEs, the addition of new skills and responsibilities to existing positions is more common.

Recommendation 3. It is recommended that tailored training programs be used to develop skills in existing employees in order to meet specific needs. Because there is a need for workers to develop new skills, as opposed to strictly learning a technique, it is recommended that continuous training programs be implemented, with assessments performed on a regular basis and support tools developed and adapted to human resources in SMEs.

6.4 Developing Employee Awareness Programs

Finding: Regulations, non-tariff barriers and prohibition of chemical and hazardous materials evolve constantly. In addition, analysis shows that new sustainable development and social responsibility standards and certifications are continuously appearing in the market.

Recommendation 4. It is recommended that programs and events be created to provide a continuous venue for informing and raising awareness in employees.

6.5 Disseminating Information on Best Practices

Finding: It is clear from this analysis that Canadian enterprises don't communicate much about their environmental and social performance. They also seem largely unconcerned with sustainability, presumably due to a lack of knowledge, but perhaps also because they are confused about the concrete implications of sustainability.

Recommendation 5. In light of observed experience in other industries, regular and continuous dissemination of best practices is a solution that may raise awareness in decision makers and provide a source of influence for actions to be taken or lessons to be learned. It is recommended that an efficient communication plan be established and tools identified (e.g.: knowledge networks, newsletters, webinars, etc.) to reach textile decision makers in order to expose them to an environmental watch in their industry.

These videos could then be broadcast one after another on a weekly basis during a one-year period. Multiplatform technologies (tablets, smartphones, etc.) and techniques such as design thinking, visual thinking, and interactive scenarios now make it possible to substantially expand message penetration by reaching a greater number of decision makers on a more frequent basis. It is therefore suggested that interactive, Web 2.0 tools be employed in the deployment of this report.

6.6 Developing Reliable Knowledge of Best Practices

Finding: One of the limits of this report is that it is intended as an overview of the best practices found in literature: it is not a comprehensive and extensive study.

Recommendation 6. In order to follow the evolving needs of the employers and adapt technical, professional, and academic training content accordingly, it is recommended that more in-depth studies be undertaking concerning:

- the number of key positions directly related to sustainable development in the Canadian textile industry;
- an inventory of the performance indicators that are referred to in the textile industry in order to be able to benchmark Canada against the United States; and
- quantification of environmental and social impacts on the entire life cycle of the textile industry.

6.7 Accelerate the Integration of Sustainable Practices in the Textile Industry

Finding: The most advanced Canadian firms in terms of sustainable development are lagging considerably behind textile firms in the United States, Europe and the rest of the world. This backwardness can partially be explained by the project-based approach that is predominant in Canada, rather than an integrated approach. It has been demonstrated that this practice fails to capture the overall possible gains of an ecodesign and sustainability approach.[51]

Recommendation 7. Sustainable development must cease to be perceived as a simple integration of environmental concerns with existing procedures and processes. Social, environmental, and financial dimensions must be taken into account by organizational governance. It is recommended that textile industry strategies be aligned with the principles of sustainability in order to accelerate integration into management practices. Investments will be necessary at many levels in order to facilitate the training of staff, dissemination of best practices, development and adaptation of tools, ecodesign of products, and even development of certification organizations.

6.8 Support Sector Synergy Through a Forum for Dialogue

Finding: This analysis has demonstrated that the first firms (InterfaceFLOR, Patagonia, etc.) to have integrated sustainable development practices into their operations in the 1990s and at the beginning of 2000 were generally on their own. Their actions were more the result of personal convictions held by executives than a response to a business case. However, with this success in mind, a growing number of organizations have decided to follow in their footsteps. Those firms that have progressed more markedly have united either around specific issues or on the basis of economic activities.

Recommendation 8. It is recommended that a forum be created to promote dialogue specific to the issues facing the textile industry. What form it should take remains to be determined (round table, association, leaders club, etc.). The goal will be to involve textile firms engaged in a sustainability approach. Because this initiative has to do with a new path and new way of thinking, as opposed to a procedure, the group's mission must be flexible enough to evolve along with the concerns of its members. Ideally, in order to avoid unnecessary duplicating of mandates, this space would be integrated within an existing organization that already represents the industry. This solution, quite in line with sustainable development, will allow optimization of existing resources.

[51] IDP, 2011.

7 Conclusion

A summary review of the textile industry's best practices in sustainable development was carried out in the scope of this report. In total, 44 enterprises — mainly located in Canada, the United States, Europe, and China — were identified for their cutting edge practices, based on a list of 17 assessment criteria.

A general overview describing the level of integration of sustainable management practices in the textile industry was prepared using this sample, which shows that Canada suffers considerable delays in relation to firms in the United States and Europe. Moreover, even when Canadian enterprises do implement practices, the study reveals that these actions remain targeted and isolated. The literature surveyed clearly shows that they would benefit from the development of an integrated approach to sustainable development.

An analysis of core skills required by occupation type was also carried out, and it was found that an upgrading of job profiles will be necessary. Indeed, the literature review showed that adaptation of existing skills will be required for almost all positions, though a certain number of new positions specifically responding to the requirements of sustainable management are of necessity emerging in larger organizations.

This study clearly demonstrates that there exist major initiatives in the textile industry that aim at taking into account the challenges posed by overexploitation of resources, greenhouse gas emissions, and destruction of ecosystems. One goal of these initiatives is also to improve competitiveness in firms and ensure both their continued existence and that of the planet.

In order to catch up with other textile producing nations and be successful in the 21st century, the Canadian textile industry will have to accelerate integration of sustainability practices within its activities. To assist decision makers in developing a more sustainable textile sector, a series of eight recommendations were elaborated.

Improved sustainable development knowledge in the Canadian textile industry will be a valuable asset, in particular with regards to occupations in the sector relating specifically to sustainability. The resulting inventory will then facilitate, among other items, a clear identification of the training and tailoring needs that will be required in the coming years. It would be beneficial, as well, to quantify environmental and social performance of the entire life cycle of the various processes used in the textile sector.

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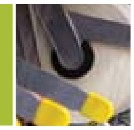
APPENDIX:

Ecolabels and Environmental Declarations



Ecolabels and Environmental Declarations

Environmental declarations play an important role in a company's sustainability strategy, enabling the promotion of social and environmental responsibility improvement initiatives between a company and its stakeholders and customers or clients.

There are three recognized types of environmental labels and declarations, which serve to advertise a product's sustainable features:

- Type 1. **Ecolabels**, governed under ISO 14 024, are certifications managed and awarded by a third party responsible for analysis and evaluation of a product's environmental impact throughout its life cycle.
- Type 2. **Self-declared Environmental Claims**, governed under ISO 14 021, are made by a manufacturer or distributor without third-party auditing, and are generally limited in their scope to one environmental feature and one single life cycle stage.
- Type 3. **Environmental Product Declarations** offer a detailed account of the outcome of a life-cycle analysis conducted in compliance with ISO 14 025 and audited by a third party.

Following are a few examples of ecolabels:

EcoLogo® is the Canadian environmental label managed by TerraChoice. It includes several certification categories covering various types of products.[1]

New certification categories appear on a regular basis to address the needs of some sectors. A company can undertake an initiative with TerraChoice in order to contribute to the development of a category, as was the case with Korhani. This company wanted to commercialize residential carpeting at a time when certification covered only commercial products. Thanks to the development of a new certification category, Korhani was able to position its product with large distributors including Wal-Mart.

In other parts of the world, the European **EU Ecolabel** certification covers textile products.

In addition, there are a number of certification standards which each address one particular aspect of the textiles production cycle. While some certify the production method of raw material, such as France's national organic agricultural certification label **AB (agriculture biologique)**, other certification standards are concerned with work conditions and wages (e.g.: fair trade certification).

The **Oeko-Tex**® certification targets various stages of the value chain, aiming to reduce the potential toxicity of products for the users.

[1] www.ecologo.org

The ***Cradle to Cradle®*** ecolabel refers to the entire life-cycle of a product, from production to end of life waste, aiming to ensure that a certified product is infinitely recyclable when integrating technical materials or compostable in the case of produce and other products of nature, while posing no threat whatsoever to the health of humans.

Self-declared environmental claims may identify the percentage of recycled materials present in a product, often displayed using a Mobius Loop, or other features such as emissions of volatile organic compounds (VOCs), recyclability, etc.

There also exist various types of declarations and certifications that apply at a corporate scale:

- **ISO 14 001** certification on sustainable management guides continued improvement initiatives pertaining to the management of activities, products and services, as well as their potential environmental impacts.
- **ICI on recycle** certification, administered by Recyc-Québec, supports companies in the improvement of their management of waste material.
- **Sustainability reports** are likely to be published within recognized media such the Global Reporting Initiative (GRI)[2] or AA10003[3] standards.
- ***Guide SD 21 000*** and its Quebec equivalent, **BNQ 21 000**, are targeted at the integration of sustainability principles within corporate and organizational management.
- The **ISO 26 000** standard targets the social responsibility of companies and their stakeholders.
- Miscellaneous

2 www.globalreporting.org
3 www.accountability.org