International Journal of Applied Research 2018; 4(8): 10-17

International Journal of Applied Research

ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 5.2
IJAR 2018; 4(8): 10-17
www.allresearchjournal.com
Received: 04-06-2018
Accepted: 05-07-2018

SM Farhana Iqbal
Assistant Professor, Bangladesh University of Textiles, Tejgaon, Dhaka, Bangladesh

Correspondence
SM Farhana Iqbal
Assistant Professor, Bangladesh University of Textiles, Tejgaon, Dhaka, Bangladesh

Energy-efficiency improvement opportunities in the textile industry

SM Farhana Iqbal

Abstract
The textile industry is one of the most complicated manufacturing industries because it is a fragmented and heterogeneous sector dominated by small and medium enterprises (SMEs). Energy is one of the main cost factors in the textile industry. Especially in times of high energy price volatility, improving energy efficiency should be a primary concern for textile plants. There are various energy-efficiency opportunities that exist in every textile plant, many of which are cost-effective. However, even cost-effective options often are not implemented in textile plants mostly because of limited information on how to implement energy-efficiency measures, especially given the fact that a majority of textile plants are categorized as SMEs and hence they have limited resources to acquire this information. Know-how on energy-efficiency technologies and practices should, therefore, be prepared and disseminated to textile plants.
An analysis of the type and the share of energy used in different textile processes is also included. Subsequently, energy-efficiency improvement opportunities available within some of the major textile sub-sectors are given with a brief explanation of each measure.

Keywords: Energy efficiency, cost-effective, analysis, improvement opportunities

Introduction

This analysis of energy-efficiency improvement opportunities in the textile industry includes both opportunities for retrofit/process optimization as well as the complete replacement of the current machinery with state-of-the-art new technology [1]. However, special attention is paid to retrofit measures since state-of-the-art new technologies have high upfront capital costs, and therefore the energy savings which result from the replacement of current equipment with new equipment alone in many cases may not justify the cost [2]. However, if all the benefits received from the installation of the new technologies, such as water savings, material saving, less waste, less waste water, less redoing, higher product quality, etc. are taken into account, the new technologies are more justifiable economically [3].

Furthermore, i have tried to present measures for which we could find quantitative values for energy savings and cost. However, in some cases i could not find such quantitative values, yet since some measures are already well-known for their energy-saving value, i decided to include them in the article despite lacking quantitative metrics of their potential. I believe that the qualitative information given for such technologies/measures can help the textile plant engineers to identify available opportunities for energy-efficiency improvements. However, it should be noted that the energy saving and cost data provided in this article are either typical saving/cost or plant/case-specific data. The savings from and cost of the measures can vary depending on various factors such as plant and process-specific factors, the type of fiber, yarn, or fabric, the quality of raw materials, the specifications of the final product as well as raw materials (e.g. fineness of fiber or yarn, width or specific weight of fabric g/m^2, etc), the plant‘s geographical location, etc. For instance, for some of the energy-efficiency measures, a significant portion of the cost is the labor cost. Thus, the cost of these measures in the developed and developing may vary significantly [4].

Material & Methods
Energy Management Programs
Strategic energy management programs
Changing how energy is managed by implementing an organization-wide energy management program is one of the most successful and cost-effective ways to bring about energy-efficiency improvements. Ideally, such a program would include facility, operation, environmental, health, safety and personnel management. A sound energy management program is required to create a foundation for positive change and to provide guidance for managing energy throughout an organization. Continuous improvements to energy-efficiency, therefore, only occur when a strong organizational commitment exists. Energy management programs help to ensure that energy-efficiency improvements do not just happen on a one-time basis, but rather are continuously identified and implemented in a process of continuous improvement [5].

In companies without a clear program in place, opportunities for improvement may be known, but may not be promoted or implemented because of organizational barriers, even when energy is a significant cost. These barriers may include a lack of communication among plants, a poor understanding of how to create support for an energy-efficiency project, limited finances, poor accountability for measures, or organizational inertia adverse to changes from the status quo. The major elements in a strategic energy management program are shown in Figure 1. It could be noted that the concept shown in this figure for energy management system builds from the ISO quality management system‘s philosophy of Plan-Do-Check-Act.

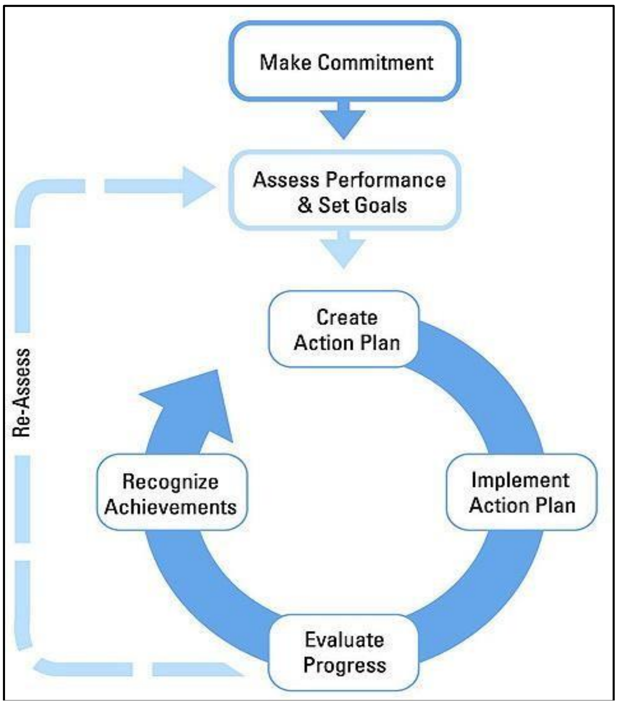

Fig 1: Main Elements of a Strategic Energy Management Program [6].

A successful energy management program begins with a strong organizational commitment to the continuous improvement of energy-efficiency. This involves assigning oversight and management duties to an energy director, establishing an energy policy, and creating a cross-functional energy team. Steps and procedures are then put in place to assess performance through regular reviews of energy data, technical assessments, and benchmarking. From this assessment, an organization is able to develop a baseline of energy use and set goals for improvement. Such performance goals help to shape the development and implementation of an action plan [7].

An important aspect for ensuring the success of the action plan is involving personnel throughout the organization. Personnel at all levels should be aware of energy use and goals for efficiency. Staff should be trained in general approaches to energy efficiency in day-to-day practices. Evaluating performance involves the regular review of both energy use data and the activities carried out as part of the action plan. Information gathered during the formal review process helps in setting new performance goals and action plans and in revealing best practices. Establishing a strong communications program and seeking recognition for accomplishments are critical steps to build support and momentum for future activities [8].

Create an action plan
In practice there are barriers that prevent the successful implementation of energy-efficiency measures recommended in the energy audit report. Therefore, it is necessary to establish a clear procedure, which ensures the successful realization of improvements. The action plan should be described in a simple way with clear aims, savings targets and definitions of roles and responsibilities for its execution [9].

A detailed action plan helps to ensure a systematic process to implement energy-efficiency measures. Unlike the energy policy, the action plan is regularly updated, most often on an annual basis, to reflect recent achievements, changes in performance, and shifting priorities. While the scope and scale of the action plan is often dependent on the organization, the steps below outline a basic starting point for creating a plan:

1. Define technical steps and targets.
2. Determine roles and resources.

Before finalizing the action plan, it is better to consult and brainstorm with division managers and key engineers in the plant to get their input on the action plan [9].

Define technical steps and targets
The results can give an indication of the technical performance of the plant and its gap from efficient performance. Based on this, opportunities for energy-efficiency improvements can be identified and prioritized. Three key steps are:

- Create performance targets for each facility, department, and operation of the organization to track progress towards achieving goals.
- Set timelines for actions, including regular meetings among key personnel to evaluate progress, completion dates, milestones and expected outcomes.
- Establish a monitoring system to track and monitor the progress of actions taken. This system should track and measure energy use and project/program activities [10].

Determine roles and resources
Identify internal roles
The action plan should determine who is involved in the energy-efficiency program and what their responsibilities

are. Depending on the organization and action plan, this might include departments such as:

- Facility and operations management,
- Financial management—capital investments, budget planning,
- Human resources—staffing, training, and performance standards,
- Maintenance,
- Supply management—procurement procedures, energy purchasing and equipment and materials,
- Building and plant design,
- Engineering,
- Communications marketing, and
- Environmental, health, and safety

Identify external roles

The action plan should determine the degree to which consultants, service providers, vendors, and other product providers will be used. Some organizations may choose to outsource entire aspects of their action plan while others may only want to contract with specific vendors for limited projects. If contractors will be used, the action plan should determine what standards will be used to evaluate bids and incorporated these metrics into agreements with contractors.

Determine resources

For each project or program in the action plan, management must estimate the cost for each item in terms of both human resources and capital/expense. Then, management should develop the business case for justifying and gaining funding approval for action plan projects and resources needed.

Implement the action plan

To successfully implement the action plan, it is vital to gain support from personnel within the plant involved in the efficiency improvement programs. To implement the action plan, the following steps should be considered:

- Create a communication plan: develop targeted information for key audiences about your energy-efficiency action plan,
- Raise awareness: build support for all levels of your organization for energy-efficiency initiatives and goals,
- Build capacity: through training, access to information, and transfer of successful practices and procedures you can expand the capacity of your staff,
- Motivate: create incentives that encourage staff to improve energy performance to achieve goals,
- Track and monitor: use a tracking system developed as part of the action plan to track and monitor progress regularly [11-13].

Results and Discussion

Evaluate progress

Plants can evaluate the progress of their activities using energy data and the formal review of activities taken as part of the action plan and compare them to the established goals. This formal review can be used to revise the action plan and see the lessons learned. The regular evaluation of energy performance and the effectiveness of energy-efficiency initiatives also allows energy managers to:

- Measure the effectiveness of projects and programs implemented,
- Make informed decisions about future energy projects,
- Reward individuals and teams for accomplishments,
- Document additional savings opportunities as well as non-quantifiable benefits that can be leveraged for future initiatives.

Energy-efficiency technologies and measures in the spun yarn spinning process

Table 1. Shows the list of measures/technologies included in this article for the spun yarn spinning process.

Table 1: List of Energy-efficiency Measures and Technologies for the Spinning Process *

No.	Energy-efficiency Technologies and Measures	Fuel saving	Electricity saving	Capital Cost (US$)	Payback Period (Year)**
5.1	**Spinning**				
5.1.1	**Preparatory process**				
1	Installation of electronic Roving end-break stop-motion detector instead of pneumatic system		3.2 MWh/year/machine	180/roving machine	< 1
2	High-speed carding machine			100,000/cardiac machine	<2
5.1.2	**Ring Frame**				
3	Use of energy-efficient spindle oil		3% - 7% of ring frame energy use		
4	Optimum oil level in the spindle bolsters				
5	Replacement of lighter spindle in place of conventional spindle in Ring frame		23 MWh/year/ring frame	13,500 /ring frame	8
6	Synthetic sandwich tapes for Ring frames		4.4 - 8 MWh/ring frame/year	540 -683/ring frame	1 - 2
7	Optimization of Ring diameter with respect to yarn count in ring frames		10% of ring frame energy use	1600 /ring frame	2
8	False ceiling in Ring spinning section		8 kWh/ year/spindle	0.7/spindle	1.2
9	Installation of energy-efficient motor in Ring frame		6.3 -18.83 MWh/year/motor	1950 - 2200 /motor	2 - 4

10	Installation of energy-efficient excel fans in place of conventional aluminum fans in the suction of Ring Frame		5.8 - 40 MWh/year/fan	195 - 310 /fan	< 1
11	The use of light weight bobbins in Ring frame		10.8 MWh/year/ring frame	660 /ring frame	< 1
12	High-speed Ring spinning frame		10% - 20% of ring frame energy use		
13	Installation of a soft starter on motor drive of Ring frame		1 – 5.2 MWh/year/ring frame		2
5.1.3	**Windings, Doubling, and finishing process**				
14	Installation of Variable Frequency Drive on Autoconer machine		331.2 MWh/year/plant	19500/plant	< 1
15	Intermittent mode of movement of empty bobbin conveyor in the Autoconer/cone winding machines		49.4 MWh/year/plant	1100/plant	< 1
16	Modified outer pot in Tow-For-One (TFO) machines		4% of TFO energy use		
17	Optimization of balloon setting in Two-For-One (TFO) machines				
18	Replacing the Electrical heating system with steam heating system for the yarn polishing machine	increased 31.7 tonnes steam/ year/machine	19.5 MWh/year/machine	980/ humidification plant	< 1
5.1.4	**Air conditioning and Humidification system**				
19	Replacement of nozzles with energy-efficient mist nozzles in yarn conditioning room		31MWh/year/humidification plant	1700/ humidification plant	< 1
20	Installation of Variable Frequency Drive (VFD) for washer pump motor in Humidification plant		20 MWh/year/humidification plant	1100/ humidification plant	< 1
21	Replacement of the existing Aluminium alloy fan impellers with high efficiency F.R.P (Fiberglass Reinforced Plastic) impellers in humidification fans and cooling tower fans		55.5 MWh/year/fan	650/ fan	< 1
22	Installation of VFD on Humidification system fan motors for the flow control		18 -105 MWh/year/fan	1900 -8660/ fan	1 - 2
23	Installation of VFD on Humidification system pumps		35 MWh/year/ humidification plant	7100/ humidification plant	2.7
24	Energy-efficient control system for humidification system		50 MWh/year/ humidification plant	7300 to 12,200/ humidification plant	2 - 3.5
5.1.5	**General measures for Spinning plants**				
25	Energy conservation measures in Overhead Travelling Cleaner (OHTC)		5.3 - 5.8 MWh/year/ OHTC	180 -980/ OHTC	0.5 - 2.5
26	Energy-efficient blower fans for Overhead Travelling Cleaner (OHTC)		2 MWh/year/fan	100/fan	< 1
27	Improving the Power Factor of the plant (Reduction of reactive power)		24.1 MWh/year/plant	3300/plant	1.8
28	Replacement of Ordinary ‗V – Belts' by Cogged ‗V – Belts'		1.5 MWh/year/belt	12.2/belt	< 1

* The energy savings, costs, and payback periods given in the table are for the specific conditions cited. There are also some ancillary (non-energy) benefits from the implementation of some measures. Read the explanation of each measure in the report text to get a complete understanding of the savings and costs.

**Wherever the payback period was not provided, but the energy and cost were given, the payback period is calculated assuming the price of electricity of US$75/MWh (US$0.075/kWh).

Preparatory process

Installation of electronic roving end break stop-motion detectors instead of pneumatic systems

In a simplex (roving) machine, the roving end-break system can be converted from a pneumatic suction tube detector to a photoelectric stop-motion system end-break detector in order to save energy. This measure is implemented in many textile plants around the world. The average energy saving reported from implementation in two Indian spinning plants is 3.2 MWh/year/machine with an average investment cost of about US$180 per roving machine.

High-speed carding machine

This machine is used in the secondary processing of raw cotton. The machine separates the lumps of small fibers that result from the disentangling of tufts in the ―opening-and-picking‖ stage of primary processing, and simultaneously removes impurities, lint balls, and short fibers, improving the arrangement of good quality fibers in the longitudinal direction, and producing fiber bundles (slivers) in strands.

This new carding machine is large and each machine consumes considerable amounts of electricity. On the other hand, since productivity is high, 1/3 the number of new machines and half the total power can produce the same production capacity as ordinary carding machines. For instance, twelve conventional machines requiring 27kW/machine can be replaced by four of the new machines requiring 41 kW/machine, and thus results in power-savings of 160kW. There are many examples of installation of new carding machines in major plants throughout Japan and this technology is certainly applicable in any developing country. The capital cost of the new carding machine is about US$100,000. The payback period for the investment is about 1.3 years.

Ring frames

Use of energy-efficient spindle oil

The incorporation of a dispersant additive system to the mineral-based spindle oil may result in energy savings of up to 3% when compared to conventional oils. The amount of actual savings will depend upon the condition of the machinery and their operation condition. Energy saving also can be achieved by using light weight spindles. However, synthetic-based spindle oils (energy-efficient grades) along with certain metal compatibility additives may result in higher energy savings, in the range of 5 – 7% depending upon viscosity. The energy-efficiency potential of particular oil can be assessed in two ways:

1. The reduction in electricity consumption, and
2. The reduction in bolster temperature rise over ambient: energy saving oils result in lesser temperature increases.

While selecting any energy saving spindle oil, one should carefully evaluate important characteristics related to the service life of the oil, i.e., temperature rise, thermal stability, metal compatibility, sludge forming tendency and anti-wear/antifriction properties.

Optimum oil level in the spindle bolsters

The electricity consumption in the Ring frame increases with an increase in the oil level in the bolsters because of resistance caused by the oil. Also, an excessively high oil level in the bolster may disturb the proper running of the spindle. Normally, 75% of the bolster capacity is filled with oil. The usual method of determining the depth of oil level in the bolster is by lifting the spindle and observing the oiliness of the spindle blade. This assessment method may not be accurate if one is trying to find out the normal and minimum level of oil required. The correct or exact amount of oil for each type of spindle insert could be assured by using a dipstick. The dipstick has two distinct markings, i.e. the bottom marking for minimum and the top marking for maximum oil levels.

The normal tendency in many plants is to fill up the bolster to a near full level at the time of filling and then topping up as needed – this leads not only to wastage of lubricant but also to higher energy consumption. The oil level should, therefore, be checked with a dipstick after every topping and the level should be maintained within the limits prescribed by the machinery manufacturers. In this regard, various oil dosing equipment are available today for filling and topping spindle bolsters with the predetermined quantity of oil. The novel feature of these equipment is the volume control mechanism, which facilitates dosing out required quantities of spindle oil (5 cc to 20 cc) to suit the capacity of different bolsters used in Ring frames. As there is no excess filling of spindle oil into the bolster, it prevents wastage of oil as well as energy‖.

Replacement of lighter spindles in place of conventional spindles in ring frames

As mentioned above, ring frames are the largest energy consumer in the ring spinning process. Within a ring frame, spindles rotation is the largest energy consumer. Thus, the weight of the spindles is directly related to the energy use of the machine. There are so-called high efficiency spindles on the market which are lighter than the conventional spindles and hence use less energy. A spinning plant in India replaced the conventional spindles with lighter weight ones in their ring frames and on average saved 23 MWh/year/ring frame. The investment cost of this measure was around US$13,500 per ring frame.

Synthetic sandwich tapes for ring frames

Synthetic sandwich spindle tapes are made of polyamide, cotton yarn and a special synthetic rubber mix. Sandwich tapes run stable, have good dimensional stability, don‗t break, result in less weak-twist yarn, do not cause fiber sticking, and are made of soft and flexible tape bodies. Because of these special characteristics, these tapes offer 5 – 10% energy saving. Based on an assessment conducted for a spinning plant, replacing cotton tapes with synthetic sandwich spindle tapes can result in average savings of 8 MWh/ring frame/year (92.5 kWh/ton/year). The capital cost of replacement is US$540 for each ring frame (with a payback period of about 10 months).

In another spinning plant, the installation of energy-efficient tapes in ring frames in average resulted in energy savings of 4.4 MWh/year/ring frame for a capital cost of US$683 per ring frame. The cause of the difference between energy saving of these two case-studies could be the difference between the size of the ring frames in each plant (number of spindles in each ring frame).

Optimization of ring diameter with respect to yarn count in ring frames

Ring diameter significantly influences the energy use of the ring frame. Larger ring diameters facilitate higher bobbin content with a heavier package, resulting in excess energy consumption. A reduction of about 10% in bobbin content lowers ring frame energy intensity by about 10%. For finer yarn counts, 38 millimeter (mm)/ 36mm diameter and for medium yarn counts, 40mm ring diameters are recommended. The cost of implementation is about US$1600 for a long length ring frame of 1008 spindles and the payback period is about 2 years. Before ring diameter modification is undertaken the technical feasibility of the modification should be assesses, which may include the following items:

- The yarn count range for a specific period is unpredictable. The solution to this issue is that, based on the count ranges, the ring frames should be segregated by suitable ring diameter in the way that each group of ring frames produce specific yarn count.
- The life span of existing rings is also unpredictable due to high-speed operation.
- Overall efficiency is reduced in the post spinning phase (e.g. cone winding) due to lower bobbin content. However, the reduction in efficiency in the post spinning phase can be compensated by running the machines at a higher speed.

False ceiling over the ring frames areas

The spinning process needs to be done under a maintained temperature and humidity. This is done in a humidification area within plants. The energy used by the humidification facility is directly related to the volume of the facility where the spinning process is carried out. The use of a false ceiling can help to reduce this volume, thereby reducing energy consumption. In a spinning plant in India, the volume of a spinning hall with 15000 spindles reduced energy use through the installation of a false ceiling under the hall‘s roof. This measure resulted in 125MWh/year electricity savings (8 kWh/spindle/ year). The capital cost for this renovation was about US$11000 (US$0.7/spindle).

Installation of energy-efficient motors in ring frames

As mentioned above, ring frames are the most energy intensive equipment in the spinning process. Hence, it is important to make sure that the electric motors installed in the ring frames have the highest possible efficiency. Even a slight efficiency improvement in ring frame motors could result in significant electricity savings that could pay back the initial investment in a short period. In a spinning plant, motors were replaced with energy-efficient ones in four ring frames. The efficiency of the efficient motors was 94.6%, an improvement over the efficiency of the original motors (92.5%). This resulted in significant energy savings as well as an improvement in the power factor. The average annual energy saving was 6.3 MWh per motor replaced and the investment cost was around US$1950 per motor.

Another Indian plant replaced old and inefficient ring frame motors with energy-efficient ones, resulting in higher average energy savings equal to 18.83 MWh/year/motor with higher investment cost of about US$2200 per motor. The difference between the two case-studies could be due to differences in the number of operation hours per year for each plant and the efficiency of the motors. For instance, we have information about the base case efficiency for the first case- study mentioned above, but we do not have the same information for the second case-study. It could be expected that the difference between the energy use of the base case and high efficiency motors in the second case-study is larger, so the energy savings there was higher.

Installation of energy-efficient excel fans in place of conventional aluminum fans in the suction system of ring frames

Ring frames have suction fans, which are used to collect fibers when a yarn break occurs. Energy-efficient excel fans could be installed in place of conventional aluminum fans in the suction system of ring frames. The average electricity savings from the implementation of this measure is reported to be between 5.8 and 40 MWh/year/fan with a capital cost of about US$195– 310 per fan.

The use of light weight bobbins in ring frames

In ring frames, yarn is collected on bobbins. Bobbins are rotated by spindles upon which they sit. The rotating of spindles is the highest energy consumption activity in ring machines. The heavier the bobbins are, the more energy is required for the rotation of bobbins and hence spindles. Nowadays, the use of lighter bobbins in place of conventional ones is getting more attention. In a spinning plant in India, the replacement of 30 – 35 gram bobbins (cops) with 28 gram bobbins resulted in average electricity savings of 10.8 MWh/year/ring frame (assuming 12 doff[8] a day). The capital cost for this retrofit measure was US$660 per ring frame.

High-speed ring spinning machine

This machine has an increased operating speed by 10 – 20% with similar power consumption as compared to conventional equipment. As a result, the power requirement is 36.0 – 40.5kW in comparison with that of 45kW for conventional ring spinning machines for the same production capacity. Furthermore, this equipment adopts an energy saving spindle that uses a small diameter warp, which contributes a power savings of approximately 6%.

Installation of a soft-starter on ring frame motor drives

The starting current drawn by an induction motor is directly proportional to the applied voltage. A soft-starter is designed to make it possible to choose the lowest voltage possible (the ―pedestal voltage‖) at which the motor can be started – the lowest voltage being dependent on the load on the motor. The voltage is ramped up from this pedestal level to full voltage within a preset time. Pedestal voltage and ramp-up time can be set at the site. It is also possible to provide controlled- torque soft-starts with current limit options. The soft-starter is also suited to situations where a smooth start is desirable to avoid shocks to the drive system or where a gradual start is required to avoid damage to the product/process/drive system and accessories.

In spinning plants, a soft-starter can reduce the costs incurred by yarn breaks on a ring frame when its motor starts after each doff, as smooth starts and gradual acceleration of motors eliminate shocks during starting. Average electricity savings reported from the implementation of this measure on ring frames is about 1 – 5.2 MWh/year per ring frame. The payback period of this measure is about 2 years. In addition to the electricity savings, the other advantages of this measure are a reduction in the maximum power demand and an improvement in the power factor.

Windings, doubling, and yarn finishing process

Installation of variable frequency drives on Autoconer machines

Autoconer is the name of the machine which usually is used subsequent to ring frames in the yarn spinning process. The small bobbins of yarn are rewound onto larger cones by this machine. The installation of variable frequency drives (VFD) on an Autoconer‘s main motor can help maintain a constant vacuum and save energy. The adoption of this measure in a spinning plant resulted in electricity savings of 331.2 MWh/year (however, the number of Autoconers in which this measure was applied is not given). The investment cost associated with this measure was about US$19,500.

Intermittent modes of the movement of empty bobbin conveyors in Autoconer/cone winding machines

The continuous movement of empty bobbin conveyor belts can be converted into an intermittent mode of movement. This measure results in not only substantial energy saving but also results in maintenance cost savings and waste reduction. In a spinning plant, they converted the continuous conveyor system to an intermittent mode whereby the belts are running for 6 minutes only and stopping for 54 minutes in an hour. This resulted in electricity savings of 49.4 MWh/year (the number of Autoconers to which this measure was applied is not reported). The investment cost associated with this measure was about US$1100.

Using a modified outer pot for two-for-one (TFO) machines

The process of twisting and doubling is an indispensable means of improving certain yarn properties and satisfying textile requirements that cannot be fulfilled by single yarns. The method of twisting two or more single yarns is called doubling, folding or ply twisting. Such yarns are designated as doubled yarn, folded yarn or plied yarn and the machines which conduct this work are called doublers, ply-twisters or two-for-one (TFO) twisters. Traditionally, ring doublers were used for ply twisting spun yarns and up twisters were used for twisting filament yarns. Nowadays, TFO twisters are gaining world-wide acceptance in both the spun yarn and filament yarn sectors mainly because of their inherent advantages like the production of long lengths of knot-free yarns, which facilitates better performance in the subsequent processes and results in higher productivity.

In two-for-one twisting machines, the balloon tension of yarn accounts for about 50% of total energy consumption. The balloon diameter can be reduced with a reduction in yarn tension by providing a modified outer pot. This measure saves about 4% of total energy consumption in TFOs. Research shows that there is no deterioration in yarn quality.

Optimization of balloon settings in TFO machines

It has been observed above that that TFOs consume less electricity at lower balloon settings. Balloon size can be optimized by taking account of various studies with respect to different yarn counts. In a study a textile plant saved about 250MWh/year by optimizing the balloon setting of its TFO machines without any investment required (the number of TFO machine in which this measure was applied is not reported).

Replacing electrical heating systems with steam heating systems for yarn polishing machines

After applying a liquid polishing material on yarns, the yarn becomes wet and needs drying. In some plants yarn polishing machines use electrical heaters. These electrical heaters can be replaced by steam heaters which can reduce overall energy use. A textile plant implemented this measure for two polishing machines. Steam consumption increased by about 31.7 tonnes steam/year for each machine, while electricity use declined in average by about 19.5 MWh/year/machine. The investment cost for this retrofit measure is reported to be about US$980 for each machine (with a payback period of about half a year).

Air conditioning and humidification system

Replacement of nozzles with energy-efficient mist nozzles in yarn conditioning rooms

In some textile plants the yarn cones are put in a yarn conditioning room in which yarn is kept under a maintained temperature and humidity. In such rooms, usually water is sprayed in to the air to provide the required moisture for the yarn to improve its strength, the softness and quality of the yarn and to increase its weigh. The type of nozzles used for spraying the water can effectively influence the electricity use of the yarn conditioning system. In a case-study in a plant, the jet nozzles were replaced with energy-efficient mist nozzles in a yarn conditioning room, resulting in 31MWh/year electricity savings. The cost of this replacement was about US$1700.

Installation of variable frequency drives (VFD) for washer pump motors in humidification plants

In humidification plants, an inverter can be installed on washer pump motors with auto speed regulation, which can be adjusted to meet the required humidity levels**.** Usually the pumps runs at 100% speed and humidity is controlled by by-passes, resulting in wasted energy**.** With VFDs, pump motor speed can be adjusted according to the requirements of the humidification plant. This could result in electricity saving a high as 20 MWh/year with an investment cost of about US$1100. The standard relative humidity (RH) in the different process steps of spinning and weaving plants are presented in table 2.

Table 2: Standard Relative Humidity (RH) in Different Process Steps

Process step	Cotton (%)	Worsted (%)	Synthetic Fibers (%)
Blending and Scutching	45 - 60	-	-
Carding	45 – 55	65 – 70	55 – 65
Combing	55 – 65	60 – 70	55 – 65
Drawing	50 - 60	50 – 60	55 – 65
Pre-spinning (Roving)	50 - 60	50 – 60	55 – 65
Spinning	50 – 65 [a]	50 – 55	60 – 65
Winding	60 - 70	50 – 60	60 - 70
Twisting	60 - 70	50 – 60	

Wrapping	60 - 70	50 – 60	
Weaving	70 - 85	50 – 60	

Temperature: 24 – 29 degree Celsius

Conclusions

Energy is one of the main cost factors in the textile industry. Especially in times of high energy price volatility, improving energy efficiency should be one of the main concerns of textile plants. There are various energy-efficiency opportunities in textile plants, many of which are cost- effective. However, even cost-effective options often are not implemented in textile plants due mainly to limited information on how to implement energy-efficiency measures, especially given the fact that the majority of textile plants are categorized as SMEs. These plants in particular have limited resources to acquire this information. This article provides information on energy-efficiency technologies and measures applicable to the textile industry. For some measures the guide provides a range of savings and payback periods found under varying conditions. At all times, the reader must bear in mind that the values presented in this article are offered as guidelines. Actual cost and energy savings for the measures will vary, depending on plant configuration and size, plant location, plant operating characteristics, production and product characteristics, the local supply of raw materials and energy, and several other factors. For instance, for some of the energy-efficiency measures, the significant portion of the cost is the labor cost. Thus, the cost of these measures in the developed and developing may vary significantly. Therefore, for all energy-efficiency measures presented here, individual plants should pursue further research on the economics of the measures, as well as on the applicability of different measures to their own unique production practices, in order to assess the feasibility of measure implementation.

References

1. Abdel-Dayem AM, Mohamad MA. Potential of solar energy utilization in the textile industry-a case study‖. Renewable Energy. 2001; 23:685-694.
2. Alesson T. All Steam Traps Are Not Equal. Hydrocarbon Processing, 1995, 74.
3. ASEAN Center for Energy. LP Microwave Drying Machine for Cheese Dyeing. Technical Directory for Industry, 1997. Available at: http://www.aseanenergy.org/download/projects/promeec/td/industry/LP%20Microwave%20drying%20machine%20for%20cheese%20dyeing%20%5Btex%5D.pdf
4. Austrian Energy Agency. Step by step guidance for the implementation of energy management. Benchmarking and Energy Management Schemes in SMEs Project of Intelligent Energy – Europe, 2007. Available at: http://www.iee-library.eu/index.php?option=com_jombib&task=showbib&id=1013&return=index.php%3Foption%3Dcom_jombib%26amp%3BItemid%3D30%26amp%3Bcatid%3D48
5. Barclay S, Buckley C. Waste Minimization Guide for the Textile Industry, 2000. Available at: http://www.c2p2online.com/documents/Wasteminimization-textiles.pdf
6. Barnish TJ, Muller MR, Kasten DJ, Motor Maintenance: A Survey of Techniques and Results‖. Proceedings of the 1997 ACEEE Summer Study on Energy efficiency in Industry. American Council for an Energy-Efficient Economy, Washington, D.C, 1997.
7. Bureau of Energy Efficiency (BEE). Best Practice manual: Dryers, 2000. Available at: http://www.energymanagertraining.com/CodesandManualsCD- 5Dec%2006/Best%20practice%20manual%20-%20dryers.pdf
8. Bureau of Energy Efficiency (BEE). A case Study by Kesoram Rayon: Dryers, 2003. Available at: http://www.bee-india.nic.in/index.php?module=intro&id=10
9. Best Practice Programme. Good Practice Case Study 300: Energy Savings by Reducing the Size of a Pump Impeller, 1996. Available at http://www.carbontrust.co.uk/default.htm
10. Bloss D, Bockwinkel R, Rivers N. Capturing Energy Savings with Steam Traps.‖ Proc. ACEEE Summer Study on Energy efficiency in Industry, Aceee, Washington DC, USA, 1997.
11. Brückner. Eco-Heat heat recovery systems, 2010. Available at: http://www.brueckner-textile.cn/index.php?id=515&L=3
12. Caffal C. Energy Management in Industry. Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET), Sittard, the Netherlands, 1995.
13. Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET), Saving energy with Steam Production and Distribution. Centre for the Analysis and Dissemination of Demonstrated Energy Technologies. Maxi Brochure 13, Sittard, The Netherlands, 2001. Available at: www.caddet.org.