ENERGY PERFORMANCE

BENCHMARKING AND BEST PRACTICES IN CANADIAN TEXTILES WET PROCESSING

PREPARED FOR CANADIAN TEXTILES INSTITUTE AND NATURAL RESOURCES CANADA

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TABLE OF CONTENTS

1 INTRODUCTION

1. INTRODUCTION

1.1 BACKGROUND

Founded in 1935, the Canadian Textiles Institute (CTI) is the Canadian textile manufacturing industry's association. CTI's role is to proactively support a healthy, competitive textiles industry that creates employment for Canadians (currently 2.3 percent of Canada's total manufacturing employment, or 45 000 employees) and contributes to the economic prosperity of the country. CTI's members produce fibres, yarns, fabrics and textile articles for domestic and international markets.

In 2004, the Canadian textiles industry accounted for approximately $6.4 billion – 1.2 percent – of Canada's total manufacturing shipments.[1] As a sub-sector of the industry, wet processing is vital to the sustainability of Canadian textile manufacturing and, by extension, the Canadian economy.

As part of an initiative to encourage investment in energy management and greenhouse gas (GHG) reduction solutions in Canada's wet processing sub-sector, CTI, with the support of Natural Resources Canada's Office of Energy Efficiency, commissioned a study in 2003 to benchmark energy performance. This report provides an industry-wide summary of wet processing energy use, performance, efficiency opportunities and best practices.

1.2 FOCUS ON WET PROCESSING ENERGY USE

Wet processing occurs at various stages in the creation of textiles, including pre-treatment (e.g. cleaning, bleaching and heat setting), dyeing, printing and finishing. In 2001, 6 percent of Canadian textile plants performed wet processing, employing 17 percent of Canadian textile workers and generating 21 percent of the industry's revenue.[2]

Wet processing uses relatively homogeneous processes. It is the most energy-intensive aspect of textile production, accounting for 75 to 85 percent of plant utility costs.

While plants that perform wet processing often require energy for dry processes, space conditioning (i.e. heating, cooling and ventilation) and other needs, this study focuses only on the energy used for wet processing.

[1] Canadian Textiles Institute (CTI).
[2] Marbek Resource Consultants, et al. (for Environment Canada), *Identification and Evaluation of Best Available Technologies Economically Achievable (BATEA) for Textile Mill Effluents*, December 2001.

1.3 PARTICIPANT SELECTION

Twenty-two textile plants participated in the study. Together, in 2003, they represented about 17 percent of Canada's estimated 129 wet processing plants and 50 percent of the sub-sector's employees. In addition, the participating plants are representative of the geographic distribution of, and the types of textiles produced by, Canada's wet processing sub-sector.

1.4 BENCHMARKING IN THREE AREAS OF ENERGY PERFORMANCE

Whereas past benchmarking studies have typically examined only one or two dimensions critical to energy performance, the CTI-commissioned study analysed three: energy use and intensity, technical best practices and energy management practices. As a result, the study presents a relevant, holistic view of the wet processing sub-sector.

1.5 DEFINITION OF BENCHMARKS

The benchmarks in this report are intended to be used as baselines against which plants can compare their relative performances. To serve as realistic performance targets, their values are set at the 75th percentile in each of the three dimensions: energy use and intensity, technical best practices and energy management practices.

A benchmark at the 75th percentile is a calculated value, where 75 percent of participating plants underperformed and 25 percent of plants outperformed the benchmark.

1.6 LAYOUT OF REPORT

The remainder of this industry report is organized into the following five sections:

- **Section 2** examines energy use and intensity
- **Section 3** studies technical best practices
- **Section 4** analyses energy management practices
- **Section 5** outlines the challenges and opportunities of the wet processing sub-sector
- **Section 6** provides additional information sources

2

ENERGY USE AND INTENSITY

2. ENERGY USE AND INTENSITY

This section outlines how much energy the Canadian wet processing sub-sector uses and how efficiently that energy translates into textile output.

2.1 METHODOLOGY

The study compared the energy and GHG intensities from energy use of participating plants. All plant data were based on 2003 production output and utility consumption provided by each participant.

To derive the metrics, it was necessary to standardise the following units:

- **Energy use:** All quantities of energy use were converted to gigajoules (GJ) using the combustion efficiencies (for fossil fuels) and fuel conversion factors listed in Appendix A.
- **GHG emissions:** All GHG emissions were converted to units of tonnes of carbon dioxide equivalent (tCO_2e) using the average combustion emissions factors (for fossil fuels) and provincial emissions factors (for electricity) listed in Appendix A.
- **Production output:** Production output includes only dry, finished, marketable product. It was originally measured in length (e.g. metres of yarn), area (e.g. square metres of carpet) or mass (e.g. kilograms or tonnes of non-woven textiles). These production output values were then converted into metric tonnes (t).

Therefore, for this study, energy intensity and GHG intensity from energy use are defined as follows:

Energy intensity (energy use per unit production output in metric tonnes [GJ/t]):

A measure of how efficiently energy is converted into textile products. For example, textile plants that have short production runs, frequent product changeovers, high volumes of wastewater and steam, and low levels of automation generally have high energy intensity.

GHG intensity from energy use (GHG emissions per unit of production in metric tonnes [tCO_2e/t]):

A measure of the quantity of GHGs emitted from the use of energy in wet processing. Note that high energy intensity often leads to high GHG intensity from energy use, especially in regions where fossil fuels are the primary source of energy (in the form of electricity).

2.2 DATA COLLECTION

Participating plants completed a survey that focused on 12 aspects of plant operation:

1. Type of operation
2. Energy and water utility invoices and production figures for 2003
3. Utility and production sub-metering data (where available)
4. Types of wet processes used
5. Use of specific production machinery and services
6. Processes used in the finishing department and systems used in the dye house
7. Chemical costs and usage (for dye house and finishing)
8. Wastewater facility processes
9. Control and discharge temperatures
10. Boiler capacities, boiler room equipment and compressor capacities
11. Electrical power capacities
12. Plant layout

These data were then supplemented by technical data and observations made during plant visits.

2.3 RESULTS

2.3.1 ENERGY USE FOR WET PROCESSING

The plants surveyed used 84 percent of their total energy on wet processing; this amounts to 2169 TJ of energy – with a cost of $26.6 million – and 127 ktCO_2e of energy-related GHG emissions. The remaining 16 percent of total energy was consumed for dry processing and non-process uses, such as lighting, space conditioning and office use.

Fossil fuel combustion is the primary source of energy for wet processing; it supplies 1726 TJ of energy – 87 percent of the plants' total fossil fuel energy use. Electricity supplies the remaining 443 TJ (122.9 GWh) of energy used in wet processing, which accounts for 72 percent of the plants' total electricity consumption.

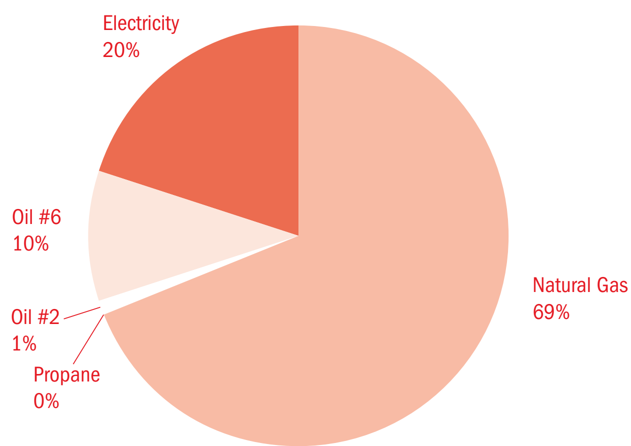
These results, summarized below in Table 2-1, indicate the energy intensiveness of wet processing relative to dry processing and non-process uses in the surveyed plants.

Table 2-1 Wet Processing Share of Plant Energy

Measure	Share Used for	
	Wet Processing	Other Purposes
Plant Energy	84%	16%
Plant Electrical Energy	72%	28%
Plant Fossil Fuel Energy	87%	13%

Of the 84 percent of plants' total energy used in wet processing, fossil fuel combustion is the primary source of energy. Natural gas (69 percent) and electricity (20 percent) constitute about 89 percent of this total, as illustrated in Figure 2-1.

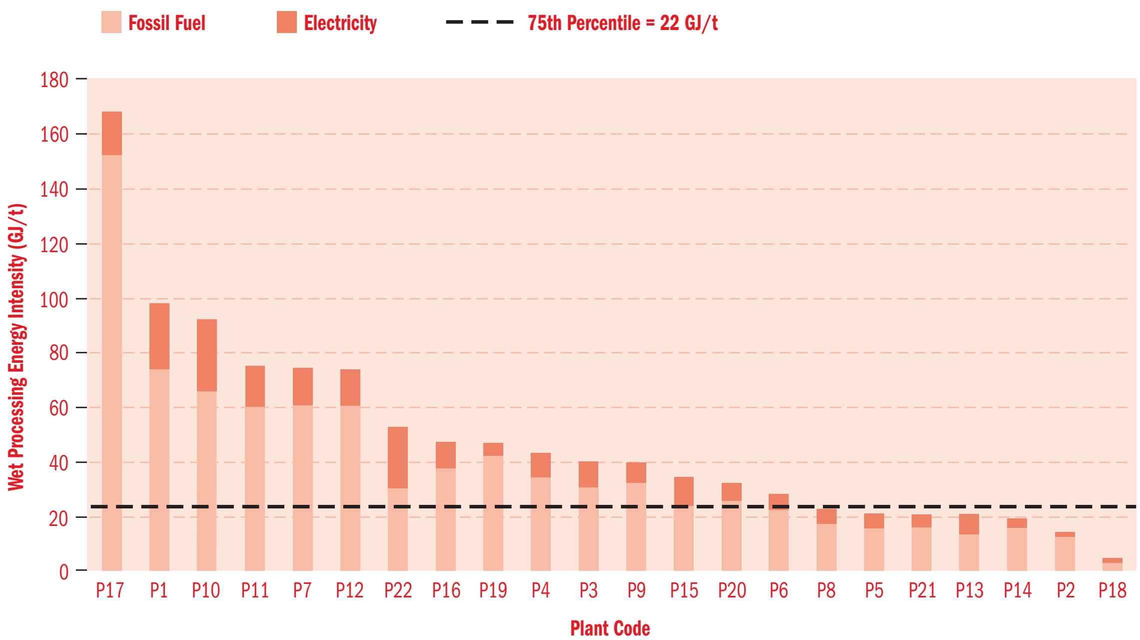
Figure 2-1 Total Energy for Wet Processing by Fuel, 2003



2.3.2 ENERGY PERFORMANCE IN WET PROCESSING

This section profiles the energy performance of participating plants, as characterized by energy intensity (see Figure 2-2) and GHG intensity from energy use (see Figure 2-3).

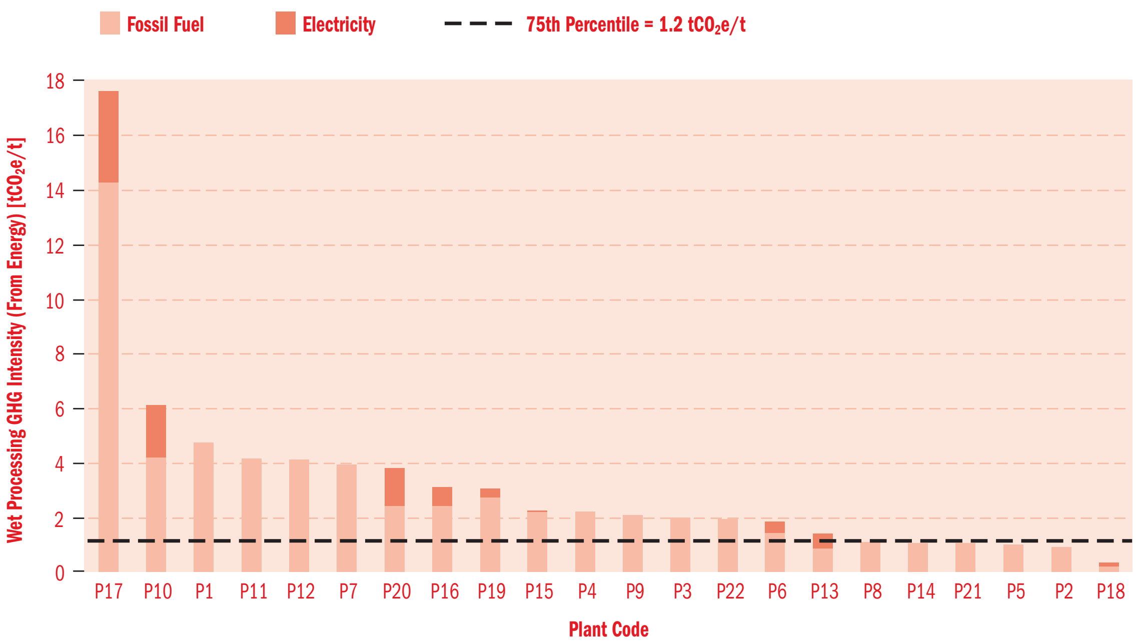
Figure 2-2 Energy Performance of Plants by Energy Intensity



As shown in Figure 2-2, a great disparity exists between the participating plants' energy intensities; P17 is 34 times more energy intensive than P18. Overall, the participating plants have an average energy intensity of 27 GJ/t (see Appendix B). The 75th percentile benchmark stands at 22 GJ/t and is represented on the graph by a dotted line.[3] While conservative, the benchmark suggests that there is considerable room for improvement in energy performance across the sub-sector.

[3] This is deemed a conservative benchmark value for energy intensity use because the extreme values were not removed from the analysis as outliers, as is common in statistical analyses of random sample sets. All values were included in the calculation because they represent real samples and were not randomly collected.

Figure 2-3 Energy Performance of Plants by GHG Intensity From Energy Use



Given the close relationship between energy intensity and GHG intensity from energy use, it is no surprise that the plant with the lowest energy intensity (P18) also has the lowest GHG intensity from energy use. In contrast, plant P17, which has an energy intensity 34 times that of P18, has 60 times P18's GHG intensity from energy use. Other factors that contribute to the wide range in GHG intensities from energy use are regional electricity emissions factors and the types of fossil fuels used by the participating plants.

The average GHG intensity is 1.6 tCO_2e/t and the 75th percentile benchmark value is 1.2 tCO_2e/t (see Appendix B).

While the 75th percentile benchmarks for energy intensity and GHG intensity from energy use serve as realistic performance goals for Canadian textile plants, certain textile outputs vary widely from others in density (i.e. weight per unit length or per unit area). This can lead to unequal comparisons for plants that produce particularly low- or high-density textiles. To address this, Table 2-2 presents wet processing energy performance by textile type – carpet, knits, yarn and woven and non-woven textiles – that was calculated from data provided by participating plants.

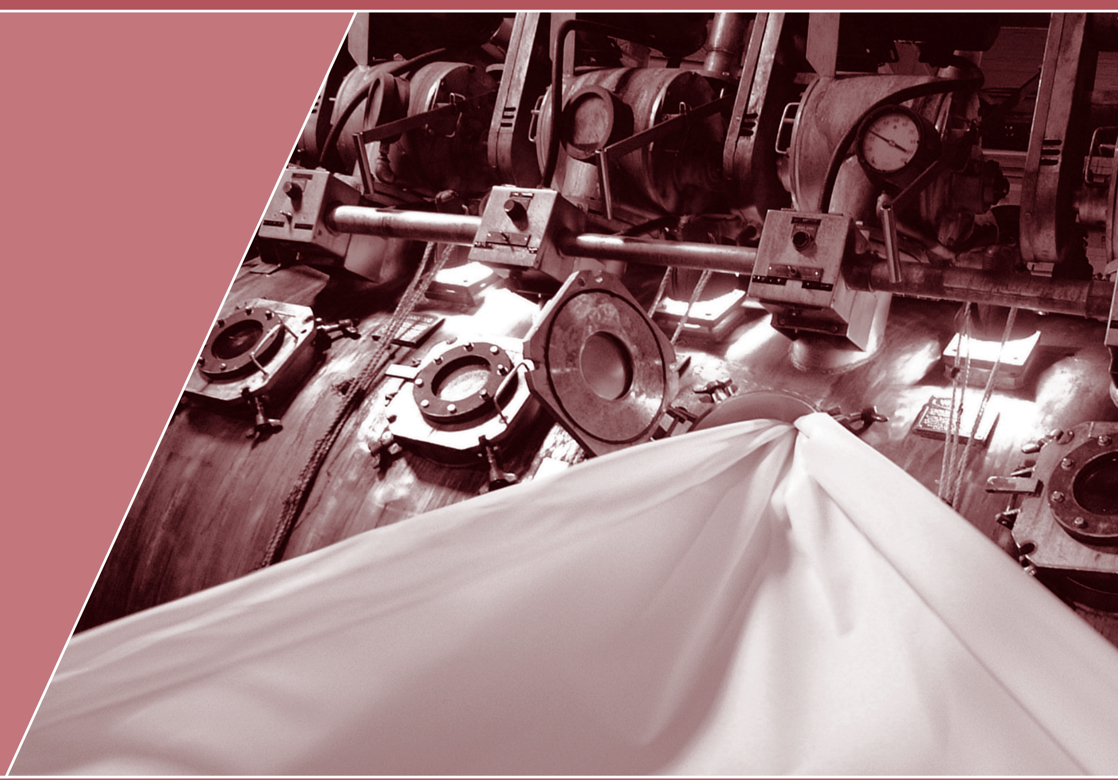
Table 2-2 Textile-Specific Wet Processing Energy and GHG Performance

Measure	Carpet	Knit	Woven	Yarn	Non-woven
Average Energy Intensity [GJ/t]	16	35	51	32	9
Average GHG Intensity From Energy Use [tCO_2e/t]	1.1	2.4	3.5	2.1	0.6

Note: Since carpet, yarn and non-woven analyses include only two plants each, the values are not representative of the sub-sector and should be treated accordingly.

3

TECHNICAL BEST PRACTICES



3. TECHNICAL BEST PRACTICES

This section outlines the penetration of technical best practices (BP) in the wet processing sub-sector.

3.1 METHODOLOGY

The study determined the percentage of applicable BP being used by the plant participants.

In energy performance benchmarking, **a technical BP is defined as a production system or efficiency measure that results in an overall reduction in energy intensity**. Technical BPs include equipment or methods that improve energy performance during specific operations (e.g. automatic microprocessor dyeing-machine controllers).

For the study, the following procedure was used to determine the technical BPs applicable to wet processing:

1. Generate a master list of technical BPs used in the wet processing sub-sector from a review of Canadian and international literature and professional experience.
2. Group the list of 48 technical BPs into six categories of wet processing systems and machinery:
   - i. Process automation and quality control
   - ii. Continuous preparation scouring, bleaching and dyeing machinery
   - iii. Batch dyeing machinery: jet, beam, package, hank, jig and winches
   - iv. Finishing machinery: dryers and tenters
   - v. Finishing machinery: steam cans
   - vi. Production machinery systems and services
3. Identify the technical BPs applicable to participating plants. For the study, a BP was deemed applicable if it could be implemented at the plant from a technical perspective. Applicability was determined during an on-site assessment of the participating plants and is not based on cost-effectiveness.
4. Determine the implementation status of applicable technical BPs in the participating plants (i.e. fully, partially or not implemented) after an on-site assessment.

Plant scores were determined by calculating[4]: $\frac{\text{no. of technical BPs } \textit{implemented}}{\text{no. of technical BPs } \textit{applicable}}$

3.2 DATA COLLECTION

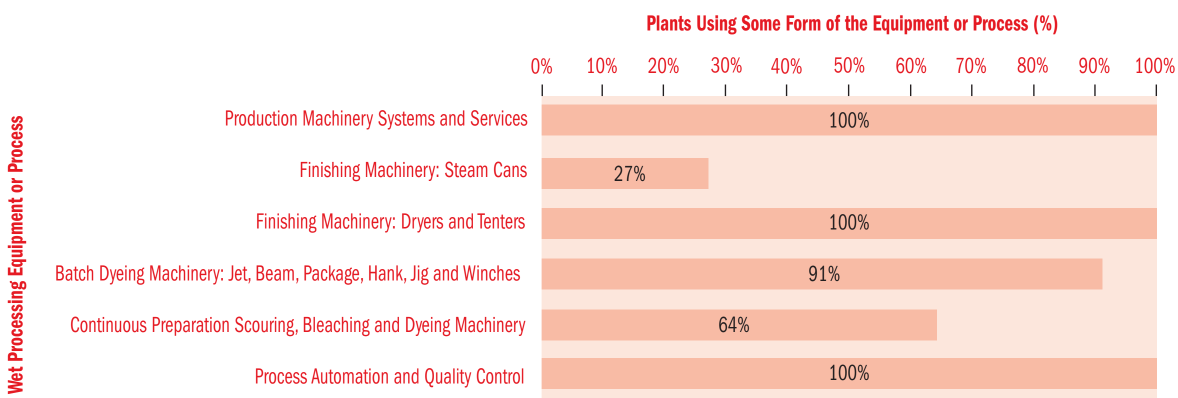
On-site assessments were conducted of all 22 participating plants to address gaps in data obtained remotely and identify any further energy efficiency measures that could be implemented.

3.3 RESULTS

3.3.1 PENETRATION OF WET PROCESSING SYSTEMS AND MACHINERY

Figure 3-1 profiles the wet processing systems and machinery currently in place among the participating plants. As detailed in Section 3.1, these systems and machinery are categories of technical BPs studied at each plant.

Figure 3-1 Wet Processing Systems and Machinery Used by Participating Plants



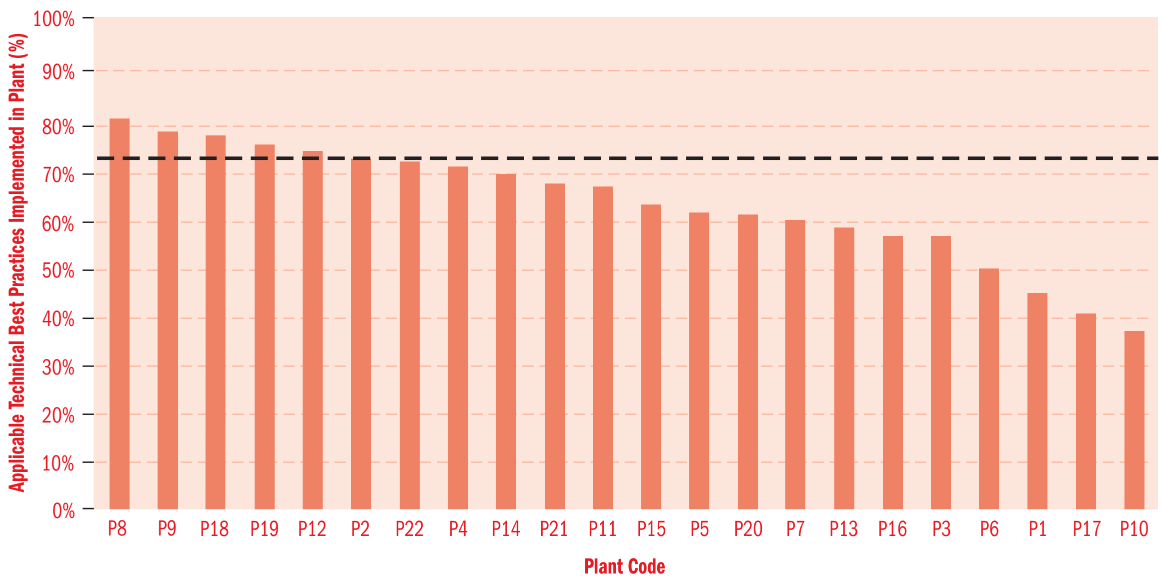
All categories of systems and machinery have high penetration among study participants, with the exception of steam can finishing machinery, which is used primarily in woven finishing plants.

[4] Each technical BP is weighed equally in this equation (i.e. no best practice is deemed more beneficial than another and worthy of a more weighted score). All "partially implemented" BPs were considered to be "half-implemented" with an implementation factor of one half. Note that, using this approach, a plant with 36 BPs implemented out of 48 applicable BPs has the same score – 75 percent – as a plant with three BPs implemented out of four applicable for that plant.

3.3.2 PENETRATION OF APPLICABLE TECHNICAL BEST PRACTICES BY PLANT

Figure 3-2 shows the percentage of applicable technical BPs implemented in participating plants; the dotted line represents the 75th percentile benchmark.

Figure 3-2 Penetration of Applicable Best Practices (BPs) by Plant



The penetration of applicable BPs ranges from 38 percent to 82 percent in participating plants. This discrepancy between high and low performance values is significantly smaller than the range of energy intensities explored in Section 2. Thus, it can be reasonably concluded that textile-specific energy intensities account, in large part, for the variety of energy intensity results represented in the previous section.

With an overall plant average of 64 percent and a benchmark value of 73 percent, the results indicate that there is considerable potential for improvement for all participating plants on the technical BPs front.

3.3.3 PENETRATION OF APPLICABLE TECHNICAL BEST PRACTICES BY CATEGORY

There are six categories of technical BPs, and Figures 3-3 to 3-8 illustrate their respective penetration in participating plants. Organized by type of wet processing system, the figures indicate the share of plants for which observed BPs are applicable and implemented, applicable but not implemented, or not applicable.

As with previous analyses in this section, a BP is deemed applicable for a given plant if the measure could be implemented technically at the plant. Applicability is not based on cost-effectiveness.

Figure 3-3 Penetration of Technical BPs for Process Automation and Quality Control

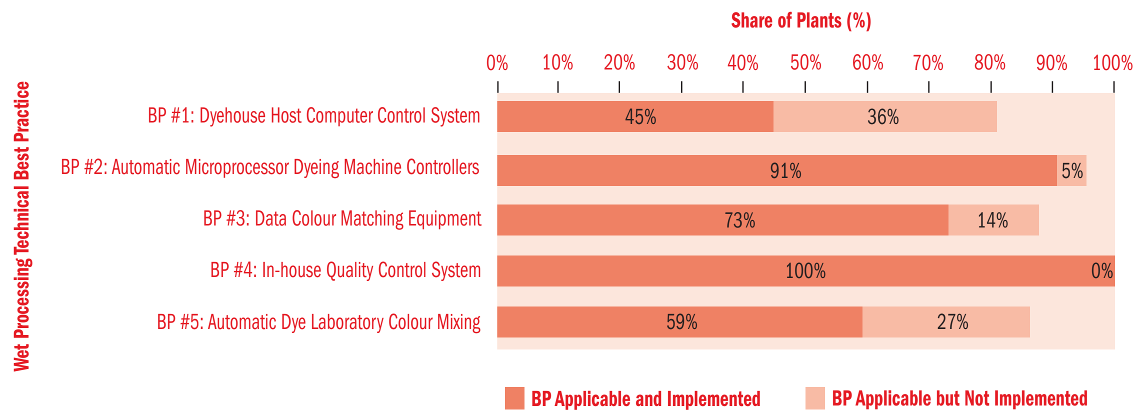


Figure 3-4 Penetration of Technical BPs for Continuous Preparation Scouring, Bleaching and Dyeing Machinery

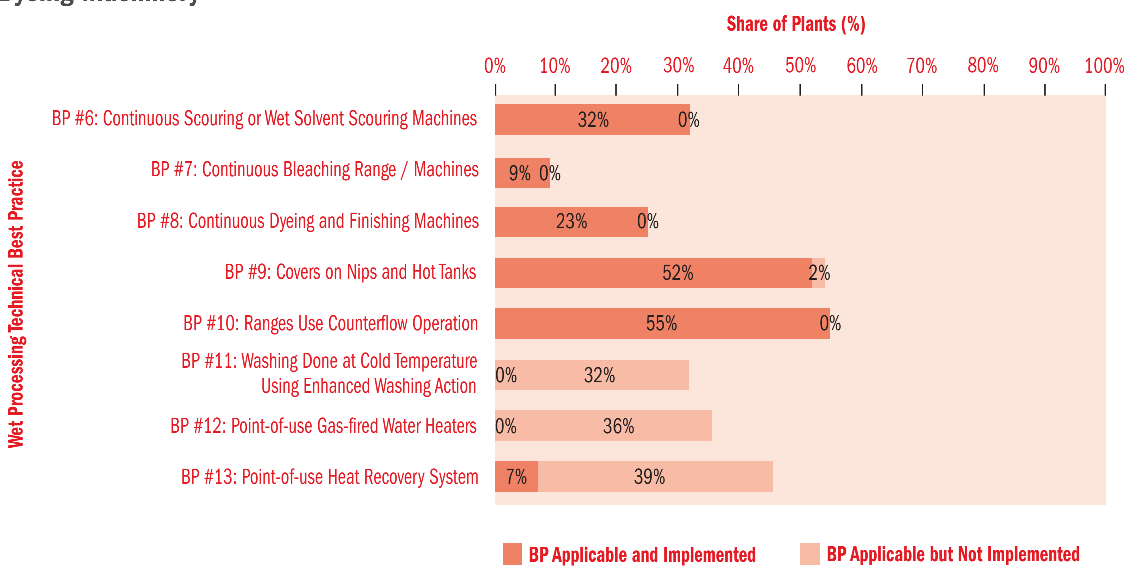


Figure 3-5 Penetration of Technical BPs for Batch Dyeing Machinery

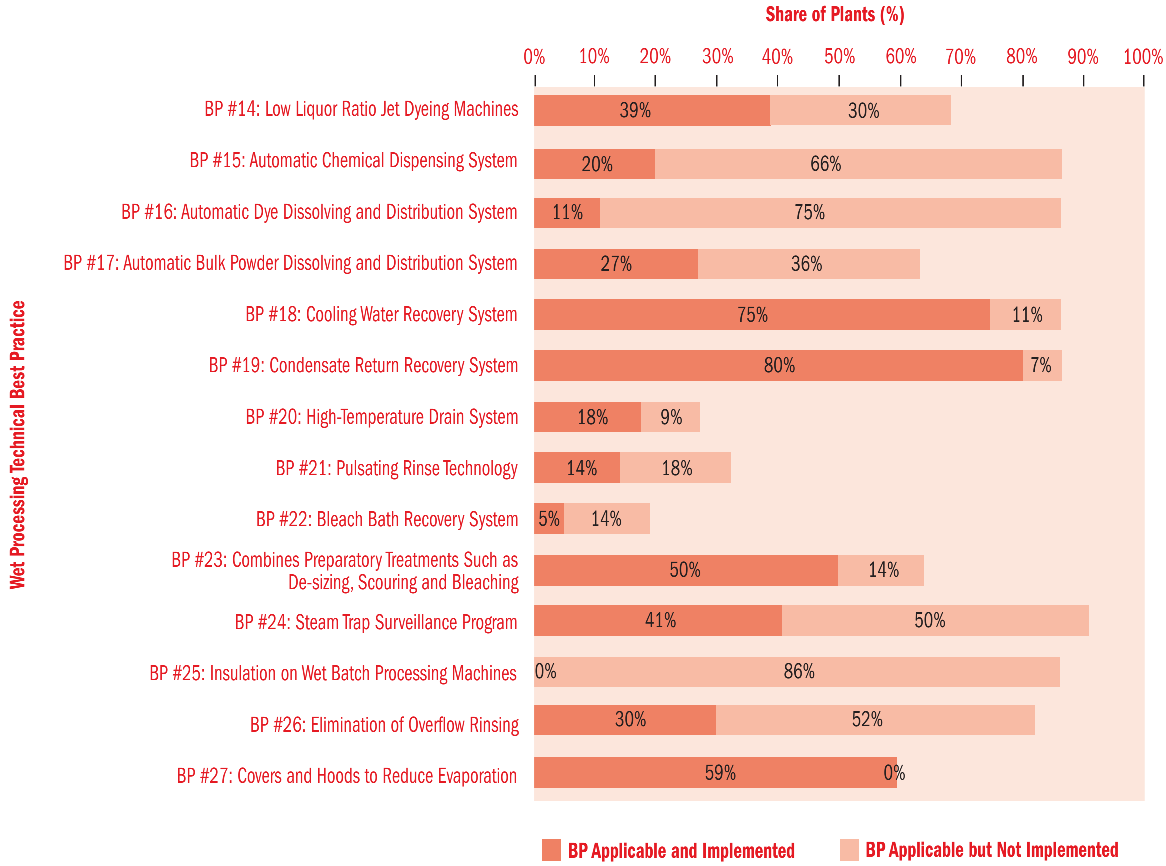


Figure 3-6 Penetration of Technical BPs for Dryer and Tenter Finishing Machinery

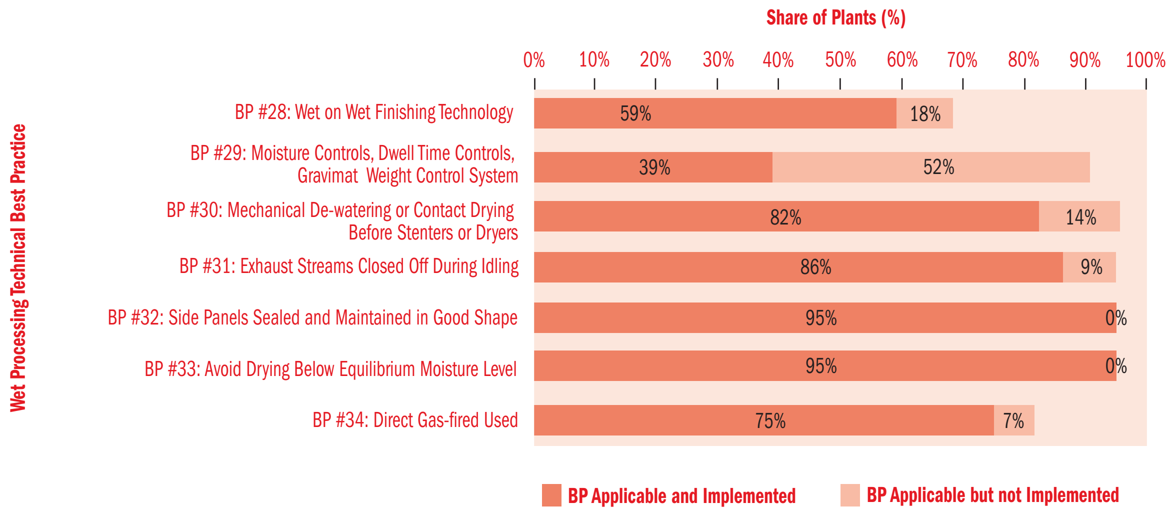


Figure 3-7 Penetration of Technical BPs for Steam Can Finishing Machinery

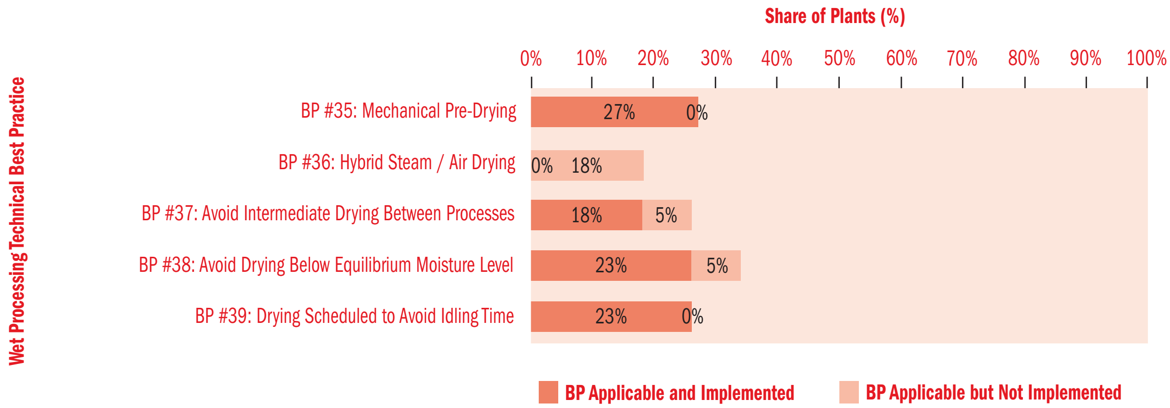
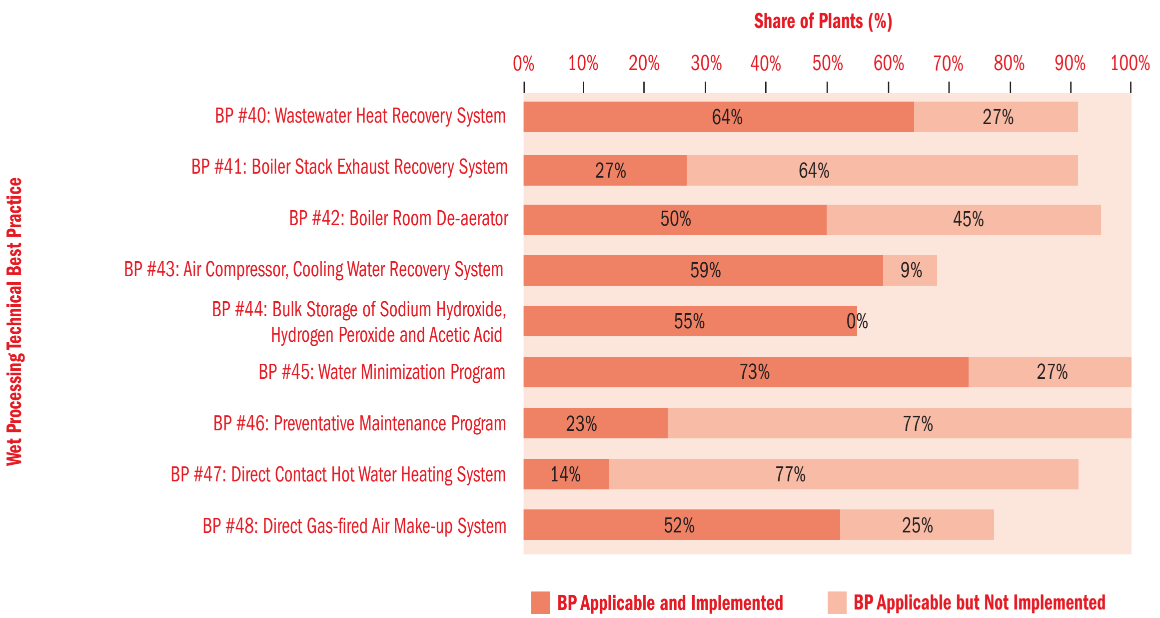


Figure 3-8 Penetration of Technical BPs for Production Machinery Systems and Services



4 ENERGY MANAGEMENT PRACTICES

4. ENERGY MANAGEMENT PRACTICES

This section outlines the degree to which energy management practices are employed in the wet processing sub-sector.

4.1 METHODOLOGY

Energy management is an influential determinant of a plant's energy performance. **Best practices in energy management are characterized by a high level of commitment, awareness, organization and action in support of energy management**. Typically, plants exhibiting energy management BP

- have broad awareness of the benefits of energy efficiency
- collect and utilise information to manage energy use
- integrate energy management into their overall management structure
- provide leadership on energy management through dedicated staff and a committed energy efficiency policy
- have an energy management plan for the short and long terms

To objectively analyse energy management best practices, this study builds on an approach first developed in the United Kingdom and later modified in Canada and around the world.[5] The energy management matrix used by plants to self-assess their energy management performance is presented in Table 4-1 on page 23.

The matrix identifies six primary aspects of energy management, each of which is rated on a scale of zero to four, where four represents a sophisticated grasp of energy issues and the commitment of the organization's management. For this study, the plants' overall energy management scores are the sum of their six category-specific ratings divided by 24 points (the maximum achievable sum). Additional details on the categories and levels of the energy management matrix are provided in Appendix C on page 36.

4.2 DATA COLLECTION

The energy management matrix tool was administered as part of a mail-out self-assessment. When necessary, follow-up calls were made to verify the accuracy of the data received.

[5] Carbon Trust, *Energy Management Priorities – A Self-assessment Tool* (*Good Practice Guide 306*), originally released under the Energy Efficiency Best Practice Programme of the U.K Department for Environment, Food and Rural Affairs (DEFRA), May 2001, www.thecarbontrust.co.uk/energy/pages/publication_view.asp?PubID=4651.

Table 4-1 Corporate Energy Management Matrix

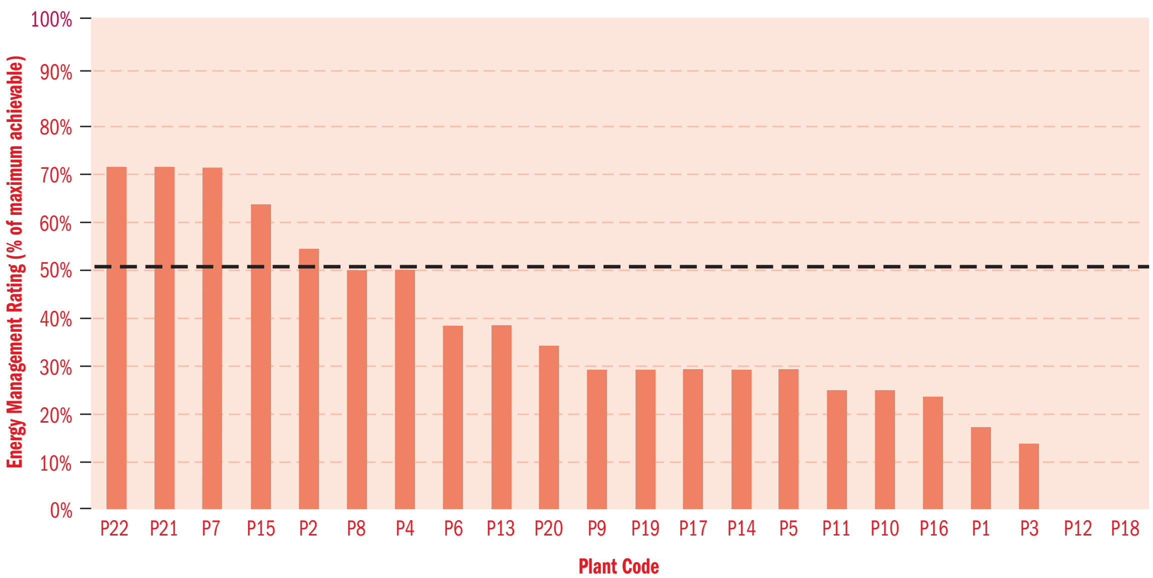
Level	Corporate Energy Policy	Organization	Skills and Knowledge	Information Systems	Marketing and Communications	Planning and Investment
4	Energy policy, action plan and regular review have commitment of top management as part of a business and environmental strategy.	Energy management fully integrated into management structure. Clear delegation of responsibility for energy consumption. Energy committee reports to the Board.	All energy users receive specific energy training integrated into other development activities. Workshops facilitate a sharing of knowledge.	Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking at end use. Feedback is actively used for corrective action.	Communicating the value of energy efficiency and the performance of energy management within and outside the organization.	Positive discrimination in favour of green schemes with detailed appraisal of all new-build and refurbishment opportunities.
3	Formal energy policy but no active commitment from top management.	Energy manager accountable to energy committee representing all users.	Key energy users receive regular and specific training. Brief awareness training provided for all energy users.	Monitoring and targeting reports for individual areas based on sub-metering. Performance against targets reported to users.	Program of staff awareness and regular publicity campaigns.	Same payback criteria employed as for all other investments. Energy management opportunities identified within overall investment plan.
2	Unadopted energy policy set by senior manager or senior departmental manager.	Energy manager in post, reporting to ad hoc committee, but line management and authority unclear.	Key energy users receive awareness training; also occasional system-specific training and its impact on energy use.	Monitoring and targeting reports based on supply meter data. Energy unit has ad hoc involvement in budget setting.	Some ad hoc staff awareness training.	Investment using short-term payback criteria only. Focus on energy management planning is ad hoc.
1	An unwritten set of guidelines.	Energy management the part-time responsibility of someone with only limited authority or influence.	Key employees participate occasionally in awareness training. Some information passed informally to energy users.	Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department.	Informal contacts used to promote energy efficiency.	Only low-cost measures taken. Planning is informal and focuses on areas within individuals' technical responsibilities.
0	No explicit policy.	No energy management or any formal delegation of responsibility for energy use.	Energy users rely on their existing knowledge and skills.	No information systems. No accounting for energy consumption.	No promotion of energy efficiency.	No investment and no planning in increasing energy efficiency in the plant.

4.3 RESULTS

4.3.1 ENERGY MANAGEMENT BENCHMARK

As detailed in Section 4.1, the plants' overall energy management scores are the sum of their six category-specific ratings divided by 24 points (the maximum achievable sum). Figure 4-1 summarizes the participating plants' overall energy management practices.

Figure 4-1 Energy Management Scores

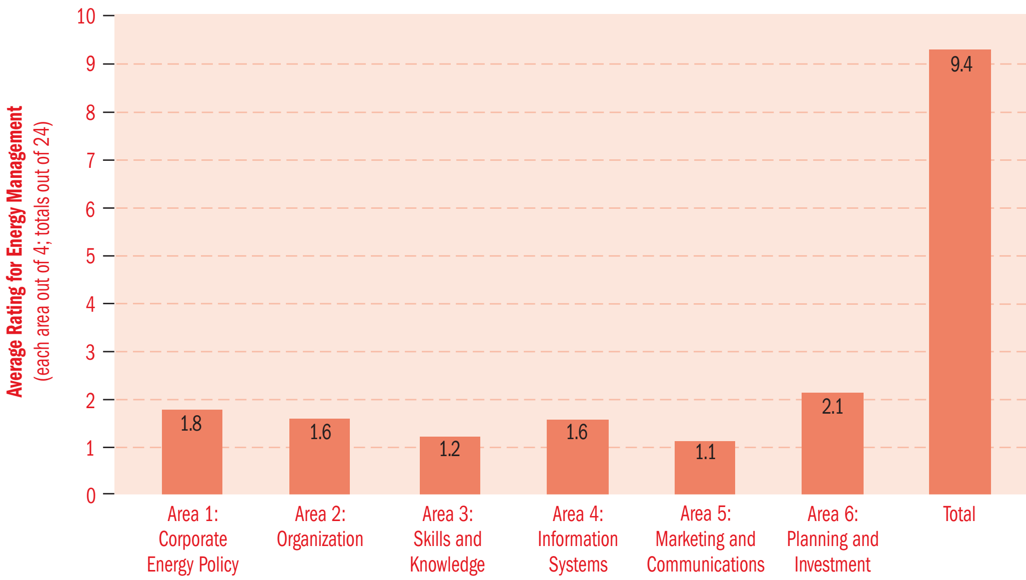


The benchmark in Figure 4-1, represented by the dotted line, is 51 percent of the maximum achievable rating for energy management. Five of the plants surveyed performed better than the benchmark value. However, none of them received a good practice rating – defined by an overall score of 75 percent.

4.3.2 AGGREGATED ENERGY MANAGEMENT SCORES PER MANAGEMENT CATEGORY

The average rating in each of the six energy management categories helps to identify areas that receive the most and least amount of emphasis in the wet processing sub-sector. Figure 4-2 summarizes energy management practices by energy management category.

Figure 4-2 Average Energy Management Ratings



As can be seen in Figure 4-2, Planning and Investment scores the highest of the six management areas, with an average rating of 2.1 out of 4, and is followed by Energy Policy, at 1.8 out of 4. The lowest rated categories are Marketing and Communications and Skills and Knowledge, at 1.1 and 1.2 out of 4, respectively. The total average rating of all six areas is 9.4 out of 24 – only 35 percent of the maximum achievable standard.

5 CHALLENGES AND OPPORTUNITIES

5. CHALLENGES AND OPPORTUNITIES

5.1 CHALLENGES

When met, the energy performance benchmarks detailed in this report will significantly reduce operating costs and increase competitiveness of the wet processing sub-sector. More importantly, they provide a basis for Canadian textile plants to conduct a self-analysis of energy performance consistent with the quality management principles and practices employed by the industry.

The study reveals a large potential for energy efficiency improvements in all three process areas examined: energy use and intensity, technical best practices and energy management practices. More specifically, the study confirms the need for a more operational approach to energy management through corporate policies and day-to-day operations. Advancing technical and management best practices requires taking a long-term view – a challenge, given the hurdles faced by the Canadian textiles industry.

In some cases, companies are already engaged in ambitious energy management programs, while little has been done in others. Indeed, the target benchmarks employed in the analysis should not be considered as the final destination for performance improvements; an even greater standard can be achieved.

5.2 OPPORTUNITIES

The challenge of controlling energy use and costs is not insurmountable. Opportunities exist in two key areas and are discussed below. Industry-wide promotion, education, support and further investigation of these opportunities are well warranted.

OPPORTUNITY 1: INTEGRATION OF ENERGY MANAGEMENT IN CORPORATE MANDATE AND STRUCTURE

Recommended Actions
To exploit this opportunity, the wet processing sub-sector should

- **Implement sound monitoring and targeting practices.** None of the participating plants monitored energy usage on a production process or end-use basis. As a result, the plants have difficulty understanding energy usage and the contributions of various processes to overall energy performance. Monitoring and targeting is an essential tool.

- **Focus on incremental improvement in Skills and Knowledge and Marketing and Communications.** The priority is to raise the lowest scores among the six energy management categories, with a long-term objective of achieving a consistent rating of 3 or 4 across all six areas of the energy management matrix.

Potential Benefits
The same study that first introduced the energy management matrix concluded that, on average, organizations realize a 5 to 8 percent savings in energy (and cost) for every improvement of six points (out of 24 points) in their energy management rating.[6]

Note: The potential benefits for each wet processing textile plant will vary based on individual circumstances.

OPPORTUNITY 2: EXTENSIVE IMPLEMENTATION OF APPLICABLE TECHNICAL BEST PRACTICES

Recommended Actions
To exploit this opportunity, the wet processing sub-sector should

- **Assess and promote technical best practices that are applicable to a large percentage of plants but have achieved a low penetration** (i.e. less than 50 percent penetration).

- **Assess and promote technical best practices** that have a low level of implementation (less than 15 percent) relative to their overall applicability.

- **Integrate energy conservation measures into the capital turnover process** to introduce new components and modify processes, thereby reducing lost opportunities.

Potential Benefits
Based on on-site observations made at the 22 participating plants, technical best practices were identified. These have an average payback in less than five years and can be practically implemented in the textiles wet processing sub-sector. They range in implementation cost between low (less than $50,000) and capital-intensive (in excess of $250,000). The various savings potentials and costs of these key measures are summarized in Table 5-1.

Note that specific plant conditions ultimately determine the total cost and savings implications of these measures.

[6] Carbon Trust, *Energy Management Priorities – A Self-assessment Tool (Good Practice Guide 306)*, originally released under the Energy Efficiency Best Practice Programme of the U.K. Department for Environment, Food and Rural Affairs (DEFRA), May 2001, www.thecarbontrust.co.uk/energy/pages/publication_view.asp?PubID=4651.

Table 5-1 Financial Returns of Key Technical Best Practices

Category of Wet Processing Systems and Machinery	Technical Best Practice	Cost		Savings Range ($)	Simple Payback (Yrs)
		Range ($)	Rating*		
A: Process Automation and Quality Control	BP #1: Dyehouse Host Computer Control System	$57,000–$150,000	M	$15,000–$30,000	3.8-5.0 (avg 4.3)
	BP #2: Automatic Microprocessor Dyeing Machine Controllers	$79,000	M	$88,000	0.9 (avg 0.9)
	BP #5: Automatic Dye Laboratory Colour Mixing	$100,000	M	$40,000	2.5 (avg 2.5)
B: Continuous Preparation Scouring, Bleaching and Dyeing Machinery	BP #13: Point-of-use Heat Recovery System	$9,000-$80,000	M	$6,000–$34,000	0.9-2.5 (avg 1.8)
C: Batch Dyeing Machinery: Jet, Beam, Package, Hank, Jig and Winches	BP #15: Automatic Chemical Dispensing System	$150,000–$890,000	H	$24,000-$405,000	1.3-6.2 (avg 2.9)
	BP #16: Automatic Dye Dissolving and Distribution System	$100,000-$400,000	H	$20,000–$70,000	4.0-5.7 (avg 4.4)
	BP #17: Automatic Bulk Powder Dissolution and Distribution System	$76,000-$600,00	H	$20,000–$80,000	3.8-7.5 (avg 4.6)
	BP #18: Cooling Water Recovery System	$90,000	M	$25,000	3.6 (avg 3.6)
	BP #19: Condensate Return Recovery System	$6,000–$40,000	L	$1,000–$16,000	2.5-6.0 (avg 4.3)
	BP #24: Steam Trap Surveillance Program	$3,200–$10,000	L	$2,000–$4,000	1.5-2.5 (avg 1.9)
D: Finishing Machinery: Dryers and Tenters	BP #29a: Moisture Humidity Controller	$20,000–$220,000	M	$8,000–$200,000	1.1-5.0 (avg 2.4)
	BP #29b: Dwell Time Controls System	$80,000–$400,000	H	$12,000–$100,000	4.0-6.7 (avg 4.7)
E: Finishing Machinery: Steam Cans	–	-	-	-	-
F: Production Machinery Systems and Services	BP #40: Wastewater Heat Recovery System	$58,800–$250,000	M	$60,000–$240,000	0.3-4.2 (avg 1.9)
	BP #41: Boiler Stack Exhaust Recovery System	$18,000–$405,000	H	$3,500–$150,000	1.4-5.1 (avg 2.9)
	BP #42: Boiler Room De-aerator	$90,000–$250,000	M	$22,500–$100,000	2.5-4.0 (avg 3.5)
	BP #43: Air Compressor, Cooling Water Recovery System	$6,000	L	$2,500	2.4
	BP #45: Water Minimization Program	$3,300–$247,50	M	$11,000–$88,000	0.3-8.7 (avg 4.7)
	BP #46: Preventive Maintenance Program	$10,000–$35,000	L	$5,000–$10,000	2.0-3.5 (avg 2.9)
	BP #48: Direct Gas-fired Air Make-up Units	$105,000–$171,000	M	$50,000–$90,000	1.9-2.1 (avg 2.0)

* Low Cost (L)= $0 – $50,000; Medium Cost (M) = $50,000 – $250,000; High Cost (H)> $250,000

6 RESOURCES

6. RESOURCES

The following is a recommended list of resources to help industry and government improve energy performance in the textiles wet processing sub-sector:

- Natural Resources Canada, Office of Energy Efficiency Web site: oee.nrcan.gc.ca

- Energy management in the wet processing sub-sector of the textiles industry:

  Carbon Trust, *Cutting Your Energy Costs – A Guide for the Textile Dyeing and Finishing Industry (Good Practice Guide 168)*, originally released under the Energy Efficiency Best Practice Programme of the U.K. Department for Environment, Food and Rural Affairs (DEFRA), March 1997, www.carbontrust.co.uk/energy

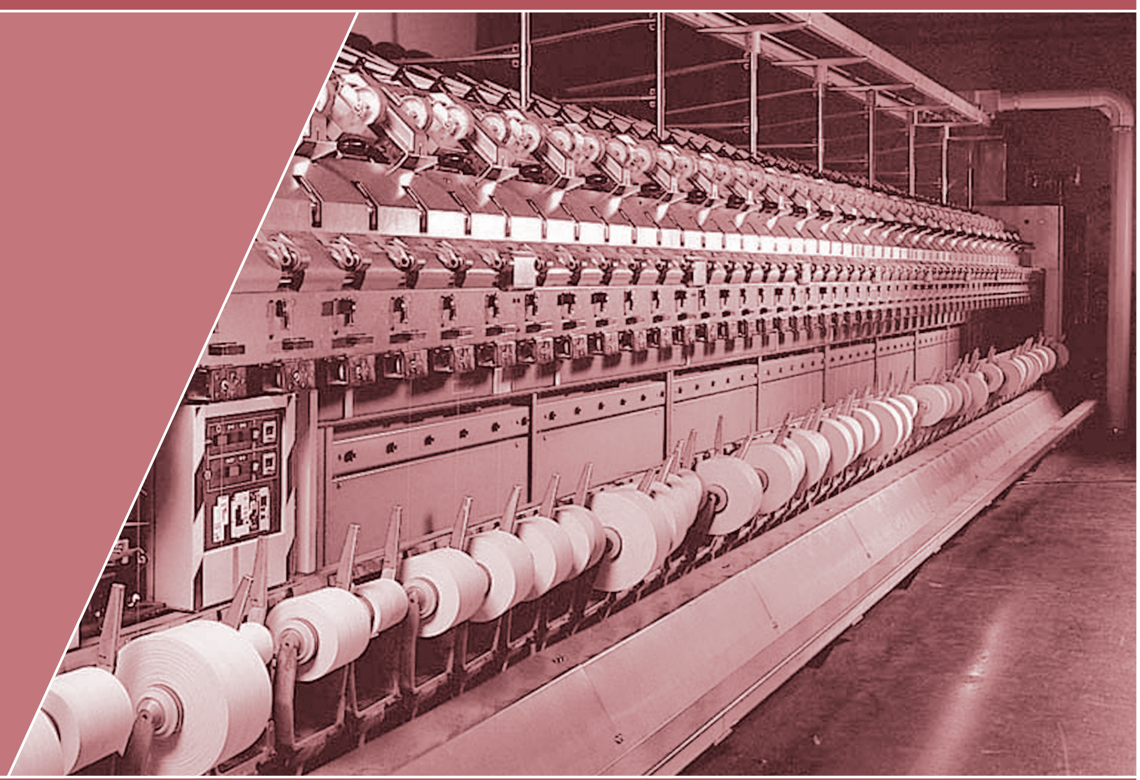
- The energy management matrix:

  Carbon Trust, *Energy Management Priorities – A Self-assessment Tool (Good Practice Guide 306)*, originally released under the Energy Efficiency Best Practice Programme of the U.K. Department for Environment, Food and Rural Affairs (DEFRA), May 2001, www.thecarbontrust.co.uk/energy/pages/publication_view.asp?PubID=4651

- Guidance on how to develop an action plan for a textile plant:

  Envirowise, offered by the U.K. Department for Environment, Food and Rural Affairs (DEFRA), *How to Profit from Less Waste and Lower Energy Use in the Textiles Industry (ET184)*, www.envirowise.gov.uk/envirowisev3.nsf/key/DBRY4PHJ3A

APPENDICES



APPENDIX A: CONVERSION AND EMISSIONS FACTORS USED

Factor/ Conversion	Description	Fuel	Value	Units	Source
Energy Content	Amount of energy in primary fuel	Natural Gas	0.03723	Gj/m^3	Natural Resources Canada, Issues Tables, 1998–1999, 1999, www.nccp.ca/NCCP/national_process/issues/index_e.html
		Liquid Petroleum Gas (LPG/propane)	25.53	Gj/m^3	National Energy Board [of Canada], *An Energy Market Assessment – Conversion Factors*, Retrieved December 2004
		Light Fuel Oil #2	38.68	Gj/m^3	Natural Resources Canada, *Canada's Emissions Outlook: An Update, 1999*
		Heavy Fuel Oil #6 (Bunker C)	41.73	Gj/m^3	
Capacity Factor	Average efficiency of combustion over year	Natural Gas	80%	%	Marbek Resource Consultants
		Liquid Petroleum Gas (LPG/propane)	70%	%	
		Light Fuel Oil #2	80%	%	
		Heavy Fuel Oil #6 (Bunker C)	80%	%	
GHG Emissions Factors	Industrial combustion	Natural Gas	1.902	kgCO_2e/m^3	Environment Canada, *Canada's Greenhouse Gas Inventory*, *1990–2002*; Annex 7: Emission Factors, August 2004
		Liquid Petroleum Gas (LPG/propane)	1534	kgCO_2e/m^3	
		Light Fuel Oil #2	2840	kgCO_2e/m^3	
		Heavy Fuel Oil #6 (Bunker C)	3112	kgCO_2e/m^3	
GHG Emissions Factors	Ontario average in 2002	Electricity	0.258	kgCO_2e/kWh	Environment Canada, *Canada's Greenhouse Gas Inventory*, *1990–2002*; Annex 13: Electricity Intensity Tables, August 2004
	Quebec average in 2002	Electricity	0.0018	kgCO_2e/kWh	
	Nova Scotia average in 2000	Electricity	0.759	kgCO_2e/kWh	
Volume Conversion	–	–	1000	litres/m^3	www.onlineconversion.com/
Energy Conversion	–	–	277.8	kWh/GJ	

APPENDIX B: WET-PROCESSING ENERGY PERFORMANCE AND BENCHMARKS – STUDY PARTICIPANTS

Measure	Average[b]	Units	Min.	Max.	Variance[b]	75th Percentile Benchmarking		
						Benchmark[b]	Plants Out-performing	Plants Under-performing
Quantitative Performance Indicators								
Energy Intensity – Industry-wide[f]	**27**	**GJ/t**	**5**	**168**	510%	**22**	6	16
Energy Intensity – Carpet only[a,e,f]	16	GJ/t	15	21	30%	–	–	–
Energy Intensity – Knit only[a,f]	35	GJ/t	21	168	380%	30	3	7
Energy Intensity – Woven only[a,f]	51	GJ/t	20	119	130%	40	2	6
Energy Intensity – Yarn only[a,e,f]	32	GJ/t	21	47	50%	–	–	–
Energy Intensity – Non-woven only[a,e,f]	9	GJ/t	5	98	990%	–	–	–
GHG Intensity (from energy use) – Industry-wide[a,d,g]	**1.6**	**tCO_2e/t**	**0.3**	**17.5**	990%	**1.2**	6	16
GHG Intensity (from energy use) – Carpet only[a,c,e,f]	1.1	tCO_2e/t	0.9	1.4	20%	–	–	–
GHG Intensity (from energy use) – Knit only[a,c,f]	2.4	tCO_2e/t	1.0	17.5	630%	1.9	3	7
GHG Intensity (from energy use) – Woven only[a,c,f]	3.5	tCO_2e/t	1.1	6.6	90%	2.0	2	6
GHG Intensity (from energy use) – Yarn only[a,c,e,f]	2.1	tCO_2e/t	1.1	3.0	50%	–	–	–
GHG Intensity (from energy use) – Non-woven only[a,c,e,f]	0.6	tCO_2e/t	0.3	4.8	660%	–	–	–
Energy Management Assessment Scores (% of max achievable)								
Corporate Energy Policy	46%	%	0%	**100%**	50%	–	–	–
Organization	39%	%	0%	**100%**	60%	–	–	–
Skills and Knowledge	30%	%	0%	**75%**	50%	–	–	–
Information Systems	40%	%	0%	**75%**	40%	–	–	–
Marketing and Communications	28%	%	0%	**75%**	50%	–	–	–
Planning and Investment	53%	%	25%	**75%**	30%	–	–	–
Overall	**39%**	**%**	**13%**	**71%**	30%	**51%**	5	15
Technical Best Practices Assessment								
Applicable BPs Utilised (%)	**64%**	**%**	37%	81%	27%	**73%**	6	16

a. Values for each individual textile include only the estimated share of production output and utilities for that textile type.
b. Average and benchmark values are rounded to reflect the uncertainty in wet processing and per-textile percent breakdown estimates.
c. Province-specific GHG emission factors were used for electricity.
d. Maximum variance from average value.
e. Too few plants to calculate meaningful per-textile benchmark.
f. Averages are "Total averages" = Sum (numerator values for plants in study) / Sum (denominator values); i.e. NOT the "average" of each plant's results.

APPENDIX C: ENERGY MANAGEMENT MATRIX CATEGORIES AND LEVELS

CATEGORIES	
CORPORATE ENERGY POLICY	Effective management starts with the publication and distribution of a policy statement that sets measurable targets and values energy management as an integral part of the organization.
ORGANIZATION	The organization of people, allocations of energy management responsibilities, and integration of energy management in other management areas.
SKILLS AND KNOWLEDGE	Competencies pertaining to the efficient operation, maintenance, promotion and management of energy systems, action plans and equipment; includes employee training on equipment maintenance and processes vital to sustaining energy efficiency levels.
INFORMATION SYSTEMS	The process of gathering, recording, analysing and reporting data to promote energy management priorities in training, monitoring and measuring energy management and technical energy performance.
MARKETING AND COMMUNICATIONS	Promotion, both internal and external, to build and sustain awareness of energy management, openness to employee input on savings opportunities, and the provision of feedback on needs and achievements.
PLANNING AND INVESTMENT	Anticipation of future resource requirements, and investment in energy management measures and technologies.
LEVELS	
0	Suggests energy management is virtually non-existent. There is no corporate energy policy, formal delegation of energy management responsibilities or program for promoting energy awareness within the organization.
1	Indicates that, although there is no formal corporate energy policy, some energy management activities are in place. Reporting procedures and awareness are undertaken on an ad hoc basis.
2	Signifies that the importance of energy management is recognized at a senior management level, but there is little active support for energy management activities. Energy management is treated primarily as a technical issue, not a management issue, and is restricted to the interests of a limited number of employees.
3	Indicates energy management is treated seriously at a senior level and is incorporated into formal management structures. Consumption is likely assigned to cost-centre budgets, and systems are in place for reporting energy consumption, promoting energy efficiency and investing in energy efficiency.
4	Demonstrates a clear delegation of responsibility for energy consumption. Energy efficiency is regularly promoted, formally and informally, and a comprehensive system is in place to closely monitor performance against targets. Results of energy management are accounted for, reported and reinforced in the annual report.