



# Best Practices for Textile Mills to Save Money and Reduce Pollution, Bangladesh

A PRACTICAL GUIDE FOR RESPONSIBLE SOURCING

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THE EARTH'S BEST DEFENSE

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December 2012

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The accompanying  
*Best Practice Guide*  
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*This report is funded by and  
prepared in partnership with the  
South Asia Environment, Water  
Resources and Climate Change  
Unit of the World Bank*



## ACKNOWLEDGEMENTS

This report was funded by and prepared in partnership with the World Bank.

The Natural Resources Defense Council (NRDC) and the World Bank would like to thank the brands and buyers that partnered with us on the Responsible Sourcing Initiative in Bangladesh and their staff in Bangladesh: H&M, Levi's, Marks & Spencer, Walmart, Li & Fung, and The Gap.

We would also like to thank the senior and technical staff at all the factories who participated in the project, especially: DBL, Delta, Epyllion, Libas, Niagara, Partex, and Sinha.

In addition, we would like to thank the staff and management of the textile trade associations that took the time to meet with us, and agreed to consider sharing the final results with their membership: Bangladesh Garment Manufacturers Export Association, Bangladesh Knit Manufacturers Export Association, and the Bangladesh Textile Mills Association.

Thanks also to the World Bank's Bangladesh staff and NRDC's representative in Dhaka, Syed Anwar Hossain, whose efforts helped ensure the best report possible.

We would also like to thank the consortium led by Ecopsis for the technical work that informs this report. Finally, we would like to thank Naureen Chowdhury at the International Finance Corporation in Dhaka, Bangladesh, and Dr. Ali Hasanbeigi of the Lawrence Berkeley National Laboratory for serving as reviewers for this report.

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## EXECUTIVE SUMMARY

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**T**he world textile industry is a large part of our daily lives, from the clothes we wear to the napkins at eateries. Dyeing and finishing that textile can be an environmentally taxing process: One ton of fabric can lead to the pollution of up to 300 metric tons<sup>1</sup> of water with a suite of harmful chemicals, and consume vast amounts of energy for steam and hot water.<sup>2</sup> Now that the industry is centered in countries with still-developing environmental regulatory systems, such as China and Bangladesh, among others, textile dyeing and finishing has a huge environmental footprint.

To address this issue, NRDC and a group of apparel retailer and brand partners started the Responsible Sourcing Initiative (RSI) to curb pollution in the sector while saving the industry money. Starting in China, the world's largest center of manufacturing, NRDC reviewed more than a dozen textile mills and studied five in-depth to identify simple, cost-saving opportunities to reduce water, energy, and chemical use—via improvements in manufacturing efficiency.<sup>3</sup> Now, the initiative has partnered with the World Bank to take the next step to test, broaden, and improve the implementation of the best practices NRDC identified in China, by expanding the work to Bangladesh. This report summarizes the practices that we found to be the top money-saving, environmental protection opportunities in Bangladesh, which largely overlap with the practices identified in China.

The initiative broadly follows the template that NRDC established in China. No large-scale retooling of factories is required. The summarized practices are all easy-to-implement, low-cost opportunities that pay for themselves in 15 months or less. Even absent environmental benefits, factories should pursue these opportunities, because they improve mill productivity and the bottom line. Given the importance of the ready-made garments industry in Bangladesh—employing millions of people, most of them women, and serving as the largest revenue generator in the country—the continued competitiveness of the sector and related industries is critically important in Bangladesh.

**This report uses “best practice” specifically to refer to the best opportunities to reduce pollution at low or no cost, and with a quick payback period as identified by our analysis, which is based on specific criteria defined further in appendix B.**

This *Best Practice Guide* recommends metering as the first priority among these practices, since measuring resource use is the critical starting point for improvement. Next, it summarizes the six other best practices to save water and energy—those with relatively minor upfront investment and no risk to product delivery times, price, or quality (see table 1). This guide also includes additional recommendations for other potentially promising low-cost measures as well as for improvements for factories ready to go further. Finally, the guide outlines process improvements that could have big payoffs, and simple good housekeeping practices to increase savings and efficiency at mills with very little effort—even among mills not yet ready to undertake the recommended best practices.

RSI is part of the larger Clean by Design effort NRDC has undertaken to address the environmental impacts of the fashion and apparel industries. Clean by Design addresses all major impacts—from fiber growth to dye selection, fabric sourcing to consumer care.

**TABLE 1: RECOMMENDED BEST PRACTICES: AN ASSESSMENT OF FOUR BANGLADESHI FACTORIES**

PRACTICE	% RESOURCE SAVINGS		SAVINGS (TK*/TON FABRIC)		COST (TK*/TON FABRIC)		INVESTMENT COST (TK) NRDC'S TEN BEST PRACTICES		PAYBACK PERIOD (MONTHS)	
	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
Meter resource use	N/A	N/A	N/A	N/A	N/A	N/A	20,000 each	500,000 each	N/A	N/A
<b>WATER SAVING PRACTICES</b>										
Eliminate water leaks and reduce hose pipe use <sup>a</sup>	0.3	0.7	6.8	31.3	0.7	1.1	3,000	3,000	0.4	1.4
Reuse cooling water from dyeing machine	8.2	14.8	392	714	75	204	280,000	800,000	2.1	3.3
Reuse process water from rinsing <sup>b</sup>	9.0	11.9	91	426	134	196	380,000	1,000,000	3.9	25.9
<b>ENERGY SAVING PRACTICES</b>										
Steam management <sup>c</sup>	1.1	5.3	81	349	-	-	-	-	Immediate	Immediate
Insulate pipes, valves, flanges <sup>d</sup>	0.4		23		22		60,000		11.2	
Recover heat from drying operations <sup>e</sup>	20.0	20.0	527	1769	267	368	1,000,000	1,500,000	2.5	8.4

\* The costs and savings here are in Bangladeshi Taka (Tk). Conversions between Taka and US Dollars throughout the report reflect conversion rates in effect on May 9, 2012 at 82 Tk per 1 USD.

<sup>a</sup> Costs reflects use of trigger guns to reduce hose-pipe use; costs associated with eliminating leaks are insignificant. At one of the factories, while our technical consultants observed no leaks during the visit, the factory self-reported water leaks—based on the self-reported leaks, savings are estimated at Tk 31.3/ton of fabric produced. These savings are reflected in the savings range in the table above.

<sup>b</sup> Range for three of four factories; outlier excluded (93 months payback for fourth factory); see discussion and appendix A for more detail

<sup>c</sup> Percentage of resource savings reflects technical team's estimate of steam losses at the factories based on observations

<sup>d</sup> Already implemented by all but one factory, one after our initial visit; fourth factory only has a short piece of exposed pipe; factory implementation indicates that the measure is of value to factories. See discussion for more detail

<sup>e</sup> Percentage of resource savings are technical team's estimate of drying costs avoided; one factory was an outlier in terms of the costs (Tk 75/ton), savings (Tk 76/ton) and payback period (11.9 months) and has been excluded from the table; see discussion for more details.

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## OVERVIEW

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**R**SI got its start in China, the world’s largest producer of textiles. Partnering with pioneering textile retailers and brands, NRDC launched RSI as part of the larger Clean by Design effort to address the environmental impacts of the fashion industry. RSI’s aims to address the gap between the quality and scale of industrial manufacturing in the developing world, and the governments’ capacity to address the industry’s environmental impacts—focusing on areas where the private sector can take responsibility and on the actions it can take. The best way to achieve this goal is to reduce waste by targeting resource inefficiencies in the manufacturing process, thereby enhancing the profitability of mills, while reducing their environmental footprint.

NRDC identified and assessed a group of dyeing and finishing textile factories to identify ten low-cost and no-cost best practices to reduce pollution and resource use, while saving factories money. The driving insight behind the approach was that these best practices are self-reinforcing—even without consideration of the environmental impacts of textile discharges or governmental oversight—because they are good for business. Now, in partnership with the World Bank, we have expanded our efforts to Bangladesh, to test and further sharpen our understanding of the best practices, and test their applicability outside of China.

Whereas North America and Europe have few textile mills and mature environmental regulatory structures, China and developing nations lack resources to adequately monitor the thousands of mills within their borders, or to enforce existing standards. Governments cannot solve the problem alone—the private sector needs to step up and play a key role in resolving the problem of pollution generated by textile production. The best way to achieve this goal was to reduce waste by targeting resource inefficiencies in the manufacturing process, thus increasing mill profitability, while reducing their environmental impacts.

That is why NRDC partnered with a number of pioneering multinational apparel retailers and brands to launch RSI. These companies can enhance and maintain the value of their brands and motivate their suppliers to improve production practices to reduce pollution; meanwhile, the factories can save money and reduce the environmental burden on the communities in which they operate. Of course, compliance with environmental discharge standards is equally important for factories not only from an environmental but also a competitive perspective—buyers are increasingly concerned about environmental compliance, and even full implementation of all NRDC’s best practices will not eliminate the need for effective wastewater treatment and air pollution control.

The textile dyeing and finishing sector is more water intensive than most, with as much as 300 tons of water used for every ton of textile dyed and finished.<sup>5</sup> Steam used in the process is often generated from inefficient industrial boilers. In addition, the chemicals needed for textile processing contain many toxic and oxygen depleting constituents—these have a very damaging impact on human health and the environment if not properly treated. All of this is highly relevant in Bangladesh.

Textiles are a huge part of Bangladesh’s industrial sector, contributing more than 80 percent of its foreign earnings.<sup>6</sup> Most of us have probably seen a “Made in Bangladesh” tag on clothing we wear. The sector has grown enormously in the last decade: Bangladesh has steadily climbed up the list of biggest clothing exporters, and now sits high on the list.<sup>7</sup> Those strides have largely been in the garment sector.<sup>8</sup> Unlike China, which has more than 50,000 textile mills,<sup>9</sup> Bangladesh’s dyeing and finishing sector is yet to catch up to its garment sector (5,150 factories), and is currently represented by 1,700 mills.<sup>10</sup> These mills only meet 10 percent of the export-quality cloth requirements of the garment industry.<sup>11</sup> In part, that is what makes Bangladesh the right place to move forward the Clean by Design efforts to reduce pollution and save money for factories.

Dyeing and finishing factories in Bangladesh are poised on the cusp of huge growth. According to McKinsey & Company, Bangladesh’s ready-made garments sector is likely to double by 2015 and nearly triple by 2020, with apparel buyers increasingly focusing their production there.<sup>12</sup> The brand partners see Bangladesh as an important strategic region for future expansion. Explosive growth in the garment sector presages growth in the dyeing and finishing sector. In addition, trade provisions are encouraging growth in both textile and garment production in Bangladesh.<sup>13</sup> Industry trends are also fueling vertical and regional integration in the textile sector.<sup>14</sup> As margins decline, the costs of importing and transporting finished textiles from other countries with stronger currencies may threaten the garment sector’s profits. The government recognizes the need for what it describes as “backward linkages” and has incentives in place to encourage growth in the production of textiles.<sup>15</sup> Demand for domestically produced textiles is also expected to grow.

This growth is poised to take place in the alarming context of an overtaxed water system, making the environmental gains from greater efficiency and less pollution all the more vital. Bangladesh is facing a water crisis. A country historically bedeviled by too much water, it also faces the lesser-known problem of too little usable water. Dhaka, a city of 12 million people, is surrounded by extremely polluted surface waters, large sections of which are biologically dead,<sup>16</sup> including four rivers so polluted they are deemed “ecologically critical.”<sup>17</sup> Industrial pollution accounts for 60 percent of pollution in the Dhaka watershed,<sup>18</sup> and the textile industry is the second largest contributor. The water pollution adversely affects the lives of millions of people.

Water pollution is so severe here that water-borne diseases affect nearly 80 percent of people living in the Dhaka watershed. Fish have either disappeared from the rivers or have declined in number and in health, thereby cutting off the sources of livelihood of thousands of people who rely on fishing.<sup>19</sup> The pollution also puts additional pressure on the groundwater resources that supply drinking water for 80 percent of Dhaka.<sup>20</sup> The textile industry primarily draws groundwater for industrial use from the same aquifer that people rely on for drinking water. Thus, the textile industry’s use threatens both the quality and quantity of drinking water available to the residents of Dhaka. Not only are the environmental and human health impacts enormous, this pollution also threatens the growth of the industry and Bangladesh’s economy, because the textile sector relies on groundwater for its use. The greater the pollution, the greater the treatment required to render the water suitable for dyeing and finishing. Also, the more water that is used, the more quickly the resource on which these factories rely will be depleted.

This situation is a clarion call to pilot and implement measures to reduce the water used and pollution generated by these mills, save factories money in the process, and encourage more careful thought about resource use in factory decision-making before significant new infrastructure is put in place. Reaping the full benefits of the projected growth means managing expansion sustainably. McKinsey concludes that significant challenges will have to be overcome to take advantage of the growth potential, including compliance with environmental standards and better use of natural resources.<sup>21</sup> Initiatives such as RSI and the International Finance Corporation’s Cleaner Production program will be key to overcoming these challenges. Notably, the newer factories we visited in Bangladesh, constructed in the last five to 10 years, already reflect a greater degree of built-in resource efficiency than older factories, since these factors are considered up front, before investments are made.<sup>22</sup>

Bangladesh is also an ideal place to test the applicability of our China findings, because it is similar to other developing countries that now produce textiles and are at an earlier stage of development than China. Unlike North America and Europe, which have few mills and mature environmental regulatory structures, China, Bangladesh and other developing nations lack the capacity to adequately monitor the thousands of mills operating within their borders—or to enforce existing standards. If anything, the regulatory infrastructure in Bangladesh is even more strained than in China. This makes RSI’s goal

of identifying self-reinforcing best practices to close the gap between the scale of industrial manufacturing and governmental capabilities to address the pollution associated with that manufacturing by identifying self-reinforcing best practices all the more relevant.

Finally, there are important differences between the way Bangladesh and China utilize resources. Thus, our Bangladesh work represents both an important test of the broader applicability of the concept we studied in China, and an opportunity to broaden the relevance of the best practices. For instance, Bangladeshi factories rely on natural gas for power generation on site, so practices specifically targeting coal handling in China are not applicable in Bangladesh. In addition, Bangladeshi factories rely on pumped groundwater rather than on municipal supply, affecting the perception of the costs of these resources: Factory managers tend to view water as free. However, there is a cost for the water used at these mills. We quantified water-use costs based on estimates of the cost of pumping water and treating it to make it suitable for use, as well as the costs of effluent treatment. Finally, Bangladeshi factories are generally much smaller than their Chinese counterparts, and therefore resource savings will be commensurately smaller per factory.

In Bangladesh, as in China, through expert efficiency assessments of real-world manufacturing practices in typical mills, NRDC identified best practices that would immediately make the dyeing and finishing process more efficient, and deliver substantial environmental improvements at the same time (see table 1: Recommended Best Practices). Based on the assessments, taken together, the best practices can save up to 27 percent of water and significant amounts of the energy and chemicals used in a typical knit fabric dyeing mill—all with initiatives that can pay themselves back in less than fifteen months.

Of course, compliance with local environmental laws remains crucial for all textile manufacturing: Multinational apparel buyers must continue to insist on compliance with local environmental emissions and discharge standards as a prerequisite for doing business. Even the best-run and most efficient manufacturing practices generate pollution that must be treated prior to discharge. The *Best Practice Guide* provides an important supplement for reducing the environmental impacts and the costs of textile manufacturing, but it will not completely substitute for or eliminate the need for effluent treatment.

A short description of the four textile mills studied in depth is provided in appendix A. The mills all processed knit cotton fabric but ranged in size. Three of the four mills generally fell in the middle range of production efficiency—they were neither state-of-the-art manufacturing operations nor the worst performers—and one of the mills was in the higher range of performance. The opportunities at this last mill demonstrate that many of the practices discussed here continue to be relevant, even for more advanced operations.

Therefore, the opportunities identified in these mills should be very widely applicable to mills across Bangladesh and the developing world.

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## FIRST ORDER OF BUSINESS: INSTALL METERS TO BENCHMARK USE AND MEASURE SAVINGS

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The issues we identified in Bangladesh bear many similarities to those we found previously in China. It all starts with inadequate information on resource use, especially at a process level. Factories rely mainly on aggregate utility bills or on estimates of total usage based on factory and equipment capacity, thus not allowing for benchmarking of resource consumption for different processes. We repeatedly encountered inconsistencies in estimates of resource use and cost and variations in or changes to the information when these estimates were confirmed at a later date. We also encountered wide variation in reported use of resources. Such resource use is necessarily estimated in the absence of metering, since the mills self-generate both water and electricity and do not purchase measured quantities of the resources.

Therefore, as in China, the best practice that underpins all of the other opportunities recommended here, and that should be adopted immediately by all dyeing and finishing textile mills, is the same: **measuring consumption with meters that track water, steam, and energy consumption in total, as well as at the process and equipment levels.**

RSI assessments revealed that although many textile mills in Bangladesh *estimate* total water, energy, and chemical consumption based on capacity of pumps and machines, they do not know either total resource use or *specific* resource use in different areas in the factory, or in particular pieces of equipment. Meters, or better yet, measurement software at key locations inside a mill enable a factory to closely track resource and energy consumption for specific processes, directing managers to focus resources on improving efficiency in the most resource-intensive processes. Several mills investigated in RSI had in-machine metering in dyeing machines for process control, but had little metering otherwise to track full resource use in the process. At minimum, factories should meter resource use at the main point of supply. Next, they should prioritize workshop level metering, then metering at machines that are major consumers of a given resource.<sup>23</sup>

As we have noted previously, installing and operating accurate meters and/or measuring software are fundamental steps to benchmarking performance and to initiating efficiency improvements. Such monitoring allows plants to identify and respond to leaks and to detect unusual spikes in resource use, and provides positive feedback on the effectiveness of the measures mills adopt to improve processes.

In this way, meters and measurement software reinforce the benefits of efficiency measures and encourage continuous improvement. Importantly, measurement software allows process efficiency information to be sent to other locations electronically, thus enabling benchmarking of performance and identification of best-in-practice mills in an objective and straightforward manner.



**METERS AND MEASUREMENT SOFTWARE ARE RELATIVELY INEXPENSIVE.**

Average cost of water flow meters:<sup>24</sup>

**Mechanical type:**

Tk 20,000 to 100,000/unit (~ US \$200 to \$1,200<sup>25</sup>/unit)

**Electromagnetic type (higher accuracy, longer life time):**

Tk 50,000 to 100,000/unit (~ US \$600 to \$1,200/unit) (Indian/Chinese origin)

Tk 300,000 to 500,000/unit (~ US \$3,700 to \$6,100/unit) (European/Japanese origin)

Investment in more sophisticated addressable, or pulse-type meters, over basic meters allows remote data capture and more real-time analysis, and is preferable for major meters (above 25mm) to automatically track usage.<sup>26</sup> Costs in China averaged approximately Tk 164,200 to 246,200 (US \$2,000 to \$3,000) per meter.<sup>27</sup>

Estimates place the cost of steam meters at Tk 300,000 to 400,000 (~ US \$3,700 to \$4,900).<sup>28</sup> Costs in China for steam meters range between approximately Tk 127,200 to 387,800 (US \$1,550 to \$4,725).<sup>29</sup> High-accuracy integrating steam meters cost more. However, integrating meters are only called for to measure the main site supply and perhaps for use at major buildings or plants.<sup>30</sup> For process lines and major machines, basic steam flow or condensate meters should suffice. Basic steam flow meters will likely even suffice for major buildings and plants.

Electricity meters cost approximately Tk 82,100 (US \$1,000) or less each in China.<sup>31</sup> We do not have an estimate for Bangladesh.

Measurement software is available for approximately Tk 1.2 million (US \$15,000), a figure that includes the price of remote collection.<sup>32</sup>

For more on recommended metering architecture, see appendix D.

## BEST PRACTICES: SAVING WATER, ENERGY, CHEMICALS, AND MONEY

The focus of Clean by Design’s RSI continues to be on practical, low-cost (or even no cost) improvement measures. The initiative focuses particularly on factory infrastructure improvements that would improve the steam production and water heating processes, recycle process water, and recover heat. These infrastructure initiatives provide a particularly easy starting point for increasing manufacturing efficiency when compared to process optimization methods. For each opportunity identified, RSI evaluated:

- **Costs**—both upfront investment and ongoing operational costs
- **Payback period**—the time required to recoup upfront investment through savings in water, materials, and energy costs
- **Resource savings**—water, energy, and chemicals

All cost, return, and impact estimations and calculations are based on the four factories audited as part of the Initiative in Bangladesh, supplemented with previous RSI experience in China. The RSI team selected practices based on greatest impact, lowest cost, and quickest return. (See appendix B for full list of 30 practices evaluated and selection criteria.) These criteria vary somewhat from those we employed previously because of the differences in circumstances in Bangladesh, such as factories pumping groundwater at the site to meet their water needs, and using natural gas for fuel rather than coal.

Three of the six non-metering best practices cost less than Tk 410,400 (US \$5,000) each; two of these cost almost nothing (see table 1). The cost ranges for two other practices start at less than Tk 410,400 (US \$5,000). None requires more than 15 months to recoup costs. From an environmental standpoint, the best practices each deliver either savings of at least one ton of water per ton fabric, or at least one percent of the factories’ total use of steam, gas, or electricity, or at least 10 percent of materials or costs on a particular activity. The one exception concerns insulation of pipes, valves, and flanges. The factories had largely implemented this measure before our assessment, and so we did not have baseline pre-installation data to estimate the savings after installation: However, our China experience, and the fact that the factories themselves identified this as a need, suggests that it is a best practice. In total, if implemented together at the same mill, the improvements could reduce consumption of water by as much 27 percent, and reduce energy use significantly.

### THREE WATER-SAVING BEST PRACTICES

Water consumption varies among processes within a textile mill, as well as by machine type and setup. Recycling and reuse of process water can yield great savings, and, since the water recovered is often hot, these improvements can save energy as well. Steam condensate and non-contact cooling water is a second valuable source of water to recover, because it is high in both quality and temperature. Finally, water is used for general washing and cleaning throughout the factory, and good housekeeping practices can substantially reduce wasteful use of water in cleaning as well. In Bangladesh especially, reductions in water use also lead to savings in energy and chemicals, because the factories pump and treat their own water prior to

use. While these energy and chemical savings are not described in table 2, we note that the total financial savings listed here represent a combination of savings from avoided pumping costs (saving energy) and avoided chemical treatment costs (saving chemicals) since the factories do not pay directly for the water.<sup>33</sup>

RSI identified three best practices to conserve water (see table 2). A mill that implemented all of the water best practices suggested could save between 18 to 27 percent of its total water use (rounded to the nearest whole number).

**TABLE 2: WATER SAVING BEST PRACTICES**

PRACTICE	% RESOURCE SAVED (WATER)	FINANCIAL SAVINGS PER TON OF FABRIC PRODUCED (TK/TON)	WATER SAVINGS PER TON OF FABRIC PRODUCED (TON WATER /TON FABRIC)
Eliminate water leaks and reduce hose pipe use	0.3% to .7%	7 to 31	1.0 to 1.5
Reuse cooling water from dyeing machines	8% to 15%	392 to 714	19.8 to 35.3
Reuse process water from rinsing operation	9% to 12%	91 to 426	21.6 to 23.5

## ELIMINATE WATER LEAKS AND IMPROVE HOSE-PIPE USE

Although individual leaks may not seem important in the overall consumption picture, they can be responsible for a surprisingly significant loss of resources over the course of a year. Based on sampling and observations during factory visits, RSI estimates conservatively that leaks of water are responsible for up to 0.2 to 0.34 percent of water use at two of the factories. For factories losing water at the same rate as these two factories and using water at the same levels as the four factories that participated in the assessment (see appendix C), eliminating leaks can thus mean savings of water ranging between approximately one-third of a ton of water per ton of fabric produced. The savings from eliminating water leaks could be higher, judging from the relevant literature.<sup>35</sup> The other two factories that participated in the assessment already recognized the value of eliminating leaks to an extent that no visible leaks were detected.

Additional savings can be expected from efforts to reduce unnecessary use of water in cleaning operations. Water is wasted too often at many of the factories we visited—when hoses or cooling water are left running even after machinery is shut down, after cleaning is completed, and/or while cleaning is in progress. Rather than relying on workers to reduce water use, low-flow and shut-off valves or trigger guns should be installed on hoses, and thermally-controlled shut-off valves can be installed on process units.<sup>36</sup> RSI’s technical team estimates that the number of hose pipes in use could be reduced from current usage levels of 12 to 20 to two to three hosepipes, with the remaining hosepipes fitted with trigger guns. The estimated savings from improved use of hose pipes ranged from 0.2 to 0.7 percent of water use at the four factories. Combined savings from eliminating water leaks and reducing hose pipe use range from 0.3 percent to 0.7 percent of water use at the four factories assessed, or savings of Tk 6.8 to 31.3 per ton of production (~ US \$0.08 to \$0.38/ton of production).

Eliminating leaks consists of routinely investigating sources of water leaks, and implementing an effective preventive maintenance program, requiring virtually no investment costs and thus delivering instant payback. Likewise, using a trigger gun or shut-off valves is cheap (~ Tk 1,000 or US \$12 per trigger gun) and pays back within two months at the most. Proper metering can be an immense help in identifying leaks and potentially excessive use of hose pipes.

## REUSE COOLING WATER FROM DYEING MACHINES

Non-contact cooling water should always be recycled. It is high in quality and temperature and can thus be reused beneficially in various processes, such as in de-sizing, scouring, washing, or rinsing. Furthermore, the discharge of water at high temperature and considerable water volume stresses the wastewater treatment system. It is thus highly beneficial to keep such large quantities of hot, clean water out of the treatment system.

One particularly promising reuse opportunity revealed in our research was to reuse the cooling water used to reduce the temperature of dyeing baths before they are drained out. In batch dyeing operations, at least three cycles of the process in the dyeing machines are carried out at near 95°C. But the water cannot be drained out without reducing the water temperature below 80°C. Heat exchangers are used to reduce the dye bath water temperature. Cold water passes through the heat exchanger to reduce the temperature of the machine water via heat transfer. Currently, this clean cooling water is being drained out to the effluent treatment plant, and the heat of the water is being wasted. RSI found that some mills were either not reusing this water at all or were using it in cold water processes that did not benefit from the heat.

To use the warmed-up cooling water, factories could use an insulated hot water reservoir tank to collect and store water and then recycle this warm water either into the dyeing process or in the boiler as feed water. The collected water reduces the need to heat new cold water. However, if water is reused in the dyeing process, care must be taken to restrict the initial dye liquor temperature to avoid dyestuff strike-rate problems and fabric creasing.

This best practice requires installation of a water reuse system—pipes, valves, pumps, holding tanks, and a control system. The RSI technical team estimated that costs are modest, Tk 280,000-800,000 (estimated to be between US \$ 3,400 and \$ 9,700) and return on investment is less than four months.<sup>37</sup> This best practice is already implemented at one of the mills assessed.

## REUSE PROCESS WATER FROM RINSING OPERATIONS

After dyeing, fabric is washed with clean water to remove surplus or unabsorbed dye. While the water from the initial rinses is highly colored, later washes are low in both color and chemicals. In current practice, this water is discharged for effluent treatment. Instead, this water can be reused for other processes that do not require high-quality water, with minimal treatment such as a sand or carbon filter.

The reuse of water used to remove surplus dye requires purchasing pipes and fittings, water tanks, and electrical pumps to store and return water to the process, as well as a filter. The RSI technical team estimated investment cost would range from Tk 380,000 (~ US \$4,600) to Tk 1,000,000 (~ US \$12,100) in upfront costs, plus operating costs of another Tk 200,000 to Tk 500,000 (~ US \$2,400 to \$6,100), depending on mill size and layout.<sup>38</sup> For two of the four factories assessed, the investment pays itself back within eight months.<sup>39</sup> A third factory pays back within 26 months. The last factory is an outlier with a payback period of 93 months, which we believe is not representative, since its payback period is more than three times the payback period of the other three factories. Some mills will not need to purchase new equipment but can adapt existing equipment and systems to this use. Since the payback period for two of the four factories was quick (less than eight months), we included this measure in the list of best practices.

We note that other process water can also be reused in principle. While not assessed in Bangladesh, in China we also found that the water discharged from bleaching and mercerizing machines can be collected and reused for other processes, instead of being discharged directly to wastewater treatment.<sup>40</sup> The water quality has to be evaluated, but can often meet quality requirements for scouring after simple filtration.

## THREE ENERGY SAVING BEST PRACTICES

In China, we discovered that the generation of steam is by far the largest energy-consuming activity in a textile dyeing mill. Usually generated in an on-site industrial boiler, steam generation emits conventional pollution as well as global warming gases (mainly from carbon dioxide emissions) to the atmosphere. With this in mind, RSI best practices for energy improvements focus on increasing the efficiency of steam use in the production process through insulation and maintenance

of the steam delivery system. Substantial additional energy is saved with some of the best practices for water efficiency as well, as discussed above.

The pressure on the natural gas supply for textile mills is a particularly important incentive for mills to become more energy efficient. In Bangladesh, natural gas supply is inconsistent, and factories already face occasional shortages of natural gas—such incidents may increase in frequency.<sup>41</sup> And of course, substantial costs are associated with purchasing and using natural gas in mills. The efficient use of energy is thus paramount.

**TABLE 3: ENERGY-SAVING BEST PRACTICES**

PRACTICE	PERCENTAGE OF RESOURCES SAVED (ENERGY OR ENERGY PROXY)	SAVINGS PER TON OF FABRIC PRODUCED (TK/TON)*
Steam management	1% to 5% of total steam used	Variable (81, 123, 270, 349)
Recover heat from drying operations	20% of drying costs	Variable (527, 770, 1769)
Insulate pipes, valves, and flanges	0.4% of total natural gas used	23

\* The Tk per ton figures represent savings for the number of factories where the measure was applicable. See text below for more information.

## STEAM MANAGEMENT

If a steam distribution system is not managed properly, the result will be steam energy and condensate losses. Such losses result from blocked or broken steam traps and loose fittings, and other leaks in the steam distribution system. When the quality of fittings is not sufficient, steam quality is affected and extra condensate is introduced into the steam system. The extra condensate must be discharged, otherwise, it can lead to the “water hammer” effect, which can result in inefficiencies and losses in energy equivalent to five percent.<sup>42</sup>

Steam traps play an important role in maintaining efficient transportation of steam through a mill: The traps remove moisture from the steam lines and prevent further condensation, thereby preventing heat loss and reducing fuel consumption (and saving money). In steam systems that been inadequately maintained, between 15 percent and 30 percent of the traps may fail.<sup>43</sup> Steam traps should be repaired or replaced as soon as they are out of order. A good rule of thumb is that leaking traps should account for less than five percent of the trap population.<sup>44</sup> In addition, steam traps should be installed at appropriate intervals—typically one about every 27 yards (25 meters)—in the main steam headers.<sup>45</sup>

This best practice requires routine inspection of leaks in the steam system, loose fittings, and steam traps (monthly testing is recommended) and repair or replacement of leaks, faulty fittings, and broken steam traps as soon as the problem is detected. Because no significant expenses are associated with implementing this practice, it pays for itself immediately (less than one month). Each of the factories assessed had opportunities to improve steam management.

## RECOVER HEAT FROM DRYING OPERATIONS

Drying and stenter operations generate heat that is vented to the atmosphere at a temperature of 120° C to 150° C.<sup>46</sup> The heat of the gas is wasted. The heat could be captured and used to heat incoming process water.<sup>47</sup> In some circumstances, the hot air itself could be beneficially reused in the dryer or elsewhere; the air stream would require filtration prior to use,<sup>48</sup> and the filters would require daily cleaning.<sup>49</sup> RSI’s technical team estimates savings from reuse of recovered heat to be at least 20 percent of drying costs, based on experience.<sup>50</sup> Textile mills also have other valuable sources of heated air, such as stack gases, whose heat could also be captured.

The RSI technical team estimates that an air to water heat exchanger would cost about Tk 389,850 (US \$4,700) per unit for main exhaust outlets.<sup>51</sup> Reusing the hot air would require the installation of pipes and filters. Investments for such reuse were estimated to be Tk 1,000,000 (~ US \$12,200) for three of the factories and Tk 1,500,000 for the fourth (~ US\$18,300), which was using a thermal oil dryer in addition to steam and stenter drying.<sup>52</sup> Payback periods for hot air reuse at three of the four factories assessed were estimated at less than eight and a half months. The fourth factory was an outlier in all categories, with both costs and savings at less than a third of the other three factories. This fourth factory is not reflected in the table above, but its payback period was still less than 12 months.

## INSULATE PIPES, VALVES, AND FLANGES

Textile mills use steam in a variety of machines and processes. Because of widespread use of steam at locations across the factory, losses during steam transportation are considerable. If all the steam pipelines in a typical factory were well insulated, heat loss through them could be reduced by up to 90 percent.<sup>53</sup> As noted earlier, the factories had largely insulated their pipes before our assessment, and so we did not have baseline pre-installation data to estimate the savings after installation: However, our China experience, and the fact that the factories identified this as a need on their own, suggests that insulating pipes is a best practice. The one factory that had not implemented the measure completely had only a short stretch of pipe exposed; materials costs were low, about Tk 60,000 (~ US \$700), and paid back in a little more than 11 months. We also noted that the factories rarely insulate valves and flanges. Although we do not have an estimate of savings from insulating valves and flanges specifically, we believe that practice is another effective means of improving energy efficiency at the factories.

To implement this practice, factories should carry out routine inspection and insulation of all pipes, valves, and flanges in the factory. Breaches in insulation (tears) should also be repaired and replaced. It is important to ensure the use of good quality insulation material. In some cases, factories use regular aluminum foil for insulation, which defeats the purpose of insulation.<sup>54</sup>

## MORE POTENTIALLY LOW-COST MEASURES

In addition to the measures described above, the assessments in Bangladesh uncovered several other attractive opportunities to reduce resource use and save money. We believe these measures are promising, but we either did not have sufficient data to include these practices in the list of best practices, or they did not meet all the criteria for selection as best practices.

**Optimize compressed air system:** The technical team estimated that every factory it visited produces more compressed air than necessary in an attempt to maintain a high pressure, and that significant savings are possible.<sup>55</sup> There might be opportunities to optimize compressed air usage by reducing pressure as much as possible, with energy savings of five to eight percent possible with each one bar of drop in pressure. However, the specific opportunities depend on the specific circumstances at the factory in question.

A factory may have different pressure needs for different machines, and may have either a centralized or non-centralized system. In considering its system, a factory should calibrate pressure output to the needs of the highest pressure and largest share of pressure needed, as well as the distance from the location where the compressed air is generated. When lower-pressure requirements constitute the majority of compressed air needs, it may be better to separate the compressed air network for different pressure needs. In other circumstances, a factory will be better off optimizing to the minimum pressure output. If more than three air compressors are in place, one or more external controllers may be installed to control the compressed air delivery. Controllers cost about Tk 118,500 (~ US \$1,400).

**Reuse condensate:** Large savings are possible when condensate is reused, because textile mills rely on a large amount of saturated steam in the dyeing process. Some steam converts into condensed water (condensate) high in temperature and purity. This water can be collected in several places in the mill, including in the drying cylinders, where fabric is dried by heat from steam, and in steam traps.<sup>56</sup> The most efficient use of condensate is to return it to the boiler and convert it back into new steam. Two of the four mills recognized the value of the measure and were already implementing the practice. At the other two mills investigated by RSI, condensate was not being reused to the full extent possible. Between five percent and 15 percent of condensate was being wasted and not reused. This is additional water that would need to be pumped, and an additional burden on the effluent treatment plant. Therefore, there are also significant energy savings from this measure. For companies whose boiler is located too far from the process, the condensate can also be reused as water supply for washing or de-sizing, thereby recovering both water and heat.

This practice requires installation of pipes and lines to capture and return condensate. Costs for a condensate reuse system may vary considerably, depending on factory layout and existing infrastructure,<sup>57</sup> ranging from approximately Tk 49,900 to Tk 1,862,000 (US \$600 to \$22,700).<sup>58</sup> Care should be taken to ensure that the pipes are corrosion-resistant, in order to avoid contamination of the water. In the two Bangladeshi factories where this practice was evaluated, payback periods varied significantly, in part because of the large difference in potential savings. One of the factories was estimated to have a payback period of a little less than six months, while the other factory would take nearly two years to recoup costs.

The variability in costs led us not to include this measure in the list of best practices for Bangladesh. That said, we continue to believe that this could be a very effective measure for some factories.

**Improve boiler blow-down practices:** When steam is generated, dissolved solids and particles in the water are left behind and eventually build up to levels that make boiler operation increasingly inefficient. Boiler blow-downs (water bleed-off) shut

the boiler down and remove water from the boiler to remove the accumulated particles. If more blow downs than required are carried out, it means that extra water is consumed and heat is lost. If fewer blow downs than necessary are carried out, this can result in the formation of scale in the boiler, higher energy consumption and reduction in the working life of the boiler. This happens because boiler water contains impurities that increase in concentration over time, eventually forming a sludge that impairs boiler efficiency.

Facility managers should optimize blow-down frequencies by relying on measurements of total dissolved solids (TDS) in the boiler. This can be carried out via an automatic boiler blow-down system, which has an investment cost of Tk 100,000 (~ US \$1,200). One of the visited factories uses an automatic device that facilitates automatic boiler blow down when TDS reaches above a certain level (values can be set between 2,700 to 3,500 mg/l). Alternately, factories could invest Tk 5,000 (~ US \$61) in a TDS meter to periodically check TDS build-up and conduct boiler blow downs based on TDS levels.<sup>58</sup> Though this measure is promising, we did not have sufficient factory-specific data to include it in the list of best practices.<sup>59</sup>

**Recover heat from hot-process discharged water:** The standard batch dyeing process involves 15 cycles in the batch dyeing machine, three of which involve raising the temperature to 95°C and then discharging the hot water after cooling to 80°C. The heat of this water is currently being wasted at all of the factories visited. The factories can recover energy from the high temperature process discharge water for heating wash water: the heat of the discharged water can be reused to pre-heat water for the subsequent dye baths which require water at around 60°C.<sup>60</sup>

For this measure, factories will need to add a jacketed line and other piping modifications. We had limited data to assess this practice, but rough calculations by the consulting team place the cost between Tk 2,000,000 to 2,500,000 (~ US \$24,400 to US \$30,500) depending on mill size and layout, with payback periods ranging between three and a half and 13 months.

**Reduce wasteful lighting:** Many of the factories visited were not maximizing their use of natural light. Factories could replace opaque roofs with transparent panels. In addition, switching lights off when they are not in use and replacing old, inefficient bulbs with new energy-saving models can substantially reduce electricity costs. Factory floors could be equipped with light sensors to automatically switch lights on and off in response to light conditions. Light sensors cost approximately Tk 6,000 (~ US \$73). Measuring brightness in different areas of the mill and removing unnecessary light tubes is also helpful. Estimated savings from using light sensors and replacing opaque roofs with transparent ones at three of the factories ranged from Tk four to eight/ton (~ US \$0.05 to \$0.10 per ton) of fabric produced. Estimated upfront costs at the three factories where this measure is applicable were very low, ranging between Tk 25,000-60,000 (~ US \$300 to \$700), but payback period is slightly long at 21 to 23 months. One factory has already implemented this measure.

*Note: a switch to energy efficient bulbs also requires an effective recycling program to ensure proper disposal of bulbs, which contain minor amounts of mercury. Apparel buyers may be able to play a role in facilitating such a program.*

**Improve efficiency and consistency in bulk chemical preparation:** At many of the factories visited, workers carried bags of chemicals to the dyeing area and manually transferred chemicals to solution tanks, leading to waste of chemicals. Based on observations, we assumed a conservative estimate of 0.2 percent loss of chemicals (sodium sulfate, caustic soda, and soda ash) to spills. Bulk chemicals are best prepared in a solution that is pumped to dyeing machines as needed. Only required amounts of chemicals or prepared solutions should be taken to the production areas, with minimal surplus. Chemical waste was noted at each of the factories visited, and each has the potential to save money and reduce pollution with no upfront investment. Rough estimates suggest that savings are likely to be in the range of Tk 71,500 to 134,000 (~ US \$900 to \$1,600) per year or Tk 19 to Tk 49 (~ US \$0.23 to \$0.60) per ton of fabric produced. Payback is expected to be immediate. This practice did not make the list of best practices only because the small dataset of observed spills is difficult to extrapolate broadly.

*Note: We learned during our visits that some factories are using a magnetic technology for controlling scale in boilers, and thus reducing chemical use. The effectiveness of this technology is disputed. We recommend that factories carefully evaluate this technology before use.*



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## RECOMMENDATIONS FOR MILLS READY TO DO MORE

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In addition to the best practices and other low-cost measures identified above, the audits in Bangladesh also revealed some opportunities with great potential to both reduce resource use and save money in the long term that require a significant upfront investment or especially careful consideration of specific factory conditions before implementation. These practices may be especially suitable for new factories being established and for factories that are expanding or replacing equipment, and are thus especially relevant to Bangladesh's expanding textile sector. The measures may require further study and trial at the individual factories before they can be implemented.

We also note that in addition to the measures outlined here, a number of others are commonly described in the efficiency literature. For more on these measures, such as combination of preparatory treatments, cold-pad-batch pretreatment, and counter-current washing, see the Lawrence Berkeley National Laboratory report, *Energy-Efficiency Improvement Opportunities for the Textile Industry*, available at <http://china.lbl.gov/Textile.Section>.<sup>61</sup>

**Improve liquor ratio:** The liquor ratio refers to the weight of fabric processed to the weight of dye solution. The lower the ratio, the less water is used to produce the colored fabric. Lower liquor ratios also result in lower chemical usage and less effluent treatment needs. The average factory visited was using dyeing machines that have a liquor ratio of one to eight. Some newer factories in Bangladesh are already using dyeing machines with liquor ratios of one to six. This drop in ratio can result in savings of up to 25 percent of water and chemicals. Dyeing machines with even lower liquor ratios are available. Achieving best results may require close consultation with the dyeing machine vendor. Costs range between approximately Tk 16 million to 41 million (US \$200,000 to \$500,000).<sup>62</sup>

**Minimize washing and rinsing operations:** The technical team's research suggests that factories maybe able to save water and money by exploring reduction of the number of overflow rinses and the amount of water used per overflow rinse. The number of overflow rinses could potentially be reduced from four to six rinses to three to four rinses, depending on color. Amount of water used per rinse could potentially be reduced from the observed average of 21 l/kg to 10 l/kg, based on the experience of one factory visited.<sup>63</sup> Implementation will require trial and error and close collaboration with equipment vendors to ensure that quality does not suffer, and that maximum effectiveness is achieved. Two factories are already implementing this measure.

**Use co-generation plants:** Many mills in Bangladesh use natural gas generators to meet their power requirements, as well as steam boilers fueled by natural gas. The fuel is used at two sources—one for electricity generation (power plant) and other for steam generation (boiler). These are two different setups.<sup>64</sup> During energy production thermal energy is converted to electrical energy, resulting in a electricity generation efficiency factor (power plant) of 35 percent and a combined efficiency factor (power plant and boiler) of only 58 percent.

Factories could potentially reduce energy use by about 30 percent by using a co-generation plant for combined production of steam and power. The system generates high-pressure steam and uses the steam in a turbine for power generation. Once pressure dissipates, the low-pressure steam could be further utilized for steam application to fabric. Co-generation plants have a combined efficiency factor of 85 percent.<sup>65</sup>

Investment is expected to be in the range of Tk 50,000,000 to 60,000,000 (~ US \$609,800 to \$731,700) with a payback period starting at around two years.<sup>66</sup>

**Recover heat from power generation vent:** During power generation, gases are released into the atmosphere at a temperature of 400° to 500°C. Only 35 percent of the natural gas is utilized for power generation; the rest is given off as heat. This heat could be captured and reused for producing steam. Currently, steam generation costs are in the vicinity of Tk 500/ton (~ US \$6.09/ton).

A detailed design would require consideration of various factors, such as flue-gas velocity, stack diameter and height, distance from the steam boiler, as well as steam-boiler capacity and flue-gas.

Factories in Bangladesh that have installed waste heat or exhaust gas recovery boilers produce 2,000 kg/h of steam per megawatt power generation capacity. The cost of a six ton/hr waste heat recovery boiler is estimated at Tk 25,000,000 (~ US \$304,600), but can be recovered in approximately 13 months for a factory with a power generation capacity of three megawatts and steam costs of Tk 500/ton (~ US \$6.09/ton).<sup>67</sup> One factory has already implemented this measure.

## MORE OPPORTUNITIES FOR SAVING MONEY AND REDUCING POLLUTION

**Process improvements:** Several other process improvements, summarized below, hold great promise for benefitting the environment and saving money. Many of these measures must be tailored to the circumstances at each factory. Bangladeshi factories should evaluate the relevance of these measures to their operations.

**TABLE 6:<sup>68</sup> PROCESS IMPROVEMENTS CHECKLIST**

PROCESS IMPROVEMENTS
Undertake a failure analysis when things go wrong
Standardize optimal methods and recipes
Substitute enzymes technology in beaching pretreatment
Investigate opportunities to reduce salt in individual reactive dyeing recipes
Increase reliance on higher fixation dyes
Improve machine utilization
Schedule coloring to minimize extensive cleaning between each batch
Monitor continuously to check whether implementation of improvement is in place

**Good housekeeping:** Many textile mills can take significant steps toward reducing waste and cost by implementing small changes in behavior, regardless of whether they also implement the RSI best practice list. As discussed earlier, good housekeeping practices, such as switching off lights when not in use, can have a significant impact on resource use at factories. The box below lists these and several additional good housekeeping measures.

**TABLE 7:<sup>69</sup> GOOD HOUSEKEEPING CHECKLIST**

GOOD HOUSEKEEPING
Clearly mark stored goods
Demarcate special storage areas and raise floor
Use first-in, first-out system for chemical inventory
Routinely clean the workspace
Install shut-off valves to reduce running water
Use dedicated dye scoops
Calibrate equipment
Optimize boiler blow down schedule
Switch off lights when not in use, replace with energy efficient bulbs

These good housekeeping initiatives require little or no investment beyond improved management and attention to detail, but do not qualify as best practices because their savings are difficult to quantify or because they promise only modest environmental benefits. However, the recommendations are easy to understand and implement and should prove to be an appealing starting point for some mills. Adopting these quick and easy opportunities will help mills develop a clean production mentality that can translate into the managerial commitment needed to support more substantial improvements. And, they can have a big impact in some cases: as much as five to ten percent resource savings in some experts' experience.<sup>70</sup>

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## APPENDIX A

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**Description of Mills.** Four Bangladeshi textile mills of various sizes participated in the RSI. NRDC's consultants visited more than 25 factories and identified a shortlist of factories that had significant opportunities for improvement. NRDC then approached these factories about participating in a more detailed assessment, to flesh out opportunities and to provide data for this report. All these factories are engaged in cotton knit dyeing. RSI focused only on opportunities for improvement in dyeing and finishing yarn and fabric because that is where the largest opportunities for improvements can be found. Generally, resources required for knitting or garment manufacturing were subtracted out of the total resource use of integrated mills, in order to fairly compare usage per unit of product for dyeing and finishing. However, steam use and loss, water leaks, condensate loss, as well as compressed air loss were assessed across all processes.<sup>71</sup>

All four fabric mills produce their own energy and steam onsite in natural gas generators and boilers. All the mills also pump groundwater for the factory's use and treat their own effluent.

**Delta Composite Knitting Industries Ltd.** is a medium integrated textile mill with 5,000 employees engaged in knitting, dyeing, and garment manufacturing, primarily in garment manufacturing. The mill produced 6,340 tons of cotton knits in 2009. The factory is ISO 9001-2008, Oeko-Tex 100 and WRAP certified.

**Libas Textiles Ltd.** is a small, integrated textile mill that produced 2,640 tons of cotton knits in 2009 and 3,745 tons in 2011.

**Niagara Textile Ltd.** is a medium integrated textile mill with 3,600 employees, primarily engaged in garment manufacturing. The mill produced 2,900 tons of cotton knits in 2009. The factory is Oeko-Tex and WRAP certified. Niagara is part of the Bangladesh Knitwear Industrial and Business Welfare Foundation (IBWF).

**Sinha Textile Group** is a large group of five mills, two of which produce cotton knits. These two mills employ 800 people and produced 3,900 tons of cotton knits in 2009. The other Sinha mills produce denim and cotton wovens.

## APPENDIX B

### Best Practice Selection

To choose the best practices among the 30 mills we assessed in the study, we categorized practices based on three factors: cost, payback, and environmental impact. This is a rough categorization to help us identify the most attractive measures for implementation.

#### Cost:

- Low < Tk 1.2 million (~ US \$15,000)
- Medium Tk 1.2 million to 3 million (~ US \$15,000 to \$37,000)
- High > Tk 3 million (~ US \$37,000)

#### Payback:

We have expanded the categories to be broader than those used in China because both water and electricity are self-generated at lower cost and also because data has consequently been more uncertain.

- Immediate < one month
- Quick one to eight months
- Medium eight to 15 months
- Long > 15 months

#### Environmental impact:

*Water (tons water/ton of fabric)*

We have placed a higher value on water savings in Bangladesh in light of the dire water situation in Bangladesh and the special focus on water measures there.

- High > five tons
- Medium one to five tons
- Low < one ton

*Energy/Chemicals (percent savings in resources)*

Savings estimates for the various energy and chemical measures were in several different units and were, in many cases, based on resource-or cost-savings estimates for the specific measure. We have therefore relied on the estimated percentage of resource or cost savings as a proxy to determine the significance of the environmental impact.

- High > two percent of total natural gas, electricity, or steam use *or*  
> 20 percent of costs/materials consumed for specific activity
- Medium one to two percent of total natural gas, electricity, or steam use *or*  
10 to 20 percent of costs/materials consumed for specific activity
- Low < one percent of total natural gas, electricity, or steam use *or*  
< 10 percent of costs/materials consumed for specific activity

These criteria were applied to 30 potential efficiency measures and clean production practices, identified in table B.

TABLE B: Summary of best practices candidate applicability<sup>72</sup> (✓=Applicable, i.e. not in use at factory)

**TABLE B: SUMMARY OF BEST PRACTICES CANDIDATE APPLICABILITY**  
(✓=APPLICABLE, I.E. NOT IN USE AT FACTORY)

FACTORIES		DELTA	LIBAS	NIAGARA	SINHA
<b>WATER</b>					
1	Eliminate water leaks in taps and pipes	✓	✓		
2	Reuse water drained out of steam condensates	✓	✓		
3	Minimize washing and rinsing operations	✓	✓		
4	Reuse of first wash water from solution preparation tanks	✓	✓	✓	✓
5	Restrain use of open hose pipe	✓	✓	✓	✓
6	Reuse cooling water	✓	✓	✓	✓
7	Sort and reuse process water	✓	✓	✓	✓
8	Increase fabric to water ratio to 1:6	✓	✓	✓	✓
<b>ENERGY</b>					
9	Steam management	✓	✓	✓	✓
10	Insulate pipe line, valves and flanges*			✓	
11	Optimize operation of air compressors	✓	✓	✓	✓
12	Use transparent roofs and light sensors	✓	✓		✓
13	Use of good squeezing operation to reduce energy at drying stage	✓	✓	✓	✓
14	Recovery of heat from drying operations	✓	✓	✓	✓
15	Better control of drying operation	✓			
16	Automatic boiler blow down mechanism	✓	✓	✓	✓
17	Reuse of hot water for baths	✓	✓	✓	✓
18	Recovery of heat from gas generation vent	✓	✓	✓	
19	Use co-generation plants	✓	✓	✓	✓
<b>PRODUCTS AND CHEMICALS</b>					
20	Reduce spillage of chemicals	✓	✓	✓	✓
21	Optimize correct temperature and volume to reduce salt, auxiliary and dye consumption.				
22	Collection of surplus printing paste and using the same as black paint	N/A	N/A	N/A	N/A
23	Use of magnetic device to soften water in boiler inlet	✓	✓	✓	✓
24	Recycling of caustic in mercerizing operation	N/A	N/A	N/A	✓
25	Recovery of sodium sulfate	✓	✓	✓	✓
<b>TRANSVERSAL ISSUES</b>					
26	Improved process control stages to avoid reprocessing				
27	Improve practices with trials in laboratory	✓	✓	✓	✓
28	Sufficient number of solution preparation vessels	✓			
29	Use dry cleanup methods	✓	✓	✓	✓
30	Explore recovery of size in cotton processing	N/A	N/A	N/A	N/A

\* None of the visited factories are routinely insulating valves and flanges.

## APPENDIX C

### Range of reported production, resource use/ton of fabric produced, and resource costs.

Annual production:	2,760-4,074 tons/year (dyeing and finishing)
Water use:	181-301 tons/ton of fabric produced
Steam use:	7.63-18.5 tons/ton of fabric produced
Energy use:	822-2,520 kWh/ton of fabric produced
Natural Gas use:	1,449-3,182 m <sup>3</sup> /ton of fabric produced
Compressed Air use:	1,282-3,007 m <sup>3</sup> /ton of fabric produced
Sodium Sulfate use:	4000-7000 kg/day
Caustic Soda use:	300-450 kg/day
Soda Ash use:	1400-2604 kg/day

Water unit cost:	Tk 1.75-4.10/ton
Effluent treatment unit cost:	Tk 5.60-22/ton
Steam cost:	Tk 375.42-613/ton
Self-generated electricity cost:	Tk 1.97-4/kWh
Steam drying cost:	Tk 1.75-11/kg fabric
Natural gas cost:	Tk 5.25-5.84/m <sup>3</sup>
Stenter drying cost:	Tk 3.7-7/kg fabric
Sodium sulfate cost:	Tk 12-17/kg
Caustic soda cost:	Tk 42-52/kg
Soda ash cost:	Tk 24-35/kg
Water softening cost:	Tk 1-3/m <sup>3</sup>

## APPENDIX D<sup>73</sup>

Metering water, steam and electricity consumption in total and at the process and equipment levels is recommended by NRDC as fundamental to benchmarking performance and to initiating efficiency improvements. An effective energy management system should at least have metering coverage at the total factory level and at each workshop level. NRDC considers this level of metering the basic target for all mills and the necessary level for meaningful benchmarking and goal setting. Comprehensive metering coverage capable of detecting abnormal performance or accurately assessing gains from improvement measures needs coverage at the major equipment level. A comprehensive metering program should consider both metering coverage in the factory and how different meter types enable data collection and accuracy, preferably changing existing basic mechanical meters that require manual readings to addressable smart meters, which can communicate to an electronic network and can be logged and analyzed with measuring software. This approach allows the plant to identify and respond to leaks and to detect unusual spikes in resource use—it also provides feedback on the effectiveness of measures taken to improve processes. In this way, meters and measurement software reinforce the benefits of efficiency measures and encourage continuous improvement through energy management. Importantly, measurement software allows process efficiency information to be sent to other locations electronically, thus enabling benchmarking of performance and identification of best-in-practice plants in an objective and straightforward manner.

### Electricity Metering

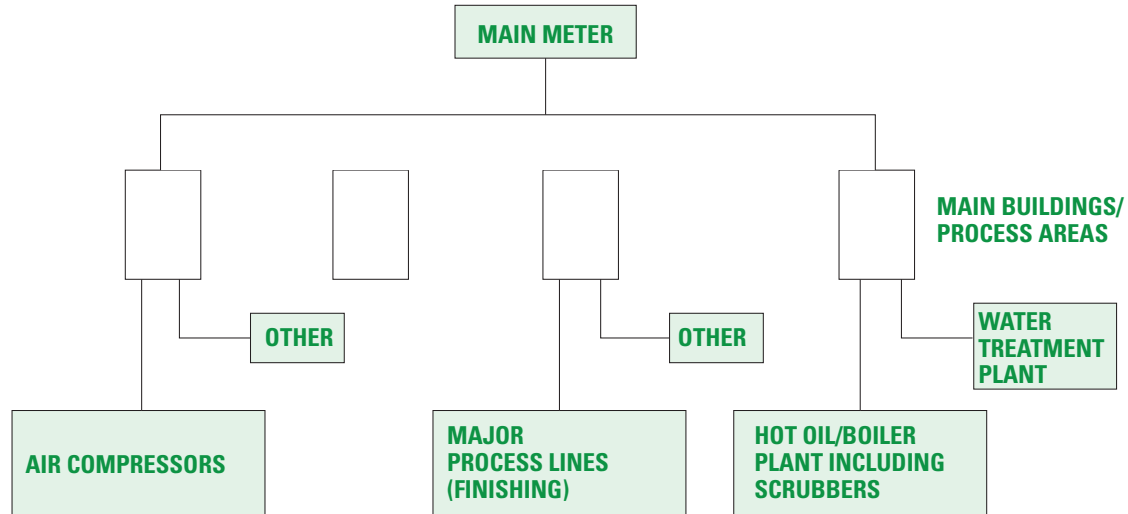
Individual major circuits to workshops should be upgraded to smart power analyzer type sub-meters, and smart metering at other major electricity consuming equipment should be progressively implemented. Periodic manual readings can be used in the interim to increase the extent of breakdown information available at moderate cost. In the first instance, the following format is suggested for individual metering:-

- Individual production departments / process line sections
- Air compressors
- Lighting and small power (feasible by subtraction)
- Dyeing tanks (pumps)
- Dryer fans
- Waste water treatment plant
- Fresh water treatment plant

*Note:* The exact configuration should follow the site's power architecture. "Other" loads could be obtained by subtraction of "sub-distribution load" meter values from respective "main load" meter values. Ideally, electronic power analyzers should be used and networked to allow centralized data recording analysis.



A typical architecture is shown below:



Typical electricity sub-metering format

### Steam Metering

The complexity and consequent cost of the steam metering installation should reflect scale. Where steam is not used in direct process injection, condensate is systematically collected in condensate recovery vessels related to each major dyeing or finishing process, and where flash steam is properly collected and energy recovered, condensate metering can be used as a low cost method of tracking steam usage in individual process lines. High accuracy integrating meters (calculating energy usage from steam flow and pressure /temperature) are only really cost-justifiable for main building supplies.

Ideally the following architecture should apply to thermal metering:

- Main site supply - high accuracy integrating meter
- Major buildings / plant - high accuracy or basic steam flow
- Process lines and major machines - basic steam flow or condensate meters

*Note:* The final selection of steam meters is subject to assessment of the range of flow rates in use as accuracy is limited to a particular flow rate range – typically a turndown ratio of up to 30:1 is possible.

### Water Metering

On-site fresh water production and usage is complex. Basic mechanical water meters should at least be upgraded to pulse type meters to allow remote data capture and more real-time analysis. Preferably major meters should be electromagnetic flow meters or other non-mechanical meters with significantly greater accuracy and capability to automatically track usage.

A recommended architecture is suggested as follows:

- Total fresh water delivered to sites (with breakdown between city mains, boreholes, rivers, extraction, and recycled treatment plant water)
- Fresh water to each main building / major process
- Fresh /recycled water to each total loss or evaporative cooling system
- Effluent flow off-site or flows into waste treatment plant

### **Gas Metering**

Recommended provision of addressable sub-meters for gas normally includes:

- Canteen kitchen
- Each major process use
  - Singeing
  - Setting/heat treatment/drying
  - Future co-generation from IC engines/micro gas turbine installations

## Endnotes

- 1 All tons listed in the report are metric tons.
- 2 Personal communication with Naureen Chowdhury, International Finance Corporation (IFC), based on factory assessments carried out by IFC.
- 3 Linda Greer, Susan Egan Keane, Zixin Lin, *NRDC's Ten Best Practices for Textile Mills to Save Money and Reduce Pollution*, February 2010.
- 4 Unless otherwise noted, savings and cost figures are based on calculations provided by the technical consultants on this project, the Consortium of Ecopsis+Sofies+HB in their report entitled *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011). Descriptions of measures also rely on the *Task B Report*. The Ecopsis Consortium calculations were updated with the latest information on 2009 production, resource use, and unit costs provided by factories. The "percent resource savings," "savings (Tk/ton fabric)," and "cost (Tk/ton fabric)" calculations were then carried out by NRDC from the Ecopsis-based calculations. Since Libas did not have reliable 2009 records, we used 2011 data for Libas.
- 5 Personal communication with Naureen Chowdhury, International Finance Corporation (IFC), based on factory assessments carried out by IFC; Linda Greer, Susan Egan Keane, Zixin Lin, *NRDC's Ten Best Practices for Textile Mills to Save Money and Reduce Pollution*, February 2010, at 3.
- 6 Julian M Allwood, Søren Ellebæk Laursen, Cecilia Malvido de Rodríguez, University of Cambridge Institute for Manufacturing, *Well dressed? The present and future sustainability of clothing and textiles in the United Kingdom*, 2006, at 10, [http://www.ifm.eng.cam.ac.uk/sustainability/projects/mass/uk\\_textiles.pdf](http://www.ifm.eng.cam.ac.uk/sustainability/projects/mass/uk_textiles.pdf) (last visited November 9, 2011); Board of Investment Bangladesh, Prime Minister's Office, *Garments and Textiles*, <http://boi.gov.bd/key-sectors/garments-a-textiles> (last visited November 9, 2011).
- 7 WTO, "Leading Exporters and Importers of Clothing 2010," from *International Trade Statistics 2011, Section 4.6*, [http://www.wto.org/english/res\\_e/statis\\_e/its2011\\_e/its11\\_merch\\_trade\\_product\\_e.htm](http://www.wto.org/english/res_e/statis_e/its2011_e/its11_merch_trade_product_e.htm) (last visited November 9, 2011).
- 8 Board of Investment Bangladesh, Prime Minister's Office, *Garments and Textiles*, <http://boi.gov.bd/key-sectors/garments-a-textiles> (last visited November 9, 2011).
- 9 Linda Greer, Susan Egan Keane, Zixin Lin, *NRDC's Ten Best Practices for Textile Mills to Save Money and Reduce Pollution*, February 2010, at 3.
- 10 Board of Investment Bangladesh, Prime Minister's Office, *Garments and Textiles*, <http://boi.gov.bd/key-sectors/garments-a-textiles> (last visited November 9, 2011); International Finance Corporation, Press Release: *IFC Cleaner-Production Initiative Yields Significant Savings for Bangladeshi Textile Factories*. (October 17, 2011), <http://www.ifc.org/IFCExt/Pressroom/IFCPressRoom.nsf/0/3F39F8701FDB88378525792C004BBC1E> (last visited November 9, 2011).
- 11 Board of Investment Bangladesh, Prime Minister's Office, *Garments and Textiles*, <http://boi.gov.bd/key-sectors/garments-a-textiles> (last visited November 9, 2011).
- 12 McKinsey & Company, *Bangladesh's ready made garments landscape; The challenge of growth*, (November 2011), at 4-10.
- 13 Board of Investment Bangladesh, Prime Minister's Office, *Garments and Textiles*, <http://boi.gov.bd/key-sectors/garments-a-textiles> (last visited November 9, 2011).
- 14 IFM Report at 11.
- 15 Board of Investment Bangladesh, Prime Minister's Office, *Garments and Textiles*, <http://boi.gov.bd/key-sectors/garments-a-textiles> (last visited November 9, 2011).
- 16 World Bank, *Bangladesh Country Environmental Analysis: Bangladesh Development Series Paper No: 12* (September 2006), at 27 and 28.
- 17 Bdnews24.com, "HC rule on poor river upkeep Tue," July 11, 2011, <http://www.bdnews24.com/details.php?cid=2&id=200594>(last visited November 9, 2011).
- 18 World Bank, *Presentation: Water Pollution Management (Greater Dhaka Watershed)* March 2, 2010, at p.4 of handout, as included in *Bangladesh Consultation Country Report: Environment Strategy 2010*, <http://siteresources.worldbank.org/ENVIRONMENT/Resources/244380-1250028593656/6382907-1252510780845/6428643-1256655379723/6510806-1270468173931/20100302-Bangladesh-Country-Consultation-Report.pdf> (starting at p. 62 of PDF document) (last visited November 9, 2011).
- 19 World Bank, *Presentation: Water Pollution Management (Greater Dhaka Watershed)* March 2, 2010, at p.69 of PDF document.
- 20 World Bank, *Bangladesh Country Environmental Analysis: Bangladesh Development Series Paper No: 12* (September 2006), at 29.
- 21 McKinsey & Company, *Bangladesh's ready made garments landscape; The challenge of growth*, (November 2011), at 12-13.
- 22 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at Chapter 1, p.5.
- 23 RESET Energy, NRDC, *Clean by Design Assessment Report of Denim Factory G Redacted Edition*, July 2011 at 13.
- 24 Costs based on estimates provided by Ion Exchange Environment Ltd. for mechanical flow meters and by Cosmos Energy Services Ltd. for electromagnetic flow meters. Companies are located in Dhaka, Bangladesh, estimates were provided in mid-2011.
- 25 To remove artifacts of currency conversion and improve readability, dollar amounts were rounded as follows: values less than a million are rounded to the nearest hundred and greater than a million are rounded to the nearest hundred thousand (i.e. 23,760 = 23,800 and 6,243,123 = 6.2 million)
- 26 RESET Energy, NRDC, *Clean by Design Assessment Report of Denim Factory G Redacted Edition*, July 2011, at 54.
- 27 Based on reports for factories evaluated in China.
- 28 Personal communication with Naureen Chowdhury, International Finance Corporation.
- 29 Based on reports for factories evaluated in China.
- 30 RESET Energy, NRDC, *Clean by Design Assessment Report of Denim Factory G Redacted Edition*, July 2011, at 53.
- 31 Linda Greer, Susan Egan Keane, Zixin Lin, *NRDC's Ten Best Practices for Textile Mills to Save Money and Reduce Pollution*, February 2010, at 4.
- 32 Ibid.
- 33 Personal communication with Derko Kopitopoulos, Ecopsis (October 28, 2011).
- 34 S. Barclay and C. Buckley, "Waste Minimization Guide for the Textile Industry – A Step Towards Cleaner Production, Volume III." In: UNEP/IEO ICPIIC *International Cleaner Production Information Clearing House*, 1993.
- 35 Linda Greer, Susan Egan Keane, Zixin Lin, *NRDC's Ten Best Practices for Textile Mills to Save Money and Reduce Pollution*, February 2010, at 6.
- 36 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), , at p. 4, chapters 2, 3, 4, and 5.

- 38 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at p. 5, chapters 2, 3, 4, and 5.
- 39 Estimates of savings rely on 21.6 to 23.5 liters of water use per ton of fabric produced per 10-minute rinse based on observation of water levels maintained in dyeing machines during rinsing and an assumption that the water used reflects twice the maintained level (based on conversation with Tareq Amin, HB, who prepared the estimate). We believe this is a reasonable assumption and it is consistent with estimates prepared by one factory that participated in the Initiative. Our savings estimates are based on this estimated water use. However, the level of water use reflected in this practice alone seems inconsistent with the total reported level of water use of factories, which one would expect to be higher based on this usage. This inconsistency highlights the importance of metering of natural resource use.
- 40 Linda Greer, Susan Egan Keane, Zixin Lin, *NRDC's Ten Best Practices for Textile Mills to Save Money and Reduce Pollution*, February 2010, at 7.
- 41 Conversations with factory personnel. Also see AFP. *Bangladesh Signs Deal for First Nuclear Power Plant*. Nov. 2, 2011, <http://news.yahoo.com/bangladesh-signs-deal-first-nuclear-plant-175455575.html> (last visited Nov. 9, 2011).
- 42 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at p. 6, chapters 2, 3, 4, and 5.
- 43 Linda Greer, Susan Egan Keane, Zixin Lin, *NRDC's Ten Best Practices for Textile Mills to Save Money and Reduce Pollution*, February 2010, at 8.
- 44 Ibid.
- 45 Ibid.
- 46 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at p. 8, chapters 2, 3, 4, and 5.
- 47 Personal communication with Cyrus Lam, RESET Energy.
- 48 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at p. 8, chapters 2, 3, 4, and 5.
- 49 *Reset Denim Factory G Report*.
- 50 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at p. 8, chapters 2, 3, 4, and 5.
- 51 Personal communication with Cyrus Lam, RESET Energy.
- 52 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at p. 8, chapters 2, 3, 4, and 5.
- 53 Linda Greer, Susan Egan Keane, Zixin Lin, *NRDC's Ten Best Practices for Textile Mills to Save Money and Reduce Pollution*, February 2010, at 9.
- 54 Personal communication with Naureen Chowdhury, International Finance Corporation (IFC).
- 55 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at p. 7 of Chapters 2, 3, 4, and 5.
- 56 Linda Greer, Susan Egan Keane, Zixin Lin, *NRDC's Ten Best Practices for Textile Mills to Save Money and Reduce Pollution*, February 2010, at 7.
- 57 Ibid.
- 58 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at chapter 6.
- 59 Consortium of Ecopsis+Sofies+HB, *Task A: Showcase of Three Top-Performing Facilities* (July 29, 2011, as updated October 28, 2011),
- 60 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at p. 10, chapters 2, 3, 4, and 5.
- 61 Ali Hasanbeigi, Ernest Orlando Lawrence Berkeley National Laboratory, *Energy-Efficiency Improvement Opportunities for the Textile Industry* (September 2010).
- 62 Cotton Incorporated. 2009. *A World of Ideas: Technologies for Sustainable Cotton Textile Manufacturing*, at 23-24.
- 63 Personal communication with factory personnel (meeting Nov. 2011).
- 64 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at p. 6, chapter 1.
- 65 *Task B Report*, at p. 6 of chapter 1; Sarkar, Rashid M.A. "Cogeneration and Energy Savings," in *Short Course on Energy Efficiency* (Eds.) Kahn Shahidul I. & Obaidullah M. Dhaka: Centre for Energy Studies, 2008. P 61-96.
- 66 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at p. 6, chapter 1.
- 67 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at chapter 2, p. 10, and Chapter 3, p. 10.
- 68 Linda Greer, Susan Egan Keane, Zixin Lin, *NRDC's Ten Best Practices for Textile Mills to Save Money and Reduce Pollution*, February 2010, at 11.
- 69 Linda Greer, Susan Egan Keane, Zixin Lin, *NRDC's Ten Best Practices for Textile Mills to Save Money and Reduce Pollution*, February 2010.
- 70 Ibid.
- 71 Personal communication with Tareq Amin, HB.
- 72 Consortium of Ecopsis+Sofies+HB, *Task B: Assessment of Five Medium Performing Facilities* (July 29, 2011, as updated October 28, 2011), at p. 1, chapter 1.
- 73 Taken from work of RESET Energy, Hong Kong for NRDC, 2011, 2012.