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Viyellatex Ltd.

297, Khortoil, Gazipura, Tongi, Gazipur

A Report commissioned by GTZ Progress as part of a Public-Private Partnership (PPP) on Energy Saving Measures in Bangladesh Readymade Garment Industrial Sector

January 2010

Title	Viyellatex Ltd.
Customer	GTZ Progress Energy Saving Initiative Programme
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M J Birks
Energy Consultant
Traversay
86510 Chaunay
France

M Omar Faruq
Faruq M&E Consultants
House 57/D (1st Floor), Road 5, Old Dohs, Banani
Dhaka -1206
Bangladesh

	Name	**Signature**	**Date**
Author	Mike Birks		
	M Omar Faruq		
Approved by	Elke Shrestha GTZ-PROGRESS		

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Executive Summary

GTZ-PROGRESS has entered into Public Private Partnerships (PPP) with the Bangladesh Readymade Garment (RMG) Industry to undertake a Energy Savings Initiative Programme (ESIP). The work is to identify opportunities for energy saving measures that can both help increase company profitability and help meet target energy saving for the companies. This report identifies the energy savings opportunities at Viyellatex Ltd. (VIYELLATEX).

The VIYELLATEX has set up a working group of five employees to undertake and achieve energy savings. This team consists of the following members: -

1. Engr. Abdus Salam — DGM, Maintenance – Team Leader
2. Mr. Sohel — AM, Maintenance
3. Mr. Toufiqur Rahman — Executive Dyeing
4. Mr. Razab Ali — Electrical In-charge
5. Mr. Rabiul Alam — Officer SS

The VIYELLATEX primarily uses electricity and natural gas for its energy source both for captive generators and boilers. They have 4 generators each having 1064 kW capacity. Three steam boilers are used, 2x6 tons, 1x5 tons capacity. In 2008 (Jan-Dec), total energy consumption was 92.0 million kWh and the company paid BDT.42.0 million.

Single energy meter is installed at the intake of electricity from DESCO, and separate individual gas meters are installed each for boilers, generators and for cooking in the Canteen.

Energy Source	Energy Consumption		Energy Consumption Cost		CO_2 Emissions
	Consumption/year (kWh)	%	Amount/year (BDT.)	%	Ton/year
Electricity (Utility)	846,612	1%	3,595,623	9%	593
Natural Gas (Captive generation)	33,872,083	37%	10,597,962	25%	6,978
Natural Gas (Boiler)	57,317,365	62%	27,538,725	66%	11,807
Total Energy consumed	**92,036,060**	**100 %**	41,732,310	**100 %**	19,378

Table 1. Breakdown of energy use, cost and CO_2 emission by fuel type

Improving energy management will provide significant cost savings to the factory. However to fully achieve these benefits more energy data should be collected and analysed on a routine basis, which will require the installation of cost centre-wise new sub-meters. With the installation of sub-metering for electricity to all main consumers of energy, the data collected can be analysed against production figure to give an indication of how energy is consumed per product output.

The company has brought together their Energy Saving Team (EST) which is seen as a very good initiative, and it is recommended that they should be the driving force toward new energy management work in order to ensure that savings measures are undertaken quickly and cost effectively. The committee will be responsible for monitoring the status of plant energy performance, status and action plan. They will also review the non-conformance performance indicators as well as the corrective and preventive action needed to rectify these goals.

The VIYELLATEX runs factory for almost 354 days a year and use natural gas for electricity generation (37%) and significant amount of natural gas for steam production (62%). They hardly use DESCO electricity (1%). Therefore, reducing natural gas consumption in boilers and captive generation will provide significant savings through low cost and medium/high cost opportunities.

The electricity load profile analysis can reduce size of the generators as well as burning of natural gas. Electrical load could be classified as base load, medium load and peak load. Base load is the amount of electricity constantly needed by the factory, medium load is when most of the factory machinery runs and in contrast, peak load is the electricity demanded at a certain peak times and has a short duration. Running oversized generator at a base load is extremely inefficient and costly to operate. A precisely co-ordinated configuration of generators of different capacities, loading each up to 70-80% has proven to be the best solution. The same scenario also applies to both steam boilers and air compressors.

If all the projects identified in the Action Plan are implemented, the aggregated savings represent a 23.4% reduction in energy consumption and a 31.1% reduction in costs; this would give CO_2 savings of 4,846 tonnes pa.

Action Plan

No	Description	Cost	Savings	Savings	Elect.	Natural Gas	Payback	CO_2/yr
		Thousand BDT.	Thousand BDT.	(kWh/yr)	%	%	Years	ton
Zero/Low Cost Saving Opportunities								
1	Power factor correction (energy savings kVr)	Cost penalty paid by Viyellatex in 2008 is BDT.66,859 The company now maintain their PF at 0.9						
2	Compressed air leakage	10	273	447,871	100	0	Immediate	97
Medium/High Cost Saving Opportunities								
3	Steam leakage Pipe Insulation Steam Condensate	1,000	3,324	5,731,737	0	100	0.30	1181
4	Switching to energy saving CFL lights	1,000	1,566	2,569,183	100	0	0.64	557
5	Appropriate mechanical ventilation system design and implementation	500	846	1,388,748	100	0	0.59	538
6	Switching to servo motors in Sewing Machines	1,500	2,459	4,034,312	100	0	0.59	538
7	Improved maintenance and housekeeping practices	2,000	4,515	7,362,885	38	62	0.44	1,597
	Total	**6,010**	**12,984**	**21,534,736**			**0.46**	**4,846**

Table 2. Energy Management Opportunities

The next step in the Public Private Partnerships is for VIYELLATEX to put together an **implementation plan** based on the action plan developed in this audit report. The GTZ audit team will visit VIYELLATEX in February 2010 as part of our Phase 3 work and we will:

1. Present the findings of the Phase 2 work through a Powerpoint presentation to the VIYELLATEX company Energy Savings Team (EST)
2. GTZ Auditors will discuss the action plan and agree with VIYELLATEX implementation plan.
3. Phase 3 of the work will also include some training. It is important that some members of the EST attend the training to:
    a. Get a better understanding of Energy Management opportunities. VIYELLATEX could improve energy management and if they adopt some simple measures VIYELLATEX can make some very high energy and cost savings at little investment
    b. The training will include some help to VIYELLATEX EST on how to implement the energy savings identified in the Action Plan of this audit report. The GTZ team will advise on all aspects of technical energy savings measures

The GTZ auditing team will focus during the Phase 3 training on the issues identified through the work undertaken during the audits however there are some other issues that will be included which are seen as important and represent good energy savings to VIYELLATEX. These are:

1. Energy saving equipment. Electrical motors used at VIYELLATEX probably represent 67% of all electricity consumption and there are lots of good opportunities to limit energy use on motors. GTZ will give tips on the use of energy efficient motors class EFF1 as well as Variable Speed Drives (VSDs)
2. Boiler plant. There are some excellent opportunities to optimise boilers and steam/heat distribution systems. In most cases boiler plant are operated at very low efficiencies in Bangladesh through poor operating practices and design. The GTZ team will advise the training delegates how best to improve their steam systems.
3. Providing VIYELLATEX agree the opportunity will be taken to measure the energy savings from the cloth dryer which features a heat recovery system.

1 Introduction

Viyellatex Ltd. (VIYELLATEX) is a 100% export oriented knit garments having knitting, dyeing, printing, washing, embroidery & garmenting units and was established in 1996. The factory is located on 8 acres of land at 297, Khortoil, Gazipura, Tongi under Gazipur district with a built up area of 53,375 sqm. Electricity is supplied by the Dhaka Electric Supply Company Ltd. (DESCO) and natural gas is by Titas Gas Transmission and Distribution Co. Ltd. Both are Government utility departments.

The product range of VIYELLATEX covers t-shirt, polo shirt, tank top, jog set, suited shirt, rugby shirt, nightwear, fashionable wear, hooded jacket etc.

The present production capacity of the garments section is 2.5-3.0 million pcs/month with 80 sewing lines, knitting section 520 tons/month, dyeing section 780 tons/month. The VIYELLATEX has a complete Effluent Treatment Plant (ETP) with a treating capacity of 70 cubic metres/hr of waste water. Nearly, 5400 workers work for six days a week with Friday as the weekly holiday.

VIYELLATEX ’s major clients are Marks & Spencer, S. Oliver, Esprit, Puma, G-star etc.

2 Energy Audit Methodology

The energy audit team appointed by the GTZ comprises with the following engineers: -

1. Mike J Birks - International Energy Consultant
2. Engr. M Omar Faruq - Electrical Engineer, National Consultant
3. Engr. Tofazzal Hossain - Electrical Engineer
4. Engr. Madhab Bikash Dev Roy - Electrical Engineer
5. Engr. Sabbir Hossain Khan - Mechanical Engineer

The audit team first visited the factory site on 15 Aug 2009. The audit commenced with a kick off meeting with the factory Energy Management Team headed by Engr. Salam, DGM (Maintenance) of VIYELLATEX. Detailed discussions focused mainly in the areas of power factor correction, steam use, leakages, compressed air use, lighting, ventilation and sewing machines. Information from the pre-visit questionnaire was used as the basis for initial questions.

Following the meeting, the team undertook a walk-through survey of the main plant areas including all production areas, electrical substations, power factor improvement units, generator rooms, boiler rooms, air compressor rooms and electricity, steam, compressed air distribution network. The team also looked for energy inefficiency that includes oversized equipment, cooling towers, inappropriate location & installation of air compressors, steam & air leaks, reuse of condensate, and absence of lagging in steam pipelines, design of takeoff bends as well as unregulated open blowing of compressed air. At the end of the site visit a meeting was reconvened to discuss the findings of the walk-through audit. Many more follow up visits were carried out to the factory site and air compressor No-load leakage test was carried out.

SI Units are used for calculating and analysing energy data. Standard formulae are used for calculating plant efficiency, leakage tests, conversion to kWh etc. The Electricity is supplied by Dhaka Electricity Company Ltd. (DESCO) and natural gas is supplied by Titas Gas Transmission & Distribution Co. LTD. Tariff rates of electricity and gas considered in this report are as follows: -

Utility	Rates			Power Factor Correction Charges		Gas Pressure Correction Factor
	Flat (BDT.)	Peak Load (BDT.)	Off Peak Load (BDT.)	Peak Load (BDT.)	Off Peak Load (BDT.)	
Electricity (DESCO)	3.97/kWh	6.73/kWh	3.14/kWh	6.73/kWh	3.14/kWh	-
Natural Gas (Generators)	3.34/m^3	-	-	-	-	2.0862
Natural Gas (Boilers)	4.69/m^3	-	-	-	-	2.0183

Table 3. Electricity and natural gas tariff rates

3 Production Plants and Facilities – Overview

VIYELLATEX is a knit garment industry having knitting, dyeing, printing, washing, embroidery & garmenting units and CAD-CAM design studio.

(1) The sewing section has 2223 sewing machines from famous brands like Brother, Juki, Sunstar Kansai Special, Feiyue, Pegasus machines. Most of the sewing machines are induction type clutch motors. A few sewing machines have servo motors in place of clutch motors. (2) The knitting section has 71 world class circular knitting machines like Pailung, Fukuhara, Mayer & Cie, Terrot etc. (3) The dyeing section has 22 Fongs and Thies machines with a total capacity of 10 tons/day (4) The washing and drying section has 12 Cosmotex machines (5) The finishing section has stenter and de-watering machines from Bruckner and Sun Super, Heliot, Carino and Bianco etc. (6) The embroidery section has 8 Tajima machines.

4 Energy Demand, Usage and Cost

The VIYELLATEX primarily uses electricity and natural gas for its energy source both for captive generators and boilers. In 2008 (Jan-Dec), total energy consumption was 92.0 million kWh and corresponding consumption cost was BDT.42.0 million.

Energy Source	Energy Consumption		Energy Consumption Cost		CO_2 Emissions
	Consumption/year (kWh)	%	Amount/year (BDT.)	%	Ton/year
Electricity (Utility)	846,612	1%	3,595,623	9%	593
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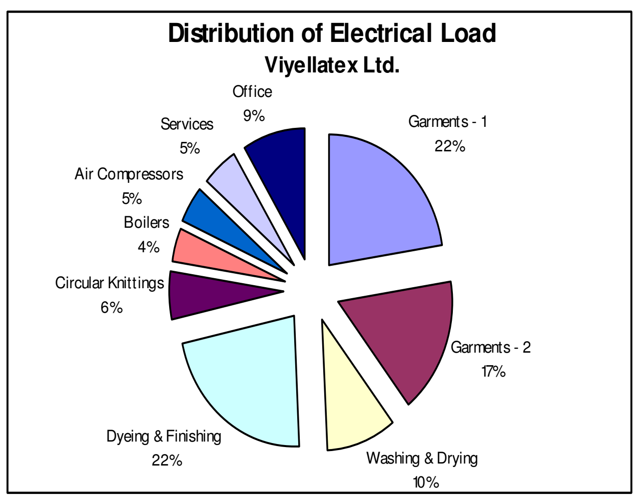
Total Energy consumed	**92,036,060**	**100 %**	41,732,310	**100%**	19,378

Table 4. Breakdown of energy use, cost and CO_2 emission by fuel type

4.1 Electrical Energy Use

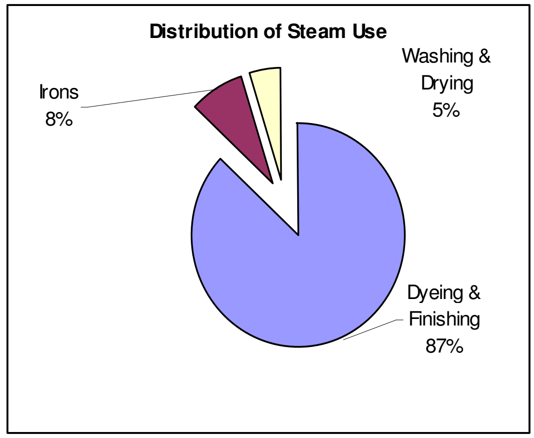
VIYELLATEX has four gas generators of 1,064 kW capacities each. Three generators are housed in one room and one generator is housed in a separate room supplying power to the office building. A 11/0.4 kV, 750 kVA transformer is housed in a separate substation getting power from DESCO. But because of irregular supply of DESCO power, factory generally runs on captive power which takes 25% of the total energy cost of the factory and use 37% of the total gas used. The major load covers sewing machines and tube lights. The second highest is the dyeing & finishing with 22%, washing & drying is in the third position with 10% consumptions; remaining 29% is more or less evenly distributed among office building, circular knitting machines, air compressors, boilers and services.



The electrical energy used by each section shall help to identify where opportunities for savings should be investigated during the survey. Whilst the estimates were supplied by the factory energy team, it was agreed that more information on totals in each of the main areas would be very helpful to get a better understanding of electricity use and therefore identifying energy saving opportunities.

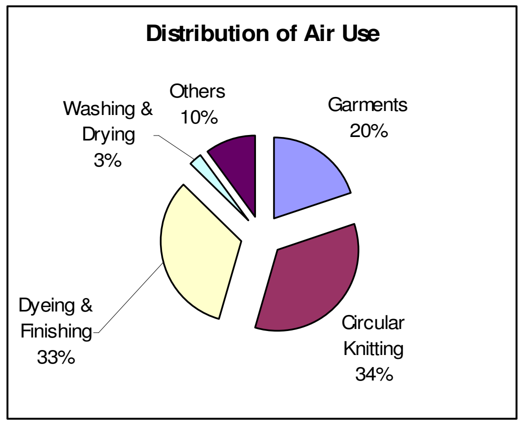
4.2 Steam Generations

Steam is produced by three boilers of total 17 tons/h capacity (2x6 tons, 1x5 tons capacity). The boilers use natural gas for heating which costs 66% of the total energy and consumed 62% of the total gas used and is the highest natural gas consumer of the Viyellatex factory complex at Khortoil. The pie graph identifies the various steam consumers. Dyeing & finishing section consumes 87% of the total steam produced; ironing section consumes 8% and 5% by washing and drying section. One six ton capacity boiler is housed in one room and other two (1x6 tons & 1x5 tons) in a separate room. Boilers in two separate rooms are interconnected to supply large amount of steam to 22 dyeing machines. A line diagram (Annexure-1) is given for clear understanding of the steam distribution network.



4.2 Compressed Air

VIYELLATEX has four screw type air compressors with a total free air delivery (FAD) of 553 l/s. Two 1x145, 1x78 l/s compressors are housed at the first floor of the electrical substation and the other two 1x145, 1x185 l/s are housed at the first floor of the generator room-2. Compressors in two rooms are not interconnected. Compressed air in Viyellatex is used mostly for pneumatic control of machines in dyeing, circular knitting, and garment Unit 1 & 2 as well as for cleaning purposes. A line diagram (Annexure-2) is given for clear understanding of the steam distribution network



4.2 Ventilation

The production floor ventilation is done by large extraction fans of various sizes and evaporative cooling system. Many of the windows were seen open.

4.3 Lighting

Lighting of the production floors and different sections are standard T8 tube lights with magnetic ballast in closely connected matrix format. Floor lights are switched off using circuit breakers on regular basis.

5 Observations and Overall Impression

5.1 Observations

5.1.1 Production Plants and Facilities

Plant machineries are a mixture of world class branded old and new machines. Highest productivity and low energy consumption are obtained when machines are run at 70-80% load.

In Stitching Section, sewing machines run continuously throughout the 8 hours shift in both engage and idle mode. The motor is engaged by clutch plate when the operator needs to use needle for stitching which is hardly last for more than few seconds and may not be more than 1.5 hrs continuous engage time in an eight hours shift. In case of servo motor run sewing machine, it runs only when the needle is engaged saving electricity consumptions during the idle time and can save up to 83% of electricity consumed. Therefore, significant amount of energy use could be reduced and productivity increased if all the clutch motors are replaced by servo motors. According to the operators of servo motor fixed sewing machines, they can deliver at least 20% more output than clutch motor sewing machines.

GTZ Energy Audit Team observed that general housekeeping of the production floor is good but there is an ample scope to improve further.

5.1.2 Captive Generators

The electricity load profile analysis can reduce size of the generators as well as burning of natural gas. Electrical load could be classified as base load, medium load and peak load. Base load is the amount of electricity constantly needed by the factory and in contrast, peak load is the electricity demanded at a certain peak load times and has a short duration. Running oversized generator at a base load is extremely inefficient and costly to operate. A precisely co-ordinated configuration of generators of different capacities, each loading up to 70-80% has proven to be the best solution for cost reduction and energy saving opportunities.

General housekeeping of the generator room is good but there is an ample scope to improve further. Ventilation system of the generator room can't be said adequate. Circuit Breakers, cable joints, electrical distribution boards and cable runs need improvements to reduce system loss.

5.1.3 Electrical Distribution

There is a lot of opportunity in improving electrical distribution system which will not only improve the reliability of the system but will also save energy. Defective distribution boards, circuit breakers, cable joints, cable runs needs replacements. Earthing of the factory buildings, electrical substations rooms, generator room, boiler rooms, air compressor room should be checked so that resistance of neutral to earth remain below 1 ohm during the summer time.

5.1.4 Steam Boilers

VIYELLATEX has 3 Nos. natural gas fired tube boilers with a total 17 ton/hr capacity. The boilers have water pre-heater and steam condensate collection mechanism but needs more improvement. There is no super-heater or economizer installed with the boiler.

Therefore, there is an ample opportunity to reduce burning of the natural gas in the boiler which is 66% of the total energy cost of the factory. Installing air preheater and superheater using hot flue gases from the boiler furnace can reduce considerable gas consumption. Superheater increases temperature of saturated steam without raising its pressure.

Oversize boilers are commonly installed to handle peak demand and anticipate possible expansion. This is wasteful since oversize boilers rarely operate at peak load, and their part-load efficiency can be as low as 20%. Several smaller units can be more efficient and economical than a single large one. They can be sequenced to operate at or near peak efficiency if piped and controlled appropriately.

Viyellatex has a complete steam condensate collection mechanism which carries approx. 25% of the steam heat to pre-heat feed water of the boilers. Part of the cost of installing the energy saving measures has already been taken by collecting the steam condensate.

GTZ Energy Audit team observed that general housekeeping of the boiler room is good but there is an ample scope to improve further. Lagging of the steam distribution and condensate pipes need improvement. Steam take-off bends at the machine and ironing needs redesigning to increase steam pressure and reduce water particles.

5.1.5 Air Compressors

The cost of using compressed air is almost nine times the cost of using electricity and has efficiency of only 10%. 90% of the electrical energy used to produce compressed air is not converted into useful energy. This is because of the inefficiencies of the motor running the compressor, the compressor itself, and leaks in the system, friction loss in the piping, air pressure reductions, and the inefficiencies of the device or process where the compressed air is finally applied. The reduction of the operating pressure by 1.0 bar will result in saving of about 6-10% electricity cost.

VIYELLATEX has 4 Nos. screw type compressors with a total Free Air Delivery (FAD) capacity of 553 l/s. As such GTZ energy audit team focused on the energy saving opportunity from the compressed air system. The team observed that there is a 1.0 to 1.5 bar pressure drop between the compressor and the final connection point whereas allowable pressure drop should not exceed 0.1 bar. Pressure drop is the main cause of increased energy consumption and underperforming air driven tools and pneumatic controls. The team did "No-load air leakage" test to ascertain the air leakage and found 53% leakage in the system.

The location of the air compressor room is also important as 4^0C lower inlet air temperature results in 1% increase in efficiency. Lower inlet air temperature can reduce substantial amount of energy use. As such air compressor rooms should not be located near or adjacent to a boiler or generator room since high room temperature increases inlet air temperature of the compressors. The apertures for inlet air should be located in shaded walls and not in direct sunlight. Acceptable limit of compressor room is maximum 40^0C.

An air demand analysis can reduce size of the compressors that are being used now at the factory. Air demand can be classified as base demand, medium demand and peak demand. Base demand is the amount of air constantly needed by the factory and in contrast, peak demand is the air demanded at a certain peak times and generally has a short duration. Running oversized air compressor at a base demand is extremely inefficient and costly to operate. A precisely co-ordinated configuration of compressors of different capacities, each loading up to 70-80% has proven to be the best solution for cost reduction and energy saving opportunities. Besides, 94% of the heat could be recovered and reused from the compressed air production which will give additional energy savings.

GTZ Energy Audit team observed that general housekeeping of the compressor room is not adequate and needs further improvement. Scraps kept in the compressor room require removal and electrical panel boards need improvement. Ventilation system of the room should be such that compressors always get cool inlet air at least lower than 40^0C.

5.1.6 Ventilation

The ventilation system of a factory is often overlooked in terms of design and concept where not much emphasis is given. A badly designed ventilation system can actually become an outlet for energy waste and worker's discomfort. The goal of a proper design is to achieve a good indoor quality in a closed environment while minimizing energy usage in an optimal manner. Proper ventilation is also a requirement in some areas under Occupational and Safety Standards (OSHA).

Ventilation is the intentional movement of air from outside a building to the inside using either thermodynamic property of the medium, using naturally induced pressure differential or by mechanical system. By creating ventilation, indoor air pollutants, moisture, chemicals, odour can be removed from the factory floor and also providing human comfort in a closed environment.

The GTZ energy team observed that evaporative cooling system as well as various sizes of air extraction fans are used in the floor and kept some of the windows open which causes losing of pressure differential, worker's comfort and increase in energy usages. By blowing in air and extracting air at the same time, the floor will be balanced or be slightly negative or positive. This condition will hinder the ventilation rate as there will not be enough pressure differentials to create an effective air movement.

Therefore, it is essential that appropriate ventilation design is done to improve indoor air quality and worker's comfort. The main target should be the required Specific Energy (ES) of the floor which is the ratio of the required output, airflow and the energy used.

5.1.7 Lighting

The factory floor lighting is also an area which is taken lightly. Standard fittings are almost always installed because it is the easiest and lowest cost method. Efficient lighting design may be higher than standard cost, but 30-40% more efficient when compared to the standard lighting.

At present there are several types of new technology available that can be used to improve lighting efficiency and reduce electricity consumptions. Compressed Florescent Lamp (CFL) bulbs and Light Emitting Diode (LED) bulbs are gaining popularity in recent years. Standard tube lights (T8) along with the magnetic or electronic ballast can easily be replaced by energy saving CFL bulbs without compromising machine operator's illumination requirement.

The GTZ energy audit team observed that many of the lights are still on while operators were not seen around. Occupancy sensors could be installed so that lights are automatically switched off when operators leave the working table and switched on when they come back.

5.1.8 Computer Monitors

A 15" Cathode Ray Tube (CRT) computer monitor draws up to 230W power where new technology high resolution Liquid Crystal Display (LCD) monitor draws only 135W of equivalent size. This lower power consumption will save 58% energy for each of the computers. Instantaneous response shall come from the UPS which can support the computer for a longer period when power supply is absent.

5.1.9 Electrical Earthing System

Earthing of a building by itself does not save energy. It is the cause and effect that saves energy. Earthing of an electrical system with a resistance less than 1 ohm improves the performance of the equipment, motors, lights and machines. A good low resistance earthing system takes out harmful and destructive transients and harmonics in the electrical system that reduces premature failures and heat generations resulting in efficient operation of equipment, motors, machines, lights, cables etc. Motors draw less power when it is cool and thus saves energy.

5.2 Overall Impression

Based on the GTZ energy audit team experience from the walk-through audit, energy savings in terms of gas bills of BDT.4,956,971 should be possible at Viyellatex Ltd. (VIYELLATEX). However, significant amount of energy saving could be achieved in terms of electricity and gas bills if standard tube lights with CFL bulbs, changing clutch & plate motors to servo motors are replaced. Optimizing usage of existing generators, boilers and air compressors based on the load demand (base load, medium load and peak load) analysis and improvement in electricity, steam and compressed air distribution network can save electricity and future capital investment. Besides, improvement in substations and factory buildings earthing and balancing electrical load distribution system shall reduce voltage drop, overheating of cables, motors, and panels as well as increase in machinery efficiency.

Savings in energy usages from changing of clutch & plate sewing machines to servo motor sewing machines and tube lights to CFL lights shall collectively facilitate new factory expansion without further capital investment for additional power.

6 Energy Management Recommendations

6.1 The Current Situation

An assessment of the current position of Energy Management at VIYELLATEX has been undertaken and is indicated in the Energy Management matrix Table 6 below. The matrix is used internationally to assess the opportunities for improvement in six key areas as shown. Based on the audit team assessment, VIYELLATEX has not done very well and could do much more to improve the level of energy management resulting in some good energy savings at low cost. Typical energy savings would be between 5-10% dependent on the current level of energy management and because VIYELLATEX could do a great deal to improve it, we have used 8% to identify the savings opportunities.

Energy Management Improvement	
Total project cost	**2,000,000 BDT**
Annual energy savings	**7,362,885 kWh**
Annual cost savings	**4,515,000 BDT**
Simple payback on investment	**0.44 years**
Annual reduction in CO_2 emissions (tons)	**1,597**

Table 5. Energy management opportunities for VIYELLATEX Ltd.

6.2 Analysis of the Current Energy Management Position

Energy Management Matrix

Level	Energy Policy	Organising	Motivation	Information systems	Marketing	Investment
4	Energy policy, action plan and regular review have commitment of top management as part of an environmental strategy	Energy management fully integrated into management structure. Clear delegation of responsibility for energy consumption.	Formal and informal channels of communication regularly exploited by energy manager and energy staff at all levels.	Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking.	Marketing the value of energy efficiency and the performance of energy management both within the organisation and outside it.	Positive discrimination in favour of 'green' schemes with detailed investment appraisal of all new-build and refurbishment opportunities.
3	Formal energy policy, but no active commitment from top management.	Energy manager accountable to energy committee representing all users, chaired by a member of the managing board.	Energy committee used as main channel together with direct contact with major users.	M&T reports for individual premises based on sub-metering, but savings not reported effectively to users.	Programme of staff awareness and regular publicity campaigns.	Same payback criteria employed as for all other investment.
2	Un-adopted energy policy set by energy manager or senior departmental manager.	Energy manager in post, reporting to ad-hoc committee, but line management and authority are unclear.	Contact with major users through ad-hoc committee chaired by senior departmental manager.	Monitoring and targeting reports based on supply meter data. Energy unit has ad-hoc involvement in budget setting.	Some ad-hoc staff awareness training.	Investment using short-term payback criteria only.
1	An unwritten set of guidelines	Energy management is the part-time responsibility of someone with limited authority or influence.	Informal contacts between engineer and a few users.	Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department.	Informal contacts used to promote energy efficiency.	Only low cost measures taken.
0	No explicit policy	No energy management or any formal delegation of responsibility for energy consumption	No contact with users.	No information system. No accounting for energy consumption.	No promotion of energy efficiency.	No investment in increasing energy efficiency in premises.

Table 6. Energy management matrix assessment for VIYELLATEX LTD.

6.3 Recommended Energy Management Actions

VIYELLATEX could improve their energy management and in order to do so, they need to undertake the following:

- **Policy -** VIYELLATEX should prepare a one page energy policy and post it in a prominent position in the factory so that all staff can see the commitment that the management is making to energy savings. The Policy should be signed by the company CEO. This will also be helpful to demonstrate to potential clients when they visit. Page 2 of the document should include an Action Plan similar to the one shown in the summary of this report and it should also identify the timescale to make the improvements. The Action Plan should be updated on a regular basis, every six months is suggested.
- **Organizing** - VIYELLATEX should include energy efficiency and conservation on its board meeting agenda and the head of the energy team should report on progress. This action again raises the profile of energy management.
- **Motivation -** Give all staff feedback on energy savings. The members of the energy team should use any meetings held with the workforce to promote energy savings.
- Information systems - VIYELLATEX should produce information leaflets or have a 'green notice board' giving details of energy savings and how the company is progressing to meet their targets.
- **Marketing** - Promoting energy efficiency both inside the company and to VIYELLATEX customers would help raise the profile. It would also help to encourage staff to participate in good practice and might be a good promotional tool of green credentials to any customers.
- **Investment –** VIYELLATEX have invested in some good energy and environmental measures however there are some low cost opportunities. Any financial savings should initially be used to invest in more energy saving measures which will help to pay for any medium or high cost savings opportunities. The company should actively invest in energy savings measures.

7 Technical Energy Saving Opportunities

Utility	Rates			Power Factor Correction Charges		Gas Pressure Correction Factor
	Flat (BDT.)	Peak Load (BDT.)	Off Peak Load (BDT.)	Peak Load (BDT.)	Off Peak Load (BDT.)	
Electricity (DESCO)	3.97/kWh	6.73/kWh	3.14/kWh	6.73/kWh	3.14/kWh	-
Natural Gas (Generators)	3.34/m^3	-	-	-	-	2.0862
Natural Gas (Boilers)	4.69/m^3	-	-	-	-	2.0183

Table 7. Electricity and natural gas tariff rates

The above figures exclude VAT and any standing charges.

Calculations have been made to identify the fuel use and from this, the level of $C0_2$ has been calculated at:

- Electricity (DESCO) 0.700 tCO_2/MWh
- Electricity (Captive generation by diesel) 0.263 tCO_2/MWh
- Natural gas fired boilers 0.206 tCO2/MWh

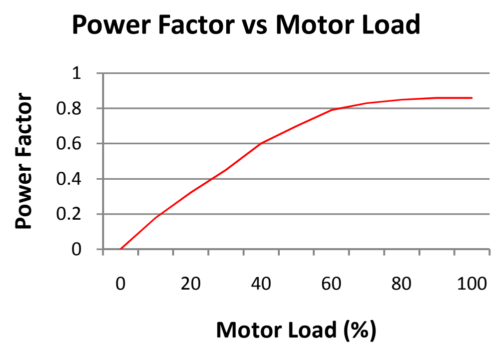
In Phase 2 of our work the GTZ team have updated the CO_2 data in line with Bangladesh Government published statistics. For electricity generation delivered from the supply network which in Bangladesh is predominantly generated by natural gas burning power stations a figure of 0.7tCO2/MWh has been used. This level of CO_2 use takes into consideration the transmission and distribution losses on the electrical network and therefore represents the CO_2 calculated of electricity delivered to the 'factory gate'. For VIYELLATEX the amount of electricity taken from the district supply network is a very small percentage of the total and for this reason the base line CO_2 data (energy used January to December 2008) has not changed significantly.

For natural gas and diesel fuel used for 'on-site' generation and for use on boilers and process burners the CO_2 emissions used are based on the CO_2 content of the fuel.

7.1 Power Factor Correction (PFC)

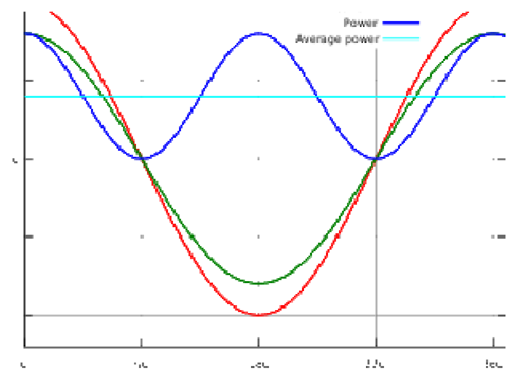
In an electric power system, a load with low Power Factor (PF) draws more current than a load with a high power factor (range from 0 to 1.0) for the same amount of power requirement. Low power factor reduces electrical system's distribution capacity by increasing current flow, causing voltage drop, overheating of cables, motors and premature failures of motors and other inductive equipment. The higher currents increase the energy lost in the distribution system. A load with a power factor of 1.0 (a purely resistive load) will result in the most efficient loading of the supply. In a purely resistive AC circuit (PF=1) or appears to be resistive, voltage and current waveforms are in phase, changing polarity at the same instant in each cycle as shown in the Graph 4.

Because of the costs of larger equipment and wasted energy, electrical utility department usually charge a higher cost to industrial customers where there is a low power factor. Dhaka Electric Supply Company (DESCO) charges for low power factor when it goes below 0.9. VIYELLATEX paid BDT.66,859 for low power factor penalty by the DESCO in 2008. 26% current could be reduced when power factor is improved from 0.7 to 0.95. Graph 5 indicates the waveforms of voltage, current and power when the system has PF=0.7. Inductance in the motor windings somewhat delayed current flow, resulting in a phase shift by 45^0. This transmits less net power than perfectly time matched voltage and current (Graph 4.) of the same RMS values.



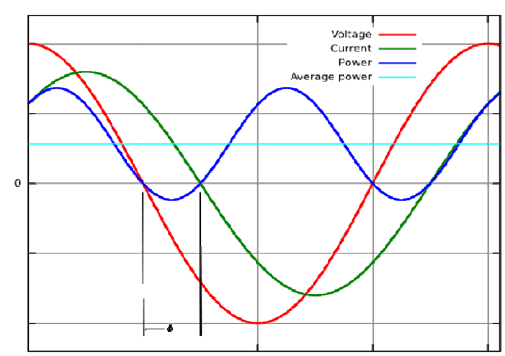
Graph 6. Illustration of Power Factor vs Motor Load

The expression "Power Factor Correction" refers to reducing the reactive power (kVAr) in an electrical circuit by adding capacitors (power factor improvement panel or PFI panel) in parallel at the switch board or distribution boards which is known as bulk correction. The reactive power is induced to the circuit by motor windings, transformer windings, tube light magnetic ballasts, solenoid coils and similar equipment that have magnetic components. High reactive power translates to low power factor.



Graph 4. Illustration of Voltage, Current and instantaneous Power Waveforms when PF=1

The readymade garment industry in Bangladesh uses large number of motors in the production process and magnetic ballasts for tube lights. The GTZ Energy Audit team had measured production floor Power Factors in factories and found PF in the range of 0.34 to 0.85. The large variations of power factor may be due to idle running of large numbers of motors and presence of magnetic ballasts for tube lights. Clutch & Plate motors of sewing machines run continuously at "No-load" conditions. The motor is engaged by clutch plate when the operator needs to use needle for stitching which is hardly last for more than couple of seconds and may not be more than 1.5 hrs continuous engage time in an eight hours shift causing lower power factor of their electrical system as well as higher energy consumption.



Graph 5. Illustration of Voltage, Current and instantaneous Power Waveforms when PF=0.7.

Variation of loads in motors significantly affect power factor. A motor running with "No Load" will have low power factor and a motor running at full load may have a relatively high power factor. Between the No Load point and Full Load point, the power factor increases steadily with the loading. These trends can be seen on the typical power factor vs. motor load performance data in Graph 6. The graph shows that with the 20% motor loading power factor remains around 0.3 and steadily increases up to 0.85 when motor attains load more than 70% and thereafter not much changes in power factor.

Therefore, in order to save energy and reduce operational cost it is essential that capacitor bank is installed in each floor to improve power factor. Significant power factor improvement can also be achieved if clutch & plate sewing machines are replaced by servo motor driven sewing machines and tube lights with magnetic ballast by energy savings CFL bulbs having appropriate lightshades.

VIYELLATEX presently maintains power factor greater than 0.90.

7.2 Compressed Air Leakage

In Viyellatex, compressed air is estimated to use 3% of the total electricity consumed on the site, equivalent to 1,041,561 kWh/year. In general, 10 kWh of electricity is required to generate 1 kWh of compressed air and most of the electrical power is turned into waste heat. It is therefore an expensive and valuable commodity and every opportunity should be taken to optimise the system. The distribution network of the compressed air is attached in Annexure – 2.

The GTZ Energy Audit team had measured the air leakage on the compressed air system which was 53% of all air generated. Leakages in the distribution system usually do not have adverse impact on the production process, are not visible and in most cases remain undisclosed. VIYELLATEX should aim to reduce this to no more than 10%. Reducing compressed air leaks is a very simple task that can be undertaken by the maintenance department, and although there is little cost involved, it does need to be checked regularly to ensure that leaks are kept to a minimum. If this could be achieved, then the potential energy savings would be 43% of the energy used to produce compressed air each year. The following table identifies the possible savings.

Repair Compressed Air Leaks	
Total project cost	**10,000 BDT**
Annual energy savings	**447,871 kWh/year**
Annual cost savings	**273,000 BDT**
Simple payback on investment	**Immediate**
Annual reduction in CO_2 emissions (tons)	**97**

Table 8. Annual cost savings due to compressed air leakage repair

7.3 Steam Leakage, Improved Pipe Lagging and Return More Steam Condensate

VIYELLATEX has 3 Nos. natural gas fired tube boilers with a total 17 ton/hr capacity. The boilers have water pre-heater and steam condensate collection mechanism but needs more improvement. There is no super-heater or economizer installed with the boiler.

87% steam is used in dyeing and finishing section, 8% in ironing section and 5% in washing & drying section. A line diagram of steam use is attached in Annexure A. Heat radiation by naked condensate return pipes were 123^0C as measured by the GTZ Energy Audit team. This additional heat contributes to increased temperature. Uninsulated steam distribution and condensate return lines are a constant source of wasted energy. The table 9 shows typical heat loss from uninsulated steam distribution lines. Insulation can typically reduce energy losses by 90% and help ensure proper steam pressure at plant equipment.

The auditing team believes VIYELLATEX could reduce the steam use and therefore the fuel used to generate it. The steam pipe lagging could be improved, more and better lagging of pipes should be installed and the company should recover more steam condensate. A great deal of cost goes into generating steam in terms of fuel, chemicals and water, and not returning condensate which is a valuable commodity, is very wasteful.

Distribution line Diameter (Inches)	Heat Loss Per 100 ft of Uninsulated Steam Line (MMBtu/yr)			
	Steam Pressure (psig)			
	15	**150**	**300**	**600**
1	140	285	375	495
2	235	480	630	840
4	415	850	1,120	1,500
8	740	1,540	2,030	2,725
12	1,055	2,200	2,910	3,920

Table 9. Heat Loss per 100 ft Uninsulated Steam Line

The GTZ Energy Audit team walked through the steam distribution network and observed that the system has gradual expansion in line with the factory demand. Pipe lagging in initial installations deteriorated in places that need replacements. Reducing the length of the existing steam pipes, and insulating control valves and fittings shall have energy savings and reduce heat radiation as well as room temperature. 10% of the fuel used to generate steam is expected to be saved through rectification of above mentioned relatively low cost measures.

The table below identifies the savings potential, cost and payback that could be expected.

Steam System Improvements	
Total project cost	**1,000,000 BDT**
Annual energy savings	**5,731,737 kWh**
Annual cost savings	**3,324,000BDT**
Simple payback on investment	**0.30 years**
Annual reduction in CO_2 emissions (tons)	**1,181**

Table 10. Annual cost savings due to steam system improvements

7.4 Lighting Systems

Double florescent tube lights with magnetic ballasts are common lighting fixtures of Bangladesh readymade garment industries. Tube lights are set either in line or in matrix configuration. Magnetic ballast lowers power factor, generates heat, induces harmonics, creates noise pollution and draws 12-13 W power. Many factories install individual capacitors for each of the magnetic ballast to improve power factor. Energy saving compressed florescent Lamp (CFL) lights is gaining popularity in recent years which has replaced tube lights along with its magnetic or electronic ballasts, giving same amount of visible lights. The luminous efficacy of CFL light source is typically 60-72 lumens per watt (lm/W) as against 8-17 lm/W for incandescent bulbs. For a given light output CFL uses 20-33% of the power equivalent of incandescent lamps. The table 11 gives equivalent light power of CFL and incandescent bulb.

Luminous Power (lm)	CFL (W)	Incandescent (W)
450	9-13	40
800	13-15	60
1100	18-25	75
1600	23-30	100
2600	30-52	150

Table 11. Power (W) Equivalent of CFL against Incandescent

GTZ Energy team did Illuminance tests on CFL lights to replace standard tube light sets at the sewing floor using Lux meter in factories under this project. Three 11.5” x 10.5” (dia. x height) lightshades with inside matt finish (attached picture) were fitted with three spiral shape, daylight, 23W CFL bulbs and data were collected at the sewing table top by using Lux meter. The following table 12 gives the test results:

Light Details		Power Consumption (W)	Illuminance at Sewing Table Top (Lux)				Improvement in Illuminance (%)	Energy Savings (%)
			Table 1	Table 2	Table 3	Average		
1.	2x40W with standard ballasts tube light set with shade	90.6	398	460	450	436	-	-
2.	1x23W CFL bulb with lightshade	23.0	676	648	636	653	49.77	**74.61**

Table 12. Testing of Illumination and power consumption of CFL bulb and tube lights

The above results show that a 23W CFL bulb can easily replace 2x40W tube lights with standard ballasts but gain 49.77% Illuminance and achieved 74.61% power saving. Higher Illuminance level could be achieved by simply changing to higher wattage CFL bulb. CFL light also radiates less heat than standard tube light and ballast. VIYELLATEX has approx. 3000 tube light sets (40W) equivalent to 159 kW load. If tube lights are replaced by CFL lights, VIYELLATEX will not only save in power consumption but also improve power factor.

VIYELLATEX should make some investments in energy saving lighting. Very good savings potential has been identified by the energy audit team through investment in compact florescent light fittings. Energy used on lighting at VIYELLATEX is estimated at 10% of all electricity, the savings potential is estimated at 74% which is a good contribution to the total. The installation of saving measures is not complicated and easily accomplished at medium cost.

Picture 1 & 2. Illuminance tests carried out by GTZ Energy Audit Team with recommended lightshade

The savings opportunities are identified in the table below:

Lighting Systems	
Total project cost	**1,000,000 BDT**
Annual energy savings	**2,569,183 kWh**
Annual cost savings	**1,566,000BDT**
Simple payback on investment	**0.64 years**
Annual reduction in CO_2 emissions (tons)	**557**

Table 13. Annual cost savings due to improvement in lighting system

7.5 Ventilation Systems

Ventilation is necessary to remove or dilute CO_2, odors, and other contaminants from occupied or production process spaces. Air contaminants are defined as gasses, such as CO, CO_2, volatile organic compounds (VOCs), particulates, and other substances that affect indoor air quality (IAQ). Ventilation in industry is the intentional movement of air from outside a building to the inside using either thermodynamic property of the medium, using naturally induced pressure differential (opening windows) or by mechanical system (using fans or blowers). The mechanical system or dilution ventilation is designed to change a specific volume of air per minute. The number of air changes depends on the nature of activity and number of people within the room. ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) standard 62-1989 recommends that a human occupied area should be ventilated at a rate of 0.42 cubic meters per minute or minimum 7.1 litres per sec per person in non-smoking areas regardless of occupant usage. The CO_2 level should remain below 700 ppm greater than outdoor CO_2 level.

The GTZ energy team observed that most of the factories under this project have mechanical dilution ventilation system with big air extraction fans in one side of the production floor and windows are open in other side of the floor but still room temperature and humidity is higher than expected. The reason that could be attributed to such situation is that the extraction fans were not able to do the required number of air changes/hour within the production floor. By blowing in air and extracting air at the same time, the floor will be balanced or be slightly negative or positive. This condition will hinder the ventilation rate as there will not be enough pressure differentials to create an effective air movement. Tests were carried out by the GTZ Energy Audit team to understand the reasons in three different factories having dilution ventilation system.

Picture 3. Ventilation air flow rate test by GTZ Energy Audit team

The following table 14 gives the results of the tests carried out by GTZ Energy Audit Team:

Data Collection Point	Air Velocity (metres/second)			Mean Air Velocity (m/s)
	Factory-1	Factory-2	Factory-3	
Near to extraction fan	6.4	4.1	5.2	5.2
Middle of the production floor	0.2	0.1	0.1	0.1
Near to the main exit door	4.9	3.6	3.8	4.1

Table 14: Air velocity in a dilution ventilation system of production floors

The results show that there is little (0.1 m/sec) movement of air from one side of the room to other side of the room with many dead airflow areas. Highest (5.2 m/sec) air flow was found near to the extraction fans. Extraction fans have fixed speed drive motor which runs at a constant speed irrespective of load demand. A fixed speed fan motor shall reduce the power factor when the airflow requirement is less due to low occupancy. It will need more electricity when the ventilation demands additional airflow due to high occupancy and inrush of makeup air from frequent door openings. The power consumed by a fan is proportional to the cubic root of the shaft speed. When shaft speed is reduced by 10%, power consumption is reduced by 27%. If speed is reduced by 20%, power is reduced by 49%.

Therefore, Demand-control Ventilation (DCV) with Variable Speed Drive (VSD) fan motors should be used to maintain proper ventilation of the production floor reducing human and nonhuman generated indoor air pollutants while saving energy by almost 40%.

Viyellatex uses evaporative cooling system in their sewing section. The GTZ Energy Audit team observed during the audit period in August 09 that the room temperature and humidity was higher than it should have been. The reason that could be attributed to such situation is that the blowers were not able to do the required number of air changes/hour within the production floor and was consuming more power. Switching over to Variable Air Volume System (VAV) may improve the comfort level of the production floor and shall save energy consumption.

Ventilation is estimated to use 10% of the electrical energy used at VIYELLATEX, and it is estimated that the potential for savings is 40%.

Ventilation Systems	
Total project cost	**500,000 BDT**
Annual energy savings	**1,388,748 kWh**
Annual cost savings	**846,000 BDT**
Simple payback on investment	**0.59 years**
Annual reduction in CO_2 emissions (tons)	**538**

Table 15. Annual cost savings due to improvement in ventilation system

7.6 Sewing Machines

In Stitching Section, sewing machines run continuously throughout the 8 hours shift in both engage and idle mode. The motor is engaged by clutch plate when the operator needs to use needle for stitching which is hardly last for more than few seconds and may not be more than 1.5 hrs continuous engage time in an eight hours shift. In case of servo motor run sewing machine, it runs only when the needle is engaged saving electricity consumptions during the idle time and can save up to 83% of electricity consumed.

GTZ Energy team did tests on "No Load" condition at the production floor of the factory using FLUKE power logger on both clutch & plate operated and servo motor driven sewing machines in October 2009. The following table gives the results of the test:

Picture 4. Sewing motor "No-Load" test by GTZ Energy Audit team

	AC, Single Phase Sewing Machines	**Voltage (V)**	**Current (A)**	**Power Factor**	**Power (W)**	**Energy Savings (%)**
1.	Clutch & Plat Motor running at No Load	221.3	1.40	0.348	107.82	-
2.	Servo Motor running at No Load	221.4	0.15	0.551	18.26	83.07

Table 16. Testing of power consumptions of Clutch & Plate motor and servo motor at No Load condition

The above table shows that 83% of power could be saved by switching over to servo motor driven sewing machine. The test also shows that the production floor has low power factor even though power factor is maintained above 0.9 at the generation end. Installing appropriate size capacitor bank at the incoming MV panel of the floor can improve power factor and reduce current to give additional power to the production floor. The factory has 600-700 clutch & plate motors in 80 sewing lines; rest are already replaced by servo motors. The table below identifies the estimated cost and savings.

Sewing Machines	
Total project cost	**1,500,000 BDT**
Annual energy savings	**4,034,312 kWh**
Annual cost savings	**2,459,000 BDT**
Simple payback on investment	**0.61 years**
Annual reduction in CO_2 emissions (tons)	**875**

Table 17. Annual cost savings due to replacement of clutch motors by servo motors

8 Next Steps

The GTZ audit team have now spent significant time confirming the energy saving opportunities at the all of the RMG factories in Bangladesh including VIYELLATEX. Because of the generic nature of many of the savings measures we have been able to read across some opportunities for savings from one factory to another. A good example of this is sewing or linking machines which are common to many factories.

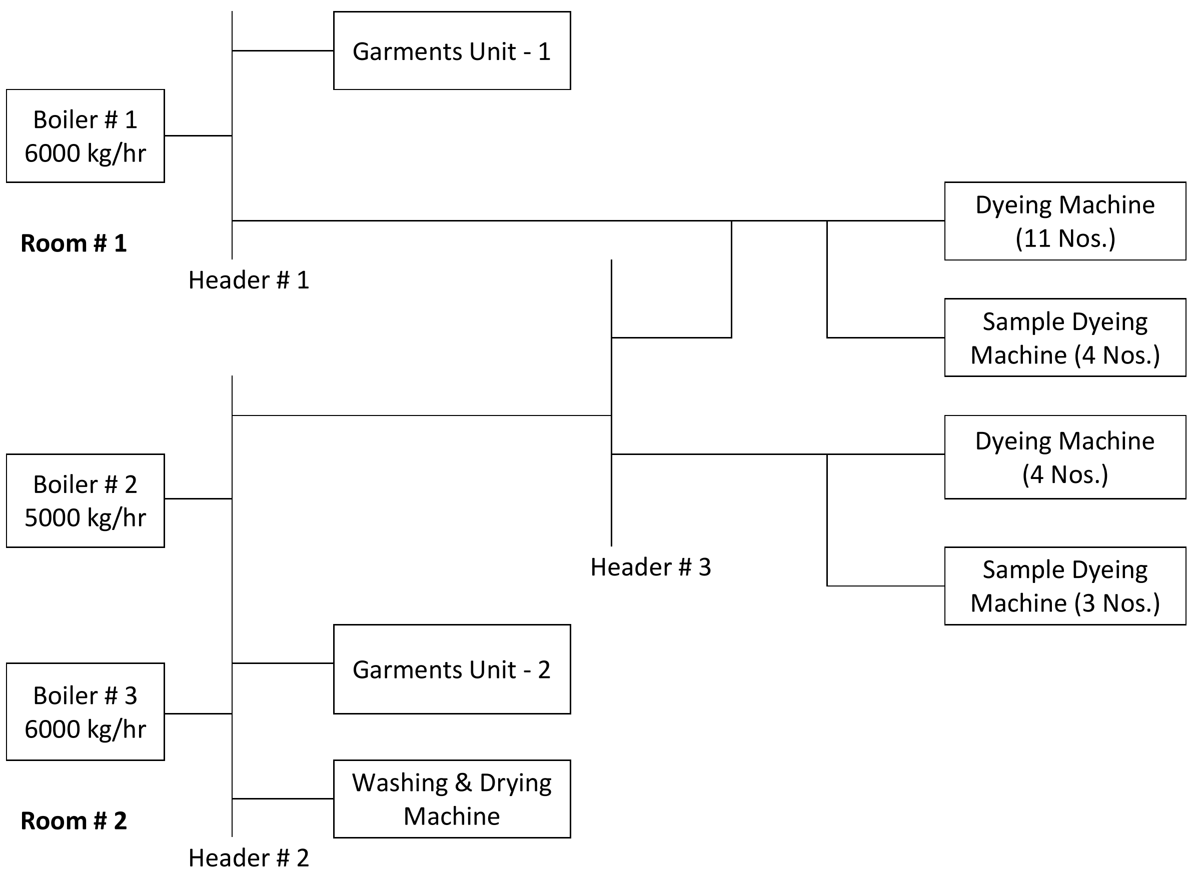
The next step in the work is for VIYELLATEX to put together an implementation plan based on the action plan developed in this audit report. The GTZ audit team will visit VIYELLATEX in February as part of our Phase 3 work and we will:

1. Present the findings of the Phase 2 work through a Power point presentation to the VIYELLATEX company Energy Savings Team (EST)
2. GTZ Auditors will discuss the action plan and agree the implementation plan.
3. Providing VIYELLATEX agree the opportunity will be taken to measure the energy savings from the cloth dryer which features a heat recovery system.
4. Phase 3 of the work will also include some training. It is important that some members of the EST attend the training to:

    - Get a better understanding of Energy Management opportunities. VIYELLATEX have a lot to learn could improve energy management and if they adopt some simple measures VIYELLATEX can make some very high energy and cost savings at little investment
    - The training will include some help to the VIYELLATEX EST on how to implement the energy savings identified in the Action Plan of this audit report. The GTZ team will advise on all aspects of technical energy savings measures

ANNEXURE 1

Line Diagram of Steam Distribution Network
Viyellatex Ltd.



ANNEXURE 2

Line Diagram of Compressed Air Distribution Network

Viyellatex Ltd.