NCPC

INDUSTRIAL EFFICIENCY IN SOUTH AFRICA

IEE GUIDELINE FOR THE CLOTHING AND TEXTILE INDUSTRY IN SOUTH AFRICA

the dtic

Department:
Trade, Industry and Competition
REPUBLIC OF SOUTH AFRICA

CSIR
Touching lives through innovation

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

EnMS	Energy Management Systems
ESO	Energy Systems Optimisation
GEF	Global Environment Facility
HEM	High-Efficiency Motor
HVAC	Heating, Ventilation, Air Conditioning
IEE	Industrial Energy Efficiency
LED	Light-Emitting Diode
LPG	Liquefied Petroleum Gas
MtCO2e	Metric Tons of Carbon Dioxide Equivalent
NCPC-SA	National Cleaner Production Centre South Africa
R-CTFL	Retail, Clothing, Textiles, Footwear and Leather
RECP	Resource-Efficiency and Cleaner Production
SME	Small and Medium Enterprise
SMME	Small, Medium and Micro Enterprise
UNIDO	United Nations Industrial Development Organization
VFD	Variable-Frequency Drive
VSD	Variable Speed Drive

1. INTRODUCTION

The National Cleaner Production Centre South Africa (NCPC-SA) is the country's leading resource-efficiency programme funded by the South African Government through the Department of Trade, Industry and Competition (**the dtic**). In 2016, the NCPC-SA embarked on Phase II of its flagship Industrial Energy Efficiency Project (IEE Project), in collaboration with international stakeholders like the Global Environment Facility (GEF), the United Nations Industrial Development Organization (UNIDO) and the Government of Italy. One of the key components of the Phase II project is the strengthening of policy implementation and support frameworks for energy management systems (EnMS), energy systems optimisation (ESO) and the ISO 50001 Energy Management Standard in South Africa.

UNIDO has committed itself to promote the achievement of the Sustainable Development Goals as espoused by the United Nations in its drive to reduce the effects of climate change. The main objective of the UNIDO IEE Programme in South Africa is to effect sustained energy management and efficiency practices in industry of developing countries and emerging economies to reduce the environmental pressure of economic growth while increasing productivity, helping to generate economic growth, create jobs and alleviate poverty.

The South African IEE Phase II Project has worked with multiple government departments and agencies to assist in implementation and coordination of policy and regulatory mechanisms. The expected outcome of this project is enhanced promotion of investment in IEE through the provision of industrial support in the clothing and textile sub-sector. This is envisaged to be achieved by providing technical assistance and capacity building to enhance existing, and inform future, regulatory frameworks that will support EnMS and ESO uptake and strengthen the coordination of associated activities across industry in South Africa.

Energy efficiency has become an important aspect of modern manufacturing. This is especially true in South Africa. The shift from being one of the lowest-cost producers of electricity in the world with a large operating power supply reserve, to being one where price increases are consistently above inflation coupled with a shortage of power supply, has been rapid and severe. This has had a major impact on the growth and stability of the national economy, including the manufacturing sector.

In a country with abundant natural resources, manufacturing is seen as an important enabler and economic growth mechanism. The clothing and textile industry in South Africa plays a significant role in the economy, so much so that government (**the dtic**, 2020) has engaged textile industry stakeholders and together have developed a master plan to promote and ensure the future sustainability of the sector.

"The South African retail, clothing, textiles, footwear and leather (R-CTFL) value chain generates an estimated R74 billion in gross value added, or 1.7% of gross domestic product."[1]

The master plan includes the objective to "enhance the value chain's cost, process and product competitiveness"[2]. Implicit in this objective is the need for energy efficiency.

[1] Quoted from: South African R-CTFL Value Chain master Plan to 2030. Available at http://www.thedtic.gov.za/wp-content/uploads/Masterplan-CTFL_Value_Chain.pdf (Accessed 26 March 2022)

[2] Ibid.

1.1 Objectives

The objective of this document is to provide a guideline for the optimisation of manufacturing in the clothing and textile sector, with a specific focus towards energy efficiency from both a local and international perspective. The emphasis therefore will be on energy-efficient practices and technologies that would reduce overall energy consumption as well as a reduction in carbon emissions. The main deliverables of the document include:

- Identifying sustainability hotspots in the clothing and textile industry in South Africa.
- Reviewing international practices and identifying best available technologies and performance benchmarks, where accessible.
- Identifying, and where possible quantifying, the opportunities for energy performance improvement in the clothing and textile manufacturing process based on experiences within the South African industry.
- Providing guidance to government and other interested stakeholders.

1.2 Methodology

Where possible, this guide has been developed from actual field experiences to accurately reflect the current state of awareness and implementation of energy efficiency within the local clothing and textile industry. The main elements included:

Literature review

The review was conducted mainly on available online literature. This included web-based publications related to the industry, as well as using popular search engines and a number of documents and websites that were identified. An online search of available books was also conducted through various libraries and publishing houses.

The review is narrative and qualitative, rather than systematic and quantitative. The focus of the review is to assess the potential value of an energy-efficiency guideline written specifically for the clothing and textile industry.

Analysis of international best practices

An analysis of international best practices and energy-related performance improvement in the manufacturing industry was completed using mainly literature reviews as well as international energy-efficiency experiences of the author. Selected countries have been included in this study. Best practices and where possible, benchmarks have been included.

Review of actual data from IEE cases

The guide has been developed largely based on field experiences of actual case data collated by the IEE Project. Thus, it is based on actual achievements and improvement opportunities. In some cases, the improvements have been specifically quantified based on the actual improvement opportunity, while in others the improvements have been inferred from overall reduction in energy consumption.

Qualitative data collection through interviews

A series of one-on-one discussions, interviews, and surveys was also conducted with selected manufacturers from within the clothing and textile industry. Companies from the footwear and leather sector were also included.

Site visits were arranged and conducted to discuss challenges and successes within the industry on a one-on-one basis. Discussions also included the prevalent themes of the Covid-19 pandemic as well as the current electrical energy supply shortage in South Africa.

2. LITERATURE REVIEW

There appears to be a large volume of literature available for industry and manufacturing, as well as for energy transitioning from traditional carbon-based sources to renewable energy sources. Very few of these publications are specifically related to energy efficiency in the textile industry.

Similarly, there are a large number of books related to energy efficiency in industry, none specifically targeting the textile industry. Some of these will include chapters related to manufacturing or the textile industry. There are also publications from government and other support agencies that include energy efficiency in textiles in their list of publications.

The main output of this study is to develop a guideline promoting energy efficiency within the textile industry in South Africa. Its relevance within the context of sustainability and economic growth will be discussed as part of this review.

Part 2 of this document presents the Energy Efficiency Guide for the clothing and textile industry.

2.1 The South African Context

The current landscape in South Africa can be summarised using a Pestel analysis. This type of analysis aims to highlight challenges to businesses from a number of perspectives: political, economic, social, technological, environmental, and legal.

Political:

- South Africa is seen as a new democracy but is currently challenged by perceived mismanagement and corruption from within government and government agencies.
- With the advent of democracy, many trade barriers were removed allowing cheaper imports and putting downward pressure on local manufacturing.
- The current war in Ukraine has resulted in fuel prices, as well as fertiliser prices, increasing drastically. This may impact the cultivation of natural fibres and increase prices of textile production[3].

Economic:

- The economy is largely resource based with gold, diamonds, platinum, cars, metals and minerals the major exports.
- Imported goods from China remain a challenge for the local industry as companies compete on a global scale with price as the main factor.
- The biggest challenge to the economy is the current energy supply constraints.
- As a solution, South Africa has embarked on an ambitious renewable energy strategy, but the effects of this must still be realised.
- During the Covid-19 pandemic lockdowns, the economy came to a near standstill.

Social:

- The country has very high levels of unemployment, reaching close to 35%.
- The health system is ailing.
- Characterised by a very unequal and divided social structure, despite almost 30 years as a democracy. In 2022, South Africa was declared the most unequal country in the world.[4] The education of workers is poor, resulting in an inadequate skills base unable to shift to higher value-added production.

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[3] https://www.news24.com/news24/southafrica/news/3-ways-russias-invasion-of-ukraine-affects-sas-economy-20220316#:~:text=Fin24%20unpacks%20how%20the%20war,and%20it%20will%20hurt%20SA)

[4] The World Bank, 2022, available at: https://documents1.worldbank.org/curated/en/099125303072236903/pdf/P1649270c02a1f06b0a3ae02e57eadd7a82.pdf (Accessed 2 March 2023)

- As a result of the Covid-19 pandemic and the resulting lockdowns, South Africans are more inclined to buy local products to support these businesses[5].

Technological:

- The country is highly advanced in technology with many business platforms including financial institutions operating in the digital space.
- Online shopping has become common practice, even more so due to Covid-19.
- Despite this, investment in new technologies in the textile sector has been slow. The industry is not dynamic enough to compete on a global level[6].

Environmental:

- The country is a popular tourist destination and has placed an emphasis on preserving its natural heritage.
- From a business perspective, the major challenge here is compliance to environmental regulations.
- Another major challenge is the water scarcity in the country.
- Significant impacts from textile production and garment assembly include the water intensity, chemical use, wastewater discharges and the lack of treatment processes, and the high energy use and carbon intensity of electricity.

Legal:

- The country has a well-defined legal system.
- From a business perspective foreign direct investment is encouraged.
- Labour laws have become onerous as government attempts to combat the effects of high unemployment.
- Illegally imported and under-invoiced goods compete unfairly with local products and present a significant challenge.

Currently, the South African textile industry faces the following threats:

- Low growth;
- Energy supply constraints;
- Cheap imports, illegal imports;
- Covid-19 after-effects on industry;
- High unemployment and low education levels; and
- The war in Ukraine may impact the prices of the textile industry.

Despite the challenges, the country is upbeat about the prospects of growth and a number of initiatives have been started by government in conjunction with stakeholders. One of these is in the textile sector, where government, suppliers and manufacturers as well as retailers have been engaged in constant liaison to promote the sector.

Today, South Africa is characterised as an energy-intensive country focused on the extraction and export of raw minerals, with the majority of the country's electricity being generated from coal. The existing energy mix is presented in Figure 2-1.

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5 Available at: https://fashionunited.com/news/business/top-trends-shaping-the-apparel-industry-in-south-africa/2021091742184)

6 (https://www.tips.org.za/research-archive/trade-and-industry/item/4307-regional-wool-value-chain)

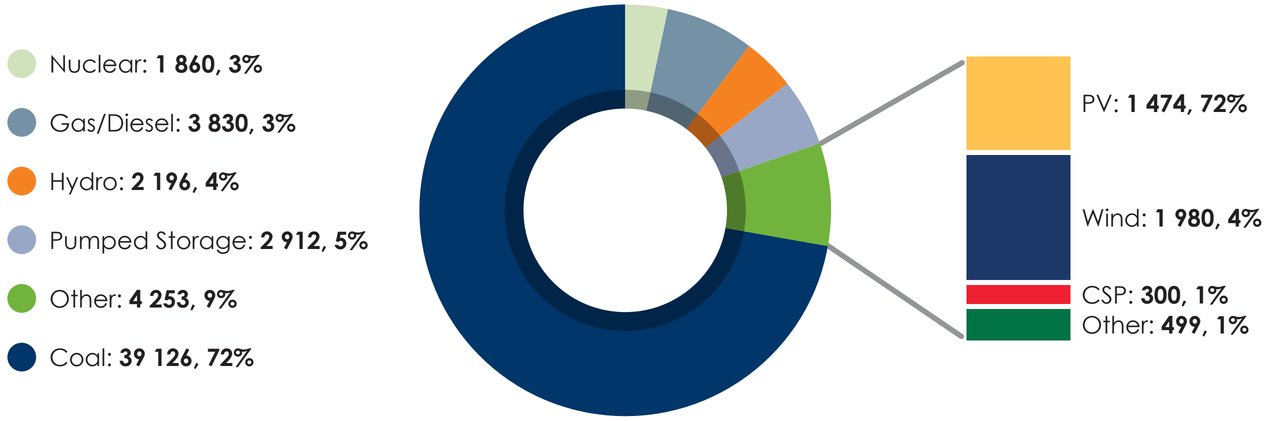

Figure 2-1: Energy Mix South Africa 2018[7]

Electricity is supplied by Eskom, which currently enjoys a natural monopoly on supply. Government has initiated plans to deregulate the industry, the first step being the privatisation of generation. Other measures include the reduction of carbon-based energy sources and the increase in renewable sources. This will be achieved through its Renewable Energy Independent Power Producer Procurement Programme which is already in its fifth cycle. Furthermore, government is also encouraging embedded (self) generation where up to 100MW of self-generation can be installed per enterprise in South Africa.

The heavy bias towards coal (72%) in 2018, has a significant contribution to climate change. The Global Carbon Atlas (2020) estimates that South Africa produced 452 $MtCO_{2e}$, ranking it 13th in the world[8]. The government has responded by promulgating the National Climate Change Response White Paper that outlines the national policy as a comprehensive plan to address both mitigation and adaptation in the short, medium and long term (up to 2050). Included in the umbra of this policy, is the UNIDO-endorsed IEE Project, which is co-ordinated through the NCPC-SA.

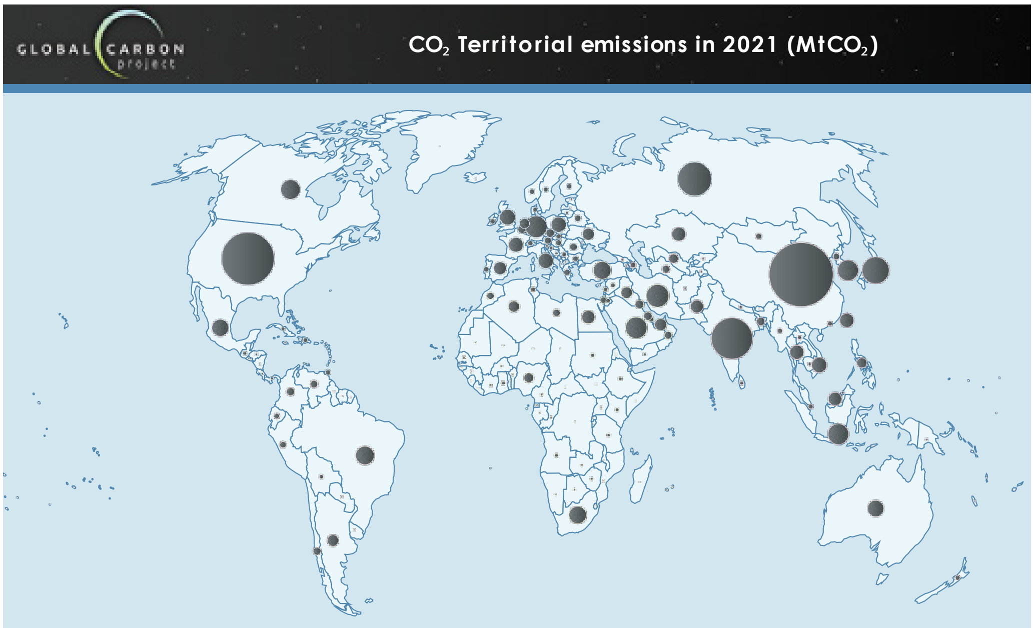

Figure 2-2: Carbon Emissions Worldwide 2021

[7] Data taken from: Department of Energy. Integrated Resource Plan 2019. Available at: http://www.energy.gov.za/files/irp_frame.html (Accessed 22 March 2022)

[8] Data taken from: Global Carbon Atlas Available at: http://globalcarbonatlas.org/en/CO2-emissions (Accessed on 22 March 2022)

According to D Eckstein (2021), the global climate risk index for South Africa has been described as moderate in comparison to other countries. The index attempts to quantify and rank the effect that climate change will have on sovereign nations. From a South African perspective, this would manifest as extreme weather events like storms, floods, and heatwaves. The impacts of climate change in South Africa have already been experienced in terms of affected rainfall trends (flooding and droughts) as well as changes in ambient temperatures. This will have a major impact on the textile industry where primary raw materials are locally grown.

2.2 South African Textile Context

The textile industry in South Africa is considered strategiy. According the **the dtic** (2020), the industry contributes 2.5% of South Africa's manufacturing output. However, the industry is labour intensive, and thus contributes significantly more to the labour market. The sector includes clothing, textiles, footwear and leather. Textiles also include some industrial textiles.

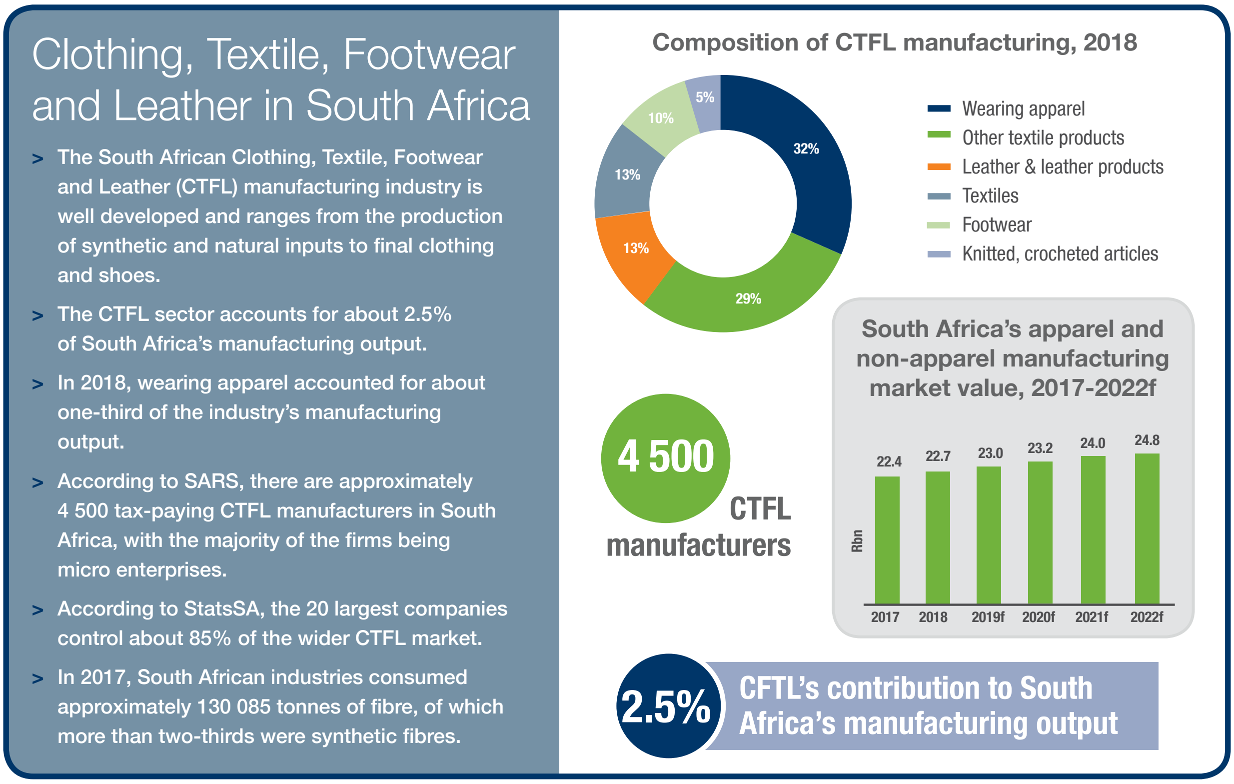

Figure 2-3: Size of Textile Industry in South Africa[9]

The textile industry has been an area of focus since the advent of the new democratic government of South Africa in 1994. According to Vlok (2006), the industry enjoyed a short period of growth following the government change in 1994. As trade barriers and sanctions were lifted, free trade became more prevalent. Local manufacturers experienced a period of increasing exports. At the same time, imports also started increasing as other international manufacturers extended their markets into a now open South Africa. For a period the market appeared stable.

[9] **the dti**. South Africa Factsheet 2020, Investing in South Africa's Clothing, Textile, Footwear and Leather Sectorwww.investsa.gov.za (Accessed 22 March 2022)

From 2002 onwards, Vlok (2006) maintains that the South African currency (Rand) started appreciating causing much of the export market to disappear. In conjunction with this was an associated decline in employment in the sector where "official statistics show a 37% reduction in employment since 1996"[10]. This includes the period up to 2006.

During this time, electricity in South Africa was relatively cheap with an oversupply in the market. Energy efficiency was thus not considered to have a key impact on the sustainability of the industry, the focus being more on unemployment and overall economic growth.

A study was done where technical skill shortages within the textile industry were identified (Morris, 2008). Sector stakeholders established training programmes via the clothingAsector education and training authority, to combat unemployment. At tht time of this study, energy efficiency had not yet been brought into the spotlight in South Africa.

In 2008, South Africa experienced energy supply shortages for the first time. The relatively unknown concept of energy efficiency was now promoted across all facets of the economy as a way to alleviate the supply constraints.

In the last decade, there has been some steady revival of the industry through active participation of government. Rebates have been offered to retailers purchasing locally manufactured or assembled goods. These local suppliers would then enjoy certain rebates when importing yarn or fabric from abroad. This move has been viewed as an improvement by some companies interviewed, as it has allowed them to retain market share, albeit mainly in the assembly of finished goods. For companies intending to grow through vertical integration, this has been limiting because of the price advantage of importing fabric rather than local manufacture from yarns.

The coronavirus pandemic and global economic lockdowns have had an immediate effect on textile production, sales, and trade. There has been a significant expansion in ecommerce and online shopping as a result of the lockdown. Clothing is a major and rapidly-growing product category for ecommerce, but textiles are a rather niche online segment.

Currently, the South African textile industry may be characterised by:
- Low growth;
- Energy supply constraints;
- Cheap imports;
- Covid-19 after-effects on industry; and
- High unemployment.

Factors that support the government's drive towards making the textile sector sustainable and competitive include:
- Local manufacturers and SMMEs can be brought online relatively quickly;
- The sector is labour intensive, and could significantly reduce unemployment; and
- Government hae the ability to intervene through regulation via tariffs and subsidies, as well as through more effective policing of illegal imports.

To this end, the government has outlined its broader plan to develop the sector's sustainability in its CTFL Master Plan (**the dtic**, 2020) through seven strategic commitments[11]:
1. Grow the local market;
2. Increase local procurement;
3. Stem the flow of illegal imports;
4. Strategic use of tariffs and rebates;

[10] Vlok E. Textile and Clothing Industry in Sub-Saharan Africa. 2006. Available at: https://library.fes.de/pdf-files/iez/03796/16suedafrika.pdf (Accessed 20 March 2022)
[11] **the dtic**. (2020). South African R-CTFL Value Chain Master Plan to 2030. Retrieved from www.thedtic.gov.za

5. Extend capital support programmes;
6. Align production capacity to sales; an*
7. Value chain transformation

Energy efficiency would be included in commitments 6 and 7.

2.3 Energy Efficiency in the South African Textile Industry

In 2008, South Africa started experiencing energy supply shortages. Rolling scheduled blackouts were experienced across the country where sections of the electrical network were switched off at specified intervals to curtail demand. The level and duration of the outages were determined by the gap between energy supply and demand.

For the first time, industry focus shifted to energy security. Demand-side management of energy usage became prevalent through awareness campaigns and training interventions.

With energy efficiency still in its infancy, the NCPC-SA embarked on the IEE Projec in 2010, fully sponsored by international funders and endorsed by(UNID). In terms of this programme (NCPC-SA, 2021), a total of 8 200 industrial professionals were trained in some form of demand-side energy management. A total of 1 747 GWh of energy was saved and 2.6 million tonnes of CO_{2e} mitigated.

The savings included interventions within the textile industry. A separate breakdown of the energy savings achieved in the textile industry in South Africa does not appear to be available in the public domain. Further research into this area will be undertaken during the development of the guideline.

Figure 2-4 presents a simplified value chain of the entire retail textile process. energy savings can be achieved across the entire value chain from growing of natural products and import transportation of raw materials all the way to consumption and usage of clothing, and the final disposal thereof. This would include strategies for energy-efficient agriculture and transportation, washing practices during usage, and the ability to recycle or repurpose products after usage. Hence, the scope of energy efficiency can be applied across the entire value chain.

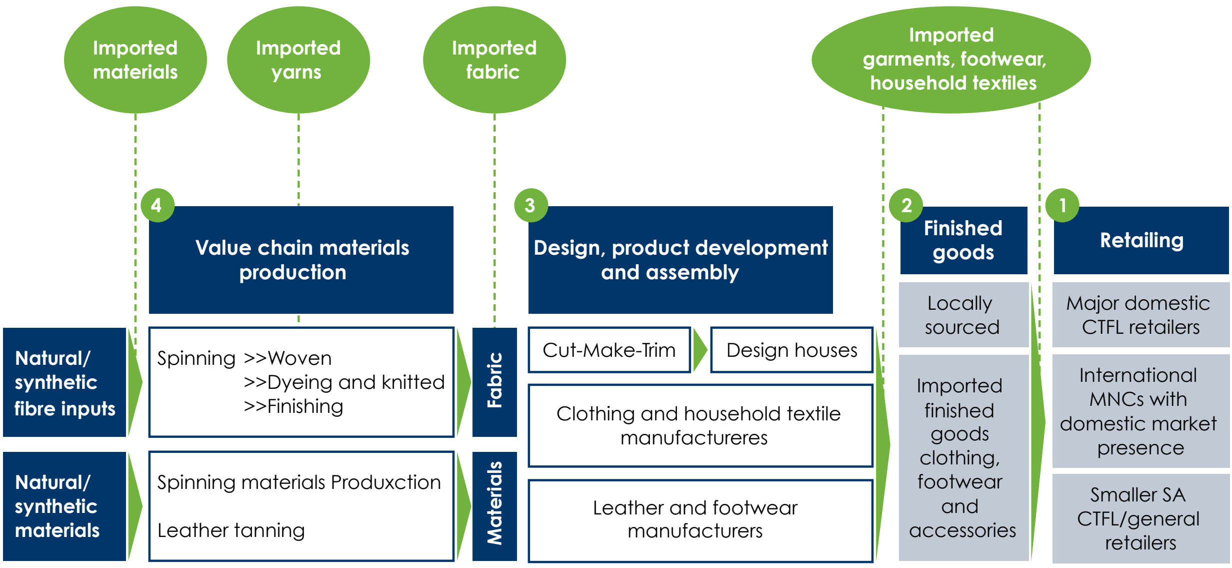

Figure 2-4: Simplified Retail CTFL Value Chain[12]

[12] **the dtic**. (2020). South African R-CTFL Value Chain Master Plan to 2030. Retrieved from www.thedtic.gov.za

This document will, however, focus on the industrial efficiency of the manufacturing processes only. A process overview of the most common industrial processes is shown in Figure 2-5: Typical Textile Manufacturing Processes as summarised by (NCPC-SA 1, 2015). Process heating and electrical energy are the most common inputs into the manufacturing processes for textiles. Process heating is usually required in the washing, dyeing, stenting and drying processes. Electrical energy is required in spinning, weaving, and almost all other processes.

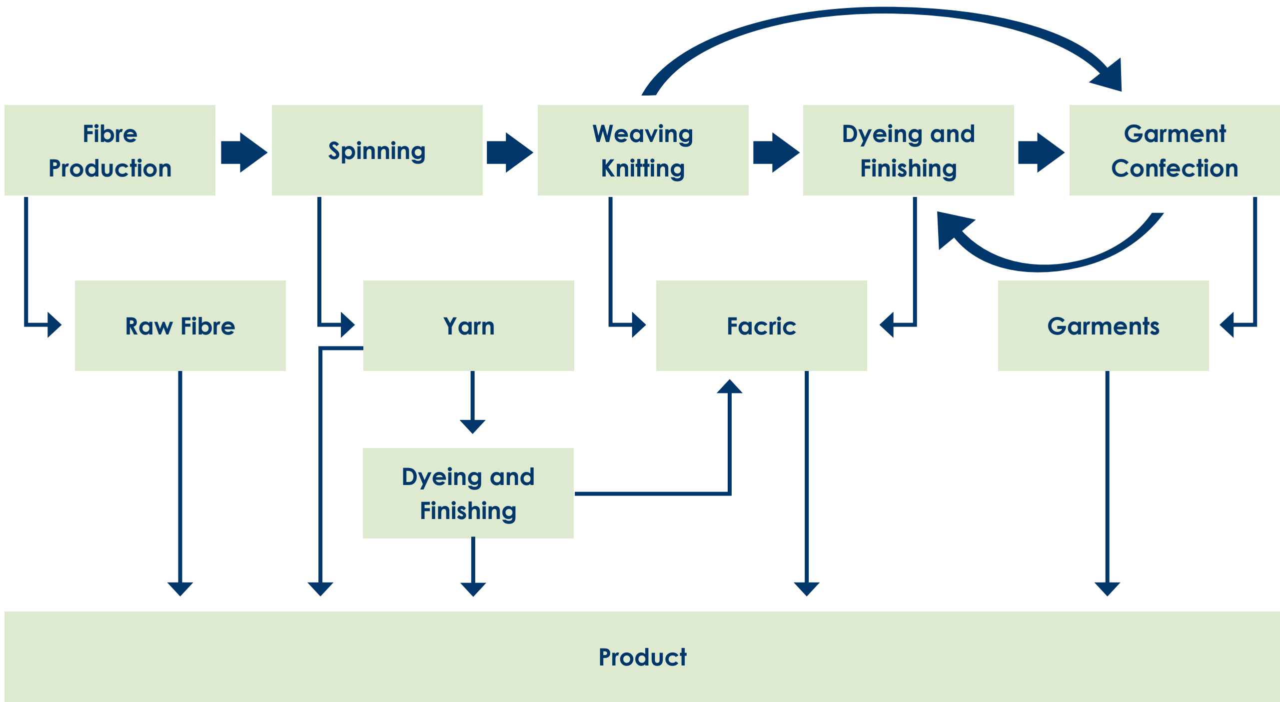

Figure 2-5: Typical Textile Manufacturing Processes[13]

From a South African perspective, the resource-efficiency and cleaner production (RECP) guideline for the textile industry (NCPC-SA 1, 2015) has proposed indicative cost-benefit analysis of some of the energy optimisation opportunities. These are summarised in the following tablw:

[13] NCPC-SA. RECP Guideline for the Textile Industry. (2015). Available from: https://www.industrialefficiency.co.za/guides-and-reports/ (Accessed 22 March 2022)

Table 2-1: Indicative Cost Benefit of Energy-Saving Interventions

RECP Indicative Cost Benefit of Energy-Saving Interventions (SA)[14]			
Energy Source	**Process**	**Activity**	**Indicative benefit**
Thermal	Steam generation	Combustion monitoring	3–5%
Thermal	Steam transfer	Insulation of piping networks	5–10%
Thermal	Steam generation	Boiler blowdown management	2%
Thermal	Steam generation	Condensate recovery	2–14%
Electrical	Compressed air	Compressor control	5–10%
Electrical	Compressed air	Leak repair	5–10%
Electrical	Compressed air	System pressure reduction	1%
Electrical	Compressed air	Intake air cooling	1%
Electrical	Fans and ventilation	Speed control	10–20%
Electrical	Pumps	Speed control	10–20%

Actual achievement of savings specific to the South African textile industry is not readily available in aggregated form in the public domain. A number of individual case studies have been published and provide some reference.

In 2019, Narrowtex, a textile manufacturer in Estcourt, KwaZulu-Natal, embarked on a campaign to reduce energy consumption. Implementing eight low-cost energy improvement projects, the company was able to save approximately 160,000 kWh per year. Projects included "the reduction of standing losses on machinery through improved insulation, installing geyser timers as well as motion sensors in locker rooms and an LED lighting retrofit programme"[15].

Belgotex, an industrial textile manufacturer in Pinetown, KwaZulu-Natal, achieved a saving of 2% of total energy consumption through the implementation of two no-cost behavioural opportunities[16].

2.4 International Textile Context

From an international perspective, there are many documents available discussing textile value chain efficiency. Many of them discuss it from a carbon mitigation or an energy transition point of view.

In his energy efficiency guideline for the textile industry, Hasanbeigi (2010) provides a breakdown of typical electricity and steam usage in textile plants. His guide provides a total of 190 different opportunities for energy performance improvement. Further breakdown of energy consumption per process is also considered, each with a discussion of savings opportunities.

[14] Adapted from NCPC-SA. RECP Guideline for the Textile Industry. (2015). Available from: https://www.industrialefficiency.co.za/guides-and-reports/ (Accessed 22 March 2022)
[15] Stander M. Article published in Mail & Guardian 2021. Available from: https://mg.co.za/special-reports/2021-12-08-when-we-know-better-we-do-better-narrowtexs-sustainability-journey/
[16] NCPC-SA. Case Study IEEP 2018. Available at: https://www.industrialefficiency.co.za/case-studies/case-studies-iee/

The breakdowns for electrical and thermal energy consumption in typical textile wet processes are shown in Figure 2-6 and Figure 2-7.

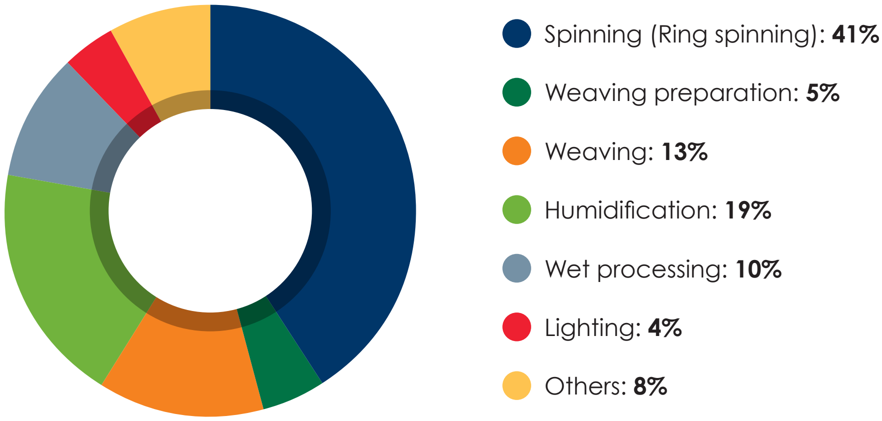

Figure 2-6: Electrical Energy Breakdown in a Textile Plant[17]

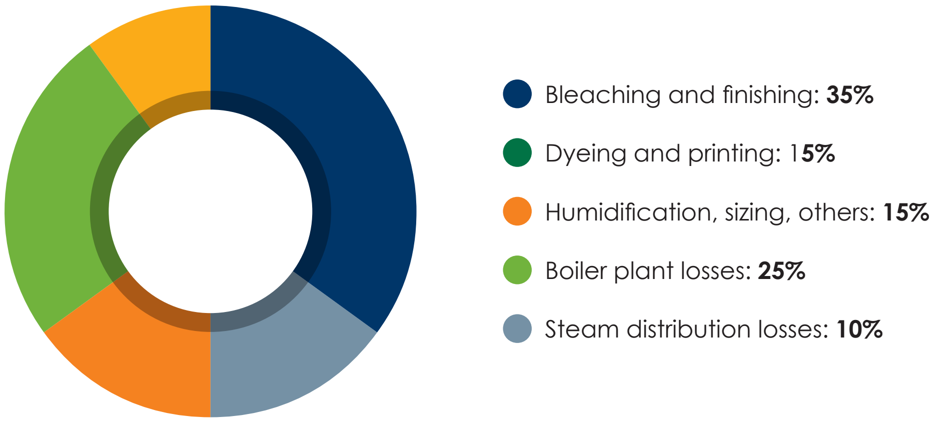

Figure 2-7: Thermal Energy Usage in a Textile Plant[18]

[17] Hasanbeigi A. Energy-Efficiency Improvement Opportunities for the Textile Industry. 2010. https://www.energystar.gov/sites/default/files/buildings/tools/EE_Guidebook_for_Textile_industry.pdf (Accessed 22 March 2022)
[18] ibid.

Table 2-2 shows a breakdown of the actual energy requirements for various machines used in the wet processes of textile plants according to Hasanbeigi (2010).

Table 2-2: Typical Energy Requirements for Textile Wet Process Machinery

Product form/machine type	Process	Energy requirement (GJ/tonne output)
Desize unit	Desizing	1.0 - 3.5
Kier	Scouring/bleaching	6.0 - 7.5
J-box	Scouring	6.5 - 10.0
Open width range	Scouring/bleaching	3.0 - 7.0
Low energy steam purge	Scouring/bleaching	1.5 - 5.0
Jig/winch	Scouring	5.0 - 7.0
Jig/winch	Bleaching	3.0 - 6.5
Jig	Dyeing	1.5 - 7.0
Winch	Dyeing	6.0 - 17.0
Jet	Dyeing	3.5 - 16.0
Beam	Dyeing	7.5 - 12.5
Pad/batch	Dyeing	1.5 - 4.5
Continuous/thermosol	Dyeing	7.0 - 20.0
Rotary screen	Printing	2.5 - 8.5
Steam cylinders	Drying	2.5 - 4.5
Stenter	Drying	2.5 - 7.5
Stenter	Heat setting	4.0 - 9.0
Package/yarn	Preparation/dyeing (cotton)	5.0 - 18.0
Package/yarn	Preparation/dyeing (polyester)	9.0 - 12.5
Continuous hank	Scouring	3.0 - 5.0
Hank	Dyeing	10.0 - 16.0
Hank	Dyeing	4.5 - 6.5

Many of the energy-savins opportunities presented do not propose any indicative cost-benefit analysis.

2.4.1 Turkey

Palamutcu (2010) estimates that in Turkey, energy accounts for between 8% and 10% of total production cost of a typical cotton textile plant. The author continues to develop(specific energy consumption parameters for the various processes, using a regression-based approach. The following figures were achieved[19]:

- 3.24 3.47 kWh/kg for yarn spinning plant;
- 0.0073 kWh/kg for warping/sizing plant;
- 1.58 2.24 kWh/kg for weaving plant;
- 0.79 1.05 kWh/kg for wet processing; and
- 0.065 0.195 kWh/kg for clothing production plant.

2.4.2 United Kingdom

The Water and Resources Action Programm focssed on the clothing and textile industry. The Sustainable Clothing Action Plan progress report of 2020, shows a 21.6% reduction in carbon footprint (WRAP Palmer, 2021). It states that, "Of the 21.6% reduction in carbon footprint, 2.3% was due to intentional improvement actions. This action plan included 13 signatories representing approximately 50% of total clothing production output in the UK.

2.4.3 India

As early as 2008, India had already started developing plans towards mitigating climate change. This included demand-side management. Kumar (2008) estimated that the potential energy savings in the textile industry in India was approximately 25%. He further stated that: "the sector is quite diverse and a wide range of processes and technologies exist in the industry for energy-efficiency improvements and reduction of carbon emissions. A number of interventions were proposed as part of his study. These included:

- Installation of inverters on supply air fan and on spray pumps of folding chiller;
- Energy-efficient motors for ring frame machines;
- Variable-frequency drive (VFD) for supply air fan and on spray pumps of air handling section;
- High-efficiency centrifugal fans and motor blowers for spinning air washer;
- Replacement of conventional spray nozzles by energy-efficient atomizer;
- Automation of dyeing machines;
- Install variable speed drives (VSDs) for circulation pumps of dyeing machines;
- Heat recovery from hot effluent to generate hot water for boiler;
- Convert cotton tapes to synthetic tapes;
- Use synthetic spindle oil in spindles;
- Optimzse the spindle oil level;
- Install uninterrupted power supply system for ring frame motors;
- Use synthetic plastic tubes instead of paper tubes;
- Install temperature and humidification controller in all humidification plants;
- Energy-efficient washers in humidification plant;
- Nylon belts in place of leather belts;
- Light weight spindle in ring frames;
- Optimization of picking mechanism in looms;
- Minimizing heat from building windows; and
- Seasonal control of fans pumps.

[19] Palamutcu S. Electric energy consumption in the cotton textile processing stages. Energy (2010). Available at: https://www.journals.elsevier.com/energy

Long-term:

- VFD for ring frame machines;
- Installation of air-ambiators and optimizing chiller loads;
- Energy-efficient stenters;
- Use of energy-efficient washers in humidification plant; and
- Heat recovery form stenter exhaust.

2.4.4 Bangladesh

Hasan (2019) explains that in Bangladesh, energy management in the industrial sector plays a key role in managing the growing energy demand in the country. The article also highlights the typical barriers within the industry limiting the implementation of energy-efficient practices. Lastly, the article estimates that savings could amount to 3 - 4% of total energy.

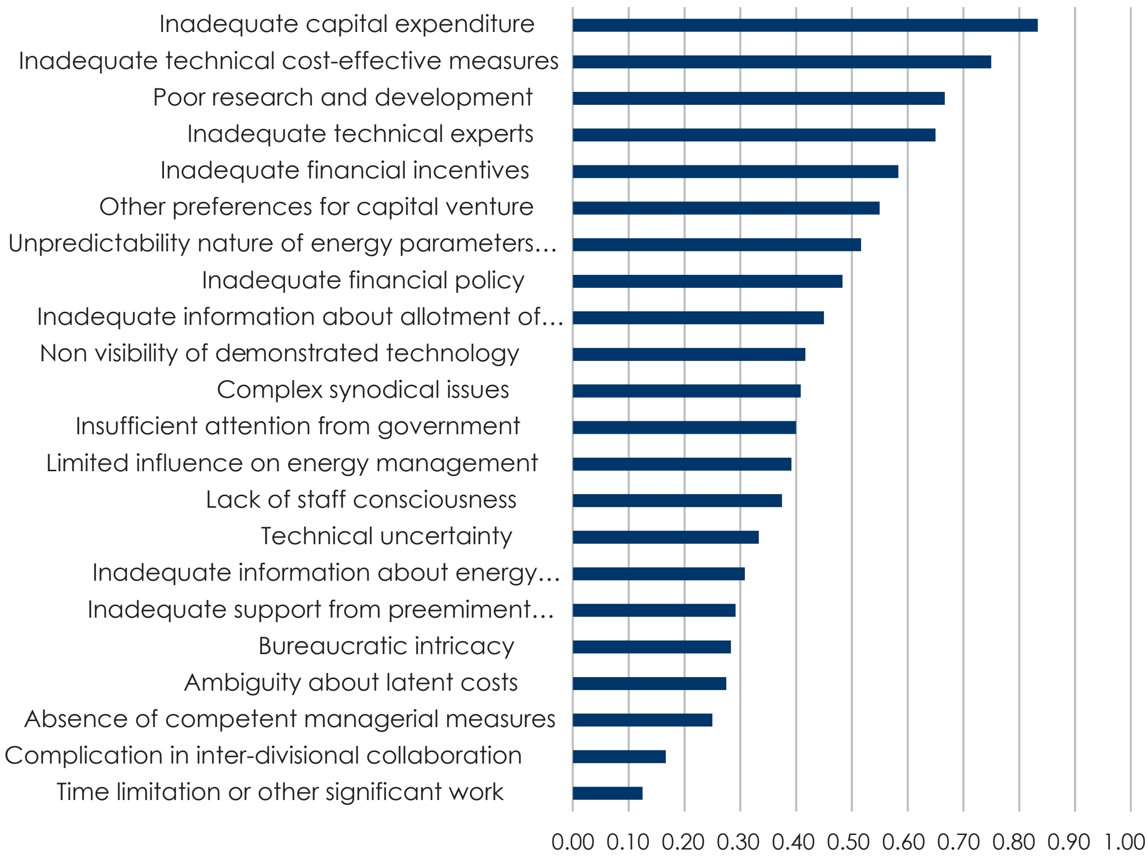

Figure 2-8: Perceived Barriers to Energy Efficiency in the Textile Industry in Bangladesh[20]

[20] Hasan ASMM, et al. Drivers and Barriers to Industrial Energy Efficiency in Textile Industries of Bangladesh. Energies 2019.

2.5 Summary

Energy efficiency has over the past 20 years become an integral part of any production strategy in manufacturing environments. Whether driven by climate change or as in the case of South Africa, by energy supply shortages, companies are interested in reducing energy consumption.

This extends to the textile industry in South Africa, where government is playing a crucial role in reviving the industry to a sustainable level. The effects of the covid-19 pandemic as well as the effects of protests, civil unrests, and rioting have been felt throughout the industry, but have not been quantified as yet. From an international perspective, the pandemic as well as climate change hae also driven energy-efficient behavioural changes.

ample literature is available regarding climate change, energy efficiency, and energy transitioning. Some of the literature ie pertinent to the textile industry. There is also literature available regarding energy-efficient practices within the textile industry. This has been documented in both established economies like the United Kingdom, as well as emerging economies like Bangladesh.

The actual savings opportunities are well identified and defined in most available literature. The actual savings that can be realised are less well known, with pockets of studies having been concluded in countries for specific types of textiles. Similarly, some benchmarking has also taken place in certain countries. However,emore benchmarking muso be conducted to draw quantifiable conclusions.

The South African textile industry is ideally suited totparticipate in efforts to quantify energy savings, given the pressure frrm a supply perspective. Although some documentation already exists, it is more qualitative rather than quantitative. Hence,ythe unmistakeable need for an energy-efficiency guideline document for the textile industry that attempts to quantify potential savings.

3. SWOT ANALYSIS OF SOUTH AFRICA INDUSTRY

A SWOT analysis was conducted based on media available in the public domain as well as from personal interviews with a small representative group of companies within the clothing and textile sector. Companies were interviewed during May 2022. A list of the companies interviewed is set out in the following tablw. A listing of the interview questions is providedeas an Appendix.

Table 3-1: List of Textile Manufacturers Interviewed

#	Location	Sub-Sector
1	Western Cape	Clothing manufacture and retail
2	KwaZulu-Natal	Home textiles supplier
3	KwaZulu-Natal	Manufacturer and supplier of fabric for formal wear
4	KwaZulu-Natal	Manufacturer and supplier of fabric and home textiles
5	KwaZulu-Natal	Manufacturer of home textiles
6	KwaZulu-Natal	Manufacturer of technical fabrics
7	Gauteng	Clothing manufacturer
8	Gauteng	Manufacturer and supplier of fabric and home textiles
9	Western Cape	Clothing manufacturer
10	Western Cape	Manufacturer of fabric and clothing

3.1 Strengths

1. Local consumer market: One of the biggest strengths of the industry is the local consumer market. Local retailers are willing to promote local manufacture as long as the price variation is not significant.

2. Resilience and flexibility: This was demonstarted during the Covid-19 pandemic where many businesses adapated their manufacturing to remain in operation. Alternative products like masks were manufactured. Other businesses altered their operating hours to ensure that staff still remained employed, albeit at a lower total remuneration.

3. Top management commitment: Most manufacturers have commited to manufacture in South Africa, with many indicating their commitment to ensure jobs and sustainability of local communities. The majority of operational personnel at the companies interviewed are breadwinners and provide for their own households. It is this commitment to the people of South Africa that has enabled the local industry to remain in business.

4. Labour availability: The textile industry is seen as a key industry for employment.

5. Technical capabilities: Good, consistent quality with well-established and long, proven track records. Development capabilities within niche markets, like wool, mohair, leather, as well as industrial textiles.

6. Other strengths include:
   - Shorter lead times to market;
   - Stable macroeconomic environment; andInformal and secondary markets are well established.

3.2 Weaknesses

1. Raw materials are sourced from overseas: Profitability is very sensitive to price variation as most raw materials are imported and subject to the exchange rate. In addition, retailers predominantly contract manufacturers based on price and delivery capability.

2. Low capital investment in research, development and new technologies: Investment in energy efficiency is low. Investment in operations to attain world-class manufacturing is low. Aging of infrastructure.

3. Aging of labour: The average age of operational staff is relatively high with few youth joining the workforce.

4. Critical skills shortage: Examples are loom tuners and maintenance technicians for textile machinery.

5. Delivery capability: Often curtailed by poor transport infrastructure. Rail network is non functional. Road transport costs have dramatically increased. Delays at ports for import of raw materials.

6. Limited knowledge of export markets: While many are interested and have attempted exporting, this is still only in limited quantities. There is a perceived lack of access to markets and the ability to demonstrate local capability and quality.

7. Lack of support from government at sectoral level: There is a perceived lack of support from government at sectoral level, where companies feel that government are not addressing the needs of the sector to promote sustanability.

8. Retailers still willing to import cheaper products.

3.3 Opportunities

1. Improve rail and port infrastructure to promote efficiency and reduce costs: This was probably the most common request from manufacturers.

2. Foster better co-operation with government at sectoral level to achieve:
   - Improved relations with retailers; and
   - Development of production of raw materials locally, including synthetics.

3. Develop markets:
   - Continued domestic market growth, including industrial textiles;
   - Further explore the African Growth and Opportunity Act and middle-income economy opportunities;
   - Promote and enable increased exports;
   - Support for niche industry exports (wool, mohair, leather, industrial textiles); and
   - Better policing of illegal imports.

4. Develop labour:
   - Skills at technical level (design, maintenance);
   - Skills at operational level;
   - Flexibility in labour laws to leverage production efficiency; and
   - Promote youth programmes to ensure generational sustainability.

5. Develop technology:
   - Capability for world-class manufacturing;
   - Upgrade of aging machinery;
   - Develop energy efficiency and promote energy resilience; and
   - Enable and promote the recycling of fibres and other resources consumed within the industry.

3.4 Threats

1. Energy supply: The biggest current threat to operations is the lack of a stable energy supply network.
2. Inability to maintain world-class manufacturing: Results in local firms being unable to be competitive in the global market.
3. Transport inefficiencies: High road transport costs, lack of rail transport capability, and slow turnaround times at ports and customs place increased pressure on local manufacturers.
4. Lack of youth entering the sector: A risk for the future sustainability of the industry.
5. Other:
   - Inflexible labour market;
   - High cost of capital;
   - Water scarcity;
   - Increasing reliance on imported raw materials;
   - Civil unrest;
   - Status quo from government;
   - Rebates; and
   - Lack of preferential trade agreements to promote exports and limit cheap imports.

4. SNAPSHOT SUMMARY FOR GOVERNMENT

Based on the literature review, the following challenges are seen as priorities to be addressed by government:
- Protection from cheap imports;
- Vertical integration of local production;
- Improvement in social welfare; and
- Rapid increase in energy costs.

4.1 Major challenges

The following major challenges were commonplace among the companies interviewed:

1. Access to energy (electricity outages);
2. Lack of accessible and efficient transport infrastructure;
3. Rapid increase in process for energy, transport and food;
4. Inflexibile labour market; and
5. Lack of sectoral support from government:
   - Import rebates;
   - Promotion of more level playing field by retailers with regard to imports;
   - Promotion of export capability; and
   - Policing of illegal imports.
6. Internal challenges:
   - Lack of investment in world-class manufacturing;
   - Aging staff complement;
   - Lack of critical skills; and
   - Inability to manufacture raw products.
7. Bargaining council restrictions regarding how employees can be remunerated.

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6. APPENDIX 1: INTERVIEW QUESTIONNAIRE

The following guideline questions were used as part of the personal interviews with the selected participants.

Table A6-1: Interview Questionnaire

Theme	Question
General	Company name Contact person Contact email/mobile
General	Current company vision and objectives
General	Current business offering
General	No. of employees No. of management/senior staff No. of female employees
Production	Largest contributor to production costs Where does energy cost rank?
Production	Do you track production and energy data? Do you have any metrics that track energy performance?
Production	Discuss current challenges in terms of the supply chain
Production	Discuss current challenges in terms of the distribution/market
Covid	How has Covid-19 affected production? • Revenue • Products/business offering • Personnel • Energy usage • Other
Energy	What are your main energy sources? (for electrical, thermal, transport)
	What is the primary input fuel for your boiler? Coal, heavy fuel oil, paraffin, diesel, natural gas, biomass, other
	Do you have a renewable energy system installed? Provide details
	Do you have an energy storage system installed? Provide details
	How does load shedding affect you? • Not at all • Have own generation (diesel/renewable) • Stop production • Partial stop in production
	Have you completed any energy-saving assessments? Or have consultants completed any?
	Have you implemented any energy-saving projects? • No cost / Low cost • Capital intensive
	If yes, please summarise the projects implemented
	For projects implemented, did you do any verification of actual energy savings achieved?
	For projects implemented, did you receive any tax rebates/incentives?
	Did you receive any funding (grants/loans) to implement energy-saving projects?
	What are the barriers/reasons for your company not implementing energy-saving projects?
General	What could government do to help your situation right now?

In addition, a short site visit was conducted to observe general practices, state of machinery and the level to which energy-efficient principles had been applied.

PART 2:
The Energy Efficiency Guide

IEE GUIDELINE FOR ENERGY EFFICIENCY WITHIN THE CLOTHING AND TEXTILE INDUSTRY IN SOUTH AFRICA

1. INTRODUCTION

The National Cleaner Production Centre South Africa (NCPC-SA) is the country's leading resource-efficiency programme funded by the South African Government through the Department of Trade, Industry and Competition (**the dtic**). In 2016, the NCPC-SA embarked on Phase II of its flagship Industrial Energy Efficiency Project (IEE Project), in collaboration with international stakeholders like the Global Environment Facility (GEF), the United Nations Industrial Development Organization (UNIDO) and the Government of Italy. One of the key components of the Phase II project is the strengthening of policy implementation and support frameworks for energy management systems (EnMS), energy systems optimisation (ESO) and the ISO 50001 Energy Management Standard in South Africa.

UNIDO has committed itself to promote the achievement of the Sustainable Development Goals as espoused by the United Nations in its drive to reduce the effects of climate change. The main objective of the UNIDO IEE Programme in South Africa is to effect sustained energy management and efficiency practices in industry of developing countries and emerging economies to reduce the environmental pressure of economic growth while increasing productivity, helping to generate economic growth, create jobs and alleviate poverty.

The South African IEE Phase II Project has worked with multiple government departments and agencies to assist in implementation and coordination of policy and regulatory mechanisms. The expected outcome of this project is enhanced promotion of investment in IEE through the provision of industrial support in the clothing and textile sub-sector. This is envisaged to be achieved by providing technical assistance and capacity building to enhance existing, and inform future, regulatory frameworks that will support EnMS and ESO uptake and strengthen the coordination of associated activities across industry in South Africa.

2. WHY THIS GUIDE

This guideline has been developed for the clothing and textile sub-sector to provide guidance and stimulate improvement in energy performance within the sub-sector. It is aimed primarily at industry and is applicable to both large and small manufacturers. It aims to:

- Provide guidance and awareness with regard to energy performance within the sub-sector.
- Promote and stimulate industry to improve its energy performance based on .
- Assist companies to develop their own improvement opportunities.
- Provide a reference to manufacturers (both large and small) by showcasing what has been achieved.

3. DEVELOPMENT OF THE GUIDE

The guide has been developed largely based on field experiences. Thus, it is based on actual achievements and improvement opportunities. In some cases, the improvements have been specifically quantified based on the actual improvement opportunity, while in others the improvements have been inferred from overall reduction in energy consumption.

The scope of this guide includes the manufacturing processes from the use of the fibre (natural and synthetic) to the creation of fabric. It also includes the final assembly of garments ready for retail.

4. HOW TO USE THIS GUIDE

The guide describes the manufacturing process and then considers opportunities in each segment of the manufacturing process. Where available, savings have been quantified based on a full-time operation (24 hours a day, seven days a week). The guide also describes best available technologies where applicable and can be used by both large and small manufacturers.

It will allow the user to:

- Identify processes that are common to the user;
- Focus on the processes that offer good opportunities;
- Identify and in some cases quantify improvement opportunities; and
- Gain confidence that the opportunities have already been implemented and savings have actually been achieved in similar manufacturing facilities.

The improvement opportunities have been divided into:

- Management;
- Process;
- Utilities; and
- Alternative energy.

A number of case studies from the South African textile industry have also been included. These provide a good reference for what has been achieved, and should be used as a platform from which other textile companies can develop their own improvement strategies.

5. OVERVIEW OF TEXTILE INDUSTRY IN SA

The textile industry in South Africa is considered strategic. According to **the dtic** (2020), the industry contributes 2.5% of South Africa's manufacturing output as shown in Figure 5-1. However, the industry is labour intensive, and thus contributes significantly more to the labour market. The sector includes clothing, textiles, footwear and leather. Textiles also include some industrial textiles.

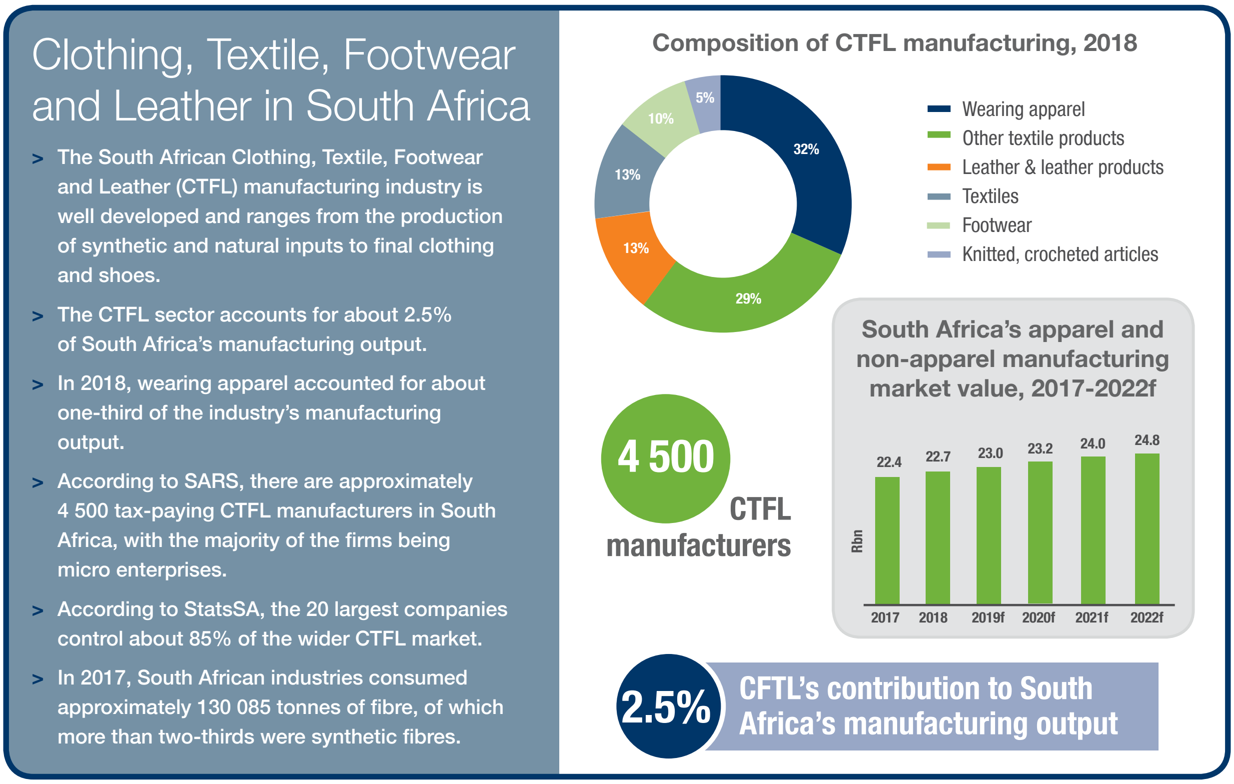


Figure 5-1: Size of Textile Industry in South Africa[21]

5.1 The Textile Value Chain

Figure 52 presents a simplified value chain of the entire retail textile process. Energy savings can be achieved across the entire value chain from growing of natural products and import transportation of raw materials all the way to consumption and usage of clothing, and the final disposal thereof. This would include strategies for energy-efficient agriculture and transportation, washing practices during usage, and the ability to recycle or repurpose products after usage.

Energy efficiency can be applied across the entire value chain from more efficient farming techniques to the end use where optimal laundry practices could be employed. This guide will, however, focus on the industrial efficiency of the manufacturing processes only.

[21] the dti. South Africa Factsheet 2020, Investing in South Africa's Clothing and Textile, downloaded from www.investsa.gov.za (Accessed 22 March 2022)

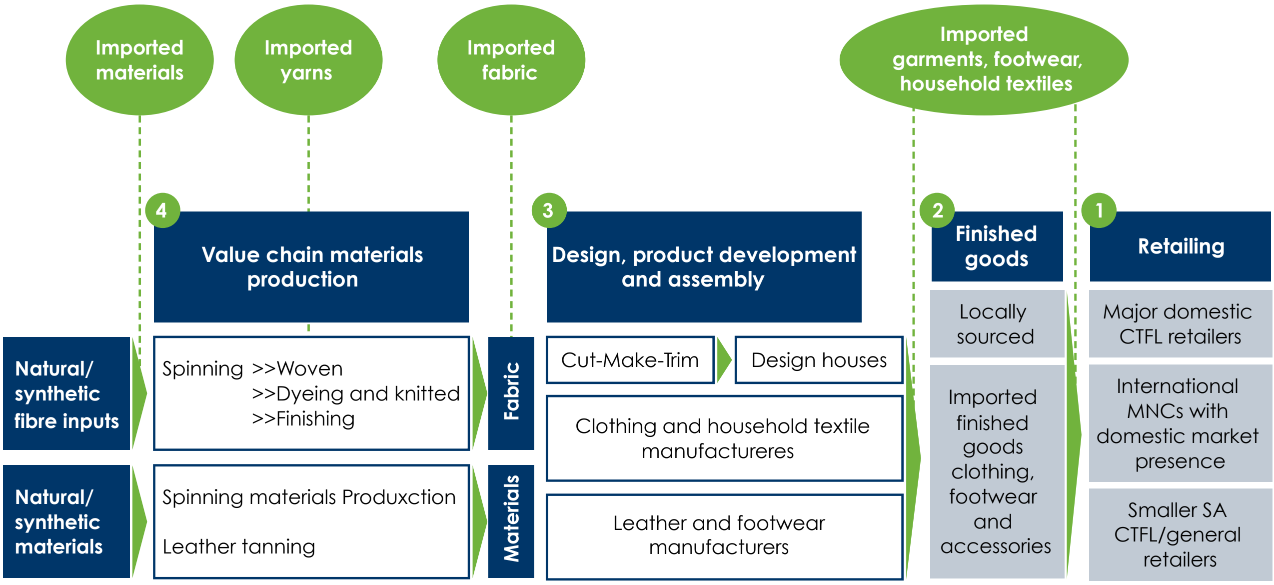


Figure 5-2: Simplified Retail CTFL Value Chain[22]

From a manufacturing perspective, the start of the process is the fibre received as the input raw material at the manufacturing plant. The production of natural fibre is often considered an agricultural process and not included. Using a life cycle approach, however, would then include this agricultural process and could lead to optimisation of those processes from an energy perspective. In contrast, synthetic fibre is usually produced in a chemical factory. Consequently, it is aggregated with the chemicals sector. Again here, a life cycle approach could potentially yield some optimisation. The process of obtaining the input raw material is not considered in this guide.

The major processes involved in the manufacturing follow:

- Spinning – the process of converting fibre into yarn.
- Weaving – the process of converting yarns into a fabric.
- Dyeing – the process of changing the colour of the yarn, or colour of the fabric, or colour of the finished garment.
- Drying – the process of removal of moisture from the yarn, fabric or garment after it has been dyed or finished.
- Finishing – the process of removal of chemicals and lubricants that were applied to the fabric during the manufacturing process, or the addition of other chemicals in preparation for final use.
- Garment assembly and confection – the process of cutting, making and trimming the final garment from the fabric or combination of fabrics.

From an energy perspective, thermal energy in the form of process heating and electrical energy to drive machinery are the most common energy inputs into the manufacturing processes for textiles. Thermal energy (heating) is usually required in the washing, dyeing and drying processes. Electrical energy is required in spinning, weaving, and almost all other processes, including the administration (offices) and auxiliary services like compressed air or the supply of water to the plant.

[22] **the dtic**. (2020). South African R-CTFL Value Chain Master Plan to 2030. Retrieved from www.thedtic.gov.za

6. ENERGY EFFICIENCY IN TEXTILE MANUFACTURING

6.1 The Textile Manufacturing Process

Best Available Technique Reference (BREF) Document (BREF, 2003) describes a typical textile manufacturing process as shown in Figure 6-1. A number of process steps are shown, with some processes in turn having a number of sub-process steps[23].

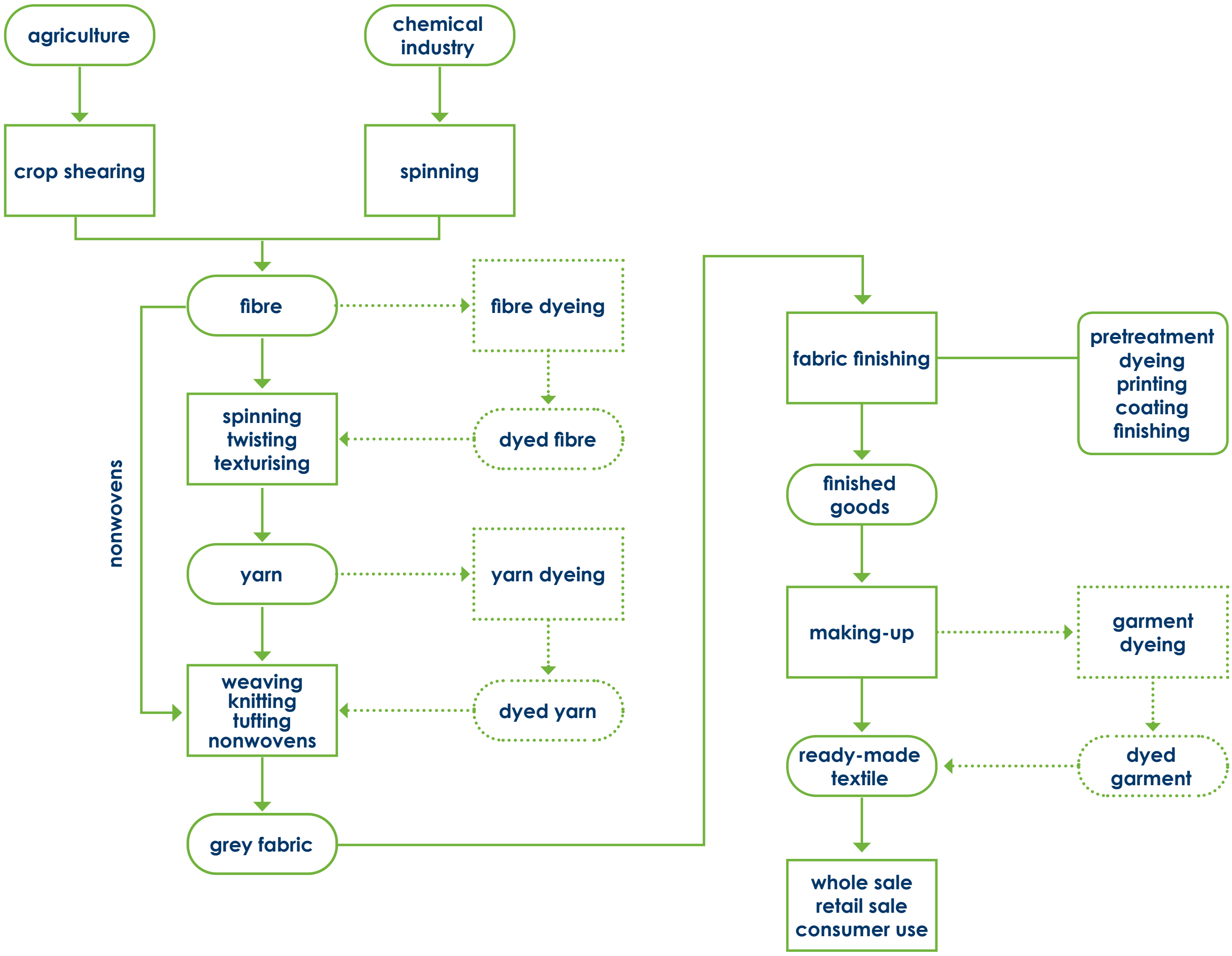


Figure 6-1: Textile Manufacturing Process[24]

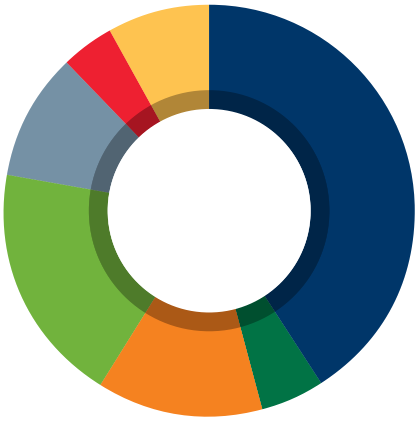
From an international perspective, there are many documents available discussing textile value chain efficiency. Many of them discuss it from a carbon mitigation or an energy transition point of view.

In his energy efficiency guideline for the textile industry, Hasanbeigi (2010) provides a breakdown of typical electricity and steam usage in textile plants. His guide provides a total of 190 different opportunities for energy performance improvement. Further breakdown of energy consumption per process is also discussed, each with a discussion of savings opportunities.

[23] Hasanbeigi A. Energy-Efficiency Improvement Opportunities for the Textile Industry. 2010. https://www.energystar.gov/sites/default/files/buildings/tools/EE_Guidebook_for_Textile_industry.pdf (Accessed 22 March 2022)

[24] European IPPC Bureau. Reference Document on Best Available Techniques for the Textile Industry (BREF). 2003. Available at https://eippcb.jrc.ec.europa.eu/reference/

The breakdowns for electrical and thermal energy consumption in typical textile wet processes are shown in Figure 6-2 and Figure 6-3.



Spinning (Ring spinning): **41%**

Weaving preparation: **5%**

Weaving: **13%**

Humidification: **19%**

Wet processing: **10%**

Lighting: **4%**

Others: **8%**

Figure 6-2: Electrical Energy Breakdown in a Textile Plant[25]

Bleaching and finishing: **35%**

Dyeing and printing: 1**5%**

Humidification, sizing, others: **15%**

Boiler plant losses: **25%**

Steam distribution losses: **10%**

Figure 6-3: Thermal Energy Usage in a Textile Plant[26]

6.2 Management Opportunities

6.2.1 Management of the Energy System

The most common management opportunities are included in the implementation of EnMS. The key activities here would include inter alia:

1. Top management demonstrating commitment by making resources available for the identification and implementation of energy improvement opportunities.
2. Assigning specific roles and responsibilities to personnel pertaining to the management of energy within the organisation.
3. Identification of areas and machinery that consume significant amounts of energy.
4. Development of relevant energy performance indicators to monitor and track energy performance.
5. Setting targets for improvement that can be achieved through implementation of identified energy improvement projects.
6. Ensuring that all personnel have been trained to operate machinery and manage processes in an energy-efficient manner.
7. Evaluating and verifying energy savings following implementation of energy projects.

[25] Hasanbeigi A. Energy-Efficiency Improvement Opportunities for the Textile Industry. 2010. https://www.energystar.gov/sites/default/files/buildings/tools/EE_Guidebook_for_Textile_industry.pdf (Accessed 22 March 2022)

[26] ibid.

Implementation of an EnMS allows for the systematic management of energy throughout the organisation. It involves activities in three critical areas, namely people, technology and data. It is also a cyclic process that follows the 'Plan-Do-Check-Act' process:

- **Plan:** Establish the context, data, objectives and processes necessary to deliver results.
- **Do:** Implement the processes.
- **Check:** Monitor and measure energy performance and the processes against the policy, objectives, energy targets, legal and other requirements, and report results.
- **Act:** Take actions to continually improve energy performance and the energy management system.

Figure 6-4 shows the savings that were achieved by early adopters of energy management systems. The 9 companies were medium and large companies from metal processing, chemicals, automotive, construction material and power generation sectors in Egypt, North Macedonia, South Africa and Turkey (UNIDO, 2021). EnMS-unique-enabled savings here would include no-cost and low-cost opportunities that did not require capital expenditure planning. They were typically behavioural changes that were identified during the initial stages of EnMS implementation.

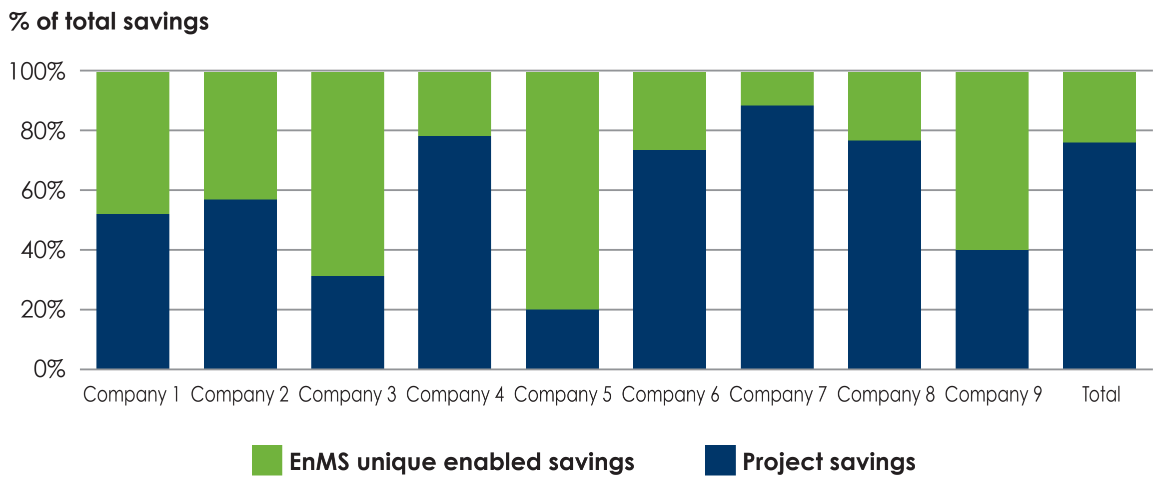


Figure 6-4: Energy Savings Achieved Through EnMS Implementation[27]

Other opportunities for improving energy performance from a process optimisation perspective have been taken from anecdotal evidence from interviews with key personnel in the industry.

6.2.2 Management of Personnel

Improvement opportunities related to no-cost energy savings invariably involve behaviour change of personnel. Depending on the type of opportunity, this could include operational, maintenance or administrative personnel. Personal interviews[28] conducted with selected textile manufacturers have revealed the importance of having the right personnel. Some of the key considerations to enable a path towards sustainability and energy performance improvement include:

1. To foster a culture of continuous learning and improvement.
2. To enable a growth (career) path for personnel within the company to improve staff retention.
3. To create an inclusive culture where management and personnel become jointly accountable for energy performance improvement.

[27] UNIDO EnMS

[28] The author conducted a number of site visits and interviews to gain a more personal insight into the challenges facing manufacturers with the South African textile industry.

6.2.3 Management of Value Chain Linkages

Personal interviews conducted with selected textile manufacturers have highlighted one of the major challenges facing the textile industry in South Africa. Access to raw material, and the ability to distribute finished goods to market have become critical success factors for textile manufacturing companies in South Africa.

This has been exacerbated by the Covid-19 pandemic, where international trade was severely restricted. Many companies experienced critical raw material shortages.

Opportunities here include:
1. Managing raw material stock and lead-time levels to ensure manufacturing operations can be sustained at an economically viable level.
2. Developing alternate sources of raw materials to reduce supply-loss risk.
3. Developing alternative energy supply solutions to manage the effects of intermittent power outages currently being experienced in South Africa.

6.3 Process Opportunities

6.3.1 General Operations

Changes to production equipment involve an element of risk, largely associated with loss of production. Most companies tend to be conservative and will seek energy-saving opportunities in auxiliary functions. This would include office and administration, lighting, heating/cooling and ventilation or other utilities like compressed air, steam, or cooling water.

In general, production machinery should be optimised to be utilised at its optimal production volume in relation to the consumption of raw materials and utilities. Improvement of existing machinery is almost always preferred to replacement or upgrading in risk-averse companies. Hence, it is recommended to first attempt to improve efficiency of existing production machinery through control and behaviour modification.

The primary opportunity for optimisation in the operational process includes the switching off of machinery when not required. In many cases this could be:
1. During lunch and tea breaks when machinery is left idling while operators are away from their workplace. Identify which machinery could be safely switched off without compromising safety or production output.
2. In the morning, or at the start of a shift; in many cases all machinery is started up simultaneously, and then left to run or idle until it is actually required. Identify processes that do not require machinery to operate immediately and delay the start of these machines.
3. Machinery left idling over weekends. This is especially true for equipment that has a warm-up period before being used. Operators would tend to leave it on so that it is ready first thing Monday morning. Timers could be installed to start machinery automatically at a pre-set time before being required.

From an energy perspective, Hasanbeigi (2010) has separated the textile manufacturing process into three main subgroups: spinning, weaving and wet processing. According to BREF (2003), wet processing is the most energy-intensive part of the manufacturing process. Wet processes include, for example, wool scouring, yarn dyeing and finishing, knitted and woven fabrics dying, and heat setting.

6.3.2 Spinning Processes

In the spinning industry, energy is consumed mainly in the form of electricity. The ring spinning machines have the highest energy consumption during yarn manufacturing among the other spinning types such as compact, rotor and air jet spinning.

The energy savings in spinning can be achieved through technological upgrading as well as setting the optimal condition for the electricity usages in spinning. For the ring spinning operations, electricity is consumed in the spindles, packaging, drafting, and operating the lifting and cleaning mechanisms. Table 6-1 shows examples of measures/technologies for the spinning process. Where possible, savings have been quantified.

Table 6-1: Examples of Energy-Saving Measures for Spinning Machinery[29]

Energy-Efficiency Technologies and Measures	Electricity Saving[30]	Payback Period (Year)
Preparatory Process		
Installation of electronic roving end-break stop-motion detector instead of pneumatic system	3.2 MWh/year/machine	< 1
High-speed carding machine	30% for same fibre output	< 2
Ring Frame		
Use of energy-efficient spindle oil	3%–7% of ring frame energy use	
Replacement of lighter spindle in place of conventional spindle in ring frame	23 MWh/year/ring frame	8
Synthetic sandwich tapes for ring frames	4.4–8 MWh/ring frame/year	1 - 2
Optimisation of ring diameter with respect to yarn count in ring frames	10% of ring frame energy use	2
False ceiling in ring spinning section	8 kWh/year/spindle	1.2
Installation of energy-efficient motor in ring frame	6.3–18.83 MWh/year/motor	2 - 4
Installation of energy-efficient excel fans in place of conventional aluminium fans in the suction of ring frame	5.8–40 MWh/year/fan	< 1
The use of light-weight bobbins in ring frame	10.8 MWh/year/ring frame	< 1
High-speed ring spinning frame	10%–20% of ring frame energy use	
Installation of a soft starter on motor drive of ring frame	1–5.2 MWh/year/ring frame	2
Windings, Doubling and Finishing Process		
Installation of VFD on autoconer machine	331.2 MWh/year/plant	< 1
Intermittent mode of movement of empty bobbin conveyor in the autoconer / cone winding machines	49.4 MWh/year/plant	< 1
Replacing the electrical heating system with steam heating system for the yarn polishing machine	19.5 MWh/year/machine	< 1

[29] Hasanbeigi A. Energy-Efficiency Improvement Opportunities for the Textile Industry. 2010. https://www.energystar.gov/sites/default/files/buildings/tools/EE_Guidebook_for_Textile_industry.pdf (Accessed 22 March 2022)

[30] The savings values described here are applicable to machinery that operate close to 8 000 hours per year.

6.3.2.1 Preparatory Phase

1. Using electronic roving end stop detector instead of pneumatic can be quite significant. In general, seven units of electrical energy is required to generate one unit of compressed air, effectively making compressed air energy seven times more expensive than electrical energy.
2. High-speed carding machines are mainly used in the cotton industry. Higher-speed machines actually consume more power than conventional units, but offer a much higher throughput. Hence, high-speed machines will consume up to 30% less energy for the same fibre output.

Figure 6-5: High Speed Carding Machine

Figure 6-6: Roving Machine

6.3.2.2 Ring Frames

A number of opportunities exist for ring frames. These are the most energy-intensive machines in the spinning department, and hence, well worth considering for energy performance improvement. The more common opportunities include:

1. Management and maintenance of lubrication oil for spindles: Reduced friction, longer service life.

2. Use lighter spindles: The spindles are rotated by motors. The less weight the motor has to turn, the less energy it will consume.
3. False ceiling: Creating an enclosure around the ring frame area to reduce the volume of air that needs to be controlled within the ring frame.
4. Using high-efficiency motors: These offer a few percentage points saving, but are only economically viable for machines that will operate close to 8 000 hours per year.
5. High-speed ring frames: Similar to high-speed carding machines, they offer a higher total output for the same total amount of energy. Capital costs are very high though.

Figure 6-7: Ring Frame Spinning Machine

6.3.2.3 Autoconers and Doubling Machines

The autoconers are used to wind the yarns onto a large bobbin which in turn will be used in the weaving process. Many of them will also do sizing of the yarns to ensure a smooth uniform yarn. Doubling machines twist two strands of a thinner yarn together to produce a heavier, stronger yarn that will be able to withstand the mechanical forces of the weaving process. The major opportunity here would be:

1. Installation of VSDs: Offer the best reduction of energy in absolute terms.

Figure 6-8: Yarn Doubling Machine

6.3.2.4 Humidification in Spinning Areas

Maintaining a stable temperature and humidity during the spinning process helps to improve the quality of the yarn and fabric being produced. Efficient operation of the climate control systems can result in significant savings.

The major opportunities here include:

1. Optimising control settings for humidification and temperature – low-cost opportunities to match supply with actual demand requirements which may vary during production or with season.Maintenance of motor system transmission systems – ensuring optimal tension in belts, or ensuring correct greasing of bearings and gearbox transmissions can often be equivalent in savings to using a motor efficiency class one level higher.
2. Replacement of flat v-belts with cogged v-belts, or if applicable, with synchronous belts. Cogged v-belts offer increased traction and hence less power losses. Synchronous belts offer much improved power transfer efficiency.Optimise fan or pump impeller to better match the load requirements.
3. Install lightweight fan impeller to reduce overall mechanical load on motor.
4. Install a VSD for pumps and pump fans – these generally result in significant energy savings.
5. Replace humidification system with more efficient modern technology.

6.3.2.5 Other General Opportunities in Spinning

Maintaining a stable temperature and humidity during the spinning process helps to improve the quality of the yarn being produced. Efficient operation of the climate control systems can result in significant savings.

The major opportunities here include:

1. Optimising control settings for humidification and temperature – low-cost opportunities to match supply with actual demand requirements which may vary during production or with season. (Payback < 12 months)
2. Maintenance of motor system transmission systems – ensuring optimal tension in belts, or ensuring correct greasing of bearings and gearbox transmissions can often be the equivalent in savings to using a motor-efficiency class one level higher. (Payback < 12 months)
3. Replacement of flat v-belts with cogged v-belts, or if applicable with synchronous belts. Cogged v-belts offer increased traction and hence less power losses. Synchronous belts offer much improved power transfer efficiency but is not always possible for use with older machinery. (Payback < 12 months)
4. Optimise fan or pump impeller to better match the load requirements. Trimming impellers for fixed load applications is a quick and easy way to make energy savings where a fan or pump is not operating at full load. (Payback < 12 months)
5. Install lightweight fan impeller to reduce overall mechanical load on motor. Impellers that are lighter in mass will have a lower inertia, requiring less power to start and also less power to keep them going. (Payback < 12 months)
6. Replace standard nozzles with high-efficiency mist nozzles in yarn humidification rooms. (Payback < 12 months)
7. Install a VSD for pumps and pumps fans – these generally result in significant energy savings. (Payback one to two years)
8. Replace the entire humidification system with a more efficient modern technology. This is usually applicable to older systems where machinery is no longer serviceable or efficiency is much lower than a new modern equivalent system. Usually requires a major stoppage in production to install and commission. (Payback two to four years)

Typical payback periods were obtained from Hasanbeigi (2010).

6.3.3 Weaving and Knitting

Weaving machines (looms) used in the production process account for more than 60% of energy consumption in the weaving department. Humidification, lighting and compressed air are the other significant energy users.

Automatic looms have become commonplace in the industry. They are complex machinery consisting of a number of small motors and other devices designed to function as a unit. Replacement of internal individual motors with more efficient units do offer small energy savings but may cause interference with other parts of the loom. It should be carefully considered before implementing. The most common opportunities exist in the maintenance and operation of the loom to ensure that the energy intensity and loom utilisation are optimised. Common opportunities here would include:

1. Loom utilisation: High utilisation is recommended to offer the best operational efficiency. Utilisation ratios of 90% or more are recommended. A 10% drop in utilisation of loom machines will increase specific energy consumption by 3%–4% (Sivaramakrishnan, 2009).
2. Use of the appropriate loom type for the weaving required: The type of weaving machine can significantly influence the energy use per unit of product. There is usually a trade-off between energy efficiency and functional capability of looms. This should be taken into account when purchasing and installing new looms.
3. Yarn quality: The yarn quality will affect the loom perfomance. Lower quality yarns will often have a higher breakage causing much more downtime and hence reducing operational efficiency.
4. Cleaning and maintenance of looms also affect performance. Removal of dust and loose airborne fibres is recommended during operations to reduce the drag effect on the moving machinery. A good dust and fibre extraction system is also recommended.
5. Lubrication of moving parts according to manufacture recommendations is also recommended.

Figure 6-9: Weaving Machine

Compressed air is often an input into the weaving process. Optimisation of compressed air systems is addressed in the utility section of this guide (refer to 6.4). From an operational perspective, however, the best opportunity here would be to supply compressed air to the loom at a pressure which is just above the minimum required for effective operation. Reduction of compressed air operating pressure by 1 bar will result in an electrical power saving of approximately 6%–7%.

Lighting offers a quick and easy method to reduce energy consumption. It is applicable to almost the entire plant, but actual savings achieved are very dependent on the existing type of lamp used as well as the production operating schedules.

6.3.4 Wet Processing

Wet processing, as the name implies, involves the use of water or liquids in the production process. This includes the preparatory phase for activities like bleaching and scouring, dyeing processes where colour is added to the fabric by liquid immersion, drying or removal of liquid from the fabric, and finishing, including pre-treatment (e.g. bleaching and scouring), dyeing and finishing.

In addition to electrical energy systems, wet processes include intensive thermal energy systems typically for the production and use of steam, hot water and for drying operations. Most of the opportunities relate to improvement in thermal energy systems.

Table 6-2: Thermal Energy Use in Dye Plant[31]

Item	Share of total thermal energy use	Way to reduce losses
Product heating	16.6%	
Product drying	17.2%	Avoid over-drying
Losses through waste liquor	24.9%	Recovery of waste heat
Heat released from equipment	12.3%	Improved insulation
Exhaust losses	9.3%	Reduction of exhaust gas
Equipment idling losses	3.7%	Stop energy during idling
Evaporation from liquid surface	4.7%	Install a cover
Un-recovered condensate	4.1%	Condensate recovery
Loss during condensate recovery	0.6%	
Others	6.6%	
Total	100%	

Energy intensity in wet processes is influenced by many factors including the type of fabric, chemicals and dyes used to condition the fabric, temperature and duration of the process, as well as liquid concentrations and dryness fractions. In many processes, production has set a minimum value for these parameters to ensure product quality. When viewed from an energy perspective, optimisation of these parameters to match actual requirements could lead to significant energy performance improvements. Automated systems that include closed feedback loops and some form of statistical process control are necessary to optimise these.

Table 6-3 shows a breakdown of the actual energy requirements for various machines used in the wet processes of textile plants (Hasanbeigi, 2010).

[31] Hasanbeigi A. Energy-Efficiency Improvement Opportunities for the Textile Industry. 2010. https://www.energystar.gov/sites/default/files/buildings/tools/EE_Guidebook_for_Textile_industry.pdf (accessed 22 March 2022)

Table 6-3: Typical Energy Requirements for Textile Wet Process Machinery

Product form/machine type	Process	Energy requirement (GJ/tonne output)
Desize unit	Desizing	1.0 - 3.5
Kier	Scouring/bleaching	6.0 - 7.5
J-box	Scouring	6.5 - 10.0
Open width range	Scouring/bleaching	3.0 - 7.0
Low energy steam purge	Scouring/bleaching	1.5 - 5.0
Jig/winch	Scouring	5.0 - 7.0
Jig/winch	Bleaching	3.0 - 6.5
Jig	Dyeing	1.5 - 7.0
Winch	Dyeing	6.0 - 17.0
Jet	Dyeing	3.5 - 16.0
Beam	Dyeing	7.5 - 12.5
Pad/batch	Dyeing	1.5 - 4.5
Continuous/thermosol	Dyeing	7.0 - 20.0
Rotary screen	Printing	2.5 - 8.5
Steam cylinders	Drying	2.5 - 4.5
Stenter	Drying	2.5 - 7.5
Stenter	Heat setting	4.0 - 9.0
Package/yarn	Preparation/dyeing (cotton)	5.0 - 18.0
Package/yarn	Preparation/dyeing (polyester)	9.0 - 12.5
Continuous hank	Scouring	3.0 - 5.0
Hank	Dyeing	10.0 - 16.0
Hank	Dyeing	4.5 - 6.5

6.3.4.1 Preparatory Phase

Reducing idling losses

Ensuring that associated systems are switched off when not needed: Sometimes the main motor of a machine or process is stopped, but associated systems are not stopped simultaneously. Many examples exist, among others:

- Stopping exhaust hood fans when the main motor is stopped in a washing process like during mercerising.
- Stopping blower fans when the main motor is stopped in a gas singeing machine.
- Stopping blower fans when the main motor is stopped in a fabric shearing machine.
- Stopping agitators or circulation pumps when a fluid mixing or rinsing process has stopped.

These systems could easily be interlocked electrically so that when one stops, the other one is also automatically stopped. Typically, these systems will have a payback period of less than six months (Hasanbeigi, 2010).

Use of counter-flow washing/rinsing systems

Traditional rinsing systems will contact the cleanest water with the dirtiest product first, thereby contaminating the rinsing water to such an extent that fresh clean water is used in the next phase of rising as well. By using a counterflow principle, the cleanest water is first contacted with the last part of the rinse cycle. There is a low contamination of the rinse water allowing it to be used in the next wash phase. This is essentially a water saving project, but it also reduces energy consumption as less rinse water is required to be heated and less rinse water is required to be pumped to the process. Energy savings vary from 40% to 60% of the rinsing process (Hasanbeigi, 2010).

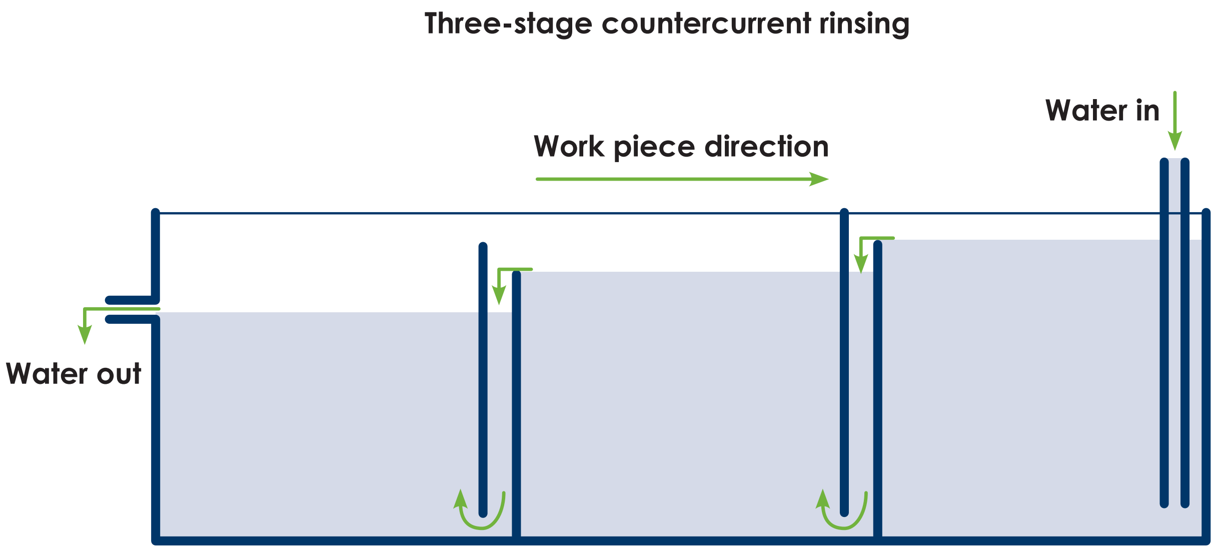


Figure 6-10: Counterflow Rinsing[32]

Single Bath Bleaching

Combining preparatory processes like de-sizing, scouring and bleaching into a single or two-step process can have significant energy savings by eliminating steam purge and intermediate washing stages. Typical energy savings could be as much as 70% according to Prince (2008).

Bleach Bath Recovery

Large volumes of water are used in wet processing. Water conservation invariably leads to energy conservation. Recycle and reuse of rinse water is thus advantageous, especially in a water-stressed country like South Africa. According to Hasanbeigi (2010), typical opportunities would include:

1. Reuse of wash water from bleaching in caustic washing and scouring make-up and rinse water.
2. Reuse of rinse water from scouring for desizing or washing printing equipment.
3. Reuse of wash water from mercerising to prepare scouring, bleaching, and wetting-out baths.

Using these methodologies can save up to 50% of water and around 10% of energy costs depending on the chemicals used as well as the water temperature.

[32] Source: NCPC-SA: RECP Expert Training Manual

Point-of-use heating systems

These are instantaneous inline heater-type systems that will heat water instantly on demand. The main advantage here would be:

- The elimination of boiler losses, piping heat losses and other standing losses associated with the transport of steam from the boiler to the point of use.
- The flexibility to heat water without the need to fire up a boiler, which could take several hours.

This method has been successfully implemented in small batch operations and can offer up to 50% energy savings. It does, however, require a capital investment.

Other more advanced opportunities include:

1. Heat recovery systems;
2. Cold pad batch pre-treatment;
3. Enzymatic removal of residual hydrogen peroxide after bleach; and
4. Use of integrated dirt removal/grease recovery loops in wool scouring plant.

6.3.4.2 Dyeing and Printing Process

- Installation of VFD on pump motor of top dyeing machines;
- Heat insulation of high temperature / high pressure dyeing machines;
- Cooling water recovery in batch dyeing machines (jet, beam, package, hank, jig and winches);
- Cold-pad-batch dyeing system;
- Discontinuous dyeing with airflow dyeing machine;
- Installation of VFD on circulation pumps and colour tank stirrers;
- Dye bath reuse;
- Equipment optimisation in winch beck dyeing machine;
- Equipment optimisation in jet dyeing machines;
- Single-rope flow dyeing machines;
- Microwave dyeing equipment;
- Use of steam coil instead of direct steam heating in batch dyeing machines (winch and jigger);
- Equipment optimisation in winch beck dyeing machine;
- Careful control of temperature in atmospheric wet batch machines;
- Jiggers with a variable liquor ratio;
- Heat recovery of hot waste water in autoclave;
- Insulation of un-insulated surface of autoclave;
- Reducing the need for re-processing in dyeing;
- Recover heat from hot rinse water; and
- Reduce rinse water temperature.

6.3.4.3 Drying Process

The drying process is very energy intensive, with thermal energy systems making up the bulk of all energy consumption. Common opportunities include:

1. Avoid over drying;
2. Maintenance of the dryer;
3. Reduce idling times; and
4. Use new drying technologies:
   a. Radio frequency;
   b. Microwave; and
   c. Infrared.

6.3.4.4 Finishing Process

Most common opportunities in the finishing process are related to thermal energy systems:
1. Use conversion of thermic fluid heating system to direct gas;
2. Firing system in stenters and dryers;
3. Introduce mechanical de-watering or contact drying before stenter;
4. Avoid over-drying;
5. Close exhaust streams during idling;
6. Close and seal side panels;
7. Proper insulation;
8. Optimise exhaust humidity;
9. Install heat-recovery equipment; and
10. The use of sensors and control systems in stenter.

6.3.4.5 General Opportunities in Wet Processing

Wet processes include thermal energy systems in addition to electrical energy systems. Most of the general opportunities relate to improvement in thermal energy systems.
1. Automatic steam control valves in desizing, dyeing, and finishing.
2. The recovery of condensate in wet processing plants.
3. Heat recovery from the air compressors for use in drying woven nylon nets.
4. Utilisation of heat exchanger for heat recovery from wet-processes wastewater.

6.4 Opportunities in Utilities

Thermal energy from steam boilers or thermic oil heaters are used mainly for the wet processes in the textile industry. These include washing, stenting and drying processes. The fuels used vary from plant to plant and is usually a function of the availability of fuel and size of the thermal energy required.

6.4.1 Thermal Energy

In most industrial scale plants, thermal energy is provided by a steam energy system. The use of thermic oil is also widespread where excessive temperatures are not required.

6.4.1.1 Boiler Utilisation

In general, high production volume plants will operate steam boilers and burners at a constant load near to full capacity. This will usually result in the boiler performance being relatively efficient. The systems are designed with effective life spans in excess of 20 years.

These days, most textile manufacturers are operating at reduced production outputs. Consequently, the boiler is operating at a reduced utilisation. Many of these have long start-up and shut-down times, resulting in inefficiencies during the transition phase. In addition, constant cooling and heating cause increased maintenance of the system and could result in faster ageing and premature failure.

Opportunities for optimisation:
1. Operating the boiler at the minimum required pressure corresponding to the thermal requirements of the plant.
2. Monitoring the thermal energy required in the production process and adjusting boiler output accordingly. In this case, the objective is to match the supply with the demand as closely as possible.

3. Excessive under-utilisation of the boiler (< 40%) may present an opportunity for small rapid-start boilers becoming economically viable.
4. An alternative would be to create some energy storage device near the point of use.
5. Investigate fuel switching.
6. Only operate the minimum number of boilers required.
7. Use of a small electric or fuel (paraffin/LPG) boiler where intermittent heat is required. For example, where a dryer is used intermittently or only a few hours a day, it might become more economically viable to operate a smaller boiler that can be started and stopped rapidly rather than operating a coal-fired boiler all the time at a low utilisation.

6.4.1.2 Combustion Monitoring

Thermal energy is generated by the combustion of a fuel in an exothermic reaction. Heat is released when combustion takes place. Combustion requires a fuel (e.g. paraffin) and oxygen in the presence of a spark or some other form of ignition. The ratio of fuel to oxygen is critical in achieving the required heat output for the optimal amount of fuel.

The objective of a combustion monitoring system would be to ensure that the fuel oxygen ratio is optimum for the thermal energy required in the process. This can be determined in a number of ways, including:
- Monitoring the oxygen content of the flue gas;
- Monitoring the temperature of the flue gas;
- Monitoring for the presence of other gases (like carbon monoxide) in the flue gas;
- Analysis of the ash for some fuels;
- Monitoring of the water temperature being fed into the boiler;
- Metering fuel flow; and
- Metering the water flow.

6.4.1.3 Boiler Blowdown Management

Solid impurities as well as dissolved substances (salts) may be introduced to the boiler through the feed water supply. As the water is boiled off to make steam, the impurities remain in the boiler aggregating over a period of time. To limit aggregation, a boiler is usually regularly subjected to a blowdown operation. A port near the base of the boiler is opened to allow all the impurities to be removed from the system. A certain amount of heated water is also removed at this time resulting in energy losses in the system.

Too high a discharge rate will result in unnecessary energy losses and reduced chemical treatment concentrations, which will result in increased corrosion rates. Conversely, too low a discharge rate will result in an increase in salt concentration with scale deposition on the boiler tubes.

Opportunities for optimisation:
1. Automated detection of impurity levels to ensure optimal blow-down operations. This means the maximum removal of impurities for the least loss in energy.
2. For large boiler systems, it may be economically viable to recover some waste heat from the hot water being discharged during a blow-down operation.

Maintenance interventions:
- Regular cleaning of heat exchange surfaces – the combustion chamber and water for generating steam are kept separate inside the boiler. Heat is transfered between the two systems. Fouling of this heat exchange surface could result in excessive fuel consumption.
- Regular inspection of monitoring equipment.
- Maintaining fuel feed grates for solid type fuels to ensure that fuel is fed into the boiler at the optimal rate.

- Maintenance of burners for liquid type fuels.
- Maintenance of auxiliary fans to ensure that the air flow into the combustion chamber as well as the exhaust gases are removed from the combustion chamber optimally.

6.4.1.4 Condensate Recovery

In some processes, steam is used to indirectly heat a process. In this case, the heat is removed from the steam, which in turn condenses to form water. In most cases, this water is very hot, close to its boiling point. If this water could be re-used in the boiler, it would only require a small amount of energy to reach its boiling point. By contrast, if new water is introduced into the boiler, it needs to heat it up all the way from its ambient temperature to its boiling point before it can produce steam. Significant energy savings could thus be achieved.

In addition, re-using condensate will result in water savings, as well as savings in chemicals used in waste water treatment before it can be safely discharged as effluent.

For indirect heating systems, condensate return should be above 85%, with the remainder lost to flash steam as the pressure of the condensate drops to atmospheric conditions.

Opportunities for optimisation:

1. Identify process areas where condensate is being fed to drain and could be re-used.
2. Implement and manage a condensate return programme.
3. Ensure all steam traps are operational.

Figure 6-11 shows the typical fuel savings that can be expected with an increase in condensate return. For example, if condensate is returned to the boiler at 60°C, improving condensate return from 25% to 75% will result in a fuel saving of approximately 3%.

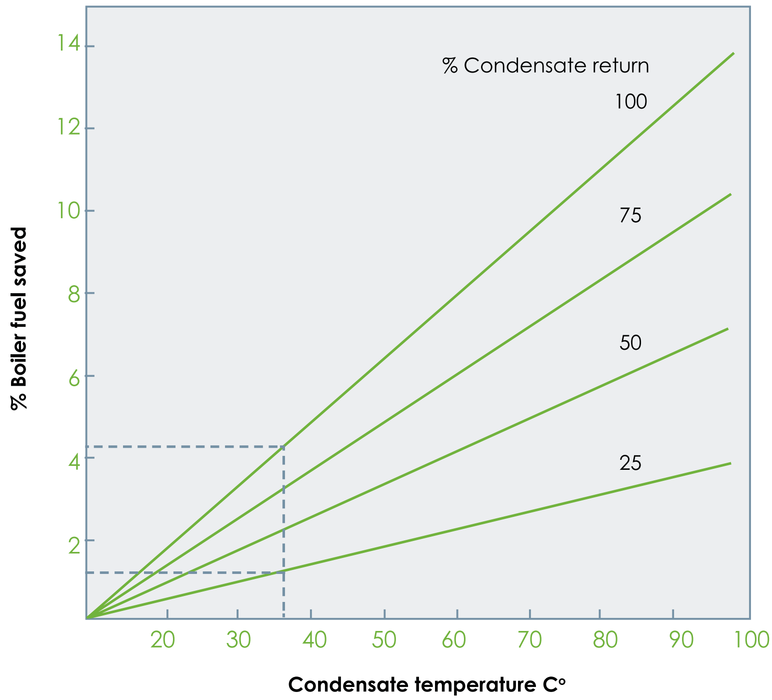


Figure 6-11: Fuel Saving Effect of Condensate Return[33]

[33] NCPC-SA. RECP Guideline for the Textile Industry. (2015). Available from: https://www.industrialefficiency.co.za/guides-and-reports/ (Accessed 22 March 2022)

6.4.1.5 Insulation of Piping Network

Thermal energy is generated in the boiler and transferred as the heat in steam to the point of use. As the thermal energy is being transported, it is exposed to the ambient environment which is usually much lower in temperature. Heat transfer takes place from the hot steam in the pipes to the environment. This results in energy losses.

Insulating the piping will reduce the rate of heat loss. This is similar in principle to a person wearing a jacket on a cold day. The jacket does not generate heat. Rather it reduces the rate of heat loss from the body to the cold environment.

Opportunities for optimisation:
1. Insulate piping.
2. Insulate valves, flanges and other piping components, where practical.
3. Reduce pipe lengths by removing unnecessary piping.
4. Install isolation valves to limit losses to an area of production that does not require thermal energy all the time.
5. Develop a maintenance schedule to identify areas that require insulation or areas where insulation has failed.
6. Install insulation in such a way that piping components are accessible for maintenance and inspection.

6.4.1.6 Fuel Source Review (Thermal)

Fuel sources for thermal systems are mainly applicable to boilers that are used to generate steam, or thermic oil heaters. Many modern boilers can be adapted to allow for various fuel type inputs.

A thorough assessment of the thermal requirements of the production facility is required to determine the optimal fuel source and boiler/thermic heater size. Future planning or expansion should also be taken into account.

6.4.2 Electrical Energy

The textile industry utilises electrical energy predominantly for driving production machinery in the textile process. In addition, there are other auxiliary services that will require motor-driven mechanical applications like pumping, fan and compressed air systems. These systems often consume more electricity than the actual production machinery. Optimisation of these systems could lead to significant savings without affecting the production output.

6.4.2.1 Energy Tariff Review (Electrical)

Often companies follow an evolutionary growth path. At inception, an energy tariff may be appropriate. Tariffs are rarely checked and updated. Supply authorities (Eskom and local municipalities) have also evolved their tariff structures to encourage certain consumption patterns. In addition, the use of smart metering has enabled more appropriate tariffs to become available. Smart meters have enabled the recording and storage of energy data using a specified time base. Opportunities here would include:
1. Periodic tariff review assessment – this can often be done with the assistance of the local supply authority personnel.
2. Where a time-of-use tariff is applied, a load-shifting assessment can be done for periodic energy-intensive processes to ensure these are completed during a period of low energy rates.

These opportunities do not necessarily generate energy savings as such, but can result in a lower overall cost of energy. The savings generated can then be used to implement energy savings projects that require capital.

6.4.2.2 Compressed Air Systems

Compressed air is a common utility in many plants. It is often misconstrued that because it is only air, it is free. This is often the most expensive form of energy in use in a plant. A unit of energy contained in compressed air would typically require seven units of electrical input energy into the compressor. In simple terms, using compressed air as an energy source is seven times more expensive than electricity. Conservation of compressed air can thus be a significant energy-saving opportunity.

Match Supply to Demand

Understand the requirements for compressed air from a process perspective and then match the supply of compressor (and air receiver) to the demand. Here, peak demand and average demand requirements need to be taken into account as well as future expansion.

Operating Multiple Compressors

- Switch off compressed air system when not required – this is a simple but often ignored strategy. The compressors are left on over the weekend or at night because either nobody has been instructed to swicth them off, or because personnel are not aware of the cost of operations. Starting up the compressed air system 10–15 minutes before production starts is often sufficient to build up the required operating pressure in the system.
- Ensure that each compressor runs in the most economical way. Idling compressors (when there is no demand for air) still consume a lot of energy without any productive output.Compressors, in general, operate most efficiently when fully loaded. An unloaded compressor consumes approximately 35% of its rated power when in unloaded mode. A standby compressor will consume less than 5% of its rated power when in hot standby.
- Stage compressors such that each unit is only brought into operation when the preceding one has reached full capacity.
- When installed, always use the VSD compressor as the final trim in a staging type operating methodology.

System Air Pressure

Use the pressure appropriate to the equipment in the system. Often times the pressure is increased when the pressure at point of use is insufficient to support production. This is usually because of another problem, like piping restrictions, water in piping, leakages, or incorrect air tool. These need to be addressed first before optimising system pressures. A reduction in system pressure of 1 bar will result in a saving of approximately 7% of compressor input power (Atlas Copco, 2015).

Repair Air Leaks

Air leaks represent the most obvious and most common form of optimisation. It is often ignored because personnel are unaware of the real cost of compressed air. In most industrial systems, compressed air leaks would represent from 10% up to 65% of all compressed air generation. Well-maintained systems will have leak rates of below 10%.

Regular inspection and repair should form part of the maintenance strategy for the plant. Walk through each branch of the distribution system, including the air consuming applications and devices. Mark-up all leaks using a tag, and repair as soon as possible during maintenance. Leaks are usually simple to repair. Leaks in difficult-to-access places can be detected by using a special leak detector.

Stop Inappropriate Usage

Most personnel are not aware of the true cost of compressed air and often consider it free as it consists of air. In effect, the cost of 1 kWh of compressed air is equivalent to the cost of 7 kWh of electrical energy. Unnecessary use of compressed air should immediately be identified and stopped. Examples include:

- Using compressed air for cooling of production equipment.
- Using compressed air for cooling of personnel.
- Using compressed air for cleaning of work surfaces or work areas.
- Using compressed air for cleaning of personnel.
- Using compressed air in certain production processes where more energy-efficient alternatives are available. For example, using it for stirring/agitation in a dye vat, or using it to clean out the boiler room, or removing dust and fibres from a loom.

Optimise Piping
- Eliminate or isolate unused sections of the pipes.
- Ensure correct pipe sizing for volume of usage required.
- Undersized pipes can lead to higher pressure requirements and higher leakage losses. Larger pipe sizes will offer reduced losses but require higher capital costs.
- Slope pipes to drain points that are fitted with drain traps that will open to expel water when full.

Heat Recovery
Install heat recovery where appropriate and financially feasible. As much as 85% of all electrical input into a compressor will be converted to heat energy and wasted to atmosphere. If a low temperature heat requirement is located near the compressor room, then consider the use of a heat recovery system for the compressor.

Other General Optimisation Opportunities
- Ensure that the compressor air intake is in the coolest possible place. This would often be outside the compressor house, i.e. in a shaded side. A reduction of 4°C in intake air could lead to approximately 1% power reduction in compressor consumption (Atlas Copco, 2015).
- Install air receivers at the point of intermittent use to limit the cycling of compressors. Air receivers generally allow for more stable operation of systems as they act as dampers to reduce short-cycling.
- Ensure that air treatment equipment is operating satisfactorily.
- Do not 'over treat' the air beyond the requirement of the end use.

6.4.3 Motor Driven Systems

Electric motors account for more than 70% of all electrical energy consumption in industrial systems. Hence, motor optimisation is an important course of action in any manufacturing facility. Motors, however, do not operate in isolation. They are connected to the electrical network on one end and a mechanical load and application on the other end. The motor system in its entirety exists to fulfil a function in the production process.

Following this, the best way to improve a motor system is to view it as a whole system. Figure 6-12 shows the functional diagram of a motor system. It consists of a power source, the motor controls, the actual motor itself, a transmission, the mechanical load application, and finally the actual function of the motor in the production system itself.

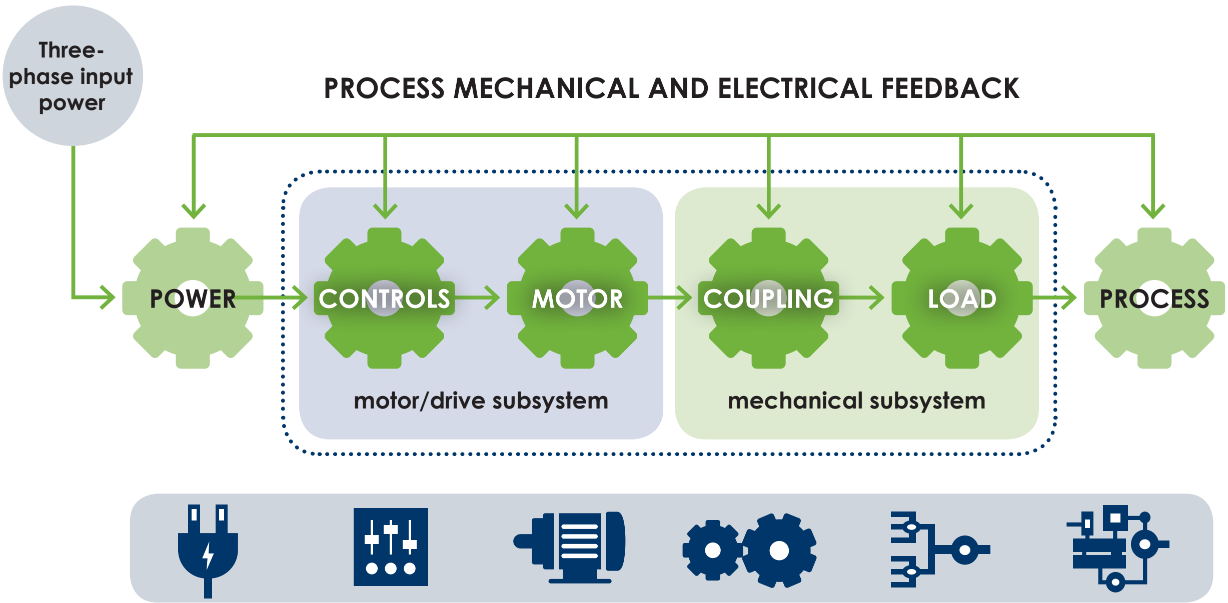
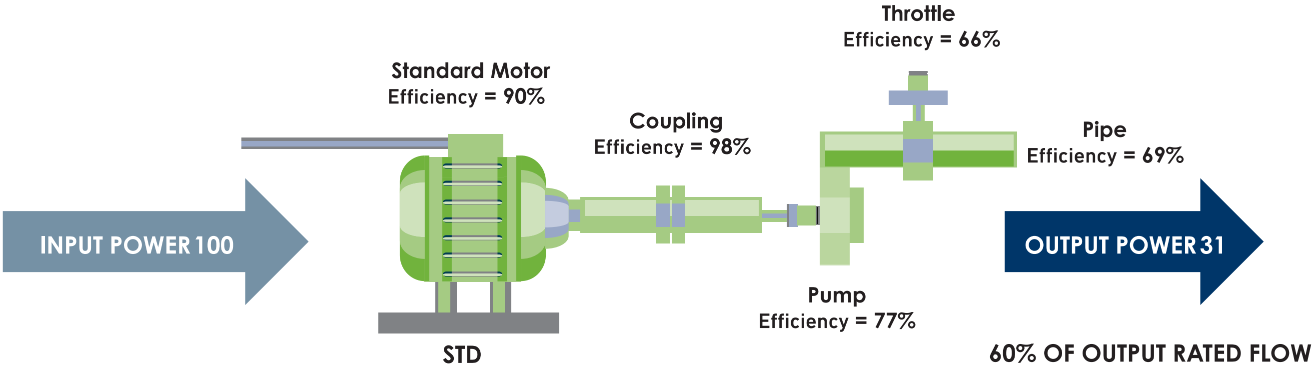


Figure 6-12: The Motor System

Conventional wisdom suggests that the easiest way to improve a motor system is to install a more efficient motor. This is very rarely the case. Figure 6-13 shows the typical system efficiency for a motor system connected to a pump that is transporting some fluid to a production process. The motor itself has good efficiency of 90%, but the overall system efficiency is only 31%. This effectively means that 69% of the total electrical energy input is being wasted in the system.

Improving the motor efficiency from 90% to 95% can be achieved by installing a new technology, high-efficiency motor. However, the system efficiency in this case will only improve to 32%. Improving other components in the motor system will lead to much better improvements with a superior return on investment.



System efficiency is the product of the efficiencies of the individual components

$$\text{Efficiency } (\eta) = \eta_{motor} * \eta_{coupling} * \eta_{pump} * \eta_{throttle} * \eta_{pipe}$$
$$= 90\% \quad *98\% \quad *77\% \quad *66\% \quad *69\% = \mathbf{31\%}$$

Figure 6-13: Typical Motor System Efficiency[34]

In this example, the following improvements were made at a cost equivalent to the high-efficiency motor (HEM):

- Replace throttle control with VSD (eliminate throttle efficiency of 66%).
- Install more efficient pump (improve to 85%).
- Cleaning blockages from piping (improve to 90%).

The system efficiency has improved to 67.5%. In this instance, the losses have been virtually halved, saving 30% of electrical energy consumption, compared with a straight HEM replacement where the electrical energy savings only improved by < 2%.

This systems approach is thus recommended for the analysis of motor systems in any industrial facility including textile plants. Furthermore, it is also recommended to start the assessment by understanding the process needs first.

6.4.3.1 Process Requirements

Understanding process requirements provides the basis of optimisation for any motor system. The most common opportunities here include:

Switching OFF

- Switching off motor systems when the process does not require it. If a production machine is not being used, switch off the auxiliaries associated with it. For example, cooling water pumps, circulating rinse water, heaters, extraction fans, material conveyors.

[34] Source: de Almeida, et al

- Similarly, switching off non-essential motors during lunch hour or over weekends. This includes extraction fans and air compressors. Ventilation fans might be kept going where the building is still occupied.

Adjusting Set Points
- Slowing down motors that have heavy start-up requirements, when not equired. Large motors like those for big extraction fans can cause power quality problems at start-up. Where possible, these motors should be trimmed down to a low speed when not required, thereby reducing energy consumption and improving power quality. Other examples will include fans in boiler houses.
- Adjusting set points depending on the product. In many instances, flow rates or temperatures or pressures are set for the biggest product. When making a different product, these settings are no longer required. For example, when drying different types of fabrics, the settings might be different. Some automation or manual change procedure could be introduced here to allow for the system to be adjusted.
- Adjusting set points depending on the weather or season. Similarly, in high humidity or different seasons, the drying requirements may be different. Ensure that the machines are optimally set to reduce the possibility of over drying.

6.4.3.2 Load Application: Pumps and Fans

The control of the mechanical load application often represents the most practical and beneficial way to improve energy efficiency of a motor system. The majority of larger pumps and fans in a textile plant will be centrifugal pumps. These conform to the affinity laws providing specific relationships between speed of the drive motor, fluid flow, fluid pressure, and fluid power. Reducing the speed of a drive motor will reduce the flow and pressure as well as the power requirement but not in the same proportion.

Identify motor systems that represent good opportunities for improvement. It is recommended to engage a technically competent person to assess each system and recommend appropriate energy-saving strategies. The following should be considered:
- Multiple pumps in parallel.
- Multiple fans in parallel.
- Fans or pumps that operate at part load and cycle on and off fairly regularly during normal production.
- Fans or pumps where the production has dramatically increased or decreased since commissioning.
- Fans or pumps that fail often.

Opportunities for improvement in textile facilities:
1. Ensure that extraction fans are clear and free of debris to keep a maximum vacuum.
2. Check fan ducting for leaks and repair as soon as possible.
3. Check that fan dampers (flow control devices) are working properly, including in the boiler room.
4. Isolate areas of the extraction system where no fan extraction is required.
5. Check for fluid leaks in pump systems and repair as soon as possible.
6. Check that gauges and instruments are working properly and that the correct settings have been applied for the production cycle in operation.

6.4.3.3 Transmission

These are usually gearboxes or transmission belts. They have been designed to operate with the respective motor and mechanical device. As a first approach:
- For gearboxes, ensure maintenance is carried out as per manufacturer instruction.
- For transmission belts, ensure correct tensioning of belts. Sometimes the adjustment of a loose belt can be equivalent in energy improvement to replacing a standard motor with a high-efficiency motor. Hence, screeching belts or loose flapping belts should be adjusted or replaced as soon as possible.

6.4.3.4 Electric Motors

Motor Replacement

As demonstrated with the systems, motor replacement or upgrade is not usually considered as a first approach to improving energy efficiency. However, when a motor fails, it may be financially viable to replace with a high-efficiency motor. The failed motor will have to be replaced or repaired anyway. The energy savings will thus have to be offset only against the extra cost of replacing with a high-efficiency motor.

Motor Maintenance

Ensure that motors are maintained and operated correctly:

- Keep area around motor clean to allow fan to cool motor and heat to be dissipated from the exterior fins of the motor. Fabric fibres that accumulate on the motor act as a thermal insulator, and may cause the motor to operate at a higher temperature, thereby reducing its lifespan.
- Ensure that the motor bearings are greased with the correct type and amount of grease.
- Inspect motors for signs of overheating, or noises, or oil leaks.

6.4.3.5 Motor Controls

Install Automation

Where motor speed control is managed manually, the operator could easily forget to make the adjustment. Installing a feedback loop related to the parameter being monitored will result in more optimal use of the electric motor.

If automation is not possible, ensure that a work procedure is documented and that all operators are trained according to the work procedure.

Install Variable Speed Drive

The most common opportunity here is to replace a mechanical control with a VSD. Savings of up to 75% have been recorded for this type of opportunity.

Advantages of VSDs:

- Energy savings associated to the speed control;
- Improvement of the dynamic performance of induction motors;
- High efficiency of the VSDs (96%–98%) and high reliability;
- High power factor (if active front end is used);
- Small size and location flexibility;
- Soft starting (savings) and controlled/regenerative braking;
- Motor protection features;
- Lower acoustic noise and improvement of the process control; and
- Less wear-maintenance needs of the mechanical components.

Disadvantages of VSDs:

- Higher initial capital cost;
- Inject harmonic distortion in the network;
- Voltage spikes leading to failure of insulation in windings of old motors;
- Bearing current leading to premature failure;
- Introduce a new element in the system (could affect total system reliability); and
- May require additional cooling.

6.4.3.6 Power Quality

Operating the electrical network at the optimal electrical parameters will assist in energy-efficient operation. It is recommended to use a qualified technical person to assist with power quality, to ensure all safety standards are adhered to.

Power Factor

This is a common problem in many manufacturing industries including textile facilities. Optimising power factor can extend the life of electric motors. Although not essentially an energy-saving strategy, power factor optimisation offers good electrical cost savings, and in most cases, will extend the life of electric motors.

It is recommended to contract a suitably qualified person to conduct a power factor review.

System Voltage and Waveforms

- Voltage: Ensure that the actual system voltage is maintained nearest to the system.
- Voltage unbalance: For three-phase supplies try to maintain a voltage unbalance of < 1.5%. This will limit excess heating of motors and prolong the lifespan.
- Harmonics: Ensure that harmonic distortion is kept to a minimum and within the specifications as determined by NRS 048 (power quality standard for South Africa).

6.4.4 Buildings

6.4.4.1 Lighting

Lighting usually represents a quick and easy opportunity to reduce energy consumption. It is also quite visible and creates immediate awareness. In addition to the lamp replacements, it is also essential that the following operational improvements be included:

In many cases, the lighting level can be improved with more efficient lamp replacements, thereby improving morale and productivity. This is an important non-energy benefit of energy-saving opportunities.

Determine the need and compliance level required:

- Illumination level (how much light is actually needed);
- Colour requirements (colour tempertaure and colour rendering index);
- Quality requirements (glare, shadows); and
- Duration of the lighting (how many hours per day).

Compliance lighting levels are described by South African standards for various work areas and work surfaces. These are listed in the Facilities Regulations incorporated into the Occupational Health and Safety Act of South Africa. Many suppliers will offer no-cost or low-cost lighting assessments and will produce a report detailing recommended lighting to meet compliance requirements.

Lighting Control

- Use natural lighting where possible.
- In many instances in large open factories, there is a single switch to light the entire work space. Consider splitting circuits to only allow the correct amount of lighting. For example, at a textile site the security cubicle is situated on the main factory floor. Because there is no separate light switch, the entire factory remains unnecessarily lit at night, just to enable lighting at the security cubicle.
- Automate lighting in seldom-used areas. For example, install motion sensors in warehouses, walkways, stairwells and toilets. Install light sensors for outdoor security lighting, so these are automatically switched on under low light conditions.

Lamp Replacement

Only lamps that are operated for a large number of hours per year should be considered for replacement.

- Replace old incandescent lamps in offices with new modern LED.
- Replace high-power discharge lamps in factories with LED or compact fluorescent equivalent.
- Replace halogen floodlights used for security with LED equivalent.
- Existing fluorescent lamps should only be replaced when they fail.

6.4.4.2 Heating, Ventilation, Air Conditioning (HVAC)

In terms of the general building areas, climatic zones gave been defined in the National Building Regulations. These provide optimised settings for temperature and humidity of HVAC systems depending on location within South Africa as well as season. These recommended settings should be applied:

- Use a central HVAC control where possible.
- Choose settings as recommended in SANS 10400 for the location to ensure the best comfort at minimum energy cost.
- Discourage the use of personal heating and cooling equipment like desktop fans and resistance type heaters.

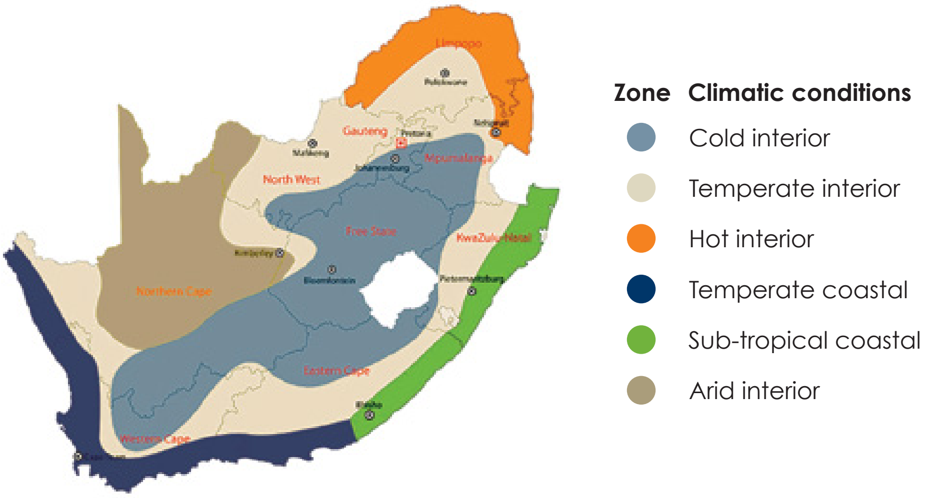


Figure 6-14: Climatic Zones of South Africa[35]

6.4.4.3 Material Conveyancing

Automated conveyancing within the textile industry appears to be limited. The more common method is using manual trolleys or by forklift or reach trucks. Traditional forklifts use diesel or petrol as an energy source. Fuel switching to LPG has become commonplace and does offer some energy savings, as well as improving environmental conditions. Forklifts powered by electric motors using a solar PV system for battery charging has also become a viable alternative.

Factory layout plays a large role in the overall operational efficiency of a production facility. A careful study of the process flow for raw material is necessary. Re-organisation of the production equipment to improve material flow can lead to significant savings in material handling costs. Extra benefits here would also be:

- Reduced idle time for electrical machinery;
- Reduction in overall manufacturing time;
- Improvement in air quality; and
- Reduced risk with safety of driving forklifts.

A shutdown would be necessary to re-organise the production equipment as well as the cost of hiring the rigging and hauling to move the machinery.

[35] Downloaded from: https://www.sans10400.co.za/energy-usage/part-xa-climatic-zones-of-sa/

6.4.4.4 Office Equipment

Recommendations here include:
- Switch off office equipment not in use. These include fax machines and printers that are not used often. These machines consume a small standby power which adds to the base load. It also creates the awareness and drives the change in behaviour for operational personnel to do the same.
- Personal computers used in daily shift operations by administration staff should be switched off when leaving the office.

6.4.4.5 Ablution Facilities

- Install timers or occupancy sensors on lights;
- Use fresh air ventilation where possible to reduce HVAC load;
- Install heat pumps to replace convenional hot water cylinders (geysers); and
- Use waste heat from processes (for example compressed air, boiler exhaust, stenter and dryer exhaust) to heat up water for ablution.

6.5 Alternative Energy

The different alternative renewable sources of energy are biomass, geothermal energy, tidal energy, wind energy and solar energy. Out of these energy sources, solar energy is abundant and is inexhaustible.[36]

Given the current constraints on the supply of electrical energy, renewable energy alternatives have become a priority in some locations. This is especially critical in textile suppliers that have stringent delivery constraints with local retailers. A number of alternatives exist including solar PV, direct solar, wind, small turbine generators, or using excess steam from boilers to drive electrical generators.

Advantages of solar PV include:
- Less reliance on grid electricity;
- Simple and easy to operate;
- Minimal maintenance required; and
- No air emissions.

While it may be advantageous to have the entire facility supplied from a non-municipal source, this may not always be financially possible. Smaller alternative energy systems could be installed to mitigate the effects of load shedding. These include:
- Industrial solar heating for water used in dyeing;
- Heat pumps for low water-heating requirements;
- Solar PV to drive electrical machinery; and
- Recycling heat from industrial processes (compressed air, stenter exhaust, dryer exhaust, dye rinsing hot water).

Vertically integrated textile manufacturers that have their own dyeing, drying and other thermal-related heat processes, will usually have their own boiler. The actual usage of this boiler should be determined. Where spare capacity is available, a backpressure turbine could potentially be installed and utilised to generate electricity with the excess boiler capacity.

While not strictly an energy-saving opportunity, it can assist in mitigating the effects of load shedding and also contribute to energy independence.

[36] https://textilesinside.com/energy-conservation-in-textile-industries-savings/ (Accessed May 2022)

7. CASE STUDIES

From a South African perspective, a number of case studies are presented here that demonstrate actual achievements in energy savings despite the challenges faced in the South African electricity supply industry.

Case Study 1 – Integrated textile mill (Thermal energy)

The company has been in existence for more than 70 years and was one of the first adopters of EnMS and energy-efficient practices in South Africa. It has a fully vertically integrated manufacturing process, including the production of yarn and fabric from fibre. Other processes include weaving, washing, bleaching, dyeing, printing, heat treatment and drying, all of which consume varying amounts of energy. In 2012, the company employed 600 people and produced more than 1.5 million metres of fabric per month on site. Products included home textiles as well as fabrics for use in clothing and the medical industry and were supplied mainly to the local southern African region including more than 200 customers.

The company implemented an EnMS and identified thermal energy as a focus area for improvement. The case study reviews improvements to the thermal energy system.

A number of new practices and projects were identified and improvement projects were initiated. From the steam generation side this included:

No-cost projects (< R10,000):
- Improvements in coal handling work practices;
- Improved maintenance of boilers, e.g. guillotine;
- Improved feedwater quality (reduced from 100 ppm to 50 ppm); and
- Improvements in coal quality – lower breakage levels and higher calorific value.

Low-cost projects (< R50,000):
- More comprehensive steam flow measurement; and
- Use of hand-held flue gas analyser and ongoing monitoring of excess air levels.

Capital cost projects:
- Improved condensate recovery rates (new pumps, repairs to seals, reductions in superheating).

These practices resulted in an improvement in the amount of steam generated per ton of coal. Figure 7-1 shows the improvement in the first year after implementation. Steam tons produced per ton of coal improved from 6.56 tons steam/ton coal to 7.33 tons steam/ton coal, improving by 11.7%.

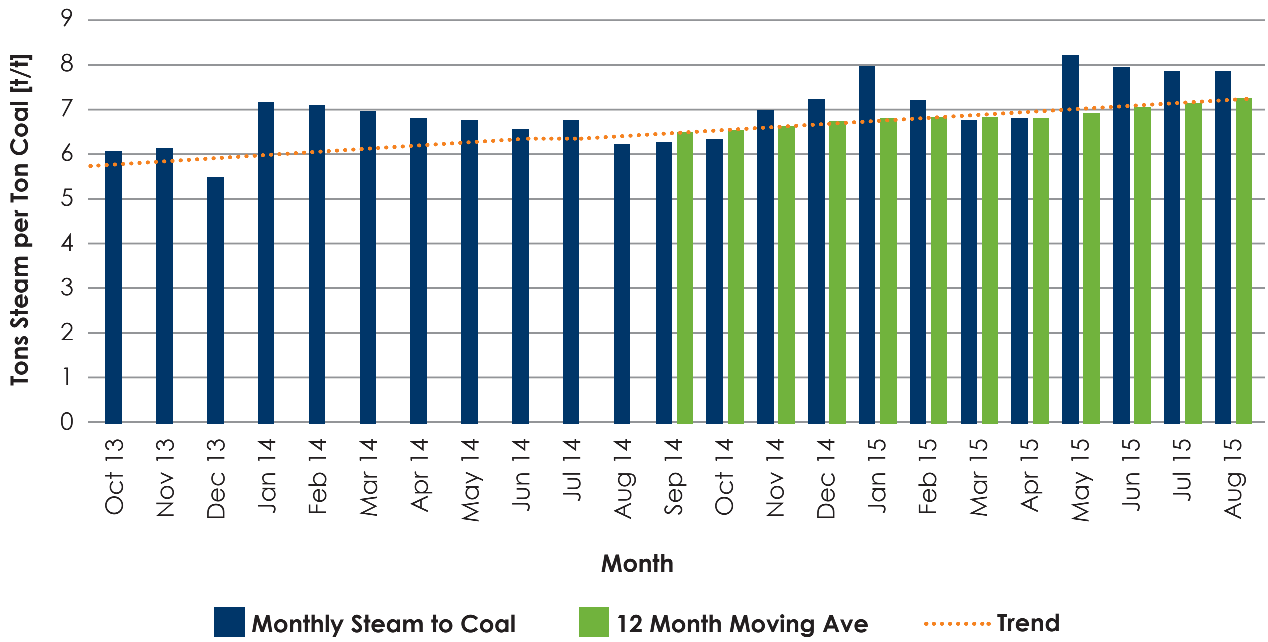


Figure 7-1: Steam Generation Improvement

New practices were also introduced on the steam distribution and usage side. These included:

Low-cost projects (< R50,000):
- Repairs to steam leaks;
- Double-glazed glass;
- Removal of dead legs in the steam reticulation system; and
- New, better insulated production equipment.

Capital cost projects:
- Insulation of steam pipelines; and
- New caustic recovery plant.

These practices resulted in a reduction in the steam usage per unit of production. Figure 7-2 shows the reduction of steam usage in the first year after implementation. Steam tons produced per ton of production reduced from 47.9 tons steam/ton production to 41.2 tons steam/ton production, improving by 14.0%.

Further projects were undertaken over the period 2012–2015, realising a saving of more than 40 GWh of energy and a reduction of 10,000 tons of CO_2.

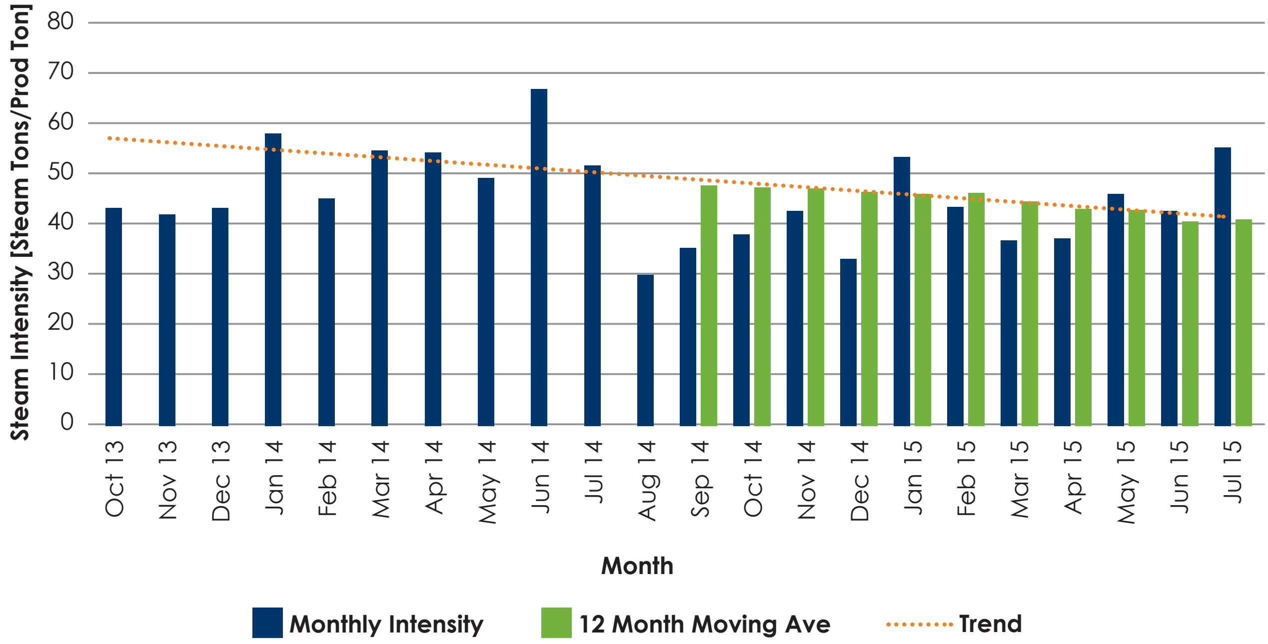


Figure 7-2: Steam Usage Improvement

Critical success factors:
- Focusing on one energy source at a time based on available resources.
- Break-up the system into manageable parts and understand the operation process of each part.
- Developing performance indicators to show the energy improvement to management.

Case Study 2 – Cotton Mill (EnMS)

A large independent spinning mill, founded about 70 years ago, with a monthly production of approximately 1 000 tons of textile. The company produces yarns, produced from cotton sourced mainly from southern Africa and supplied to local and overseas markets.

The company implemented an EnMS in 2015, mainly to combat rising energy costs. The approach was to first optimise existing operations before embarking on a renewable strategy.

Electrical energy savings were realised through a series of behavioural changes with a minimum of capital expenditure. These included the following:

No-cost projects (< R10,000):
- Switching off machines when not required. A review of processes during the EnMS implementation showed that many machines were operating during periods when not required. These included autoclaves and motes.
- Adjusting operation of air conditioning (AC) to minimise use during winter periods. Setpoints for humidity were adjusted depending on the season and AC was switched off in certain areas that did not require cooling and humidification during winter.
- Maintaining significant energy use operational equipment to ensure good performance. Maintenance of machinery included significant energy uses like ring spinners, autoconers, and motes.

- Operating periodically used machinery outside of the peak electricity tariff period. It was identified that certain machinery only operated a few hours a day. A load-shifting exercise was completed to shift these loads to off-peak tariff periods[37].
- Regular awareness sessions to persuade staff to switch off auxiliaries when not required. These sessions were held to develop an energy-conscious mindset and encourage employees to switch off electrical equipment when not required. These included, for example, lights in non-operational areas, personal heaters and fans, and warehouse lighting areas.

Through behavioural changes, the company achieved a cumulative saving of 1.45% of annual energy consumption, with a projected saving of 2.9% per year with no capital expenditure.

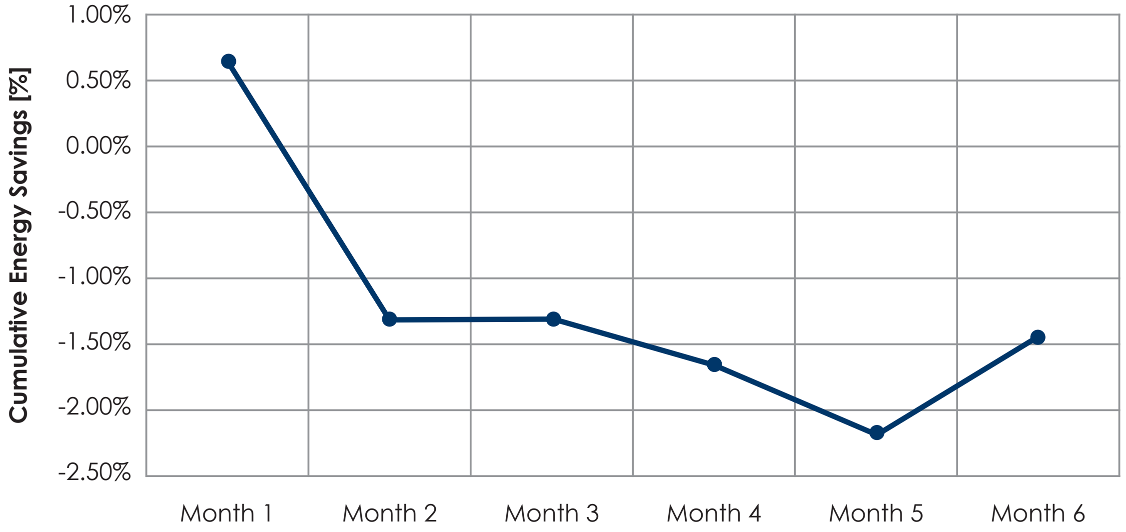


Figure 7-3: Cumulative Energy Saving (6 month)

Critical success factors:

- Awareness training of personnel and encouraging implementation of energy-efficient practices.
- Good understanding of operational processes and how and when machinery is used in the production process.
- Understanding the need for objectives and targets, as well as the metrics to manage it.

Case Study 3 – Industrial Textiles (Compressed Air)

A manufacturer of carpets and artificial grass, the company was established more than 30 years ago. The product offering includes various types of flooring including carpeting, vinyl, artificial grass, underlays and rubber, and distributes to more than 40 countries abroad, as well as locally. Sustainability is a concept that has been long embraced by top management with recycling of materials being introduced as early as 1995.

After adopting and implementing an EnMS and adopting a number of cleaner production opportunities, the company decided to focus on compressed air. This is used extensively in the actual manufacturing process and is also used for control of some machinery.

[37] Not strictly an energy-saving opportunity, it is merely shifting the time period when the energy is being consumed. It does, however, result in a saving in terms of the overall energy bill.

Electrical energy savings were realised through a series of projects related to the compressed air system. These included:

No-cost projects (< R10,000):

- Improved control of compressed air dryers: A no-cost opportunity where changes in operating procedures were made to ensure that:
  - » Dryer control has been integrated to ensure that the correct number of dryers are operational.
  - » Dryers are co-ordinated with other process steps to ensure they function only when the process requires it.
  - » Dryers are switched off when the compressors are not operational.
- Improved control on standby compressors: Improvements were made to ensure that compressors only switch on if and when required and load/unload compressors do not operate unnecessarily.
- Improved maintenance of inlet air filters: Updating the maintenance programme for the inlet filters such that they are now cleaned on a daily basis.

Low-cost projects (< R50,000):

- Identification and repair of leaks: This is done on a regular basis with the cost of diagnostic tools for detection.

Capital cost projects:

- Installation of two new high-efficiency oil-free compressors: Resulted in improvement in product quality as well as energy savings.

Figure 7-4 shows the cumulative savings for the compressed air projects initiated. Although the original assessment was completed in 2017, the no-cost projects were initiated in June 2018 and capital projects (new compressors) only installed in November 2018. Significant savings were achieved from 2019 onwards, once all operating and maintenance procedures were in place.

In the 2019 financial year, the company achieved an energy saving of 15.2% for compressed air energy savings alone.

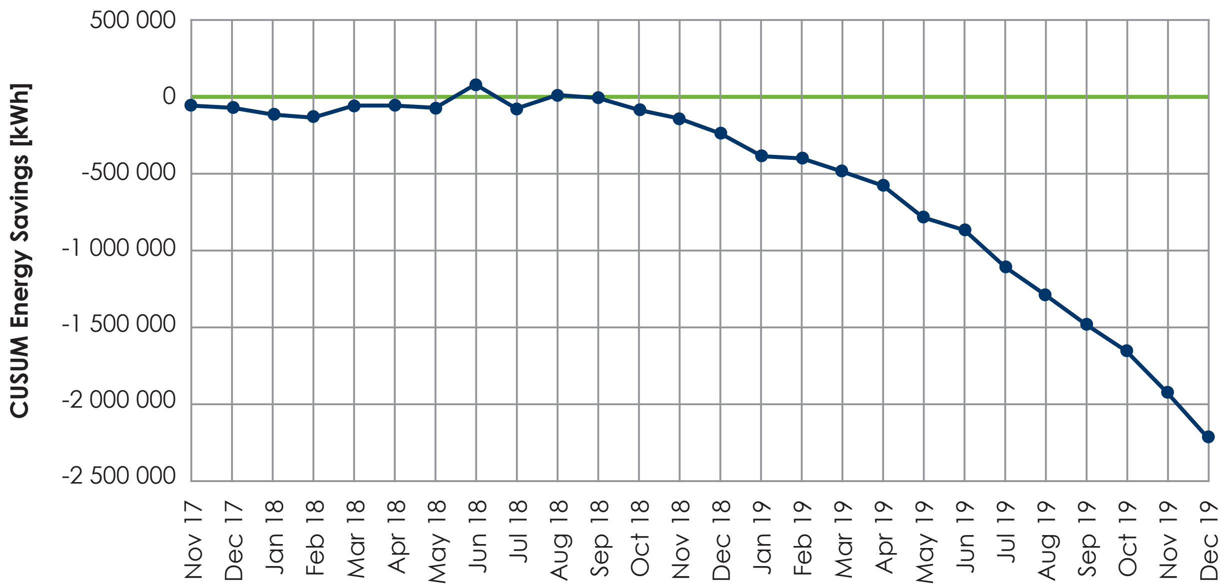


Figure 7-4: Compressed Air Cumulative Savings

In addition to the compressed air, the company also tracked overall energy consumption related to energy-saving projects implemented from the EnMS. Over the same period, the total energy savings amounted to 24.4%. This is equivalent to a consistent annual saving of 11.2% year on year.

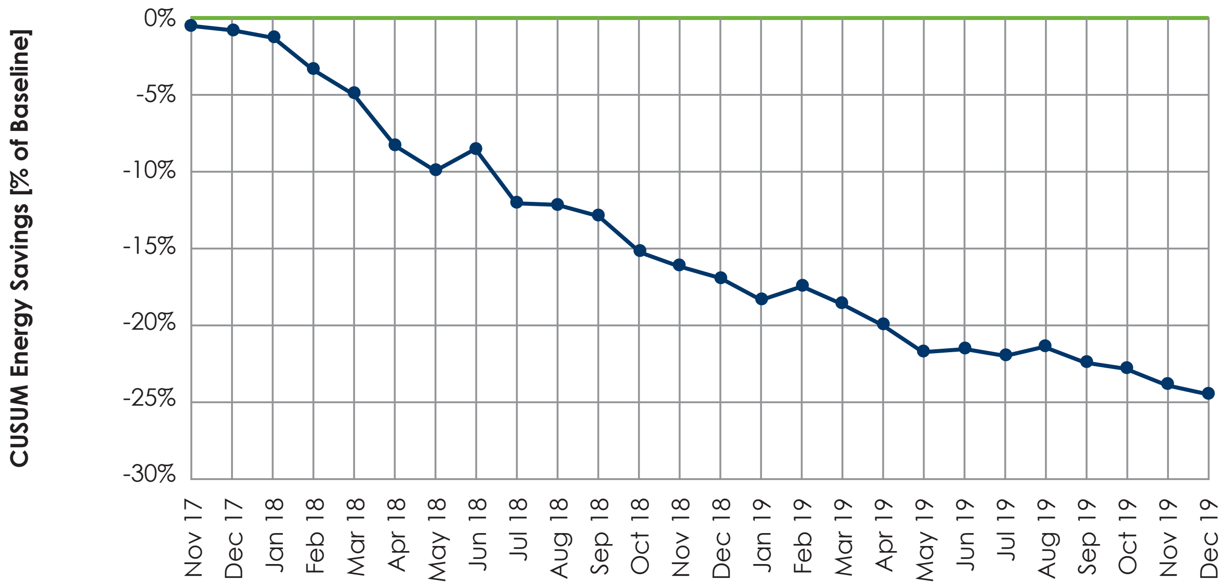


Figure 7-5: Total Plant Electricity – Cumulative Energy Savings

Critical success factors:
- Attitude and willingness of top management to improve and become more sustainable by taking a long-term view.
- Realise the importance of data and the use of energy performance indicators to track energy performance.
- Focus on one area at a time, but remain vigilant about the whole system and how it affects production.
- Open and regular communication with personnel regarding energy efficiency.

Case Study 4 – SME Garment Manufacturer (Steam & Compressed Air)

A small to medium enterprise (SME) that manufactures garments for well-known sporting brands within the athletics and leisurewear sector of the garment industry. The company was faced with an electrical supply constraint at its premises, preventing it from expanding its operations. A reduction in existing electrical energy consumption would allow it to install much needed new machinery to expand its operations and grow the company.

Typical for SMEs, there was no internal technical skills to adequately maintain utilities (steam and compressed air). Over time, there was a steady deterioration in overall equipment efficiency and reliability. The company requested an energy assessment at the facility to determine if there were any electrical energy reduction opportunities available. Following the assessment, management agreed to implement the following energy improvement options:

For steam:

No-cost projects (< R5,000):
- Condensate return lines were repaired to increase return capacity.

Low-cost projects (< R50,000):
- Improved insulation of steam lines and equipment; and
- Repair of steam leakages.

Steam generation capital cost projects:

- The existing two electric boilers were both being utilised at approximately 40% of full load each. A new appropriately sized paraffin boiler was installed.
- A new condensate tank with partial flash recovery capability was installed to improve condensate return and reduce input fuel of the boiler.

For compressed air:

No-cost projects (< R5,000):

- The system pressure was adjusted from 8 bar to 7 bar to better match the process requirements.

Low-cost projects (< R50,000):

- The compressed air leakage rate was initially calculated at 60% of total compressed air output. This was reduced through a systematic programme for leak detection and repairs.

Compressed air capital cost projects:

- A new variable speed drive compressor with a higher capacity was purchased, enabling the compressed air system to better match the fluctuating process requirements.

The switch to a paraffin boiler resulted in a 30% reduction in electrical demand. This allowed the company to install seven new knitting machines and increase production by 15%. Improving the steam distribution system resulted in an estimated steam energy saving of 20%.

The new VSD compressor with new operational set points and improvement in distribution resulted in further electrical energy savings of 15%, allowing for procurement to order an additional seven knitting machines.

The increased production resulted in an absolute increase of energy by 20%, but this was offset by the 15% energy savings from compressed air, as well as further energy savings by switching boilers.

In summary, the energy-saving interventions implemented as a result of the energy assessment, contributed to the company achieving a 30% increase in production, for the same overall energy consumption.

Critical success factors:

- Measurement of energy consumption of various energy sources and machinery allowed top management to use savings from energy improvements to offset the increase in production.
- Small companies can also realise significant energy savings by following the principles of system optimisation and measurement of significant energy users.
- Smart energy savings can result in increasing available capacity for expansion of production, without the need for major electrical infrastructure upgrades.

Case Study 5 – Home & Industrial Textiles (EnMS)

Established more than 50 years ago, this SME produces industrial and home textiles mainly from woven polyester. The company contains a fully integrated textile manufacturing facility including the production of yarns through to the final fabrics and products. More than half of all manufactured products are for overseas markets.

The company conducted a general energy assessment, mainly to mitigate the effect of rising energy costs. The company was interested in a renewable energy solution, but first wanted to take advantage of any no-cost energy reduction opportunities available. From an energy consumption perspective, the most influential processes on site were identified as sizing (drying), dyeing and dye range drying, and heat setting. These were all heat-intensive processes, which were in turn all supplied from an electrical energy source.

No-cost projects (< R5,000):
Some no-cost projects were identified for implementation. These were projects that could be implemented from the existing maintenance budget and included:

- Eliminating dryer standing losses: During standby the dryers were still consuming energy. It was found that the heaters remained on because of a faulty control circuit.
- Geyser timers: Timers were installed to eliminate unnecessary losses during periods of non-use such as weekends and holidays.
- Locker-room motion lighting automation: Motion sensors were installed in locker-rooms to control lighting based on occupancy.
- Awareness initiatives for shift supervisors and security personnel: Making them accountable for ensuring minimal wastage during quiet periods.
- Insulation of shrink-wrap machine: Existing installation was replaced and repacked. This not only reduced standing losses but also reduced warm-up time by 15 minutes.
- New insulation for drum-end of sizing machines: The ends of the sizing machines were found to have no insulation. Additional insulation was installed, reducing standing heat losses and reducing warm-up time by 25%.

Low-cost projects (< R50,000):
With the company planning a major capital project for a renewable energy solution, only a few low-cost projects were approved for implementation, and included:

- LED lighting retrofit programme: Systematic replacement of interior and exterior lighting in an on-going project.
- Compressed air receiver: Installation of a new compressed air receiver.

The company is relatively small and did not have the technology to measure each individual intervention. However, energy reduction could be calculated from production reports and energy bills. The annual saving for these interventions was calculated to be 3.7% of total annual energy consumption.

Critical success factors:

- Setting objectives to identify no-cost and low-cost opportunities.
- Using specialist technical personnel from external sources is a good way to achieve results without incurring major internal costs.
- Non-energy benefits can also be realised from energy-saving projects, including improved safety and a better working environment.

Summary of Case Studies

In summary, the case studies that were reviewed here demonstrated that it is possible to identify, implement and achieve energy savings throughout the sector. This includes the range of sizes from small to large companies, as well as the sub-sector from garment to home and industrial textiles. The energy savings actually achieved are presented in Table 7-1.

Table 7-1: Summary of Case Study Energy Savings

Summary of Case Study Energy Savings					
Intervention	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**
Overall energy saving		2.9%	11.2%	23.1%	3.7%
EnMS (No cost only)		2.9%			
Compressed air			15.2%	15.0%	
Steam generation	11.7%			13.0%	
Steam distribution & usage	14.0%				

Overall energy savings vary from 2.9% to 23% of annual energy consumption. The large variance is dependent mainly on the level of projects implemented. No-cost and low-cost projects have realised savings of less than 5%. Capital projects have resulted in significant energy savings.

Local South African companies have, however, tended to focus on utilities like steam and compressed air. This is understandable where companies use a cautious, less risky approach. Using a systems approach, as with the implementation of an integrated EnMS, will reduce the risk associated with energy improvement projects.

In companies that have an EnMS, companies are more willing to invest capital on energy improvement projects, and are also more willing to implement production-related projects.

Older studies conducted in South Africa also provide some guidance. A study completed in 2015 reviewed the cost benefits of certain common types of energy-saving projects. One such document (NCPC-SA 1, 2015) reviewed cost benefits based on RECP projects within the textile industry. These are summarised in the table that follows.

It should be noted that these are based on cost, not on actual energy units saved. Given the recent rapid rise of energy costs in South Africa, these values could be considered conservative.

Table 7-2: Indicative Cost Benefit of Energy-Saving Interventions

RECP Indicative Cost Benefit of Energy-Saving Interventions (SA)[38]			
Energy Source	**Process**	**Activity**	**Indicative benefit**
Thermal	Steam generation	Combustion monitoring	3–5%
Thermal	Steam transfer	Insulation of piping networks	5–10%
Thermal	Steam generation	Boiler blowdown management	2%
Thermal	Steam generation	Condensate recovery	2–14%
Electrical	Compressed air	Compressor control	5–10%
Electrical	Compressed air	Leak repair	5–10%
Electrical	Compressed air	System pressure reduction	1%
Electrical	Compressed air	Intake air cooling	1%
Electrical	Fans and ventilation	Speed control	10–20%
Electrical	Pumps	Speed control	10–20%

[38] Adapted from NCPC-SA. RECP Guideline for the Textile Industry. (2015). Available from: https://www.industrialefficiency.co.za/guides-and-reports/ (accessed 22 March 2022)

8. CONCLUDING REMARKS

Energy savings have been proven to be achievable within the textile industry in South Africa. Savings generated in case studies reviewed compare favourably with what has been achieved abroad. These cases involve implementation through people, process and technology.

However, current conditions present a major challenge to the textile industry and may affect the uptake and implementation of energy optimisation opportunities. Some of these challenges include a lack of effective and efficient transport infrastructure, industry pressure from parallel cheaper imports, inadequate access to raw material, difficulty to distribute finished goods to market, an aging staff complement and a lack of critical skills.

Despite these challenges, energy savings can still be achieved by using a common sense approach. Understanding the process needs and then matching the supply of resources with these needs will help identify opportunities for improvement. More often than not, no-cost or low-cost opportunities may be identified and implemented through this approach. This includes but is not limited to only energy savings.

It is hoped that this guide will encourage readers to take up the challenge to better understand their manufacturing environments and unlock opportunities for energy improvement within their respective manufacturing environments.

For more information or to request assistance, please contact:

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