# M&V Protocol for Textile Sector

## Perform-Achieve and Trade Scheme

An initiative supported by

SHAKTI SUSTAINABLE ENERGY FOUNDATION

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## ABBREVIATIONS

| | |
|---|---|
| BEE | *Bureau of Energy Efficiency* |
| CEA | *Central Electricity Authority* |
| CPP | *Captive power plant* |
| CU | *Capacity utilisation* |
| CUM | *Cubic meter* |
| DC | *Designated consumer* |
| DESL | *Dalkia Energy Services Ltd* |
| EC | *Energy conservation* |
| Escert | *Energy savings certificate* |
| ECM | *Energy conservation measures* |
| FD | *Fiber dying* |
| GCV | *Gross calorific value* |
| GtG | *Gate to gate* |
| HMBD | *Heat & Mass Balance Diagram* |
| KLPY | *Kilo liter per year* |
| LTPY | *Lakh tonnes per year* |
| MT/T | *Metric Ton* |
| M&V | *Measurement & Verification* |
| PAT | *Perform achieve & trade* |
| PD | *Piece dying* |
| SEC | *Specific energy consumption* |
| TOE | *Tonnes oil equivalent* |
| TPD | *Tonnes per day* |
| TPY | *Tonnes per year* |

# EXECUTIVE SUMMARY

This protocol has been prepared to assist the stakeholders, particularly the Designated Consumers (DCs) in the textile sector and the Accredited Energy Auditors to carry out the various tasks required for monitoring and verification of the achieved 'Gate to Gate specific energy consumption' against the target for the DC set as per the PAT notification by BEE and Ministry of Power. The recommended procedure has been outlined covering:

- Determination of the 'Gate to Gate Specific Energy Consumption' (GtG SEC) as per prescribed procedure
- Normalisation of the determined GtG SEC using the normalisation guideline recommended for each individual sector (this report is for the textile sector)
- Understanding of need for data, information and management of protocol for the same for carrying out determination of GtG SEC exercise & normalisation
- Monitoring & verification (M&V) protocol for carrying out the normalisation process

The document has been prepared on the basis of review of baseline audit reports (sample reports for each sector), BEE PAT consultation document, MOP/BEE notification booklet of July, 2012 & information from DESL energy audit report database & literature survey.

The following factors have been identified having corelatioship with GTG SEC with varying degrees for different sectors:

- Capacity utilisation (In some cases CU at even less than 30% have fair amount of impact on SEC)
- Product mix
- Fuel quality
- Source of power and mix of usage from different sources
- Other variables such as process changes and quality of raw materials

Treatment of variables such as capacity utilisation, product mix and fuel quality have been generally outlined in the BEE document. Some of the baseline reports have identified more variables and generally outlined their impact. Additional variables have been identified through literature survey and their impact studied. This document has outlined the process of using these guidelines for determination of baseline as well as PAT cycle GtG SEC. This has been done for the sector based on the review of baseline audit reports as mentioned in section 5 of this document. It has been observed that annual average value of production and energy usage may or may not truly reflect the corelatioship between CU & GtG SEC. It has been therefore, recommended to use a robust statistical methodology for establishing various corelationships.

In the textile sector, in addition to CU, product mix play important role. Variation in the raw material specifications, on the other hand has a very insignificant impact on SEC. Normalisation process for variation in the product mix has been provided based on the conversion factors generally used by the Textile industry.

Changes in the sources of power and mix of usage can distort the computed GtG SEC unless differences in the heat rates are normalised. A methodology has been developed for the same as summarised at section-6 of the report. The detailed illustration has been provided at Section 8 (Annex-I).

For the textile sector, no other variable needs to be considered.

From the perspective of PAT, it would be necessary to establish mathematical corelationship of GtG SEC to identified variables and carry out normaisation process using the corelationship factors so derived. This has to be done specifically for every unit. For this, it would be necessary to have much larger number of data points, which can help in carrying out the statistical analysis and derive the desired level of accuracy. The data protocol has been proposed accordingly. It would also be desirable to develop sector specific statistical models at BEE end so that cost of carrying out the normalisation process itself does not become a barrier.

Even after such analysis, one may not be able to achieve the set objective of level of accuracy at 0.05%. It has therefore, been proposed to carry out a second check by reconciling with the verified savings achieved from implementation of energy conservation measures.

Normalisation and validation process has been proposed accordingly to comprise of:

Sep-1-Determination of GtG SEC as has been done in the baseline audit report
Step-2-Determination of the overall normalisation factors and carrying out the normalisation process using the statistical model developed for the sector
Step-3-Verification & validation based on evaluation of implemented EE projects

Summary process has been provided at section 6.6 of the report and detail flow chart provided at section 8.

Data and information need have been assessed. The protocol for the same has been provided at section 7.2 of the document.

This document is proposed as a guideline document only. The normalisation process and M&V protocol have to be developed for every DC as the demanded accuracy can be obtained only with rigorous statistical analysis of unit specific performance data and parameters.

From the perusal of section 3 of the document, it would be seen that the gain from the PAT scheme for the sector as a whole and most of the units in particular, is quite small in financial terms. As such, the normalisation and validation process need to be kept simple so that the cost of transaction does not become prohibitive. For this, it would be best to develop a web-based tool for self validation. Only in exceptional cases, should there be need for rigorous analysis proposed in this document. The web-based protocol can be designed capturing the essence of the recommended normalisation and M&V process.

# 1. INTRODUCTION: PAT SCHEME & SIGNIFICANCE OF M&V PROTOCOL

The PAT framework has been developed considering the legal requirement under EC Act, 2001, situation analysis of designated consumers, national goal to be achieved by 2014-15 in terms of energy saving and sustainability of the entire scheme. The PAT scheme has been designed to incentivize industry to higher level of investment in energy efficiency projects. Numerous studies have indicated that investment in energy efficiency project offer attractive return due to reduced cost of energy. The PAT scheme would provide opportunity of additional revenue generation through trading of marketable instruments, which would be available as a result of achievement of higher level of savings. The additional certified energy savings can be traded with other designated consumers who could use these certificates to comply with their SEC reduction targets. The Energy Savings Certificates (ESCerts) will be traded on special trading platforms to be created in the two power exchanges (IEX and PXIL). The guiding principles for developing the PAT mechanism are Simplicity, Accountability, Transparency, Predictability, Consistency, and Adaptability. The PAT framework includes the following elements:

1. Methodology for setting specific energy consumption (SEC) for each DC in the baseline year
2. Methodology for setting the target to reduce the Specific Energy Consumption (SEC) by the target year from the baseline year.
3. The process to verify the SEC of each DC in the baseline year and in the target year by an accredited verification agency
4. The process to issue energy savings certificates (ESCerts) to those DCs who achieve SEC lower than the specified value
5. Trading of ESCerts

Specific energy consumptions (SEC) in any process would vary over time due to changes, which can be classified under controllable and uncontrollable variables. The controllable variables include those, which can be changed by internal intervention including through behavioral changes and investment in energy efficient technologies. The factors over which an individual DC does not have any control but that can impact the SEC are classified as uncontrollable. The design intent of the PAT process is to insulate the DC from variability due to changes in the uncontrollable factors. The baseline conditions are defined so that the impact of uncontrollable variables can be neutralized by application of suitable adjustment factors, which have been called 'Normalization' factors in the BEE document.[1]

The objectives of the M&V protocol are multi-fold including identification of controllable and uncontrollable variables, method of collection of data and information for the same and providing methodology to determine the normalization factors and finally development of the SEC figures in line with objectives set forth in the PAT process.

# 2. TEXTILE INDUSTRY-OVERVIEW

## 2.1 A BRIEF OVERVIEW

The textile industry in India has always occupied a pride of place due its contribution in economic and social development in the country. It is one of the oldest Industries and yet has always remained in the forefront in renewing itself by adopting the best of technology from all over the world.

[1] PAT consultative document

Indian textile sector is the second biggest employment generator in the economy, after agriculture. It provides direct employment to more than 35 million people. The export of textiles and clothing totaled US$ 22.42 billion in 2009-10[2].

"Textile industry has made a major contribution to the national economy in terms of direct and indirect employment generation and net foreign exchange earnings. One of the earliest to come into existence in India, it contributes 4% to the country's GDP, 14% to the country's industrial production and around 12% to the country's foreign exchange earnings, 18 per cent of employment in the industrial sector, 9 per cent of excise duty collections and more than 30 per cent of Indian's total exports"[3].

Processes and technologies differ considerably across factories. Composite mills cover complete sets of processes, from raw material to final products, however most manufacturing units tend only to deal with a part of the process. India's textile industry is generally divided into the organized and the unorganized sector. The organized sector includes spinning mills and composite units. The unorganized sector comprises power looms, handlooms and garment sectors.

## 2.2 OVERVIEW-MANUFACTURING PROCESS

There are broadly three manufacturing processes, spinning, weaving and processing (Figure-1). A particular unit can be either composite covering all the three processes or a unit just covering one process such as spinning.

### Spinning

In the spinning process, raw cotton is converted into yarns in several steps as shown in the first four sub-processes ending with spinning in the flow sheet below.

- **Blow Room**
  - Opening
  - Cleaning
  - Dust Removal
- **Carding**
  - Process in which the lap is separated and assembled into loose strands called sliver
- **Drawing**
  - The slivers are combined into single strands for consistent texture and thickness
  - After being combined slivers are separated into Roving's
- **Roving**
  - Sliver is converted in to thick soft roving
- **Spinning**
  - Actual conversion of roving to yarn by various technologies like Ring / Rotor/Vortex spinning

2 www.investindia.gov.in
3 Info.shine.com 7th Sept, 2012

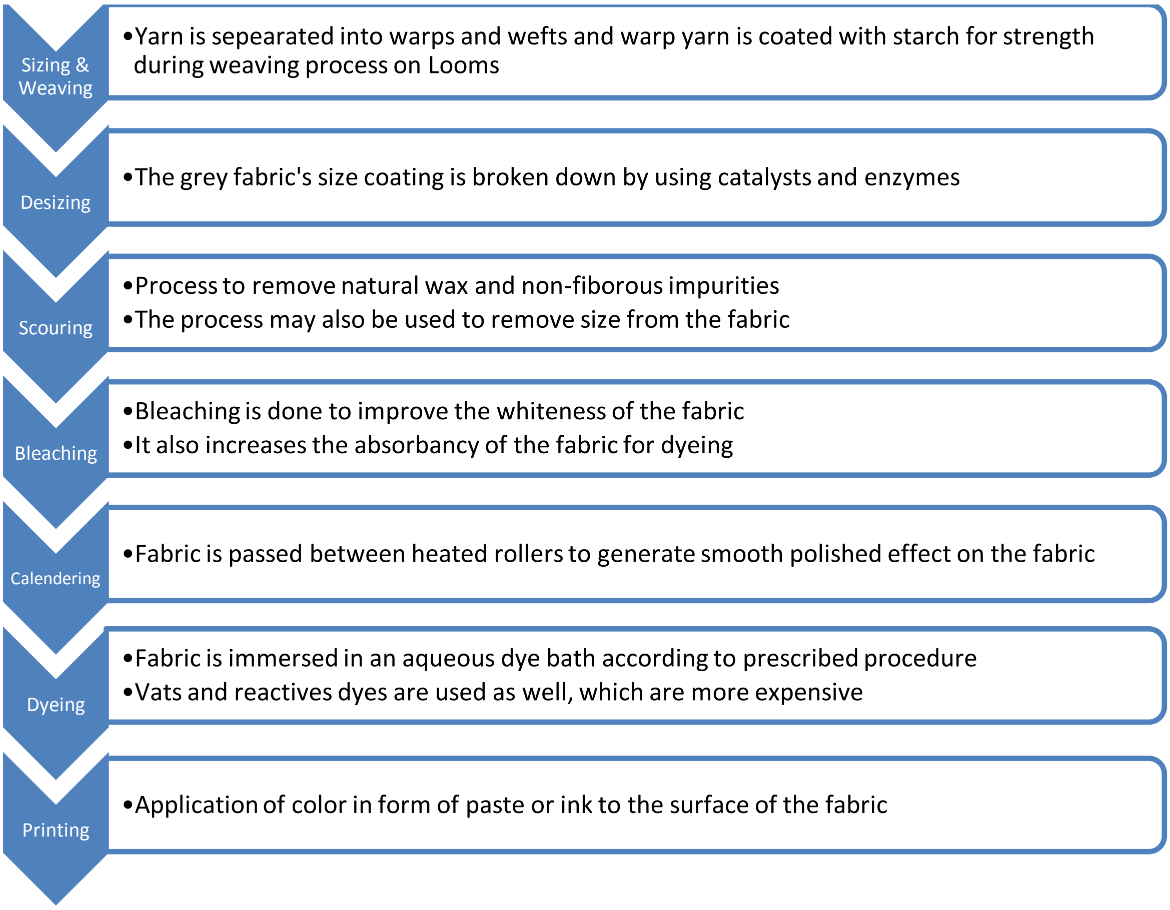


**Figure 1: Textile manufacturing process-Integrated**

## Weaving

Weaving is the process of making fabric or cloth using the yarns. In it, two distinct sets of yarns called the warp and the filling or weft are interlaced with each other to form a fabric. Yarn is a long continuous length of interlocked fibers. The lengthwise yarns which run from the back to the front of the loom are called the warp. The crosswise yarns are the filling or weft. A loom is a device for holding the warp threads in place while the filling threads are woven through them.

The following sub-processes are usually involved in weaving.

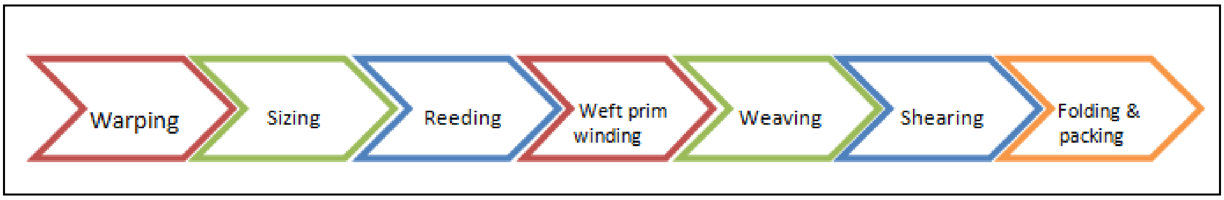


**Figure 2: Weaving process**

## Processing

It covers all processes in a textile unit that involve some form of wet or chemical treatment. The wet processing process can be divided into three phases: preparation, coloration, and finishing. It uses different types of technologies depending on the type of yarn or fabric that are dyed. Jigger, winch, padding, mangle and jet-dyeing are some of the important dyeing machines. Similarly, there are different types of printing: direct printing, warp printing, discharge printing, resist printing, jet printing, Rotary printing etc.

## 2.3 ENERGY USE IN THE TEXTILE INDUSTRY

Energy use in a textile mill depends upon the deployed process. For spinning and weaving mills, electricity is the main source of energy whereas for process houses, both electrical and thermal energy are needed, thermal constituting the major source. In an integrated mill, almost 80% of the total energy need is thermal. Typical break up of electricity and thermal energy consumption for an integrated mill is as shown in the following figure.

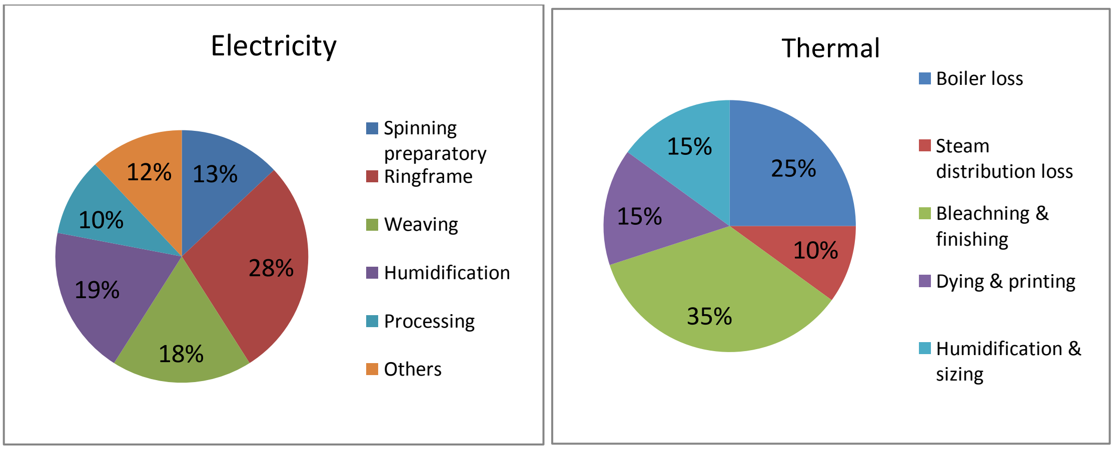


**Figure 3: Energy Consumption Breakup**

Energy consumption in a spinning mill is primarily electricity used in the production machineries and auxiliaries. A study about the power consumption in composite mill shows that 37% - 41% of the total power consumed is in spinning. In spinning of yarn, the distribution of energy consumption is as follows[4]:

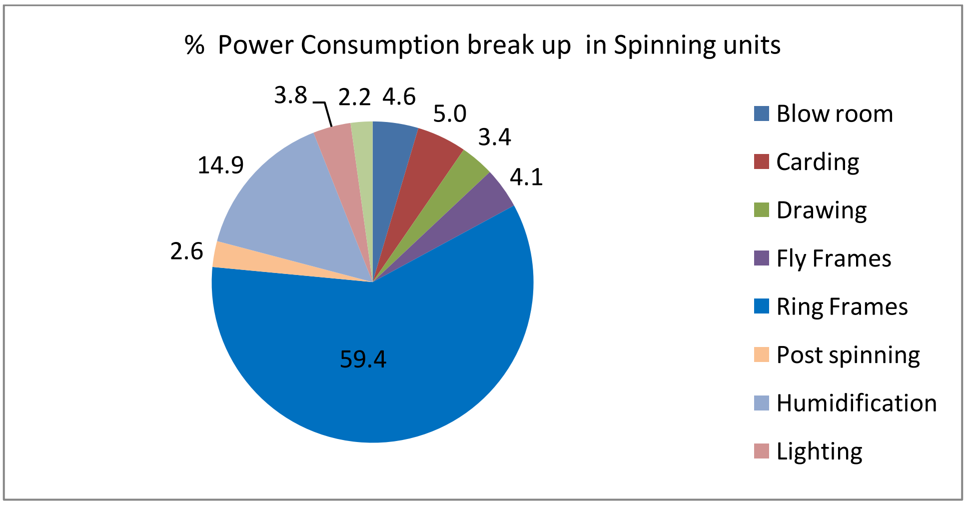


**Figure 4: Power Consumption Break Up in Spinning**

[4] BTRA Powerspin System for Estimation, Monitor and Control of Energy Consumption for Ring Frames in Textile Mills

Ring frame therefore, remains the focus for managing energy consumption in a spinning mill.

In weaving process, energy is used for operating machines, air conditioning and illuminating the area where fabrics are manufactured. In addition to these, compressors, which provide compressed air to the weaving line, use energy. Electricity is used for machines, air conditioning, illumination and compressors, while thermal energy is consumed by processes such as sizing and sometimes by air conditioning.

Energy consumption break up in a typical weaving mill is as shown in the following figure[5].

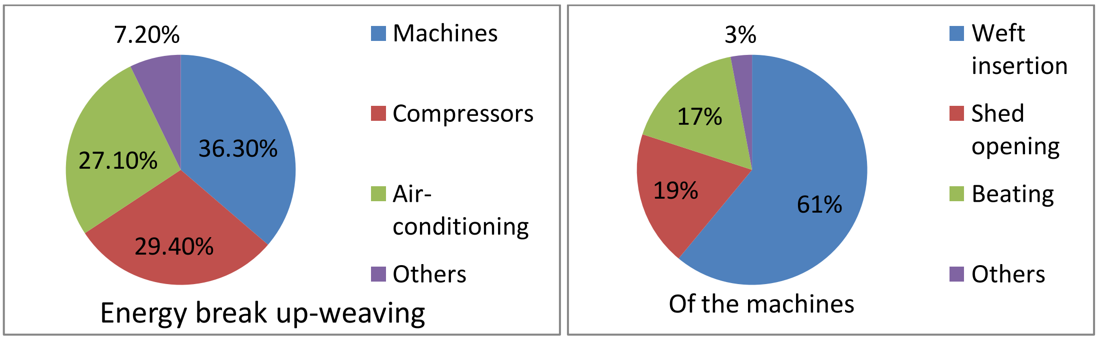


Figure 5: Energy Consumption Break up-Weaving

It is thus, seen that power consumption in auxiliary system is more than requirement in production machines and in the production process, weft inserting constitutes bulk of the consumption. Small amount of thermal energy is also used in the sizing operation. However, impact of the same on the overall energy consumption is not significant.

Thermal energy constitutes over 80% of the energy consumption in a wet processing plant. Typical breakup of the consumption has been shown in the figure 3.

## 3. DESIGNATED CONSUMERS-TEXTILES

The industry is characterized by presence of extremely large number of cottage and MSME units (over 5 million in weaving, 2000 in spinning, 2000 in processing and 75000 in apparel making[6]). Number of larger players is limited as is seen from the number of designated consumers (DCs) in the sector at only 90[7].

Even amongst these 90 players, the size in terms of energy consumption and consequently PAT targets vary widely as would be seen from the following chart. This chart shows the number of units (and percentages of total of 90) having their annual energy savings target at ton oil equivalent (TOE) as worked out from the targets and production levels provided in the BEE notification document.

[5] Analysis of energy consumption in woven fabric production, Erdem Koc et el, OM University, Cukurova University, Turkey

[6] www.cci.in

7 BEE notification

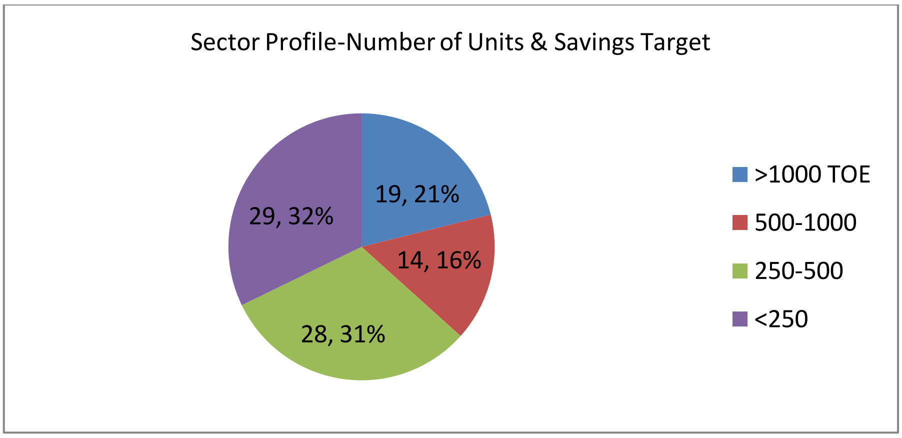


**Figure 6: Distribution of DCs**

Compliance target for over 63% of the units is less than 500 TOE/annum. While designing the M&V protocol, it would be important to make it simple for the smaller units to ensure that the cost of transaction for M&V and management of entire PAT process does not become disproportionately high compared to the gain from complying with the mandate.

All types of mills (spinning, weaving & integrated) are covered amongst the DCs and their numbers are fairly evenly distributed.

# 4. BASELINE & NORMALISATION-OVERVIEW

## 4.1 BEE GUIDELINES

The PAT scheme is, an operating unit-specific scheme, targeting reduction of energy intensity of the products being manufactured in the unit. The energy intensity has been defined as 'Gate to Gate' specific energy consumption (GtG SEC) determined by dividing the thermal equivalent of all energy inputs within the unit boundary by the product manufactured in the target period (Text box-1). With a view to neutralize the impact of uncontrollable variables, the concept of baseline and normalisation has been introduced (Text box-2).

**Text Box 1: Gate to Gate SEC**

The SEC of an industry would be calculated based on Gate-to-Gate concept with the following formula: SEC = Total energy input to the plant boundary / Quantity of the Product calculating the total energy input to the plant, all energy sources would be converted to a single unit i.e. MTOE (metric ton of oil equivalent) using standard engineering conversion formula. In this calculation, the following would be considered:

a) All forms of energy (Electricity, Solid fuel, Liquid fuel, Gaseous fuel, by products used as fuel etc.) which are actually consumed for production of output, should be considered.
b) Energy consumed in colony and for outside transportation system should not be accounted.
c) Energy used through renewable energy sources should not be accounted.
d) The 'Product' is the key parameter. The definition of product for various sectors has been indicated for the purpose of calculating SEC. This has been arrived at considering the typical practice of defining SEC and consistency in product output.

The principles for the normalisation process have been outlined with capacity utilisation as the key variable. However, it has also been provided that such normalisation factor would be applied if the capacity utilisation has deviated by more than 30% due to uncontrollable factors described in rule 4[8].

The outlining objective is to insulate the DCs against uncontrollable variables (such as change in the market, non-availability of raw materials, force majeure causes), which can impact the SEC.

**Text Box 2: Baseline & normalisation**

The base line SEC would be calculated based on the following procedure:

a) All DCs would submit the details of production and annual energy consumption since 2005-6 to 2009-10 through a notified form which is mandatory as per EC Act, 2001. Few additional sector specific information like process technology, process flow, raw material, product mix etc. would also be collected.
b) The SEC calculated from step (a) would be the 'Reported SEC' by the DC. As there may be various variable factors which affect the energy consumption significantly, some 'Normalization Factors' would be considered. It is proposed to consider the 'capacity utilization' as one of the most important parameter to have a normalization factor. However, the rationale for developing the 'normalization factors' is underway by suitable agencies through a scientific manner.
c) Now the reported SEC will be normalized after incorporating the normalization factor.
d) Normalized SEC = f (Reported SEC, Normalization factors)
e) The base line SEC will be estimated by taking the average normalized SEC of last 3 years i.e. 2007-8, 2008-9, and 2009-10.
f) The base year may be defined as 2009-10.

For the purpose of PAT, the Textile sector has been divided into following four segments:

- Spinning
- Composite
- Processing
- Fiber

While setting the targets, BEE has further classified the units under:

- Captive power based plants
- Grid power based plants

It has also been provided that in such cases, where the production is measured in meters of cloth, normalisation would be carried out taking the base weight at 125 grams per sq meter (GSM) for average width of 44 inches[9].

The permissible error shall be ±0.05% in terms of toe for the purpose of determining entitlement of energy savings certificates.

## 4.2 PROPOSED METHODOLOGY

The proposed methodology has been developed considering the followings:

- BEE/EESL guidelines
- Review of the baseline audit reports

[8] Section 1.4 © of Schedule (MOP/BEE)
[9] Section 8.2 of Schedule (MOP/BEE)

- Review of information available from DESL case studies and public domain

The production for the target period can be determined using the above methodology. Similarly, energy consumption can be determined based on input electrical and fuel energy calculated from:

- Total fuel used multiplied by the GCV
- Grid electricity import multiplied by the heat rate (BEE guideline provides for taking this value at 860 Kcal/kWh)
- Credit for export of captive power at total export multiplied by grid national heat rate (2717 Kcal/kWh)
- Heat rate of captive power (CPP) to be used while determining conversion factors for sub-products into main products

### *Using BEE/EESL guideline*

BEE document has provided clear guidelines on production and energy consumption variables as discussed at section 4.1 above. For the textile sector, following specific provisions have been noted:

'The designated consumers whose production is measured in meters of cloth, the average grams per square meter (GSM) as 125 and average width as 44 inches shall be assumed for weight calculation'.

Methodology for baseline energy audit adopted by auditing agencies as per EESL guidelines are as follows:

- Fixing up the plant boundary
- Analysis of production trends and capacity utilization
- Detailed process flow study
- Analysis of energy scenario
- Estimation of Specific Energy Consumption (SEC)
- Analysis of various factors affecting GtG SEC
- Listing of energy efficiency projects identified by the DC and assessment of impact

### *Using the baseline reports*

Few of the baseline audit reports have been obtained with a view to analyze and assess the GtG SEC based on outlined principles and develop M&V protocol for the PAT cycle. The baseline audit reports have provided sufficient information for determination of GtG SEC and capacity utilisation on major products. Information on identified energy savings projects has also been provided. One of the three reports has provided analysis on GtG SEC and CU relationship on gross production basis. Such analysis has not been provided in other reports. Similarly, impact of implementation of EC projects on reduction of GtG SEC has also not been analysed. Basic information available on these parameters has been used to study GtG SEC corelationship to CU and impact of implementation of implementation of identified energy conservation measures on reduction of overall energy consumption.

Available data and information has helped in establishing corelationship in broader term. From the perspective of PAT, it would be necessary to develop proper mathematical equations for determination of normalised values through statistical analysis. Number of data points available in the baseline report is limited-annual data for five years and monthly data for two years. More number of data would be necessary to carry out the statistical analysis and deriving desired level of accuracy. This can be done by using daily production and SEC data for the entire PAT cycle period of three years. With a view to avoid high cost of transactions for carrying out such at individual level, it would be good to develop sector specific statistical models.

Baseline reports have included adequate, though not comprehensive, information on data source and traceability. This information has been used for preparing more structured data and information format, which is recommended to be used during validation and verification processes. The frequency of data recording has been recommended keeping in mind the need for good quality statistical analysis required for establishing the desired level of accuracy.

Some data gaps have been observed in few of the reports (for example generation from captive sources during certain period and heat rate for the same). Assumptions have been made for bridging such gaps based on normative values developed from DESL database. The proposed protocol has been developed to facilitate the industrial units to record all relevant data to enable self as well as the validators carry out the normalisation process based on real data.

### *DESL analysis & recommendations-other factors*

With a view to assess the impact, DESL has carried out further analysis based on the available data and information in the baseline reports as well as further research based on DESL database and information available in the public domain. These include:

- Study of CU impact on SEC based on annual as well as monthly data for the latest year for which data is available
- Identification of other variables, data availability in respect of the same and their impact
- Impact of heat rate in case of change of power mix (Captive, grid, mix of both)

For the textile sectors, in addition to the CU factors, following other important variables have been identified:

- Counts variability
- Weft insertion variability-weaving
- Change in grid and captive power mix

**Counts variability & normalisation:**

Textile Spinning units are producing several counts as per market demand, which is having significant impact on energy consumption. For calculation of Specific Energy Consumption, different methodologies are used by various auditing agencies during baseline audit for normalisation of yarn production of various counts, but South India Textile Research Association (SITRA) methodology of converting various yarn counts to an equivalent single count of 40's by multiplying with constant normalisation factors developed by SITRA[10], are most commonly used and adopted by Textile Spinning industry in India. The specific energy consumption is calculated on normalized yarn production of 40s count.

The following figure illustrates the conversion factor for typical range of counts being manufactured in most of the mills.

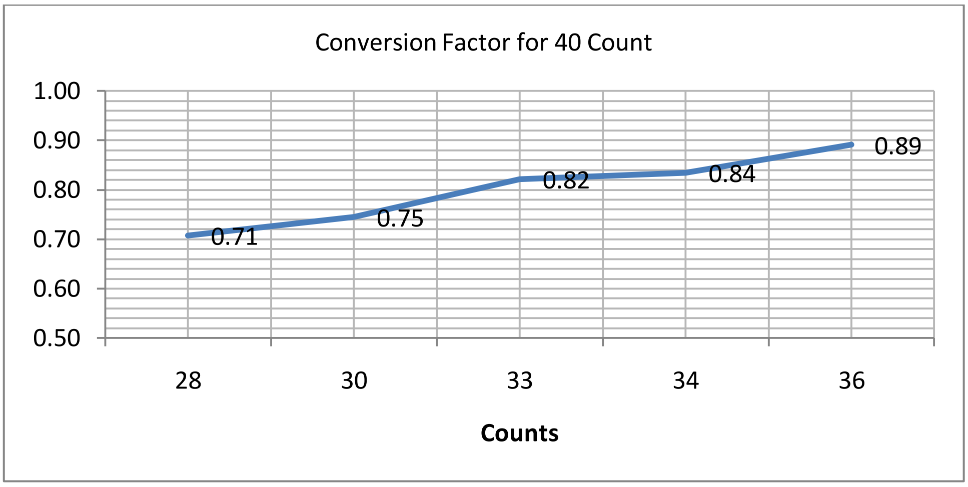


Figure 7: Count Conversion Factor

Though it is being recommended to normalise at 40 count, it is not sacrosanct. Such normalisation can be carried out based on other numbers too. However, same process should be followed during the PAT cycle as has been there during the baseline study (case of unit no-3 in this report).

**Weft insertion variability-weaving**

BEE guideline has provided standard conversion factor for converting square meter unit into Kg unit. However, specific weight can change with change of weft insertion. Thus, it is recommended that normalisation factor is used for the same. This can be easily done as information on the same is available in most of the mills.

For composite mill, normalisation for fabric production can be converted to equivalent yarn production by using factor derived from share of energy consumption by each of the processes.

**Change in captive and grid power mix:**

BEE has classified the textile sector into captive power and grid power based units. So long there is no change in the power mix as compared to the baseline year, it would not be necessary to use any additional normalisation factor on this account. However, it has been observed that the SEC figure gets distorted in case there is change in the mix. Review of the case studies indicates that in many of the cases, such would be the scenario. A methodology has been developed and explained with illustration on normalisation of SEC figures in case of such changes.

[10] SITRA yarn count conversion table from various counts to 40s count attached in Annexure-III

**Impact of energy savings projects**

The impact of identified energy savings project on the overall energy consumption and hence on energy GtG SEC on the baseline year can be computed. On implementation of the projects, performance measurement & verification is proposed to be carried out to assess the reduction in energy consumption. This would help in assessing the impact on reduction of GtG SEC. An illustrative methodology has been developed for carrying out the M&V and impact analysis and correlating to reduction in GtG SEC.

Finally, a flow sheet has been developed to help the DCs and the other stakeholders for using this document in carrying out the validation of the normalisation process.

# 5. ILLUSTRATION-BASELINE AUDIT & DETERMINATION OF GtG SEC

## 5.1 UNIT-1: SPINNING

### *GtG SEC corelationship*

The following table shows the various parameters and the computed GtG SEC as reported in the baseline report (GtG SEC has been reported in Kcal/Kg-unit changed to MTOE/T for reporting consistency).

**Table 1: Baseline parameters**

| Year | Avg. Count | Capacity Spindle installed | spindle utilization | Yarn production | Power consumption (purchase+ generated) | F.O. consumption In DG sets | HSD consumption (Hot water Generator) | Energy consumption | SEC | SEC |
|---|---|---|---|---|---|---|---|---|---|---|
| **Units** | Number | Number | % | MT | kWh | MT | Litres | MTOE | kWh/Kg | MTOE/T |
| **2007-08** | 32.14[s] | 66,288 | NA | 10,750 | 5,52,56,910 | 11,582 | NA | 12,676 | 5.14 | 1.18 |
| **2008-09** | 31.84[s] | 66,288 | NA | 10,026 | 4,92,59,795 | 463 | NA | 4,568.9 | 4.91 | .456 |
| **2009-10** | 33.26[s] | 66,288 | 98.45 | 9,883 | 5,06,00,522 | 189 | 71,600 | 4,555.9 | 5.12 | .461 |
| **2010-11** | 35.03[s] | 66,288 | 98.14 | 9,098 | 5,09,93,840 | 517 | 69,800 | 4,816.3 | 5.60 | .533 |

The GtG SEC relationship based on the production (Since CU figures are not available for two years but can be considered representative since there is no change in spindle capacity). The GtG SEC and CU corelationships are shown considering the following different conditions as follows.

- As per baseline report
  - Electrical SEC (kWh/Kg)
  - Equivalent SEC (MTOE/T)
- Normalisation for yarn count
  - Electrical SEC (kWh/Kg)
  - Equivalent SEC (MTOE/T)
- Normalising for change in power mix

The figure below shows the relationship on the basis of various baseline data.

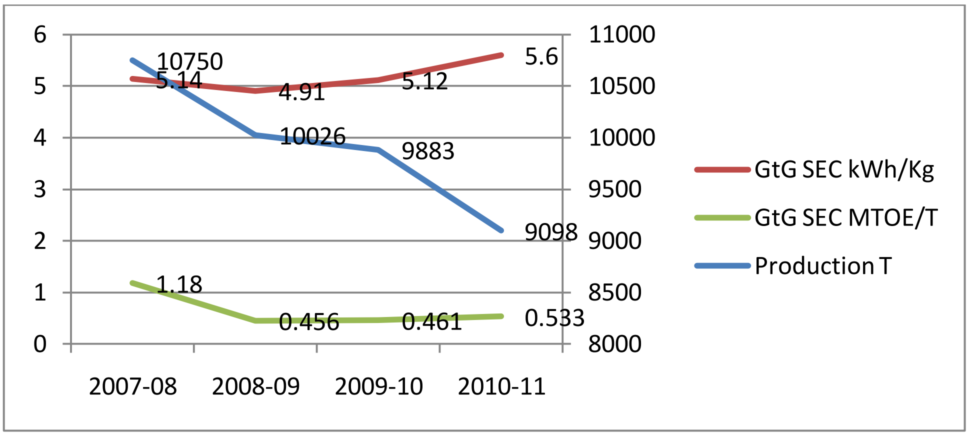


**Figure 8: GtG Production relationship-baseline data**

It is seen that there is some distortion for the year 2007-2008 and more severe on MTOE/T basis. For the balance three years, there is clear evidence of corelationship.

The normalised production figures on 40 count basis are shown in the following table.

**Table 2: Normalised production & GTG SEC**

| Year | Prod-T | Count | Conversion factor | Normalised Prod T | Total kWh | MTOE | SEC kWh/Kg | SEC MTOE/T |
|---|---|---|---|---|---|---|---|---|
| **2007-08** | 10750 | 32.14[s] | 0.79 | 8493 | 5,52,56,910 | 12,676 | 6.51 | 1.493 |
| **2008-09** | 10026 | 31.84[s] | 0.78 | 7820 | 4,92,59,795 | 4,568.90 | 6.30 | 0.584 |
| **2009-10** | 9883 | 33.26[s] | 0.825 | 8153 | 5,06,00,522 | 4,555.90 | 6.21 | 0.559 |
| **2010-11** | 9098 | 35.03[s] | 0.865 | 7870 | 5,09,93,840 | 4,816.30 | 6.48 | 0.612 |

The figure below shows the relationship on the normalised production on 40 count basis

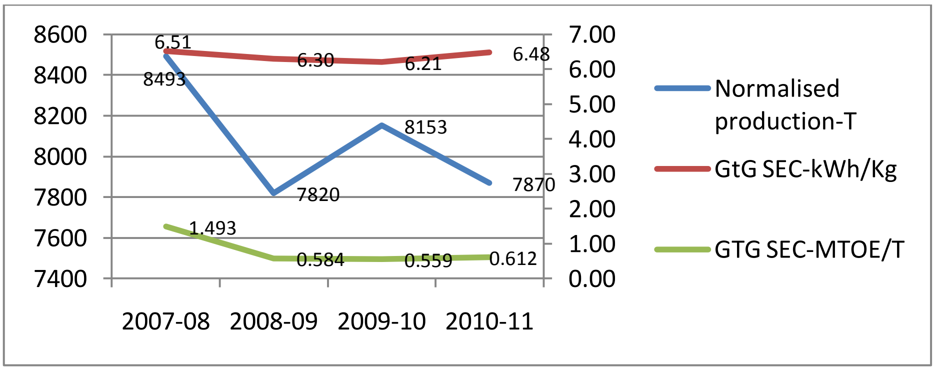


**Figure 9: GTG SEC Normalised production relationship**

Though the pattern seems to have remained the same, it is seen that the normalised production value for 2009-10 is higher than in 2008-09 in this case. There is marginal decline in SEC.

The principle for adjustment for power mix has been discussed at section 6.5 of this document. However, since the plant uses only electricity as energy input, it may be desirable to convert equivalent MTOE using the baseline conversion factor (860 KCal/kWh) and use the data on fuel consumption for reconciliation purpose only.

### *Impact of energy conservation projects*

The listed energy conservation projects in the baseline report are as shown in the following table.

Table 3: EC Project in unit-1

| Description | Annual saving in KWH | Remarks |
|---|---|---|
| **Optimization of OH Blowers in Speed Frames** | 35,640 | Maintenance Option |
| **Using PU tapes in ring frames** | 7,52,486 | Retrofit option for LR ring frames only |
| **Replace 250W lamps with 4x14W T-5 with electronic ballast.** | 33,288 | Retrofit Option |
| **Optimization of OH Blowers in autoconers** | 52,272.00 | Maintenance Option |
| **Voltage optimization at lighting feeder** | 1,46,880 | Technology Option |
| **Saving by PF Improvement** | - | Technology Option |
| **Replace 40W tubes with 28W T-5 with electronic ballast** | 3,00,809 | Retrofit Option |
| **Optimization of OH Blowers in TFO** | 80,460 | Maintenance Option |
| **Optimization in compressors** | 2,59,200 | Maintenance Option |
| **Replace 40W tube with 28W T-5 with electronic ballast retrofit type** | 1,75,655.62 | Retrofit Option |
| **Replace 70W HPSV street light with 2x24W T-5 with electronic ballast** | 12,045 | Retrofit Option |
| **Replace 150W HPSV street light with 4x14W T-5 with electronic ballast** | 36,135.00 | Retrofit Option |
| **Incorporation Of inverter drives in Autoconers** | 2,47,104 | Retrofit option and contact to OEM for implementation |
| **Total** | 21,31,974 | |

Identified savings potential at 2131974 kWh represents about 4% of the consumption for the base year, 2009-10. The unit would have to carry out more exhaustive energy assessment study for increasing the savings.

**Conclusions:**

- Barring the exception for year period 2007-08-2008-09, there is good evidence of corelationship of GtG SEC to capacity utilisation

- The yarn production is reduced by 6.7 % in 2008-09 as compared to previous year, but SEC has sharply reduced in the year 2008-09 from previous year. This has happened due to significant shift from DG generation using Furnace oil to Grid power (having 860 Kcal / kWh as per value given in PAT notification). Thus, the impact is more due to energy accounting methodology and not as result of change in energy usage efficiency. This issue has been further highlighted in section 6.5 of this report.
- Spindle CU in 2010-11 has reduced from 98.45 to 98.14 (by 0.31%), but SEC has increased by more than 12 %. This can be attributed partly to the change in count as shown by the corelationship in the following figure.

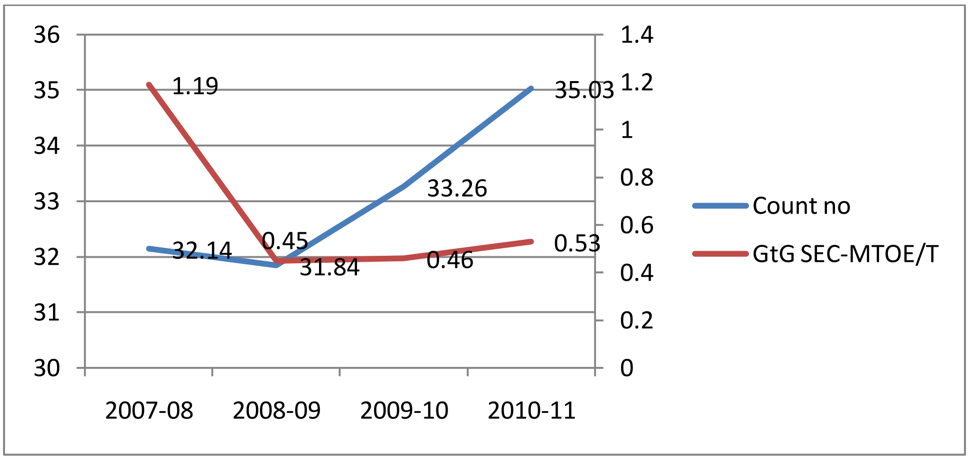


**Figure 10: Average count SEC relationship**

- On the basis of count normalised production, there is better corelationship as would be seen from Figure 9.
- The trend of 2008-09 over 2007-08 can be ignored considering the anomaly arising out of switch from DG power to the grid power. For the balance period there is evidence of corelatioship between average counts and SEC.
- The listed energy conservation projects show savings potential of 4% only. More exhaustive assessment study would have to be carried out to identify and achieve higher level of savings.

## 5.2 ANALYSIS-UNIT No.2-SPINNING

### *GtG SEC corelatioship*

The following table provides the 5 years data and computation of baseline GtG SEC as reported in the audit report.

**Table 4: Baseline data**

| Year | Avg. Count No | Capacity | %spindle utilization | Yarn production | Power consumption | Energy consumption | SEC | SEC | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | MTPY | % | MT | kWh | MTOE | kWh/ Kg | MTOE/T | |
| 2005-06 | 25.8[S] | 45120 | 97.04 | 11242 | 3,80,16,430 | 3,269.4 | 3.38 | .291 | Source of data from |
| 2006-07 | 25.9[S] | 48399 | 96.59 | 12157 | 3,97,71,920 | 3,420.4 | 3.27 | .281 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **2007-08** | 26.3[s] | 51312 | 95.17 | 11493 | 3,74,47,600 | 3,220.5 | 3.26 | .280 | account section |
| **2008-09** | 27.6[s] | 51312 | 92.78 | 7924.2 | 2,72,26,960 | 2,341.5 | 3.44 | .295 | |
| **2009-10** | 26.9[s] | 51312 | 96.69 | 10089 | 3,48,47,767 | 2,996.9 | 3.45 | .2975 | |
| **2010-11** | 25.72[s] | 51312 | 92.68 | 10111 | 3,25,80,600 | 2,801.9 | 3.22 | .277 | 11 months data |

Since this unit totally depends upon purchased power, SEC data in terms of kWh/Kg and MTOE/T are in totally consistent over all the years. The relationship between annual capacity utilisation and GtG SEC for the reported six years is shown graphically as follows.

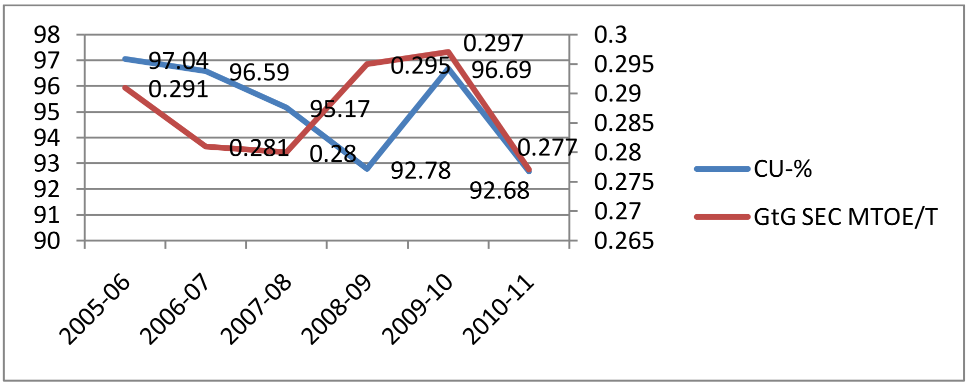


**Figure 11: CU SEC relationship**

From this, it is seen that on an annual basis, there is corelatioship only when there is significant variation such as the case for 2008-09 and 2009-10. However, once again at around the same level of capacity utilisation (92.68 % vs. 92.78%), the SEC has drastically come down. This could be attributed to one or more of the following reasons:

- There may not be significant corelatioship, which can be statistically established
- Influence of other factors

Further analysis has been made for the year 2011, for which greater number of data (monthly) is available as shown in the following graph.

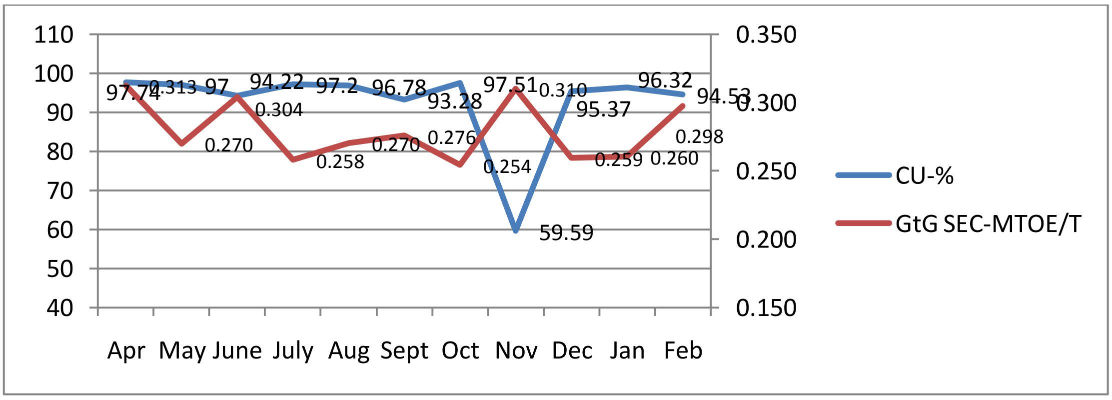


**Figure 12: CU SEC relationship-2011**

From this figure, it is observed that there is significant corelatioship in case of major reduction in the CU figure. This is in line with stipulation by BEE that impact of CU needs to be considered only in case CU figure changes by 30% or more. However, larger number of data points has to be there for carrying out statistical analysis, that would be able establish accuracy level of 0.05%.

Baseline report has included the production values in terms of overall counts too. The impact of count variation on SEC is illustrated in the following figure.

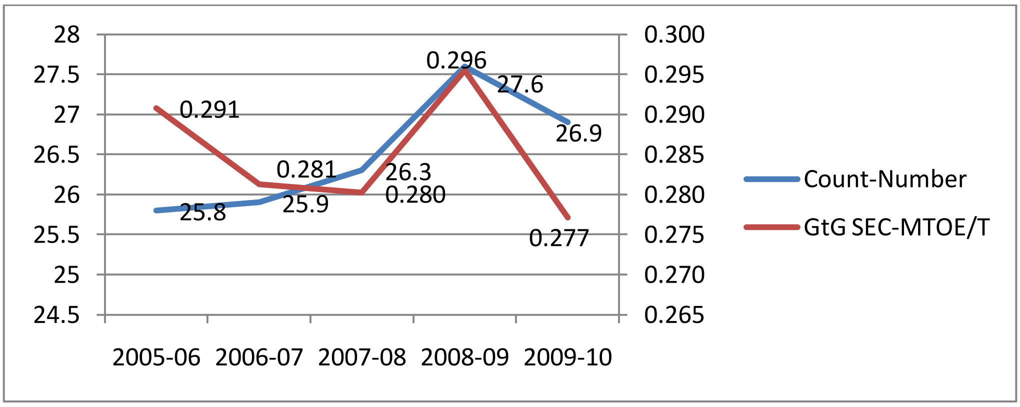


**Figure 13: Unit-2 SEC corelatioship**

### *Impact of identified energy savings project*

The following table shows the summary of energy savings project reported in the baseline report.

**Table 5: Energy savings projects**

| Description | Units Saving | Remarks |
|---|---|---|
| **suction fan operation optimization in speed frames (Option I)** | 1,63,944 | Maintenance and process option |
| **Power Saving by overall voltage optimization** | 1,75,000 | Maintenance option |
| **Savings from removal of excessive lightning** | 26,956 | Maintenance option |
| **Savings from Voltage optimization in lightning** | 43,200 | Maintenance option |
| **suction fan operation optimization in speed frames (Option II)** | 1,31,155 | Maintenance and process option |
| **Power saving in Ring frames by using PU spindle tapes in place of existing spindle tapes for energy savings** | 2,73,240 | Retrofit option for LR ring frames only |
| **Power saving in Autoconer machines by optimization of over-head Blower operation** | 95,040 | Retrofit option related to process |
| **Use of energy efficient compressors in place of old and inefficient compressors** | 5,29,200 | Technology and maintenance option |
| **Replace 70W HPSV Lamp with 36W CFL** | 1,084 | Retrofit option |
| **Savings from replacement of conventional Lightning system with energy efficient lightning Production Area** | 1,01,088 | Retrofit option |
| **in Unit-1 (P/C) power saving can be achieved by pump automation** | 81,648 | Retrofit option |
| **Savings from replacement of conventional Lightning system with energy efficient lightning Office Area** | 30,600 | Retrofit option |
| **Replace 150W HPSV Lamp with 4x14W T5** | 7,227 | Retrofit option |

| | | |
|---|---|---|
| **Use of automation i.e. incorporate inverter drives in suction fans of autoconers machines for energy savings** | 5,46,480 | Retrofit option and contact to OEM for implementation |
| **Use of Automation system in Humidification for energy savings in Unit- 2 (100%polyester)** | 2,47,277 | Retrofit option |
| **Use of energy efficient card machines in place of existing inefficient double tandem cards** | 5,44,320 | Technology change and long term option |
| **Total** | 35, 26,659 | |

The total estimated saving is 35, 26,659 kWh/year. This works out to about 10% of the annual energy consumption for the base year that is 2009-10 at 34847767.

**Conclusions:**

- There is capacity corelatioship when there is significant change. This is in line with BEE provisions in the BEE guideline. However, much larger number of data points has to be there for establishing the desired accuracy level.
- Similarly, relationship with average count is also clearly evidenced, barring exceptions. Those exceptions could be due to various other factors like fuel switch, ratio of grid power to captive power and impact of energy efficiency measures.
- The impact of fuel switch has been assessed as a general topic at section 6.4 of this document.
- Similarly, a separate section has been provided on methodology for assessment of impact of implementation of energy conservation projects.
- Overall savings potential has been identified at about 10% of the base year consumption. It should therefore, be possible for the unit to achieve the target, which can be validated.

## 5.3 Analysis–Unit No 3 (Composite Unit-Spinning & Weaving)[11]

Unit No.3 is composite textile unit having Spinning and Weaving sections in boundary limit. The unit produces Synthetic and Worsted Yarn and various types of fabrics. Very good quality data and analysis have been provided by the auditors for the unit. They have also identified and carried out fairly exhaustive analysis on impact of key variables on GtG SEC.

### *GtG SEC corelationship*

The baseline report has provided the GtG SEC corelationship graph on the basis of normalised composite production as shown below.

[11] Review of BL report of Composite Textile – Spinning & Weaving unit

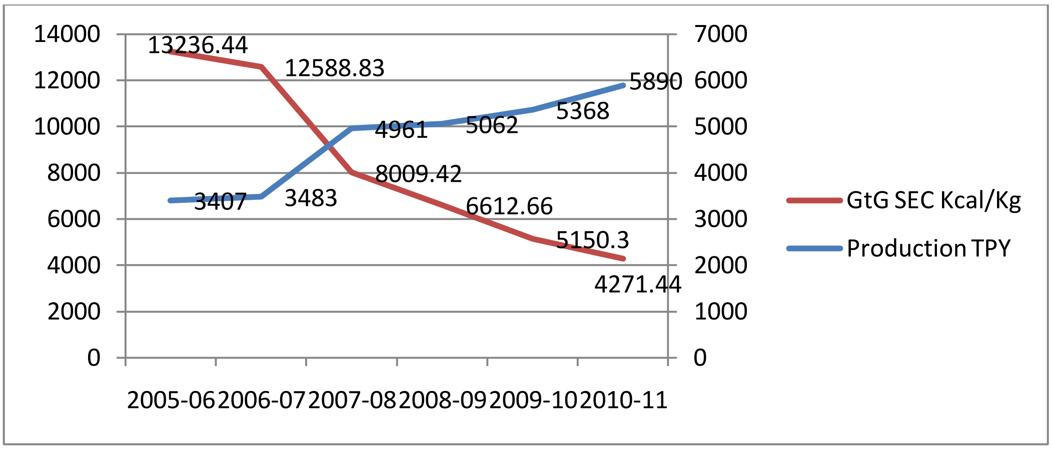


Figure 14: GtG SEC Corelatioship Unit-3

The auditors have rightly observed that there is close corelationship of GtG SEC to production but has also made the following qualifying statements:

- Significant drop in SEC figures from 2007-08 is also due to drastic reduction of captive generation from DG set and increased drawl from grid
- Number of ECM projects has been implemented during the intervening period but adequate information is not available to assess their impact.

The auditors have also identified the variables impacting the SEC as shown in the following table.

Table 6: variables impacting SEC

| Factors affecting GtG SEC | Present situation |
|---|---|
| **% Self generated energy use** | This is the most significant parameter |
| **Product quantity** | This is also significant |
| **Energy efficiency measures implemented** | Various measures implemented in 2008-09 |
| **Types/Blend of various yarns and fabric produced** | Various-normalised |

For further assessment of the GtG SEC corelationship, DESL has carried out analysis based on option alternatives such as:

- Production values for yarn and fabric normalised to a single product using standard practice followed by industry
- Separately for individual product
- On the basis of major product alone

The capacity and capacity utilisation figures for individual product category as reported in the audit report are shown in the table below.

Table 7 : Capacity & CU-Unit 3

| Year | Spinning | | | Weaving | | |
|---|---|---|---|---|---|---|
| | Capacity MT | Production MT | CU % | Capacity Lac Meter | Production Lac Meter | CU % |
| **2005-06** | 2,820 | 2,664 | 94.47 | 110.16 | 92.12 | 83.62 |
| **2006-07** | 2,820 | 2,784 | 98.72 | 106.68 | 91.08 | 85.38 |
| **2007-08** | 4,560 | 3,780 | 82.89 | 97.32 | 88.92 | 91.37 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **2008-09** | 4,560 | 3,720 | 81.58 | 96.36 | 86.73 | 90.01 |
| **2009-10** | 4560 | 3960 | 86.84 | 91.44 | 84.39 | 92.29 |
| **2010- 11** | 4560 | 4233 | 92.82 | 91.44 | 88.99 | 97.32 |

**Composite Methodology-Used In the Baseline Audit Report**

PAT scheme follows the convention of determining a single SEC for the entire production and energy consumption within the Gate to Gate Premises of the unit. However, this unit has two distinct products (viz. Yarn and Fabrics) with different SECs. However, it is possible to convert fabric production to equivalent yarn production for determination of normalised SEC for the unit as a whole.

The fabric weight normalized to yarn weight represents the weight of yarn that would have been produced using the same amount of energy as presently consumed in fabric production.

Yarn production from spinning section is also normalized in to 45s & 30s count[12] , to facilitate comparison of baseline period SEC with reporting period SEC. This is essential since yarn weight varies significantly with variation in average count.

Units per kg of Fabric (UKGF) = [Total kWh Consumed in Weaving/Weight of Fabric] kWh/kg.

Units per kg of Yarn (UKGY) = [Total kWh Consumed in Spinning/Weight of yarn] kWh/kg.

Fabric Weight Normalized to Yarn Weight = [Fabric Weight x UKGF/UKGY] kg.
Yarn Production in $45^s$ New Metric (Nm) & $30^s$ New English (Ne) Count = (68.81 x FRS x Sp. x Eff.std.) / (Actual count x 1000)

Where,

FRS = Front Roll Speed of Ring Frame for 30’s Ne (or 45’s Nm) count (Varies with different type of Ring Frames, twist multiplier, etc.)

Sp. = No. of Spindles (varies for different Ring Frame machines)
Eff.std. = Standard Efficiency (Utilization) of Ring Frame for 30’s Ne (or 45’s Nm) count
Total Production (Normalized) = [Yarn Production (Normalized) in 45’s & 30’s Count + Fabric Weight Normalized to Yarn Weight] kg.

The fabric production figures have been converted in to equivalent yarn by using a normalization factor determined from share in the energy consumption. Total production for the mill has been worked out adding the yarn production to this normalized value for fabric production.
The yarn normalized yarn production is as shown in the following table.

[12] 45s New Metric (Nm) is equal to 30s New English(Ne) count

Table 8: Normalized yarn production

| Year | Capacity MT | Production MT | Normalized Yarn Prod. MT * | CU % |
|---|---|---|---|---|
| **2005-06** | 2820 | 2457.5 | 2746.7 | 87.15 |
| **2006-07** | 2820 | 2502 | 2811.3 | 88.72 |
| **2007-08** | 4560 | 3772.1 | 3877.3 | 82.72 |
| **2008-09** | 4560 | 3644.2 | 3989.2 | 79.92 |
| **2009-10** | 4560 | 3619.8 | 4386.2 | 79.38 |
| **2010- 11** | 4560 | 4232.7 | 4753.5 | 92.82 |

*Production converted to common Ne count of 30's in this case

The fabric production for the same period is as shown in the following table.

Table 9: Fabric production (Weaving)

| Year | Capacity Lac m | Production Lac m | Fabric Weight Grams per M | Production MT | CU % |
|---|---|---|---|---|---|
| **2005-06** | 110.16 | 92.1 | 315 | 2901.15 | 83.62 |
| **2006-07** | 106.68 | 91.1 | 315 | 2869.65 | 85.38 |
| **2007-08** | 97.32 | 88.9 | 315 | 2800.35 | 91.37 |
| **2008-09** | 96.36 | 86.7 | 316 | 2739.72 | 90.01 |
| **2009-10** | 91.44 | 84.4 | 317 | 2675.48 | 92.29 |
| **2010-11** | 91.44 | 89 | 309 | 2750.1 | 97.32 |

The GtG SEC has been computed on the basis of total production as shown in the following table.

Table 10: GtG SEC on composite production basis

| Year | Total Production MT | GtG Energy MTOE | GtG SEC MTOE/MT |
|---|---|---|---|
| **2005-06** | 5648.5 | 4509.505 | 0.798 |
| **2006-07** | 5680.3 | 4384.749 | 0.772 |
| **2007-08** | 6678.3 | 3973.265 | 0.595 |
| **2008-09** | 6727.3 | 3347.501 | 0.498 |
| **2009-10** | 7059.1 | 2764.52 | 0.392 |
| **2010-11** | 7502.1 | 2515.619 | 0.335 |

The composite capacity utilisation figure and GtG SEC has been worked out on weighted average basis as shown in the following table.

Table 11: CU Vs GtG SEC

| Year | Fabric Yarn | | Fabric | | Weighted Average CU % | GtG SEC MTOE/MT |
|---|---|---|---|---|---|---|
| | Prod- MT | CU-% | Prod-MT | CU-% | | |
| 2005-06 | 2,746.7 | 87.15 | 2,901.80 | 83.62 | 85.34 | 0.798 |
| **2006-07** | 2,811.3 | 88.72 | 2,869 | 85.38 | 87.03 | 0.772 |
| **2007-08** | 3,877.3 | 82.72 | 2,801 | 91.37 | 86.35 | 0.595 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **2008-09** | 3,989.2 | 79.92 | 2,738.10 | 90.01 | 84.03 | 0.498 |
| **2009-10** | 4,386.2 | 79.38 | 2,673 | 92.29 | 84.27 | 0.392 |
| **2010-11** | 4,753.5 | 92.82 | 2,748.70 | 97.32 | 94.47 | 0.335 |

From the graphical representation of the trend of CU and GtG SEC (Figure below),

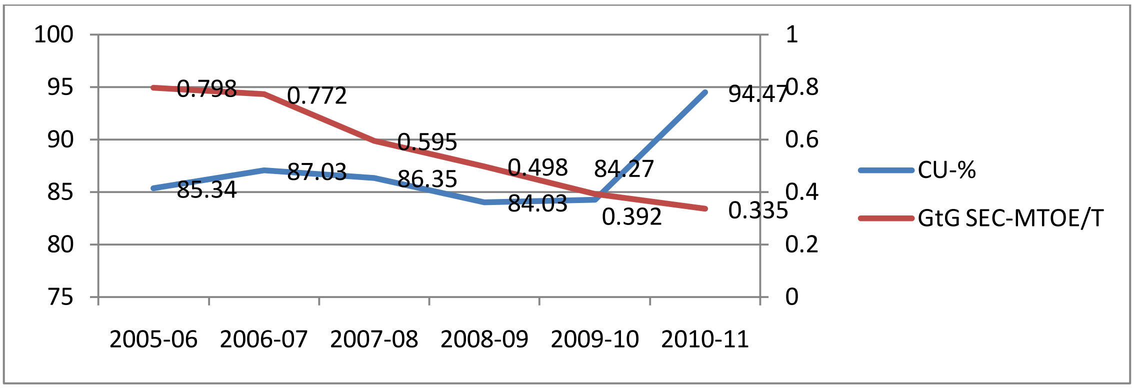


Figure 15: CU to GtG SEC relationship

***Determination of GtG SEC separately for spinning & weaving***

Present electrical distribution and metering and monitoring systems would have to be changed for determination of SEC separately for spinning and weaving. This would be impractical and as such ruled out.

***GtG SEC for major product only as allowed as per BEE guideline***

The energy consumption break up for the different processes is as shown graphically below.

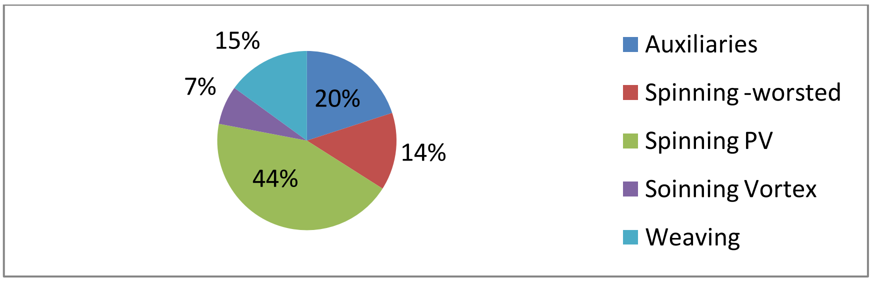


Figure 16: Energy consumption break-up

Spinning alone accounts for over 65% of the total consumption. Spinning therefore, can be considered as the major product from the perspective of PAT process. GtG SEC has been accordingly calculated taking into account the overall energy consumption and dividing by the normalized yarn production as shown in the following table and also graphically as figure 17.

Table 12: GtG SEC to CU on yarn weight basis

| Year | Yarn MT | GtG Energy MTOE | GtG SEC MTOE/Ton | CU % |
|---|---|---|---|---|
| **2005-06** | 2,747 | 4,509.505 | 1.642 | 87.15 |
| **2006-07** | 2,811 | 4,384.749 | 1.560 | 88.72 |
| **2007-08** | 3,877 | 3,973.265 | 1.025 | 82.72 |
| **2008-09** | 3,989 | 3,347.501 | 0.839 | 79.92 |

| | | | | |
|---|---|---|---|---|
| **2009-10** | 4,386 | 2,764.520 | 0.630 | 79.92 |
| **2010-11** | 4,753 | 2,515.619 | 0.529 | 92.92 |

The relationship is better seen visually from the graphical presention in Fig 17 below.

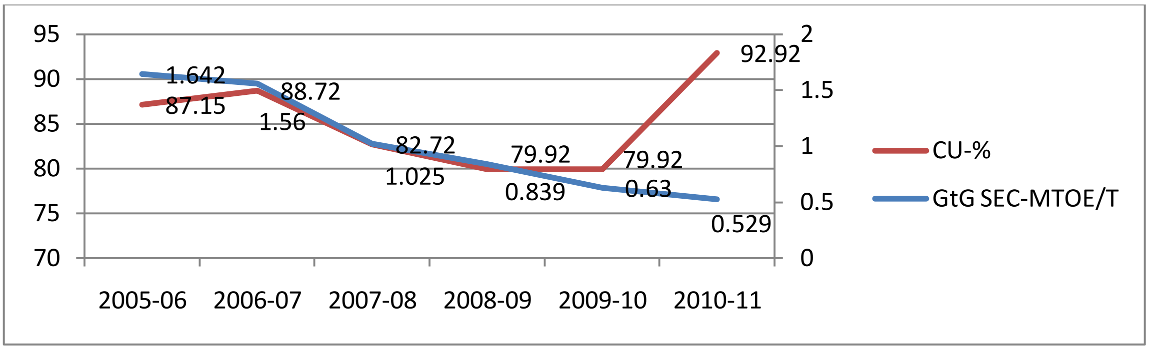


Figure 17 : CU SEC relationship on yarn basis

The relationship shows similar trend. However, in this case the impact of shift from fuel based DG system to grid power is reflected with greater clarity.

### *Impact of identified energy savings projects*

The following table shows the ECM projects and their impact as reported in the baseline report.

Table 13: Impact of ECM projects-unit-3

| Identified ECM projects | Savings potential (MTOE) |
|---|---|
| **VFD for humidification fans** | 86.68 |
| **Energy efficient LED lighting retrofit** | 83.65 |
| **Solar hot water for yarn conditioning machines** | 1.29 |
| **Total** | 171.62 |

Identified savings represent about 6% of the base year consumption of 2764 MTOE for 2009-10. This should enable the DC to meet the target set for the unit.

**Conclusions:**

- SEC behavioral trend on major product base is exactly similar to the one determined on the basis of composite production. It is therefore, possible to take only yarn production as the basis for assessment of composite unit.
- SEC has relationship with CU particularly when there is significant change in the CU
- There is major distortion in the initial period largely due to impact of fuel used in captive power generation. The calorific value taken for grid power at 860 kCal/kWh has distorted the overall SEC after major shift from captive generation based on diesel to grid power in 2007
- In the intervening period, the unit had implemented number of energy conservation projects to reduce the energy consumption in the period 2008-09. The impact of the same cannot be assessed due to lack of information
- Implementation of the identified ECM projects and results thereof should be used for reconciliation of the derived and normalized GtG SEC figures for the PAT cycle

## 5.4 ANALYSIS–UNIT No 4 (PROCESSING UNIT)

This is a processing unit carrying out both piece and fiber drying operations. Major energy consumption is for thermal energy, which represents 93% of the total energy consumption, while electricity representing the balance. In this case too very good quality data collection and analysis work have been carried out by the auditors.

## *GtG SEC corelationship*

The baseline parameters and the GtG SEC corelationship as reported by the auditors are shown in the following table and figure.

**Table 14: Baseline parameters & GtG SEC-unit-4**

| Year | Installed capacity Lac Meter | Average GLM gms/m | Installed capacity MT | Production MT | CU % | GtG SEC MTOE/T |
|---|---|---|---|---|---|---|
| **2005-06** | 245 | 316 | 7742 | 7700.1 | 99.46 | 0.839 |
| **2006-07** | 300 | 313 | 9390 | 8617.2 | 91.77 | 0.856 |
| **2007-08** | 330 | 315 | 10395 | 9743.7 | 93.73 | 0.707 |
| **2008-09** | 330 | 314 | 10362 | 9669.2 | 93.31 | 0.699 |
| **2009-10** | 330 | 308 | 10164 | 9486.5 | 93.33 | 0.696 |
| **2010-11** | 330 | 295 | 9735 | 9234.7 | 94.79 | 0.717 |

The GtG corelationship has been assessed against production rather than capacity utilisation as shown in the following figure.

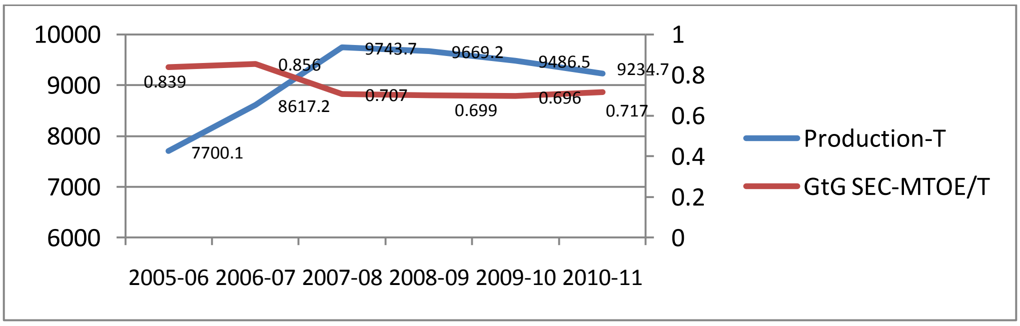


**Figure 18: GtG SEC corelationship-unit-4**

This shows reasonable corelationship between production and GtG SEC. However, the relationship changes when plotted against capacity utilisation as would be seen from the following figure.

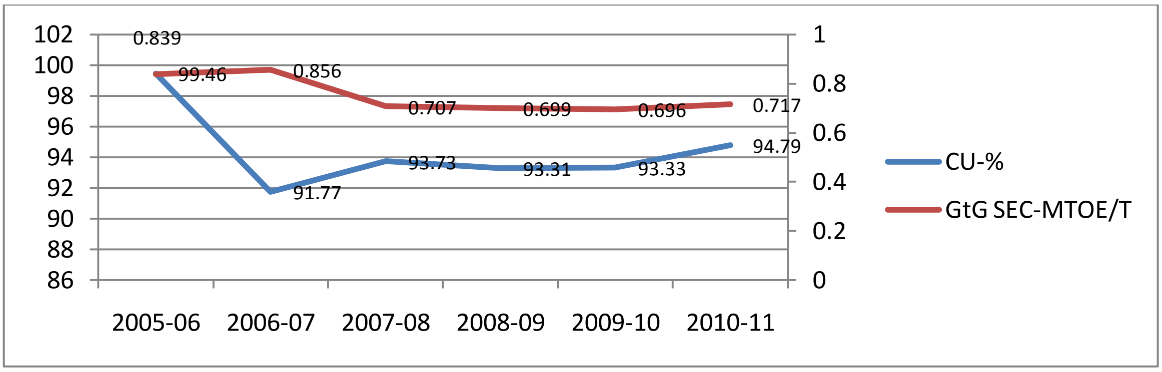


**Figure 19: GtG SEC relationship to CU-uit-4**

The auditors have identified following key variables, which directly impact GtG SEC.

- Raw materials-for example PV fabric processing requires dying operation to be carried out twice requiring more energy. In this case, share of PV fabric has gone up from historical average of about 65% till 2009-2010 to over 70% in 2010-11
- Variation in average GLM-significant reduction from historical average of about 315 till 2008-09 to 308 in 2009-10 and further down to 295 in 2010-11
- Processing need- Ratio of piece dyed (PD) to fiber dyed (FD) fabric directly affects SEC
- Finished product quality-mainly visual finish often requiring repeat processing based on perception

The auditors have presented some data showing the trend in variation of some of the parameters but have not provided analysis and corelationship to GtG SEC.

The auditors have also highlighted that the plant has increased capacity of the plant during the period and implemented many ECM projects. These would have impacted the SEC but the same has not been quantified or correlated.

Considering the fact that the thermal energy comprises of 93% of the energy consumption, change in the fuel mix can also impact the SEC. The efficiency of the steam generating units would have definite relationship with fuel quality. Higher operating efficiency as a result of better fuel would mean lesser GtG energy consumption. From the figure 20 below, it is seen that there has been significant shift in the fuel mix from lignite as the major to petcoke for the boilers.

There has also been reduction in power generation from the captive plant thereby reducing consumption of diesel fuel. However, electricity accounts for a very small percentage of the overall energy consumption hence can be ignored.

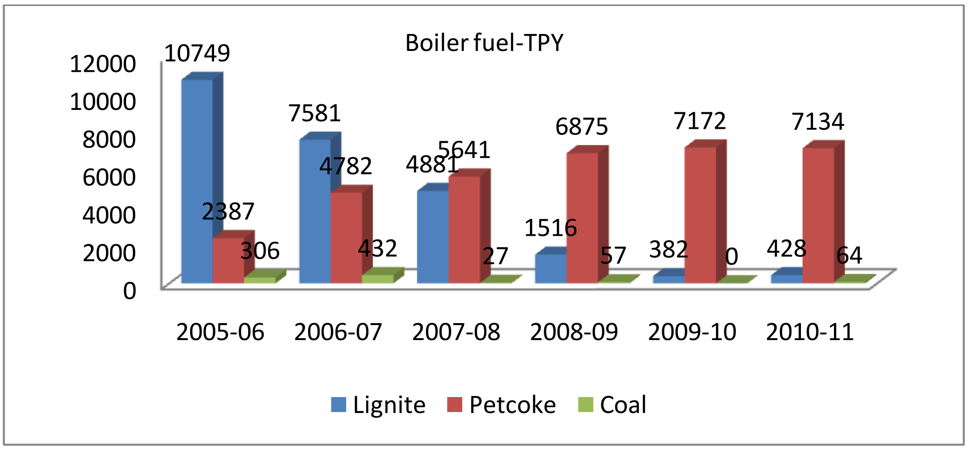


Figure 20: Change in fuel mix-unit-4

### *Impact of identified energy savings projects*

The following table shows the ECM projects and their impact as reported in the baseline report.

**Table 15: ECM Projects-unit-4**

| ECM Projects | Savings potential (MTOE) |
|---|---|
| **Insulation of drying cylinders** | 1.86 |
| **Insulation of condensate recovery tank** | 2.75 |
| **Insulation of boiler feed water tank** | 9.79 |
| **Installing efficiency monitoring system for thermopac** | 68.88 |
| **Installing efficiency monitoring system for boiler** | 86.1 |
| **Replacement of less efficient jiggers** | 69.35 |
| **Modification of radiators of few stenters** | 23.41 |
| **Total** | 262.14 |

The potential savings at 262 MTOE represents about 4% of the baseline energy consumption at about 6600 MTOE for the year 2009-10. The unit would have to carry out more rigorous energy assessment study and aim for identification and implementation of more ECM projects.

**Conclusion:**

- A decreasing trend in Specific Energy Consumption (SEC) is observed with increase in production during the last six years but the same cannot be said about relationship with capacity utilisation.
- Unit has augmented the production capacity during 2005-06 to 2007-08.
- Plant has invested in various energy conservation measures during 2005-06 to 20007-08 which has contributed the decreasing trend of GtG SEC.
- Number of other variables has been identified having impact of GtG SEC but in absence of adequate data, it would be difficult to establish specific corelationship.
- Even if data is collected for assessment in future, the cost of analysis could be too high to justify the level of required efforts
- It would be best to carry out the normalisation exercise for the production of fabrics only and carry out the reconciliation based on assessment of result of implementation of ECM projects.

## 6. VARIABILITY FACTORS AND NORMALIZATION

In addition to the review of the baseline reports and own database, DESL has carried out survey of literature available in the public domain and interaction with sectoral experts to establish the variables, which can impact the energy consumption and therefore, factored for the process of normalisation.

The review and recommendations are as follows.

## 6.1 RAW MATERIAL

Power requirement in the blow room vary according to the quality of the raw material. However, overall power consumption in blowing operation in a spinning unit ranges from 4 to 5%.[13]

In case of processing units, the impact would be higher in case of change in the mix of piece drying (PD) and fiber dying (FD) fabric quantities. However, it would require lot more data and intensive study to establish specific corelationship, making the cost of normalisation process unwieldy.

It is therefore, proposed to exclude raw material variability factors for normalisation.

## 6.2 PRODUCT-YARN

Many studies have been carried out to determine the factors affecting the energy consumption in ring spinning machines and several improvements have been made in the design of spinning machines to increase speed and efficiency of machines. The need has further increased with introduction of manufacture of compact yarn for better strength and finish characteristics. Such compact yarn essentially required higher energy consumption. Clear corelationship between yarn count and speed of machines to energy consumption has been established as would be seen from the following picture.

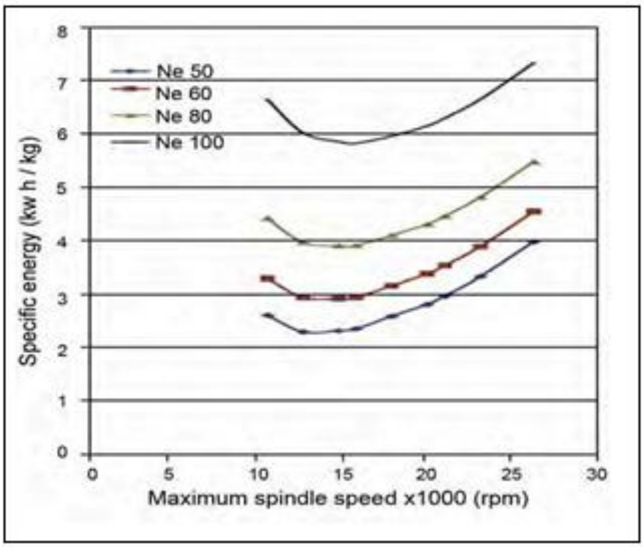


**Figure 21: Spinning SEC relationship**[14]

Thus, it can be seen that in an existing mill operating with machines designed for certain speed, it is only the count of the yarn, which would have the major impact on SEC.

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[13] BTRA powerspin system for estimation, monitor & control of energy consumption in ring frames in textile mill-S N Mishra et el, Bombay Textile Research Association

[14] Optimization of specific energy consumption for compact-spun yarns-Magdi El Messiry et el, Indian Journal of .Fibre & Textile Research, Vol. 37, March 2012

It would be therefore, necessary to convert production of different counts by adopting normalisation factors as Industries standard practice and determine the equivalent overall production on the normalized basis.

## 6.3 PRODUCT-WOVEN FABRIC

Energy is used for operating machines, utilities like air-conditioning, lighting and compressed air system and some amount of thermal energy in sizing process. Weft insertion is the major variable factors as most of the other factors do not change very much with change in product mix.[5]

As would be seen from figure 3, weft insertion is also the major consumer of energy for the weaving line. The number of insertion is a directly co relatable to the weight per meter of the woven fabric. Thus, it is possible to use only this variable and normalisation factor as per Industry practice to determine the production for computation of GtG SEC.

## 6.4 PRODUCT PROCESSED MATERIAL

Over 80% of the energy requirement in wet processing section is for thermal energy. For a particular mill, the consumption of energy can vary widely depending upon the type of textile being processed, fibre content, weight per unit area of the fabric, fabric width, construction and types of dyes and finishes being applied.[15]

As per the information available from the baseline audit reports, the variability factor of weight per unit area of fabric can be clearly established. It is therefore, proposed that this is the only factor used for normalisation from processing perspective.

## 6.5 SOURCE OF POWER and STEAM ACCOUNTING SYSTEM

At section 5.1 of this report, the distortion in SEC computation due to shift from furnace oil based DG power to grid power has been demonstrated. Similar issues would be experienced in all cases load switch under the following circumstances:

- Grid to DG or vice versa
- Grid to captive or vice versa
- Grid to Cogen/CHP of vice versa

It would be desirable to harmonise the system with a view to achieve the following desirable objectives:

- Determination of true GtG SEC
- Encouraging industry to adopt cogeneration/CHP systems

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[15] Energy benchmarking & best practices in Canadian Textile wet processing-Martin Adelaar et el; Fintex Mechanical & Process Inc.

The BEE protocol requires that the heat value of grid power be taken at 860 Kcal/kWh for import and 2717 Kcal/kWh (national average of all thermal power stations) for export. A system can be developed for accounting methodology, which would be able to achieve the harmonization objectives as stated above and at the same time maintaining the BEE guidelines.

This can be done by giving fuel credit for the difference between the heat rates as illustrated below.

Table 16: Illustrative case-heat rate accounting

| Baseline Case | Project Case |
|---|---|
| **Power-3000 KW, totally drawn from grid**<br>**Steam-10 TPH @ 700 Kcal/Kg enthalpy generated from a boiler** | Power-2000 KW generated from Cogen plant @ heat rate of 1300 Kcal/kWh<br>-1000 KW purchased from grid<br>Steam supplied from extraction system |

Cogen installation has increased the heat rate for 2000 KW power from 860 Kcal/kWh to 1300 Kcal/kWh. Thus, by usual accounting methodology plant would have adverse impact on computed GtG SEC. This can be overcome by giving fuel credit as per the following formula:

Cogen power generation-2000 KW (a)
Cogen PLF-0.8 (b)
Plant heat rate-1300 kWh/Kcal (c)
National heat rate of power-2717 kWh/Kcal (d)
Credit-1417 kWh/Kcal (e=d-c)
Annual fuel savings-e*a*b/(10000*10^3) TOE (assuming GCV of oil at 10000 Kcal/kg) (f)
Annual fuel purchase as per M&V protocol-g
Fuel for computation of GtG SEC=g-f
This would ensure that due credit has been given for adaptation of cogen. In fact higher the cogen efficiency, more benefit would be derived in line with global objective of the PAT scheme.
Detailed computation using a developed heat and mass balance diagram on the hypothetic case has been provided at Annex-I (Section 8 of this report)

## 6.6 SUMMARY RECCOMENDATION – VARIABLES AND NORMALIZATION

Based on the detailed review of the baseline audit reports for different types of textile manufacturing units, it is concluded that both **a common and differentiated methodology** would be required for normalisation of GtG SEC for the units. Considering the quantum of energy savings target, a simplified methodology has been developed, which we believe would be sufficient for maintaining the system integrity and at the same time keeping the cost of validation and reporting at the optimum level. The proposed methodology is presented in the following table.

Table 17: Normalisation process

| Normalization Factors | Manufacturing Process | | | |
|---|---|---|---|---|
| | | | | |
| **Raw materials** | Not required as impact on SEC is insignificant | Not required as impact on SEC is insignificant | Not required as impact on SEC is insignificant | Not required as impact on SEC is insignificant |
| **Finished product** | ***Count number***<br>Overall production to be determined | ***Weft insertion***<br>Total fabric production in | **Only yarn production and normalisation** | ***Fabric specific weight(GSM)***<br>Similar |

| | | | | |
|---|---|---|---|---|
| | by using count normalisation factor as per standard industry practice | meter is to be converted into MT production based on insertion and using normalisation factor as per industry standard | **factor** for spinning to be used | methodology as recommended for weaving may be used. |
| **Capacity utilisation (Common for all types)** | ***Unit specific corelatioship***<br>There is close corelatioship to be clearly established during detailed audit and validation study | | | |
| **Other factors- Specific heat rate for power (kCal/kWh)** | Specific heat rate for both captive generation and grid power to be established during baseline period. Grid power rate to be kept constant as per the baseline report whereas heat rate for captive power would be as per actual in both during baseline and validation stages. | | | |

## 6.7 VERIFICATION & VALIDATION

It would be necessary to adopt a mutli step approach for carrying out the normalisation process during the validation stage. Suggested steps are:

- Review of larger number of representative baseline audit reports to assess the CU : GtG SEC relationship, which can stand to statistical scrutiny
- The reasons for deviations particularly for units showing distinctly contra behavior need to be further analysed based on collection of larger number of data for hourly, daily, monthly and annual basis
- Impact of other variable factors such as the ones listed above need to be assessed

Methodology for baseline adjustment and reconciliation is to be developed for each unit as illustrated below.

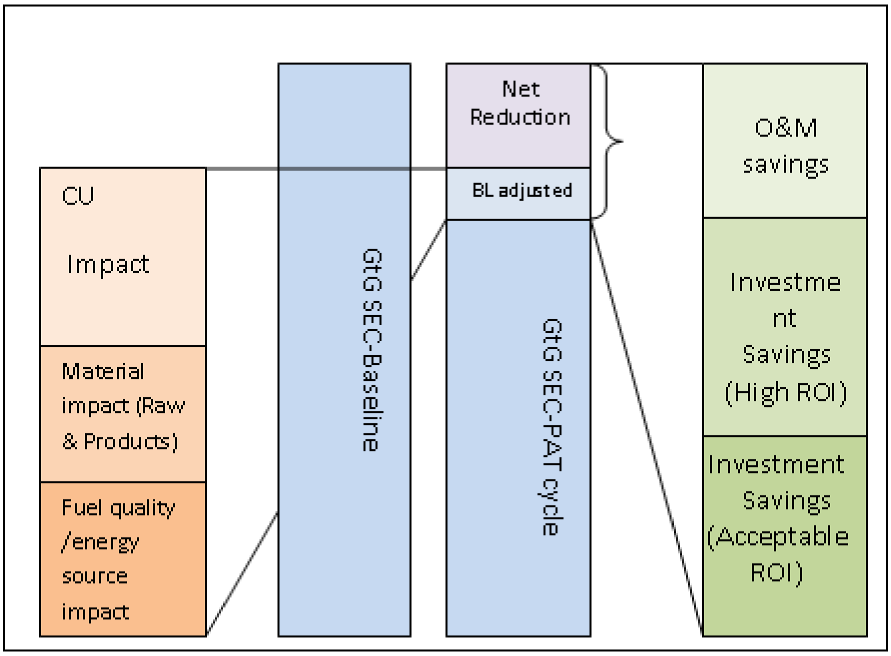



Figure 22: Normalisation and reconciliation

As illustrated, the unit has achieved the GtG SEC target, though the reported reduction figure may be lower (presented as net reduction in the figure). The gap is on account of change in baseline. The component of the baseline adjustment value has to be apportioned under each head based on proper analysis of data as explained above.

The gross reduction has to be reconciled by assessing the impact of energy savings projects under different heads as shown in the figure.

The entire protocol and the M&V process is therefore, proposed to be carried out in two parts:

- Gross assessment based on input-output measurement & accounting
- Project performance evaluation and impact assessment

Project performance assessment may be carried out using the international performance measurement & verification protocol (IPMVP) as illustrated in the following table.

Table 18: IPMVP Protocol

| Option | Description | Pros | Cons | Recommendation |
|---|---|---|---|---|
| **C-whole facility** | Energy savings can be directly determined by actual measurements of inputs and outputs | Most accurate<br><br>Results & impact can be transparently established<br><br>Easy to vary out baseline adjustment | Difficult to implement in retrofit applications particularly where inputs and outputs cannot be specifically linked to the EE projects | Can be implemented for utility systems like pumps, compressors, lighting etc. |
| **D-Calibrated simulation** | The energy savings are determined based on pilot study and applying simulation methodology for application to the whole facility or sub-facility | Reasonably accurate system can be developed for determination of energy savings by periodic test & performance analysis | Requires higher skill for carrying out simulation.<br><br>Information asymmetry can create problem of acceptability | Best suited for systems like furnace, boilers etc |
| **A-Partial retrofit isolation** | Savings are estimated based on partial measurements | Very easy and low cost of M&V | Lower level of acceptability particularly when responsibility for | Would be the practical system for most of the retrofit projects |

| | | | | |
|---|---|---|---|---|
| | and assumptions for certain parameters | | operation control is not clear-for example streetlight system | |
| **B-Retrofit isolation** | Same as above except full systems are to be measured & monitored | Robust and accurate | Very high cost of metering & monitoring | Only for high investment projects, where high cost of metering would be justified |

Alternatively, the system introduced by any unit for implementation of ISO 500001 energy management system can also be used for the same.

In either case, it is recommended to follow a process flow methodology detailed out at section 9 (Annex-II) of the document.

# 7. OVERALL M&V PROCESS AND PROTOCOL

## 7.1 METERING AND MEASUREMENT

The suggested metering and measurement plans presented in the following flow sheet.

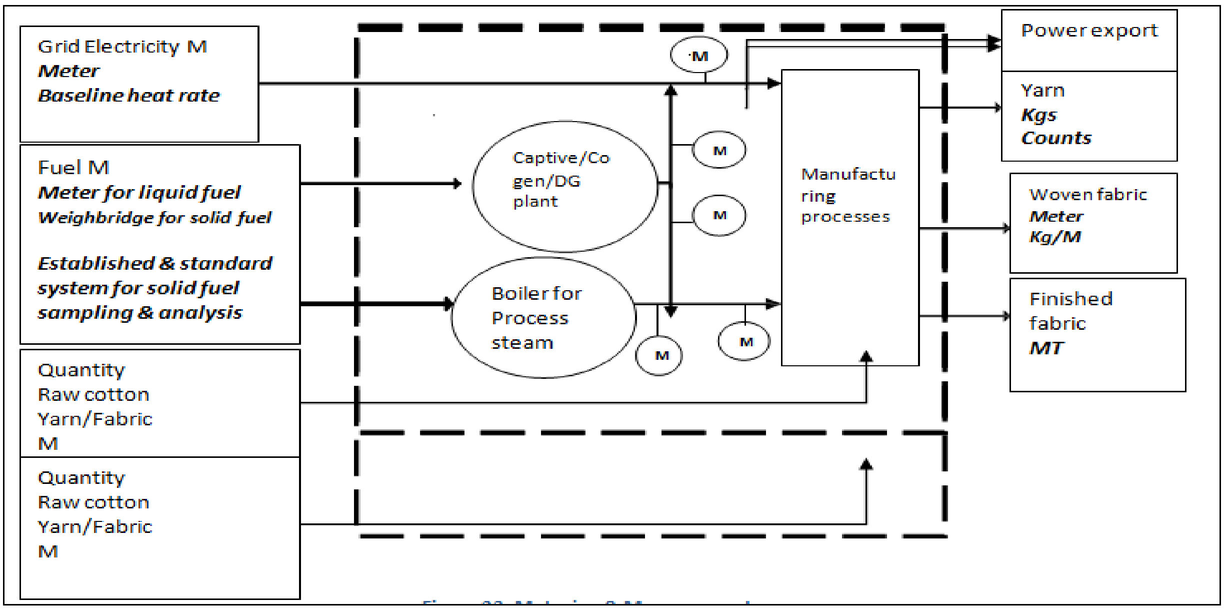



Figure 23: Metering & Measurement

The metering & measurement plant to clearly determine:

- Production of different products-yarn, fabric, processed fabric
- Import of cotton

- Import of product intermediate
- Fuel quantity & quality
    - Power generation
    - Steam/heat production
- Imported & exported power
- Power from wind and solar systems
- Power generation in CPP

The data and information management system has BEE accordingly proposed as shown at the section 7.2 below. The 'Schedule' annexed with the PAT document of July 2012 has provided guideline for carrying out the normalisation process in respect of capacity utilisation. The proposed M& V protocol for validation has been designed to address to the following specific provisions:

- The normalisation process for CU to be applied only if there is deviation of more than 30% due to uncontrollable factors
- In case of multiple products, major product can be considered for GtG SEC and normalised production value of the major product taken for both baseline & PAT cycle
- The normalisation process shall be done by performing a statistical analysis

It is but natural that for other identified variables too, similar methodology has to be adopted.

Statistical analysis would require lot more data than what could be made accessed during baseline audit. The recording frequency of data has been proposed accordingly. The validators would be expected to carry out statistical analysis based on such data and determine the annual factor.

The review of the baseline audit data has indicated that in many cases, clear corelatioship between CU & GtG could not be established. With availability of data on other identified variables, it would be possible for validators to carry out the statistical analysis required for validating the normalised GtG SEC data for issuance of certificates.

## 7.2 Data & Information Protocol

Table 19: Data & information protocol

| ID | Data variable | Source of data | Data unit | Measured (M), calculated (C) or estimated (E) | Recording Frequency | How will the data be archived? (electronic, E/ paper, P) | Comment |
|---|---|---|---|---|---|---|---|
| A | | | | **Production** | | | |
| A1 | Production Capacity (Yarn) | Balance sheet | TPY | E | Annual | E/P | |
| A2 | Production Capacity(Fabric) | Balance sheet | TPY | E | Annual | E/P | |
| A3 | Count-wise yarn production | Daily production report | TPY | M/C | Daily | E/P | |
| A4 | GSM-wise fabric production/processing | Daily production report | TPY | M/C | Daily | E/P | |

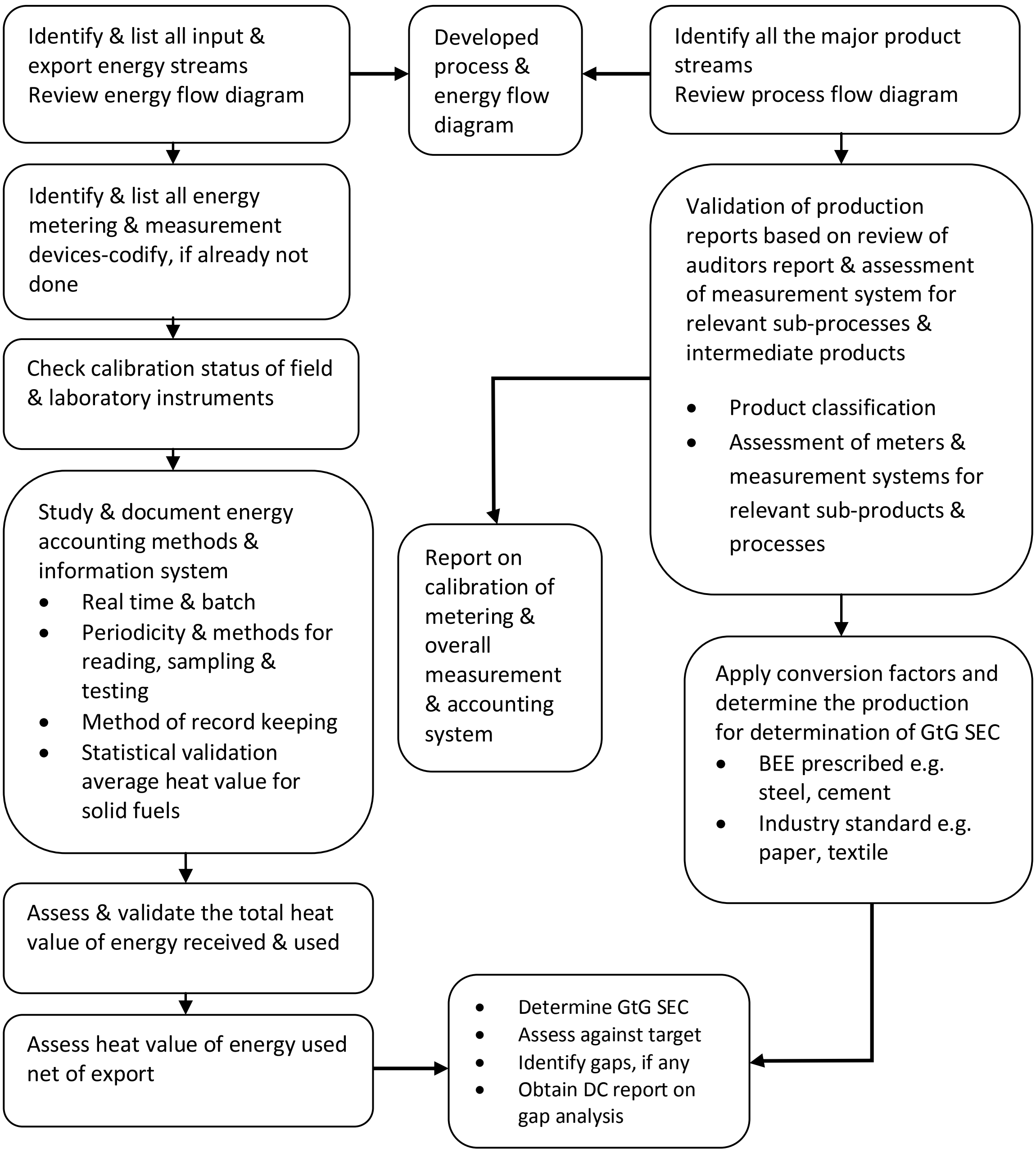
| | | | | | | |
|---|---|---|---|---|---|---|
| A5 | Opening yarn stock-count-wise | Cost Audit Report | MT | M/C | Annual | E/P |
| A6 | Closing yarn stock-Count-wise | Cost Audit Report | MT | M/C | Annual | E/P |
| A7 | Opening fabric stock-GSM-wise | Cost Audit Report | MT | M/C | Annual | E/P |
| A8 | Closing fabric stock-GSM-wise | Cost Audit Report | MT | M/C | Annual | E/P |
| A9 | Cotton purchased | P&L account | TPY | M/C | Annual | E/P |
| A10 | Yarn purchased | P&L account | TPY | M | Annual | E/P |
| A11 | Fabric purchased | P&L account | TPY | M | Annual | E/P |
| **B** | | | **Power** | | | |
| B1 | Power import | Utility bill | Million kWh(MU) | M/C | Monthly | P |
| B2 | Power export | Utility billing | Million kWh (MU) | M/C | Monthly | P |
| B3 | Import of power from renewable | Utility billing | Million kWh (MU) | M/C | Monthly | P |
| B4 | Gross generation-Unit-1 | DCS/daily report | Million kWh (MU) | M/C | Daily | P/E |
| B5 | Gross generation-Unit-2 | DCS/daily report | Million kWh (MU) | M/C | Daily | P/E |
| B6 | Gross generation-Unit-3 | DCS/daily report | Million kWh (MU) | M/C | Daily | P/E |
| B7 | Gross generation-Unit-4 | DCS/daily report | Million kWh (MU) | M/C | Daily | P/E |
| B7 | Auxiliary power consumption | Monthly report | Million kWh (MU) | M/C | Monthly | P/E |
| C | **Fuel** | | | | | |
| C1 | Imported coal quantity | Monthly cost audit reports | LTPY | M/C | Monthly | P/E |
| C2 | Imported coal GCV | Lab analysis report | Kcal/Kg | M/C/E | Per Consignment | P/E |
| C3 | Domestic coal quantity | Monthly cost audit reports | LTPY | M/C | Monthly | P/E |
| C4 | Domestic coal GCV | Lab analysis report | Kcal/Kg | M/C/E | Per Consignment | P/E |
| C5 | Lignite/petcoke quantity | Monthly cost audit reports | LTPY | M/C | Monthly | P/E |
| C6 | Lignite/petcoke quality | Lab analysis report | Kcal/Kg | M/C/E | Per Consignment | P/E |
| C6 | Biomass quantity | Monthly cost audit report | LTPY | M/C | Monthly | P/E |
| C7 | Biomass quality | Lab analysis | Kcal/Kg | M/C/E | Per | P/E |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | report | | | Consignment | |
| C8 | HSD quantity | Monthly cost audit report | Kilo Liter/year | M/C | Monthly | P/E |
| C9 | HSD quality-density | Lab analysis report | Kg/Liter | M/C | Per Consignment | P/E |
| C10 | HSD quality-GCV | Lab analysis report | Kcal/Kg | M/C | Per Consignment | P/E |
| C11 | Furnace oil (FO) quantity | Monthly cost audit report | Kilo Liter/Year | M/C | Monthly | P/E |
| C12 | FO quality-density | Lab analysis report | Kg/Liter | M/C | Per Consignment | P/E |
| C13 | FO quality-GCV | Lab analysis report | Kcal/Kg | M/C | Per Consignment | P/E |
| C14 | PNG/CNG-Quantity | Utility bill | Million SCUM/year | M | Monthly | P/E |
| C15 | PNG/CNG-Quality | Lab analysis report | Kcal/CUM | M/C | Daily | P/E |
| D | **Fuel Usage for Power Generation** | | | | | |
| D1 | Imported coal | Monthly cost audit report | LTPY | M/C/E | Monthly | P/E |
| D2 | Indian coal | Monthly cost audit report | LTPY | M/C/E | Monthly | P/E |
| D3 | Lignite | Monthly cost audit report | LTPY | M/C/E | Monthly | P/E |
| D4 | Biomass | Monthly cost audit report | LTPY | M/C/E | Monthly | P/E |
| D5 | HSD/FO | Monthly cost audit report | KLPY | M/C/E | Monthly | P/E |
| D7 | CNG/LNG | Monthly cost audit report | Million SCUM/year | M/C/E | Monthly | P/E |

# 8. NORMALISATION PROCESS

The normalisation process is proposed to be carried out in three stages:
Sep-1-Determination of GtG SEC as has been done in the baseline audit report
Step-2-Determination of the overall normalisation factors
Step-3-Verification & validation based on evaluation of implemented EE projects
The process and illustrative examples are as follows:

Step-1-Determination of GtG SEC



Step-2: Normalisation

Capacity utilisation impact-Statistical analysis
- Widen production & energy consumption database (From annual to more frequent-daily preferred)
- Carry out statistical analysis based on the daily record
- Eliminate exceptional highs & lows
- Establish CU impact
- Determine normalisation factor (N1)

↓

Fuel impact analysis (Fuel switch/solid fuel usage)
- Review fuel receipt & analysis reports
- Establish adequacy of data for statistical corelatioship
- Carry out statistical analysis (Quantitative reconciliation, heat value, ash & moisture content)
- Determine normalisation factor (N2)

↓

Power source change impact-Heat rate analysis
- Review & revalidate the process energy flow with specific reference to change in power usage mix (grid & captive)
- Review & assess the heat rate of captive power (baseline & PAT cycle) using HMBD
- Develop fuel adjustment formula taking standard heat rate for grid power & actual heat rate for captive power
- Determine normalisation factor (N3)

↓

Impact of other variables
- List key variables (recommendation for individual sector provided in this report)
- Carry out pareto analysis on sampling basis and select variables for moralization for the DC
- Review metering, measurement, recording & accounting systems for the variables & their relevant attributes
- Carry out statistical analysis on the basis of daily reports
- Establish corelatioship between the attributes & SEC
- Determine normalisation factor (N4)

↓

Normalised GtG SEC & Gap analysis
- Determine the overall normalisation factor (N=N1*N2*N3*N4)
- Determine normalised GtG SEC
- Review normalised GtG SEC against gap analysis report from DC
- Identify steps for reconciliation based on reports on implemented energy efficiency projects reported by DC along with M&V reports on the same
- Spot M&V & revalidation

Step-3: Verification & validation

**Review of audit report**

- Review of report of identified energy efficiency projects-form II & form III (Ref Form B under rule 5 & Form C under rule 7 of BEE notification)
- Establish linkage of expected results of projects on reduction of GtG SEC
- Review of M&V protocol as provided in the audit report

↓

**Assessment of implementation status**

- Review of investment approval and project implementation organisation & systems
- Physical verification of implemented projects
- Physical assessment of implementation of project M&V protocol
- Carry out spot check by performing M&V for few major impact making projects
- Review of the report on project performance from the project M&V reports of DC & spot M&V verification reports

↓

**Validation**

- Review of the project M&V protocol against GtG SEC normalisation M&V protocol
- Assessment of effective reduction of SEC from the implemented projects on GtG SEC
- Determination of the revalidated GtG SEC
- Preparation of revalidation & verification report

# 9. ANNEX-I-ILLUSTRATIVE METHODOLOGY FOR POWER ACCOUNTING

The GtG energy consumption is to be determined by converting all forms of energy into equivalent heat expressed in TOE. It is therefore, important that the process of conversion and normalisation for power and heat used is clearly established from both technical and accounting perspectives. This impact of Heat rate difference is illustrated with the following narratives for a hypothetical case wherein power and steam for processes are drawn from different types of systems.

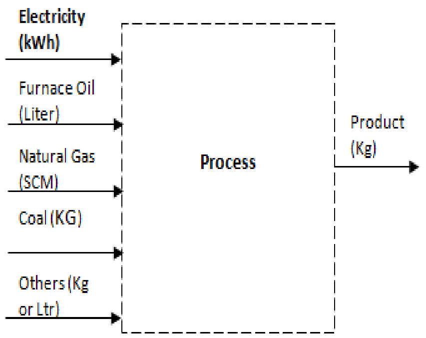



Figure 1 All energy purchased and consumed

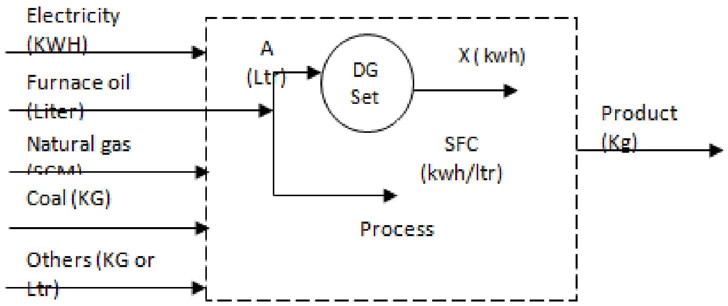



Figure 2 Electricity partially generated by (DG) set, other energy purchased & consumed

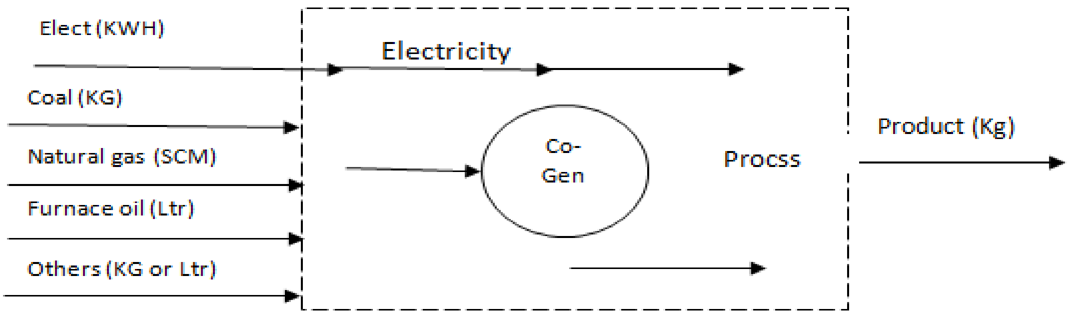



**Figure 3 Energy purchased & consumed, electricity & heat partially generated through co-generation plant**

Figure 24: Gate to Gate energy consumption

**Briefly the scenario cases are:**

1. Entire electricity is purchased from outside and fuel is used in boilers for steam generation and supply to the process
2. Part of the electricity is purchased from outside and balance generated using DG set. Steam is used by burning fuel in the boilers
3. Bulk of the electricity and process steam is supplied from captive cogeneration project; balance need for electricity is purchased from grid.

For the purpose of this document, we are considering fuel to include biomass also. Biomass is renewable fuel and as such can be considered for exclusion under clause ‘C’ of the GTG definition, if one goes by literal meaning-but we believe that renewable energy in the context means on-site generation using wind or solar technologies, which may in some cases make some marginal contribution.

More importantly, the calculation methodology for determination of overall SEC (in MJ/T or MTOE/T) needs to be assessed from energy efficiency and M&V perspective. The SEC can be calculated based on both direct and indirect method. The guideline document relies on direct method. In this method, overall energy consumption is determined by adding total fuel heat value and heat value of electricity computed by taking the heat content at 860 kCal/kWh.

Indirect method on the other hand would be a bottom up approach. Steam consumption in different processes would be aggregated on the basis of enthalpy values and overall heat value computed adjusting for losses in the boilers. Direct methodology would continue to be used for computation of electricity consumption in this case too.

The implications of using the two methodologies are explained in more detail with the help of the following Heat & Mass Balance Diagram (HMBD).

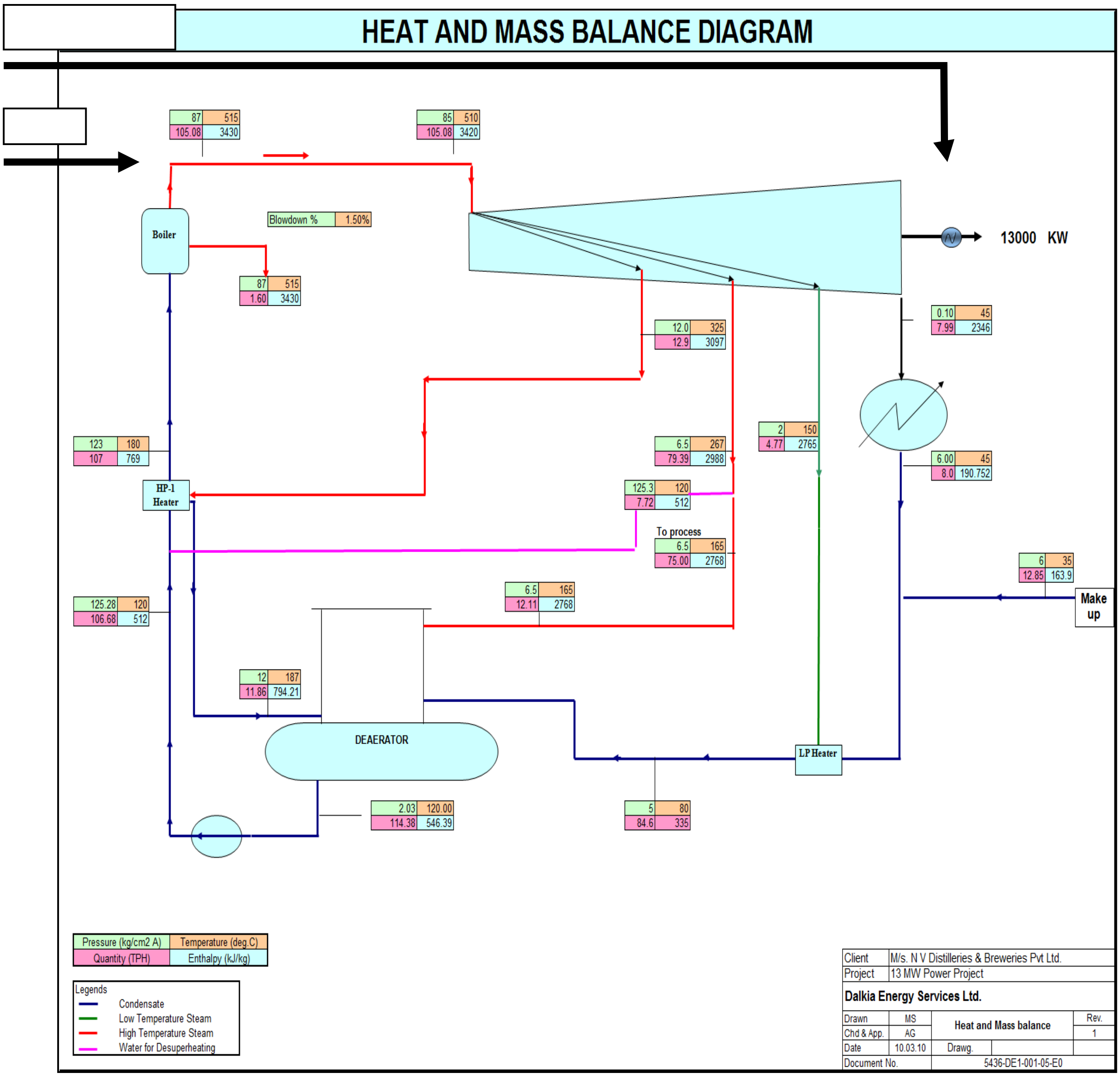



Figure 17: Heat & mass balance diagram

Let us take the following assumptions for development of case scenario:

Table 20: Overall energy consumption

| Particulars | Units | Amount | Specific Heat kCal | Eq. Heat Value kCal |
|---|---|---|---|---|
| **Scenario-1** | | | | |
| **Fuel** | Kg | 3000 | 3000 | 9000000 |
| **Power generated** | kWh | 0 | 0 | 0 |
| **Power Purchased** | kWh | 3000 | 860 | 2580000 |
| **Baseline Energy** | | | | 11580000 |
| **Steam for Process** | kg | 10000 | 700 | 70000000 |
| **Scenario-2** | | | | |
| **Fuel** | Kg | 4000 | 3000 | 12000000 |
| **Power generated** | kWh | 2000 | 0 | 0 |
| **Power Purchased** | kWh | 1000 | 860 | 860000 |
| **PAT Energy** | | | | 12860000 |
| **Steam for Process** | kg | 10000 | 700 | 70000000 |

The figures under scenario-2 have been derived from the HMBD for a hypothetical plant. In this case, the incremental fuel consumption for power generation is only 0.5 Kg/kWh. Even then by adopting cogeneration, apparent gross energy consumption for same amount of end use energy has increased. This has happened as in the 2$^{nd}$ scenario (HMBD scenario); the fuel value captures the loss in the Rankine cycle since the Cogen plant is within the gate. In the Scenario-1, this loss happens outside the Gate, thus providing an artificial benefit to the plant. But, by taking the real heat value of grid power, the scenario changes (Table below).

Table 21: Heat value at real heat rate

| Particulars | Units | Amount | Specific Hear kCal/Unit | Heat Value kCal |
|---|---|---|---|---|
| **Scenario-3** | | | | |
| **Fuel** | Kg | 3000 | 3000 | 9000000 |
| **Power generated** | kWh | 0 | 0 | 0 |
| **Power Purchased** | kWh | 3000 | 2717 | 8151000 |
| **Baseline Energy** | | | | 17151000 |
| **Steam for Process** | kg | 10000 | 700 | 70000000 |
| **Scenario-4** | | | | |
| **Fuel** | Kg | 4000 | 3000 | 12000000 |
| **Power generated** | kWh | 2000 | 0 | 0 |
| **Power Purchased** | kWh | 1000 | 2717 | 2717000 |
| **PAT Energy** | | | | 14717000 |
| **Steam for Process** | kg | 10000 | 700 | 70000000 |

* Boiler Efficiency considered at 80 % for all cases

Now, this table shows the real situation of how cogeneration plant has helped in reducing the overall heat content of the total energy system of the plant. This also shows how the unit would benefit under PAT scheme because of investment in Cogeneration.

Thus, using the methodology discussed at scenario-1 would have the following disadvantage:

- The incentive for reducing power consumption would be low particularly for the plants buying power from the grid since the plant would get credit only for 860 kCal/kWh though nationally we would be saving at least at 2717 kCal/kWh (Current grid heat rate).
- Disincentive for investment in Cogeneration from PAT perspective.

Similarly, if a plant has to use emergency power using DG set, the gross heat value would be much higher compared to grid power though end use efficiency might not change.

From the perspectives of scientific rationale, energy efficiency and robustness of the verification system, it would be more appropriate to adopt the following methodology for determination of gross energy consumption for power usage.

- Plant heat rate determined from the development of heat and mass balance diagram (HMBD) from individual plant (For the cases analysed by DESL, this value was varying from 1800 to 2600 kCal/kWh)
- 2717 kCal/kWh for grid electricity (Based on current value to be kept as the baseline value for the entire duration of the PAT cycle)
- 2300 kCal/kWh for DG electricity

However, there would be certain complexity in adopting this methodology for the present PAT cycle due to the following reasons.

- The entire baseline energy consumption and macro target has been worked out using 860 kCal/kWh for all the sectors
- It would be necessary to carry out the baseline audit once again to determine the HMBD heat rate of individual DC, which is impractical considering the status of implementation
- Using HMBD heat rate would significantly increase the baseline energy consumption value, which would not be desirable from overall perspective at this stage of the project
- Targets for individual DCs have already been set -it would be very difficult to reopen the same considering time required for consultation with stakeholders
- High level of skill and competency is required for development of HMBD for which training and capacity building exercise have to be carried out

These issues have been discussed in great detail in a meeting held with BEE experts on 20$^{th}$ March, 2012 while making presentation on the draft M&V protocol for the paper & pulp segments. DESL was advised to develop a methodology which can harmonise 'Gate to Gate' energy accounting system as per the PAT guideline document with the system proposed by DESL. The basic framework of the hybrid system was outlined as follows.

- Target setting exercise would be completed using the methodology as per PAT guideline document
- During the verification stage gross energy value would be computed using both the methodologies
- In case of deviation by more than 10%, further detailed audit would be carried out to reconcile the two values
- Computation methodology would also be developed to give due credit for cogeneration/power savings

Accordingly, DESL has developed the computation methodology to harmonise both the systems. This methodology has been developed on the basis of providing additional credit for power saving/cogeneration by netting the gross kCal saving from the fuel consumption considering the different heat rates as per DESL proposal. This is illustrated using the same hypothetical case.

Table 22: Harmonization of Heat rate impact

| Particulars | Units | Amount | Specific heat | Heat value | Particulars | Units | Amount | Specific heat | Heat value |
|---|---|---|---|---|---|---|---|---|---|
| | | | kCal/unit | kCal | | | | kCal/unit | kCal |
| Fuel | Kg | 3000 | 3000 | 9000000 | Fuel | Kg | 4000 | 3000 | 12000000 |
| Power generated | kWh | 0 | 0 | 0 | Power generated | kWh | 2000 | 0 | 0 |
| Power purchased | kWh | 3000 | 860 | 2580000 | Power purchased | kWh | 1000 | 860 | 860000 |
| **Baseline Energy** | | | | **11580000** | **PAT Energy** | | | | **12860000** |
| Steam for process | Kg | 10000 | 700 | 7000000 | Steam for process | Kg | 10000 | 700 | 7000000 |
| | | | | | HMBD heat rate | kCal/kWh | 1300 | | |
| | | | | | Savings | kCal/kWh | 1417 | Assuming national rate at 2717 | |
| | | | | | Fuel savings | kCal | | | 2834000 |
| | | | | | Revised PAT energy | | | | 10026000 |
| | | | | | Additional power savings | kWh | 500 | | 1358500 |
| | | | | | Equivalent fuel saving | All power savings should be considered as deemed export | | | |
| | | | | | **PAT savings for Escert** | | | | **8667500** |
| | | | | | %age saved | | | | 25% |

As would be seen from the table, computation method has been developed to harmonise the methodology in the guideline document with the HMBD methodology suggested by DESL. This has been done by taking the following steps:

1. Both baseline and target SEC would be determined using the methodology as per guideline document
2. During the validation process, following methodology would be adopted:
    a. Determine the gross energy level using the same concept
    b. Determine the HMBD heat rate using a simplified concept
        i. Carry out efficiency test of boiler
        ii. Determine the gross heat of steam (Fuel GCV*Efficiency)
        iii. Determine the gross heat of steam to process
        iv. Determine the heat used for power generation
        v. Determine the HMBD heat rate
    c. Assess the overall heat content of power based on HMBD heat rate
    d. Assess the gain due to cogeneration using the baseline heat rate of grid power
    e. Credit the savings so determined for calculation of savings under the PAT scheme
    f. For any additional power savings achieved through implementation of energy saving measures , it should be considered as deemed export for which guideline already provides grid heat rate for computation of energy value
    g. PAT energy would be computed after giving credit for both Cogen and power savings as has been illustrated in the table above.

# 10. ANNEX-II SITRA CONVERSION FACTORS FOR YARN COUNT

| Count | Yarn Type | Spindle Speed (rpm) | TM | TPI | 40s Conversion Factor |
|---|---|---|---|---|---|
| 10 | C | 12500 | 4.3 | 13.60 | 0.364 |
| 12 | C | 13500 | 4.3 | 14.90 | 0.406 |
| 14 | C | 14500 | 4.3 | 16.09 | 0.451 |
| 16 | C | 14500 | 4.2 | 16.80 | 0.509 |
| 18 | C | 15000 | 4.2 | 17.82 | 0.548 |
| 19 | C | 16000 | 4.2 | 18.31 | 0.575 |
| 20 | C | 16000 | 4 | 17.89 | 0.543 |
| 22 | C | 16500 | 4 | 18.76 | 0.592 |
| 26 | C | 16500 | 4 | 20.40 | 0.676 |
| 28 | C | 17500 | 4 | 21.17 | 0.708 |
| 30 | C | 17500 | 4 | 21.91 | 0.745 |
| 33 | C | 17500 | 4 | 22.98 | 0.822 |
| 34 | C | 17500 | 4 | 23.32 | 0.835 |
| 36 | C | 18000 | 4 | 24.00 | 0.891 |
| 38 | C | 18500 | 4 | 24.66 | 0.973 |
| 40 | C | 18500 | 4 | 25.30 | 1.030 |
| 41 | C | 18500 | 4 | 25.61 | 1.057 |
| 42 | C | 18500 | 4 | 25.92 | 1.078 |

| | | | | | |
|---|---|---|---|---|---|
| 46 | C | 19000 | 4 | 27.13 | 1.166 |
| 50 | C | 19000 | 4 | 28.28 | 1.264 |
| 54 | C | 19000 | 4 | 29.39 | 1.395 |
| 56 | C | 19000 | 4 | 29.93 | 1.427 |
| 60 | C | 19000 | 4 | 30.98 | 1.450 |
| 61 | C | 19000 | 4 | 31.24 | 1.482 |
| 62 | C | 19000 | 4 | 31.50 | 1.510 |
| 64 | C | 19000 | 4 | 32.00 | 1.558 |
| 65 | C | 19000 | 4 | 32.25 | 1.586 |
| 66 | C | 19000 | 4 | 32.50 | 1.618 |
| 70 | C | 19000 | 4 | 33.47 | 1.755 |
| 72 | C | 19000 | 4 | 33.94 | 1.837 |
| 74 | C | 19000 | 4 | 34.41 | 1.897 |
| 80 | C | 20000 | 4 | 35.78 | 1.934 |
| 82 | C | 20000 | 4 | 36.22 | 1.992 |
| 84 | C | 20000 | 4 | 36.66 | 2.050 |
| 85 | C | 20000 | 4 | 36.88 | 2.079 |
| 88 | C | 20000 | 4 | 37.52 | 2.171 |
| 90 | C | 20000 | 4 | 37.95 | 2.220 |
| 92 | C | 20000 | 4 | 38.37 | 2.281 |

| | | | | | |
|---|---|---|---|---|---|
| 94 | C | 20000 | 4 | 38.78 | 2.342 |
| 96 | C | 20000 | 4 | 39.19 | 2.410 |
| 98 | C | 20000 | 4 | 39.60 | 2.472 |
| 100 | C | 20000 | 4 | 40.00 | 2.510 |
| 105 | C | 20000 | 4 | 40.99 | 2.662 |
| 110 | C | 20000 | 4 | 41.95 | 2.828 |
| 115 | C | 20000 | 4 | 42.90 | 2.968 |
| 120 | C | 20000 | 4 | 43.82 | 3.102 |
| 124 | C | 20000 | 4 | 44.54 | 3.255 |
| 130 | C | 16000 | 4 | 45.61 | 3.415 |
| 135 | C | 16000 | 4 | 46.48 | 3.581 |
| 140 | C | 16000 | 4 | 47.33 | 3.769 |