M&V Protocol for Pulp & Paper Sector

Perform-Achieve and Trade Scheme

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SHAKTI
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ABBREVIATIONS

BEE	*Bureau of Energy Efficiency*
CEA	*Central Electricity Authority*
CPP	*Captive power plant*
CU	*Capacity utilisation*
CUM	*Cubic meter*
CPPRI	*Central Pulp and Paper Research Institute*
DC	*Designated consumer*
DESL	*Development Environergy Services Limited (Formerly, Dalkia Energy Services Ltd)*
EC	*Energy conservation*
Escert	*Energy savings certificate*
GCV	*Gross calorific value*
GtG	*Gate to gate*
IPMA	*Indian Paper Mills Association*
KLPY	*Kilo liter per year*
LP	*Low pressure*
LTPY	*Lakh tonnes per year*
MP	*Medium pressure*
MT	*Metric Ton*
M&V	*Monitoring & Verification*
PAT	*Perform achieve & trade*
RCF	*Recycle fibre*
SCUM	*Standard cubic meter*
SEC	*Specific energy consumption*
TOE/MTOE	*Tonnes oil equivalent*
TPD	*Tonnes per day*

EXECUTIVE SUMMARY

This protocol has been prepared to assist the stakeholders, particularly the Designated Consumers (DCs) in the pulp & paper 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
- Data and information protocol for carrying out determination of GtG SEC exercise & normalisation
- Monitoring & verification (M&V) protocol for assessment of performance of ECM projects
- Validation process and reporting of normalized GtG SEC for the PAT cycle

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

The sector has been classified under different categories based on both raw material usage and type of finished products. Treatment of variables such as capacity utilization, product mix and fuel quality have been generally outlined in the BEE document. The baseline reports have carried out the computation of GtG SEC based on gross production and energy consumption as per BEE general guideline since no specific guideline has been provided on normalisation on account of product and other variables.

Some more such variables have been identified based on DESL audit reports and literature survey and their impact studied. It has been observed that annual average value of production and energy usage as reported in the baseline reports may or may not truly reflect the correlation between CU & GtG SEC. More in depth analysis has been carried out for determination of relationship behaviors.

Conversion factors for determination of equivalent heat value for power from different sources for captive consumption as provided in the guideline can cause some distortion in the determined SEC under certain conditions. Normalisation process has been recommended to take care of such situation.

From the normalisation perspective, there are number of uncontrollable variables that can impact SEC. DESL has carried out extensive study and have identified the following key variables that need to be factored.

- Production & capacity utilization
- Raw material usage
- Finished products
- Pulping technology

- Change in mix of power and steam drawn from different sources

From the perspective of PAT, mathematical correlation of GtG SEC to identified variables is to be established and normalisation process carried out using the correlation factors so derived. For this, it would be necessary to have large number of data points for each of the variables for 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.

Summary process for carrying out normalisation and validation has been developed and provided in this document. Similarly, data and information need have been assessed. The protocol for the same has also been provided in the document. The normalisation process and M&V reports 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.

This document has been prepared for use only as a guiding document within the framework of principles and processes outlined by MOP/BEE.

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.

[1] PAT consultative document

2. PULP& PAPER INDUSTRY-OVERVIEW

2.1BRIEF OVERVIEW OF SECTOR PERFORMANCE

The Indian Paper Industry accounts for about 1.6% of the world's production of paper and paperboard. The estimated turnover of the industry is Rs 25,000 Crore (USD 5.95 billion). The industry provides employment to more than 0.12 million people directly and 0.34 million people indirectly[2].

There are over 650 paper mills in the country producing different types of papers using different types of raw materials.

Table 1: Paper production in India (2010-11)-MT/Year[3]

Product	Wood based	Agro residue	Waste paper/RCF	Total
Writing & printing	2.36	0.73	0.81	3.9
Packaging	0.77	1.5	3.15	5.42
News-print	0.03	0	0.76	0.79
Total	3.16	2.23	4.72	10.11

The consumption of different grades of paper has been growing by and large in a secular manner in line with GDP growth. However, the raw material base has been changing significantly over the year.

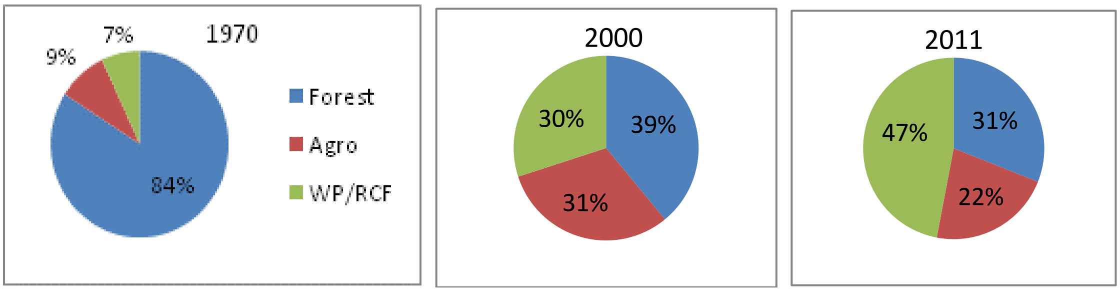

Figure 1: Change in the RM usage

Thus, from the macro perspective, the sectoral baseline specific energy consumption would also be changing due to change in the consumption pattern of the raw materials. From the perspective of PAT, one needs to remain conscious of the likely impact of this change for an individual DC and develop the baseline SEC and normalization factors accordingly. In the current PAT cycle, the DCs have been grouped accordingly.

The present PAT cycle has included only 31 of the 653 units as per the threshold energy consumption criteria laid down as per notification. These have been classified based on the usage of raw materials and finished products as per information available from various sources including the Baseline Energy Audit report, DESL audit data base and public domain.

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2 IPMA website
3 Planning commission approach document for 12th plan

The above classification has been based on the usage of the dominant raw material by the particular DC. It would be necessary to obtain data for usage of other types of raw materials, should the DC be using the same as supplementary raw materials.

2.2OVERVIEW-MANUFACTURING PROCESS

The pulp and paper industry converts fibrous raw materials into pulp, paper, and paperboard products. Pulp mills manufacture only pulp, which is then sold and transported to paper and paperboard mills. A paper and paperboard mill may purchase pulp or manufacture its own pulp in house; in the latter case, such mills are referred to as integrated mills.

The major processes employed in the pulp and paper industry include raw materials preparation, pulping (chemical, semi-chemical, mechanical, and waste paper), bleaching, chemical recovery, pulp drying, and paper making.

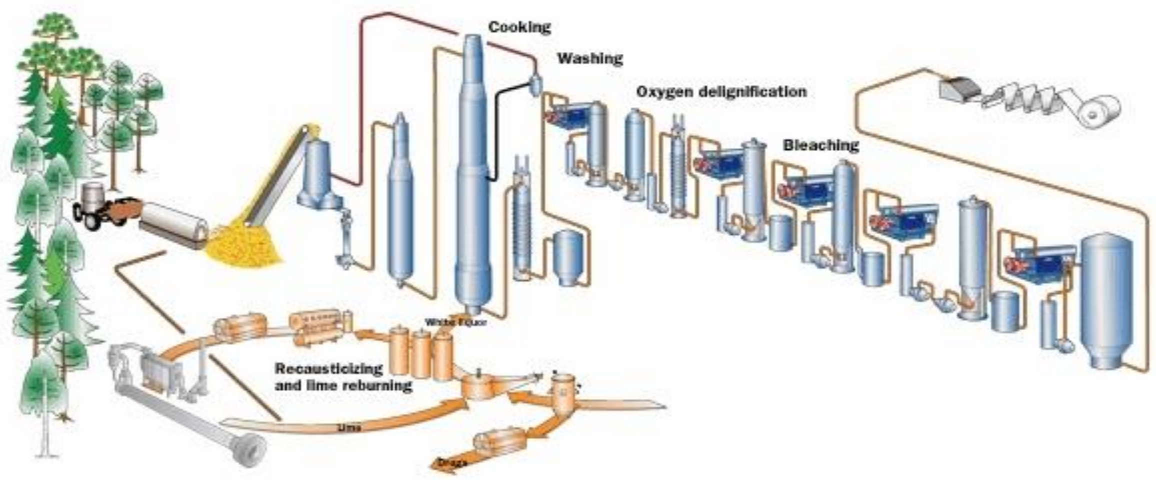


Figure 2: Pulp & paper manufacturing process[4]

Currently, about 31% of the raw material requirement is met from forest product including wood and bamboo. Logs typically arrive at the mill on trucks. Debarkers are used to remove bark from logs prior to chipping, since bark is a contaminant in the pulping process. After debarking, the logs are sent to a chipping machine (most commonly a radial chipper). Agro Agro-waste based mills use varieties of raw materials including stalks, straw and sticks. Cutters/shearing machines are used for the preparation of such materials for pulping. Increasingly, most of the mills are also using some secondary fibre in the production of pulp. Waste paper is currently the major source for secondary fibre.

The primary goals of pulping are to free fibres in wood from the lignin that binds these fibres together, and then to suspend the fibres in water into a slurry suitable for paper making. The three main processes for producing wood pulp are mechanical pulping (includes thermo-mechanical

[4] www.jsia.grp.jp

process), chemical pulping (includes kraft and sulfite pulping also), and semi-chemical pulping. Of these, the Kraft chemical pulping process accounts for practically 70 % of all the DCs covered under the present PAT cycle[5].

Mechanical pulping is the oldest form of pulping. The process employs mechanical energy to weaken and separate fibres from wood and waste paper feedstock via a grinding action. The advantage to mechanical pulping is that it produces much higher yields than chemical pulping processes (up to 95%). However, because this process does not dissolve lignin, the fibre strength and age resistance of the resulting pulp are low. The weakness of the resulting pulp is compounded by the fact that the mechanical grinding process also produces shorter fibres.

In the thermo mechanical pulping (TMP) process, wood chips are first steamed to soften them before being ground in the same manner as the RMP process. The TMP process generates the highest grade mechanical pulp but is also a high energy intensity process due to its steam use.

Chemo-thermo-mechanical pulping (CTMP) involves the application of chemicals to wood chips prior to refiner pulping. The process begins with an impregnation of sodium sulphite and chelating agents. The mixture is then preheated to 120-130 ºC and ground in the refiner.

Raw pulp can range in color from brown to crème due to the remaining lignin that was not removed during the pulping process. For paper products for which brightness and resistance to color reversion are important, such as office and printing paper, the pulp must be whitened by a bleaching process prior to the paper making phase.

The papermaking process can be divided into three basic stages: (1) stock preparation, (2) “wet end” processing where sheet formation occurs, and (3) “dry end” processing where sheets are dried and finished.

2.3 ENERGY USE IN THE PULP & PAPER INDUSTRY

The pulp and paper industry uses both electrical and thermal energy in the form of steam in almost all the sub-processes as would be seen from the following figure.

[5] Klaas Jane Kramer, et al; LBNL

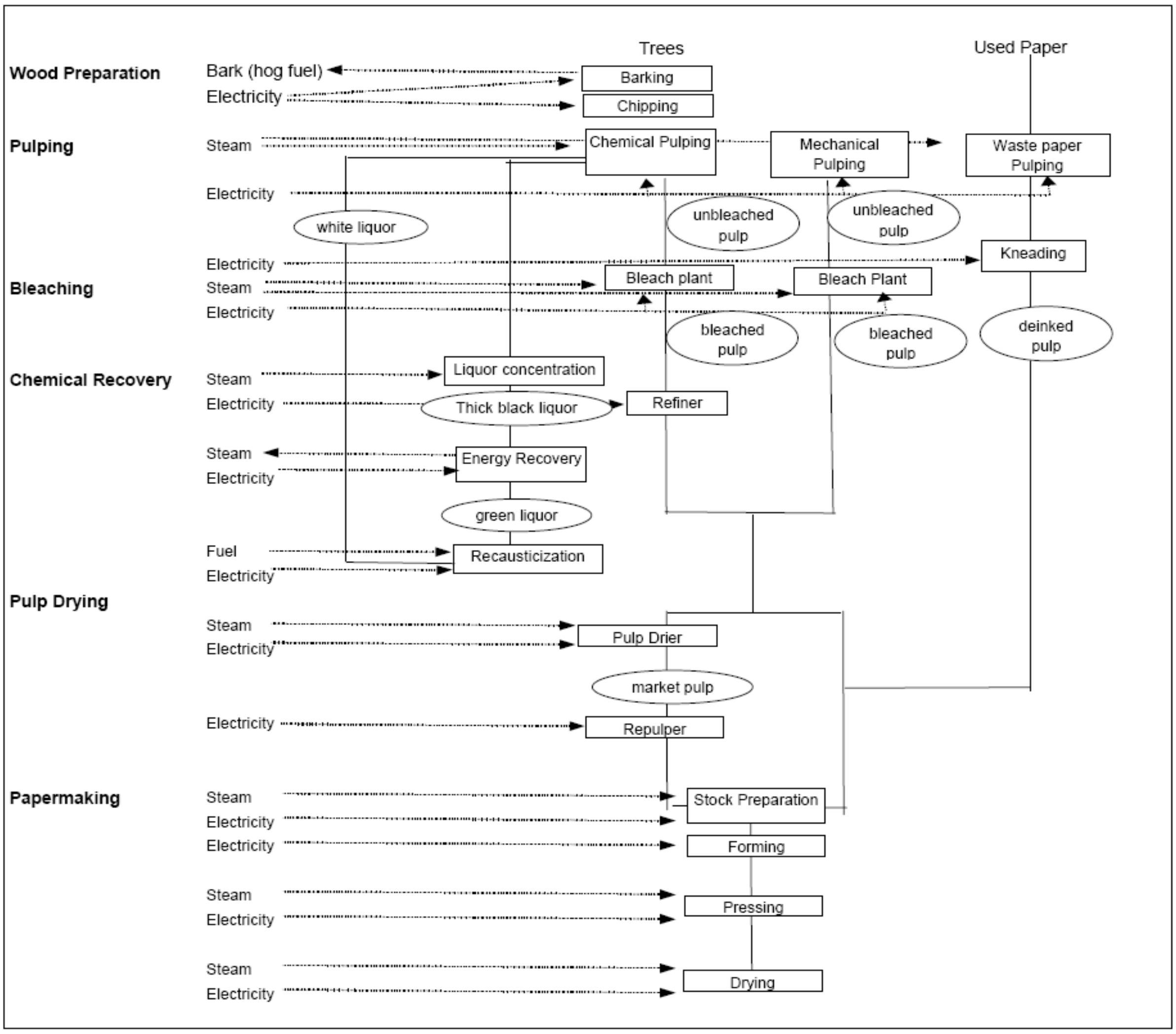


Figure 3: Energy usage in pulp & paper manufacturing6

Pulp and paper production is highly energy intensive with 60 to 80% of the energy requirement being used as process heat and 20 to 40% as electrical power[7]. The share of thermal and electrical energy depends upon variable factors such as raw materials and finished products. Energy consumption for pulping and digesting, for example, is lower if wastepaper is used instead of wood chips or agricultural residue. In general, the use of wastepaper requires about 2.5 times less energy[6] than a similar production process based on other inputs mainly because of less intensive pulping needs for wastepaper.

The ratio of steam to power makes the industry ideally suitable for deployment of cogeneration technology, simultaneous generation and power and steam, bleeding medium and low pressure steam from power turbine to meet the process demand.

Most of the energy is used in form of heat within the pulping process (digester, evaporator and washing) when raw materials have to be cooked and mechanically or chemically treated for further use in the production chain.

[6] Klaas Jane Kramer et el LBNL, USA
7 DESL audit database

Furthermore, paper making requires considerable amounts of energy in form of both heat and electricity for forming, pressing and drying of the paper.

Pulp and paper making processes account for over 70% of the total energy used in the manufacturing operation. Balance 30% is consumed mostly for various utilities and support systems[7].

3. DESIGNATED CONSUMERS-PULP & PAPER

Over 650 paper mills are operating in the country consisting of both small and large mills. Of this, 31 units have been categorized as designated consumers (DCs) based on the annual threshold energy consumption level of 30000 MTOE. From the overall PAT perspective the Pulp & paper industry has a small role as the targeted share of savings from this sector at about 0.119 Million MTOE is only 2% of the overall target.

The DCs have been broadly classified based on raw material usage consisting of:

- Wood based-17 units
- Agro based-6 units
- Recycled fibre based-7 units
- 100% market pulp based-1 unit

The number of units and the targeted range of savings are as shown in the following figure.

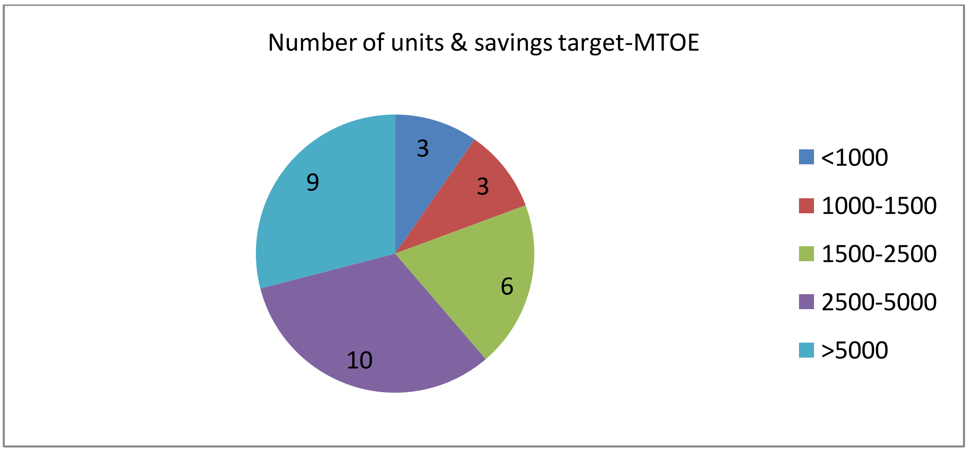


Figure 4: Units & savings targets

It is seen that the numbers are fairly evenly distributed over the range of savings target, even though the target for individual unit is fairly small. This would pose some challenge in design and management of the M&V system. There would be complexity in the M&V system due to many variables such as raw materials, finished products and means and source of fuel, power and process steam. On the other hand, the cost of transaction has to be managed so that this does not become disproportionately high compared to the gain/penalty from the PAT process.

4. BASELINE & NORMALIZATION-OVERVIEW

4.1BEE 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).

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

While 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.

With a view to neutralize the impact of uncontrollable variables, the concept of baseline and normalisation has been introduced (Text box-2).

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 a 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.

Capacity utilisation has been identified as the key variable for normalisation. 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.

The guideline has also categorized the units for the purpose of establishment of energy consumption norms and standards as follows:

- The input raw materials are Wood, Agro and recycled fibre (RCF)
- The process outputs are of Chemical Pulping, Chemi-mechanical Pulping & 100% market Pulping
- The product output of specialty paper, non-specialty paper and newsprint

No other guideline has been provided for normalisation on account of uncontrollable variables such as change in raw material or product mix or processes.

As in all sectors, it has been provided that 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 following:

- BEE/EESL guidelines
- Review of the baseline audit reports
- Review of case studies-DESL database & literature survey

Using BEE/EESL guideline

BEE document has provided clear guidelines on production and energy consumption variables for the pulp & paper sector as discussed at section 4.1 above.

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

BEE guideline has rightly highlighted the need for statistical analysis for establishment of the relationship coefficient of identified variables for the purpose of normalisation. In respect of capacity utilization coefficient, the guideline has provided for consideration only if deviation is by 30% or more.

BEE has provided guidelines on conversion of electrical energy to equivalent thermal energy for power drawn from different sources. In cases of significant switch from one source to another, this can impact the value of derived GtG SEC even if the net electrical energy use remains the same. Normalisation needs to be carried out on this account.

Using the Baseline Reports

Two 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 not carried out the statistical analysis to arrive at the CU GtG correlation. The variables having impact on SEC have also not been identified. List of identified energy saving projects provided have been used for assessing the impact on reduction of GtG SEC.

Minor deviations have been observed in the methodology used for computation of GtG SEC. These have been taken care of in the baseline data sheet by recomputing the overall energy consumption and SEC based on input data and applying BEE prescribed methodology for conversion factors for electricity to equivalent thermal energy.

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 protocol, which is recommended to be maintained by DCs and 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.

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 Pulp & paper sector, following important variables have been identified:

- Pulping process
- Capacity utilization
- Mix of raw materials
- Mix of finished products
- Change in scenario-sourcing of power and steam

5. REVIEW OF BASELINE & DETERMINATION OF GtG SEC

The particulars of the 2 DCs are as shown in the following table.

Table 2: Particulars of the units

Parameter	Unit-1	Unit-2
Installed Capacity	180000 TPY	105000 TPY
Raw materials	Wood	Wood, Bagasse, Market pulp
Pulping process	Kraft Chemical	Chemical & mechanical
Finished product	Paper & duplex board	Paper & News print
Electricity Supply	Over 97% captive, balance grid	About 75% captive, balance grid

1.1 UNIT-1

The energy auditors have reported the various SEC figures as shown in the following table.

Table 3: Reported SEC figures-Unit-1

Particulars	Units	2007-08	2008-09	2009-10
Specific Thermal Energy	GJ/Tonne	28	27.24	30.93
Specific Electricity consumption	kWh/Tonne	1165.9	1130.7	1193.1
Gate-to-gate SEC	GJ/Tonne	27.25	26.54	30.25
Gate-to-gate SEC	kCal/kg	6520	6350	7237

The relevant baseline data and computed total energy consumption data is as shown in the following table.

Table 4: Baseline data-Unit-1

Particulars	Unit	2007	2008	2009
Production and capacity utilization details				
- **Production Capacity**	Tonne	180000	180000	180000
- **Production**	Tonne	169891	173682	173638
- **CU**	%	94.4%	96.5%	96.5%
ELECTRICITY CONSUMPTION				
Electricity from Grid / Other				
Gross Total Units from Grid	Mn kWh	6.75	5.54	3.94
- **Purchased / Billed Units**	Mn kWh	6.75	5.54	3.94
- **Equivalent Thermal Energy (B1)**	M kCal	5805	4764	3388

Particulars	Unit	2007	2008	2009
Own Generation				
- **Through DG sets**	Mn kWh	10.79	9.52	3.58
- **HFO consumption**	kL	2736	2251	2368
Through Steam turbine/ generator				
- **Annual Gross Unit generation**	Mn kWh	180.53	181.33	199.65
- **Average Gross Heat Rate**	kCal/ kWh	NA	NA	NA
- **Auxiliary Power Consumption**	%	NA	NA	NA
Electricity export-grid	Mn kWh	0	0	0
Total Electricity Consumed	Mn kWh	198.07	196.39	207.17
SOLID FUEL CONSUMPTION				
Coal (Indian)				
- **Quantity purchased**	Tonnes	14053	176447	230616
- **Quantity for power generation**	Tonnes	141118	174326	220687
- **GCV**	kCal/ kg	5040	4750	4460
Thermal Energy Input- Indian coal	M kCal	711235	828049	984264
Coal (Imported)				
- **GCV**	kCal/ kg	6248	5776	5819
- **Quantity purchased**	Tonnes	33824	28483	36603
- **Quantity for power generation**	Tonnes	43005	27776	23131
- **Thermal Energy Input-Imp. Coal**	M kCal	268695	160434	134599
Total energy-solid fuel	M kCal	979930	988483	1118863
LIQUID FUEL CONSUMPTION				
HFO				
- **Quantity purchased**	kL	9972	9162	11646
- **Average Density**	kg/litre	0.958	0.958	0.958
- **GCV**	kCal/ kg	10000	10000	10000
- **Quantity for power generation**	kL	2736	2251	2367
- **Quantity for process heating**	kL	7236	6911	9279
Total HFO consumption	Tonnes	9553	8777	11157

Particulars	Unit	2007	2008	2009
HSD				
- **Gross calorific value**	kCal/ Kg	10500	10500	10500
- **Quantity purchased**	kL	20	24	0
- **Quantity for power generation**	kL	24.27	23.23	4.43
- **Average Density**	kg/litre	0.88	0.88	0.88
Total consumption	Tonnes	21.36	20.44	3.90
Total-liquid fuel	M kCal	95756	87987	111610
TOTAL ENERGY-FUEL	M kCal	1075686	1076469	1230473
TOTAL (FUEL + GRID ELECTRICITY)	M kCal	1081491	1081234	1233861
	MTOE	108149	108123	123386
SEC	MTOE/T	0.6366	0.6225	0.7106

CU GtG SEC Correlation

The corresponding CU GtG SEC relationship trends are as shown in the following figure.

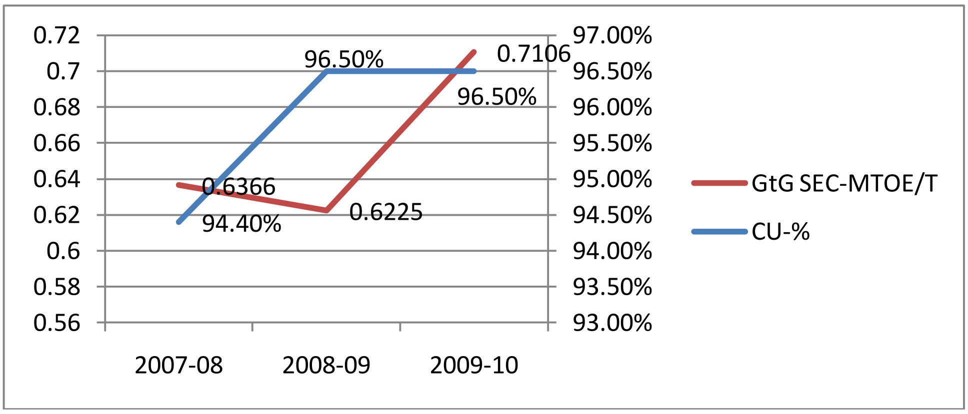


Figure 5: CU GtG SEC relationship (Without normalisation)-Unit-1

From the above, it would be seen that no clear correlation can be established between CU & GtG SEC. The production figures in the baseline report have been computed by arithmetic addition of productions of paper and duplex board. Based on the information available productions of paper and duplex board and electricity and steam consumption for the machines deployed for making these two products, following table has been constructed.

Table 5: Product SEC correlation-Unit-1

Particulars	Units	2007-08	2008-09	2009-10
Paper				
Production	TPY	112249	111494	110077
Electricity consumption	Lakh/y	654.6	653.7	657.1

Specific electricity consumption	kWh/T	583.17	586.31	596.95
Steam consumption	TPY	247916	251514	271990
Specific steam consumption	T/T	2.21	2.26	2.47
Duplex board				
Production	TPY	57642	62188	63561
Electricity consumption	Lakh/y	328.3	361.6	329.5
Specific electricity consumption	kWh/T	569.55	581.46	518.40
Steam consumption	TPY	117780	142788	137151
Specific steam consumption	T/T	2.04	2.30	2.16
Energy ratio-Duplex: paper				
Electricity SEC	%	98%	99%	87%
Steam SEC	%	93%	102%	87%

From the above, it appears that there has not been significant difference in the SEC figures calculated for Paper & duplex board though as per norm, differences should be higher.

During the three years, there has been continued reduction in drawl of grid electricity and DG sets and increase in drawl from cogeneration system. This seems to have caused apparent increase in overall energy consumption due to much higher heat rate of cogen plant compared to assumed heat rate of 860 kCal/kWh as per guideline. The net impact is shown in the following table.

Table 6: Impact of change in power mix

Power impact analysis	Units	2007-08	2008-09	2009-10
Total energy input	MKCal	1075686	1076469	1230473
Total energy for process heat	MKCal	6932	6621	8889
Total for power	MKCal	1068754	1069848	1221584
Captive plant heat rate	kCal/kWh	5586.2	5605.7	6010.8
Change in grid power drawl	Mn kWh	Base	1.21	2.81
Equivalent increase in heat rate*	MKCal	Base	6783	14474
Netting for the power effect	MKCal	Base	1074708	1066760
Normalised GtG SEC	MTOE/T	0.6366	0.6188	0.6144

*Computed on the basis of change in the drawl of grid energy multiplied by heat rate differential (Captive plant heat rate-grid heat rate (i.e. 860 kCal/kWh)).

As a result of increase in drawl from captive plant and reduction in draw from grid, the actual impact on equivalent heat on power account increased, reflected by the figures as seen at row 4 of the above table. If the heat rate of the additional power drawn from the cogen plant is taken at grid rate, equivalent heat value gets reduced as seen at row 8 (netting for the power effect) of the table.

From the figure below, it would be seen that the trend appears more rational reflecting the marginal reduction in heat rate, which can be attributed to increased production of duplex board.

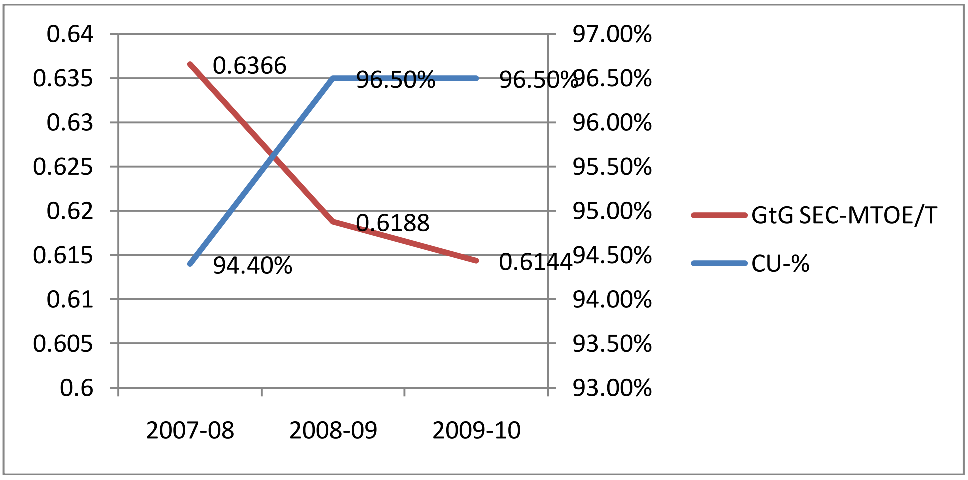


Figure 6: CU GtG relationship (Normalised)-Unit-1

However, in the SEC figures reported by auditors, increasing trend has been observed for both electrical and thermal consumptions. It is therefore, difficult to make any conclusive observation on CU GtG relationship behavior for this unit.

Impact of energy savings projects-Unit-1

The list of identified energy saving projects as provided in the baseline report is shown in the following table.

Table 7: Identified energy saving projects-Unit-1

Project	Power kWh/year	Steam MT/year
Replacement of river pumps	1461200	
Replacement of filter pumps	912000	
Replacement of ETP pumps	657600	
PVC sheet for daylighting	6800	
Paper machine I, II & III		
Grinding of dryer surface		955
Overhauling vacuum pumps	224000	
PM I pump III replacement	228000	
PM I pump IV replacement	436000	
PM I pump V replacement	528000	
PM I overhauling of pumps	376000	
PM II overhauling of pumps	276000	
PM II replacement of pump I	528000	
PM II replacement of pump X	408000	
PM III replacement of pump V	588000	
PM II replacement of pump VIII	368000	
PM II replacement of pump IX	104000	
PM II replacement of pump X	476000	
Bypassing broke chest PM I	160747	

Project	Power kWh/year	Steam MT/year
Bypassing broke chest PM II	346874	
Correction of steam condensate system		8408
Paper machine IV & V		
Replacement & modification-chest-1	580800	
Drive interchange-stock preparation	582000	
Replacement of fan pump	92000	
Others		
Energy efficiency lighting	140000	
BP Turbine for PRDS replacement	6480000	
Replacement of line shaft drive	857000	
VFD for fan pump	582912	
	17399933	9363

The identified saving at about 174 lakh kWh represents almost 30% of the present level of consumption. However, power saving of about 65 lakh kWh indicated under the head 'BP turbine for PRDS replacement' would not mean electricity saving but definitely fuel saving. So overall impact on GtG SEC would still be around 30%. Thus, the unit should be easily able to meet the PAT target and in fact can be a substantial generator of Escert in the sector.

Conclusion:

- Clear correlation between CU & GtG SEC could not be established
- Based on a normalisation factor developed considering change in the source of power, somewhat closer relationship could be developed but that also can be negated. There has been increase in both electrical and thermal SECs despite increase in CU and more production of less energy intensive duplex board
- Other variables including increased inefficiency could be reasons but the same cannot be assessed based on available information
- The unit has identified enormous energy savings potential. It should be possible for the unit to be a net positive contributor in meeting the sectoral target.

1.2 Unit-2

The reported SEC figures are as shown in the following table.

Table 8: Reported SEC-Unit-2

Particulars	Units	2007-08	2008-09	2009-10
Specific Thermal Energy	GJ/Tonne	26.56	33.53	28.90
Specific Electricity consumption	kWh/Tonne	2097.1	2089.5	2052.9
Gate-to-gate SEC	GJ/Tonne	38.8	44.5	38.2
Gate-to-gate SEC	kCal/kg	9290	10646	9140

The relevant baseline data and computed total energy consumption data is as shown in the following table.

Table 9: baseline data & computed SEC-Unit-2

Particulars	Unit	2007-08	2008-09	2009-10
Production and capacity utilization details				
Production Capacity	Tonne	105000	105000	105000
Production	Tonne	118647	109556	81411
CU	%	113.0%	104.3%	77.5%
ELECTRICITY CONSUMPTION				
Electricity from Grid / Other				
Gross Total Units from Grid	Mn kWh	48.13	52.51	41.06
Purchased / Billed Units	Mn kWh	48.13	52.51	41.06
Equivalent Thermal Energy (B1)	MKCal	41392	45159	35312
Own Generation				
Through DG sets	Mn kWh	0	0	0
Through Steam turbine/ generator				
Annual Gross Unit generation	Mn kWh	217.66	189.23	137.38
Average Gross Heat Rate	kCal/ kWh	2975	3050	3080
Auxiliary Power Consumption	%	18	22	23
Electricity export-grid	Mn kWh	7.66	6.68	8.88
Electricity export-sugar	Mn kWh	9.81	6.14	2.44
Total Electricity Consumed	Mn kWh	248.32	228.92	167.12
Solid Fuel Consumption				
Coal (Indian)				
Quantity purchased	Tonnes	147722	122919	146962
Quantity for power generation	Tonnes	147722	122919	146962
GCV	kCal/ kg	3100	2900	2900
Thermal Energy Input- Indian coal	MKCal	457938	356465	426190
Bagasse & Pith				
GCV	kCal/ kg	4000	4000	4000
Quantity used	Tonnes	53260	25605	1660
Thermal Energy Input- pith/bagasse	Million kCal	213040	102420	6640
Coal(Imported)				
GCV	kCal/ kg	5100	5750	5500
Quantity purchased	Tonnes	104235	129617	56122
Quantity for power generation	Tonnes	104325	129617	56122
Thermal Energy Input-Imp. Coal	MKCal	532058	745298	308671
Total energy-solid fuel	MKCal	1203036	1204183	741501
TOTAL ENERGY-EXCLUDING PITH	MKCal	989996	1101763	734861
HFO				

Quantity purchased	kL	355.28	396.5	337.5
Average Density	kg/litre	0.9	0.9	0.9
Gross calorific value	kCal/ Kg	10000	10000	10000
Total Thermal Energy Input	MKCal	3197.52	3568.5	3037.5
Total-liquid fuel	MKCal	3197.52	3568.5	3037.5
Total-gaseous fuel	MKCal	0	0	0
TOTAL ENERGY INPUT-FUELS	MKCal	1206233	1207751	744538
TOTAL (FUEL & GRID ELECTRICITY)	MKCal	1247625	1252910	779850
Credit for export-grid	MKCal	20812	18150	24127
Credit for export-sugar	MKCal	26654	16682	6629
TOTAL USE IN PROCESS	MKCal	1200159	1218078	749093
	MTOE	120016	121808	74909
SEC	MTOE/T	1.0115	1.1118	0.9201

The computed figures based on BEE prescribed methodology are having minor differences from the reported figures in the baseline report. However, the CU GtG relationship trend looks similar with drastic reduction in SEC with sharp fall in CU as would be seen from the following figure.

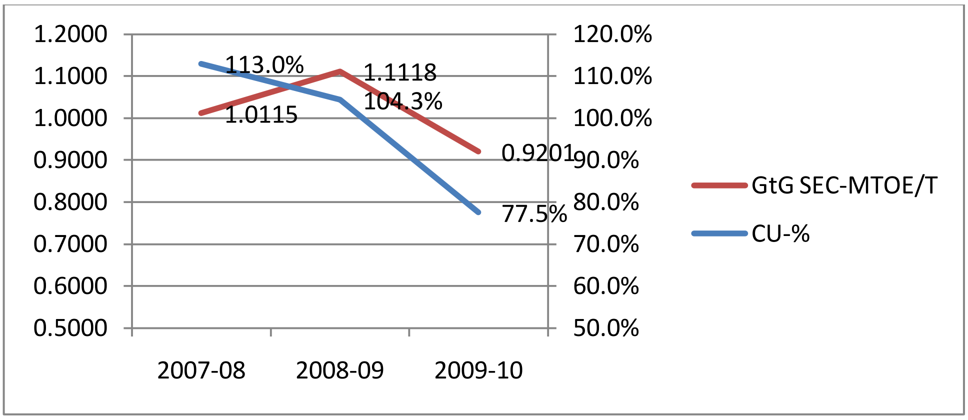


Figure 7: CU GtG relationship-Unit-2

This means that there are other variables, which have high impact on SEC. Some of these could be:

- Change in raw materials
- Change in product mix
- Shutting off of more energy consuming machines due to lower market demand
- Impact of change in mix of power draw from different sources

Information on most of the above mentioned variables is not available in the report. However, heat rate impact could be somewhat established from the following table constructed on the basis of information provided at different sections of the report.

Table 10: Reconciling SEC thermal-Unit-2

Parameters	Units	2007-08	2008-09	2009-10
Specific Thermal Energy	GJ/Tonne	26.56	33.53	28.90
Specific steam consumption	T/T	7.2	7.5	7.7
Computed steam enthalpy	GJ/T	3.69	4.47	3.75

Obviously, enthalpy of steam cannot change so drastically even if one were to consider some distribution inefficiency. It is more likely due to distortion in accounted thermal value due to change in mix of steam and power drawn from different sources. In absence of adequate data, it has not been possible to carry out further analysis and make definitive conclusions.

Further, this unit uses multiple raw materials such as wood, bamboo and bagasse and also makes multiple products. Change in ratio of raw materials and finished products may have impact on SEC. In absence of information, it has not been possible to carry out analysis to assess the impact of these changes.

Impact of energy savings projects-Unit-2

List of identified projects reported in the baseline report is shown in the following table.

Table 11: Energy saving project-Unit-2

Energy savings projects	Electricity Savings (kWh/Annum)	Fuel Savings (Tonnes/ Annum
Boiler House		
Replacement of reciprocating compressors to centrifugal compressors.	420000	
Energy Savings by installing VFD in FD Fan	647388	
VFD in Boiler Feed Pump	1600000	
Energy Savings by converting dry ash handling system to wet ash handling system	1050000	
Energy savings by increasing the recovery of condensate from present 55% to 75%		3192
Turbine Generator		
Energy saving by avoiding venting of steam		8400
CSRMP		
Energy Savings by converting existing pneumatic conveyor blower to bucket elevator	252000	
Installing VFD	248400	
Chemical Pulp Mill-2		
Installing VFD	257040	
Paper Machine -1, 2 & 3		
Energy conservation by changing line shaft drive to sectional drive	588000	
Installation of VFD for vacuum pumps	486500	
Energy savings by steam and condensate modification		8400 T of steam
Paper Machine - 4		

Energy savings projects	Electricity Savings (kWh/Annum)	Fuel Savings (Tonnes/ Annum
Installing VFD	189504	
Compressor replacement	844000	
Change blade design in agitators	613200	
Installation of VFD in fans	211680	
Chemical Recovery		
Improving Insulation		16878
Filter press for primary sludge		8750
Total	**7407712**	**37220**

In case of this unit too, identified energy savings can make a huge positive impact on achieving PAT target for the sector as a whole.

Conclusions:

- Clear correlation between CU & GtG SEC could not be established
- Data on other variables such as raw materials, finished products and changes in source of power and steam are not available and as such impact of these could not be assessed
- There are additional complexity as the plant has a sugar mill as part of an integral complex
- The unit has identified enormous energy savings potential. It should be possible for the unit to be a net positive contributor in meeting the sectoral target

6. VARIABILITY FACTORS AND NORMALIZATION-PULP & PAPER

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, need to be factored for the process of normalisation. The key variable impacting the SEC for the Pulp & paper sector are:

- Production & capacity utilization
- Raw material usage
- Finished products
- Pulping technology
- Change in mix of power and steam drawn from different sources

6.1 PRODUCTION & CAPACITY UTILIZATION

Clear correlation could not be established between capacity utilisation and GtG SEC. Trend in both directions has been observed. There is more complexity in determination of true capacity and capacity utilisation figures in a paper mill due to the following sector specific factors:

- Different grade of paper having different specific energy consumption
- Methodology has to be developed for converting all products into main products as has been done for the cement and iron and steel sectors
- Most of the mills have multiple modules for both pulping and paper making. It does provide opportunity for shutting down more energy consuming lines during less demand thereby reducing SEC at lower capacity utilisation

It would be necessary to establish mill specific data on SEC for different product grades and develop normalisation factors for converting different products into equivalent main products. Similarly, it would be necessary to develop and adopt a standard approach on how to factor the influence of individual line capacity utilisation on the overall CU & GtG SEC.

6.2 RAW MATERIAL USAGE

As would be seen from the figure 1, significant shift is in usage in raw materials with increase in use of recycled fibres and market pulp. RCF requires 40 to 50% of the energy compared to wood based plant[6]. Even for wood based plants, there is some shift from traditional material such as bamboo to plants like casurina etc, which has impact on energy required for pulping process[7].

It would be necessary to establish the correlation for individual mill based on historical data.

6.3 FINISHED PRODUCT

Grammage of the finished product impacts the SEC. It would be desirable to correlate the baseline GtG SEC to the tonnes of product for a particular grammage. The same methodology should be used for converting the production during the evaluation cycle into the equivalent grammage. Additionally, it would be also required to carry out normalisation of products, if the product mix changes during the PAT cycle.

Broadly, there are three categories of finished products-writing & printing paper, newsprint and paper boards including duplex boards. Specific energy consumption is highest for printing and writing paper followed by newsprints and paper boards.

CPPRI has carried out benchmarking studies on energy consumption for production of different grades of papers and using different raw materials[8] as shown in table 12.

Table 12: Normative SEC-Wood based plant

Wood Based Mills (Integrated)	Products			
	Bleached paper	Unbleached paper	Newsprint	Rayon (Pulp)
Total Energy MKCal/T of finished paper	7.0	5.6	7.0	3.0
Steam T/T of finished paper	9.0	7.0	8	5
Power kWh/T of finished paper	1300	1150	2100	800

Note:

1. Valid for kraft process
2. The specific power consumption standard does not include condensing steam auxiliaries. For example, in a typical 300 TPD plant, the auxiliaries of 5 MW steam turbine will have a power consumption of 15-20 kWh/ton of finished paper.
3. The power consumption does not include Lime kiln recovery section. In a typical case, 20-25 kWh/ton electric power is used in lime kiln.
4. For 60% bleached paper and 40% unbleached products, Power Consumption = (1300 x 0.6 + 1150 x 0.4)
5. For 60% Writing and Printing and 40% Newsprint products, Power Consumption = (1300 x 0.6 + 2100x 0.4)
6. For 60% Writing and Printing and 40% Rayon Grade products, Power Consumption = (1300 x 0.6 + 800x 0.4)
7. For a mill producing Writing and Printing Paper with 80% own pulp and 20% market pulp or secondary fiber, Power consumption = (1300 x 0.8+600 x 0.2)

Table 13: Normative SEC-Agro based plant

Agro Based	Bleached Paper– With Recovery	Bleached paper- Without Recovery	Unbleached paper
Total Energy MKCal/T of finished paper	7.0	5.5	5.0
Steam T/T of finished paper	7.5	4.9	3.3
Power kWh/T of finished paper	1050	925	500

[8] Development of specific energy consumption norms-CPPRI study for BEE & GTZ, 2005

Table 14: Normative SEC-RCF based plant

Recycle Fibre Based Mills	Writing/ Printing paper (With De-inking)	Newsprint (With De-inking)	Unbleached paper	Board
Total Energy MKCal/T of finished paper	4.0	6.0	3.0	4.0
Steam T/T of finished paper	3.2	3.0	2.2	2.0
Power kWh/T of finished paper	800	750	450	400

It is recommended that normalisation process is carried out for each individual mill based on CPPRI energy indices and using the following methodology:

- Convert various products into main product using the energy ratio
- Normalise the GtG energy consumption for any change in the raw material by using the SEC factors for the corresponding raw material group as per CPPRI norms
- Determine the GtG SEC figure based on normalised production and energy consumption

6.4 PULPING TECHNOLOGY

For mechanical pulping more electrical energy is used while for thermo-chemical process, more thermal energy is used, overall energy consumption is higher in thermo-chemical process. However, in the current PAT cycle, it is likely that the process would remain the same and as such. It would not be necessary to carry out any normalisation on this account.

6.5 CHANGE IN CAPTIVE & GRID POWER MIX

The computed SEC figure can get distorted due to change in the captive and grid power mix. This is due to use of different normative conversion factors assumed for determination of equivalent thermal energy for electricity drawn from different sources. DESL has made detailed study on this issue covering both electrical and thermal energy. The detailed analysis, findings and solution options have been provided at annex-I of this document. Summary recommendations are as follows:

Various scenarios for change in power mix could be projected as:

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

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

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

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 15: Illustrative case-heat rate accounting

Baseline Case	Project Case
Power-3000 KW, totally drawn from grid	Power-2000 KW generated from Cogen plant @ heat rate of 1300 Kcal/kWh -1000 KW purchased from grid
Steam-10 TPH @ 700 Kcal/Kg enthalpy generated from a boiler	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 kCal/kWh (c)
- National heat rate of power-2717 kCal/kWh (d)
- Credit to plant-1417 kCal/kWh (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 cogeneration. In fact higher the cogeneration efficiency, more benefit would be derived in line with global objective of the PAT scheme. Same logic can be applied for non-cogeneration/captive plant too except in case of adaptation of higher heat rate power from captive plant due to non-availability of grid power. In such events, power from captive plant should be treated as grid power and credit provided in fuel account for the difference.

Detailed computation using a developed heat and mass balance diagram on the hypothetic case has been provided at Annex-I.

6.6SUMMARY RECOMMENDATIONS – VARIABLES AND NORMALIZATION

Table 16: Normalisation process

Parameters	Baseline Report	Recommendations	Remarks
Production & capacity utilization **Change in mix of power and steam drawn from**	Not carried out as no methodology has been prescribed	Normalisation based on different grades of products and use of production	Most of the mills attempt to optimize running of paper machines depending upon the market demand and cost

Parameters	Baseline Report	Recommendations	Remarks
different sources		modules particularly for mills having multiple number of paper machines	of production, mainly energy cost. Normalisation process has to factor this aspect for every mill.
Raw material usage	Not factored	Needs to be factored. Normative SEC recommended by CPPRI for different mills making different products based on different raw materials can be used.	An integrated approach based on raw materials and finished products to be used.
Finished products	Information of product grades has been provided but normalisation not done	As above	As above
Pulping technology	Information available	Not to be factored	
Change in captive & grid power mix	860 Kcal/kWh for grid power, 2717 Kcal/kWh for captive power and fuel for steam	As per actual heat rate based on HMBD methodology	Can be fitted into the BEE regulation guideline.

6.7–RECONCILIATION-IMPACT OF ENERGY SAVING PROJECT

Due to complexity involved in clearly establishing the impact of various uncontrollable variables and the correlation coefficiecnt, it would be desirable to carry out a recoconciliation exercise with the achieved results from the implementation of energy saving projects. The following steps are recommended for the same.

- Review of larger number of representative investment grade audit report (basis of submission of action agenda by DCs) and further review of 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.

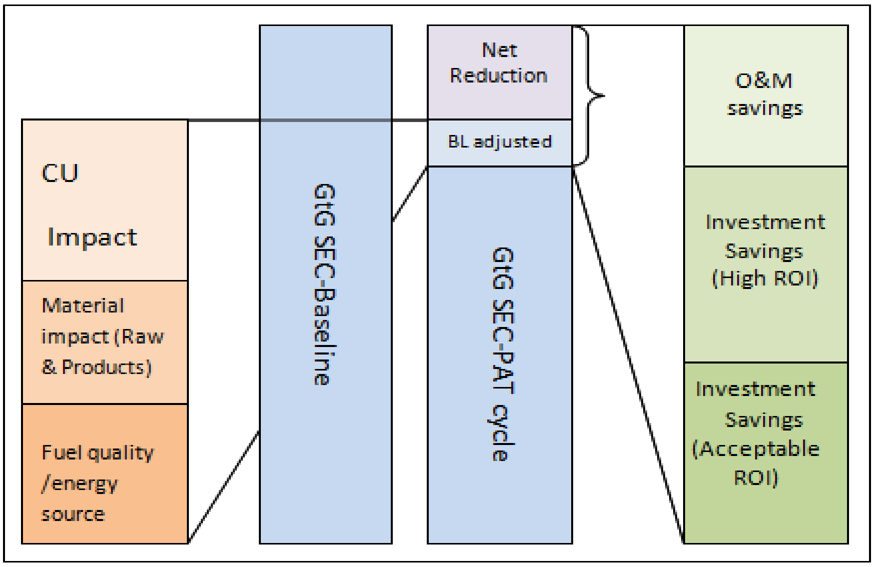


Figure 8: Normalisation & Baseline Adjustment

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

7. M&V PROCESS AND PROTOCOL

7.1 METERING & MEASUREMENT

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

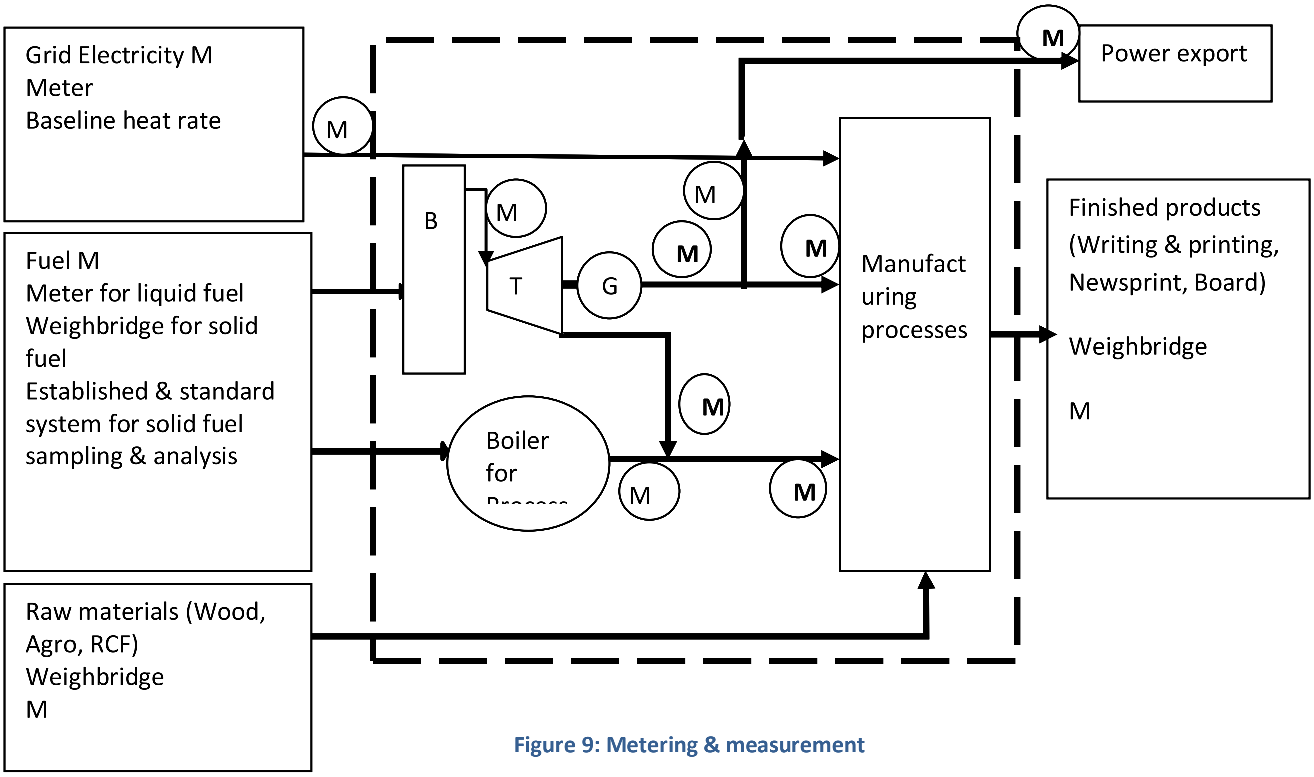


Figure 9: Metering & measurement

The metering & measurement plant to clearly determine:

- Different raw materials used
- Production of different papers-types & grammage
- Fuel quantity & quality
  - Power generation
  - Steam/heat production
  - Cogeneration
- 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 utilization. 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. This guideline would require validation based on statistical analysis of CU & GtG over the PAT cycle period

- 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 correlation 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 PROTOCOL

Table 17: Data protocol

ID	Data Variable	Source of Data	Data Unit	Measured (M) Calculated (C) Estimated (E)	Recording Frequency	Archival Method	Remarks
A	***Production***						
A1	Production Capacity (Printing & writing)	Balance sheet	TPY	E	Annual	Electronic –E Paper-P	
A2	Production Capacity(Newsprint)	Balance sheet	TPY	E	Annual	E/P	
A3	Production Capacity(Boards)	Balance sheet	TPY	M/C	Annual	E/P	
A4	Production (Printing & writing)	Daily production report	MT	M/C	Daily	E/P	
A5	Production (Newsprint)	Daily production report	MT	M/C	Daily	E/P	
A6	Production (Boards)	Daily production report	MT	M/C	Daily	E/P	
A7	Opening stock (Printing & writing)	Cost Audit Report	MT	M/C	Annual	E/P	
A8	Opening stock (Newsprint)	Cost Audit Report	MT	M/C	Annual	E/P	
A9	Opening stock (Boards)	Cost Audit Report	MT	M/C	Annual	E/P	
A10	Closing stock (Printing & writing)	Cost Audit Report	MT	M/C	Annual	E/P	
A11	Closing stock (Newsprint)	Cost Audit Report	MT	M/C	Annual	E/P	
A12	Closing stock (Boards)	Cost Audit Report	MT	M/C	Annual	E/P	

ID	Data Variable	Source of Data	Data Unit	Measured (M) Calculated (C) Estimated (E)	Recording Frequency	Archival Method	Remarks
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/Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
B5	Gross generation-Unit-2	DCS/Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
B6	Gross generation-Unit-3	DCS/Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
B7	Auxiliary power consumption	Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
B	***Steam***						
B8	Steam generation-Cogen	DCS	TPD	M	Daily	P/E	
B9	Steam generation-Recovery	DCS	TPD	M	Daily	P/E	
B10	Steam generation-Process boiler	DCS	TPD	M	Daily	P/E	
B11	MP steam for process	DCS	TPD	M	Daily	P/E	
B12	LP steam for process	DCS	TPD	M	Daily	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	
C7	Biomass quantity	Monthly cost audit report	LTPY	M/C	Monthly	P/E	
C8	Biomass quality	Lab analysis report	Kcal/Kg	M/C/E	Per Consignment	P/E	
C9	HSD quantity	Monthly cost audit report	Kilo Liter/year	M/C	Monthly	P/E	
C10	HSD quality-density	Lab analysis report	Kg/Liter	M/C	Per Consignment	P/E	
C11	HSD quality-GCV	Lab analysis report	Kcal/Kg	M/C	Per Consignment	P/E	
C12	Furnace oil (FO) quantity	Monthly cost audit report	Kilo Liter/Year	M/C	Monthly	P/E	

ID	Data Variable	Source of Data	Data Unit	Measured (M) Calculated (C) Estimated (E)	Recording Frequency	Archival Method	Remarks
C13	FO quality-density	Lab analysis report	Kg/Liter	M/C	Per Consignment	P/E	
C14	FO quality-GCV	Lab analysis report	Kcal/Kg	M/C	Per Consignment	P/E	
C15	PNG/LNG-Quantity	Utility bill	Million SCUM/year	M	Monthly	P/E	
C16	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	
D6	PNG/LNG	Monthly cost audit report	Mn SCUM	M/C/E	Monthly	P/E	
E	***Raw materials used***						
E1	Wood	Daily production report	TPD	M/C	Daily	P/E	
E2	Agro-residue	Daily production report	TPD	M/C	Daily	P/E	
E3	Recycle fibre	Daily production report	TPD	M/C	Daily	P/E	

7.3 M&V PROTOCOL-EE PROJECT

It is proposed to use the international performance measurement & verification protocol (IPMVP) for assessment of impact of EE projects. The IPMVP is being administered by USA based organization EVO. For assessment of performance of EE projects, one or more of the four following methodologies can be used.

Table 18: M&V Protocol-EE Projects

Options	Description	Pros	Cons	Recommendation
C-whole facility	Energy savings can be directly determined by actual measurements of inputs and outputs	Most accurate Results & impact can be transparently established Easy to vary out baseline	Difficult to implement in retrofit applications particularly where inputs and outputs cannot be	Can be implemented for utility systems like pumps, compressors, lighting etc.

Options	Description	Pros	Cons	Recommendation
		adjustment	specifically linked to the EE projects	
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. Information asymmetry can create problem of acceptability	Best suited for systems like furnace, boilers, cells, transformers/rectifiers loading efficiency etc
A-Partial retrofit isolation	Savings are estimated based on partial measurements and assumptions for certain parameters	Very easy and low cost of M&V	Lower level of acceptability particularly when responsibility for operation control is not clear-for example streetlight system	Would be the practical system for most of the retrofit projects
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 The back pressure turbine replacing the PRDS falls in this category

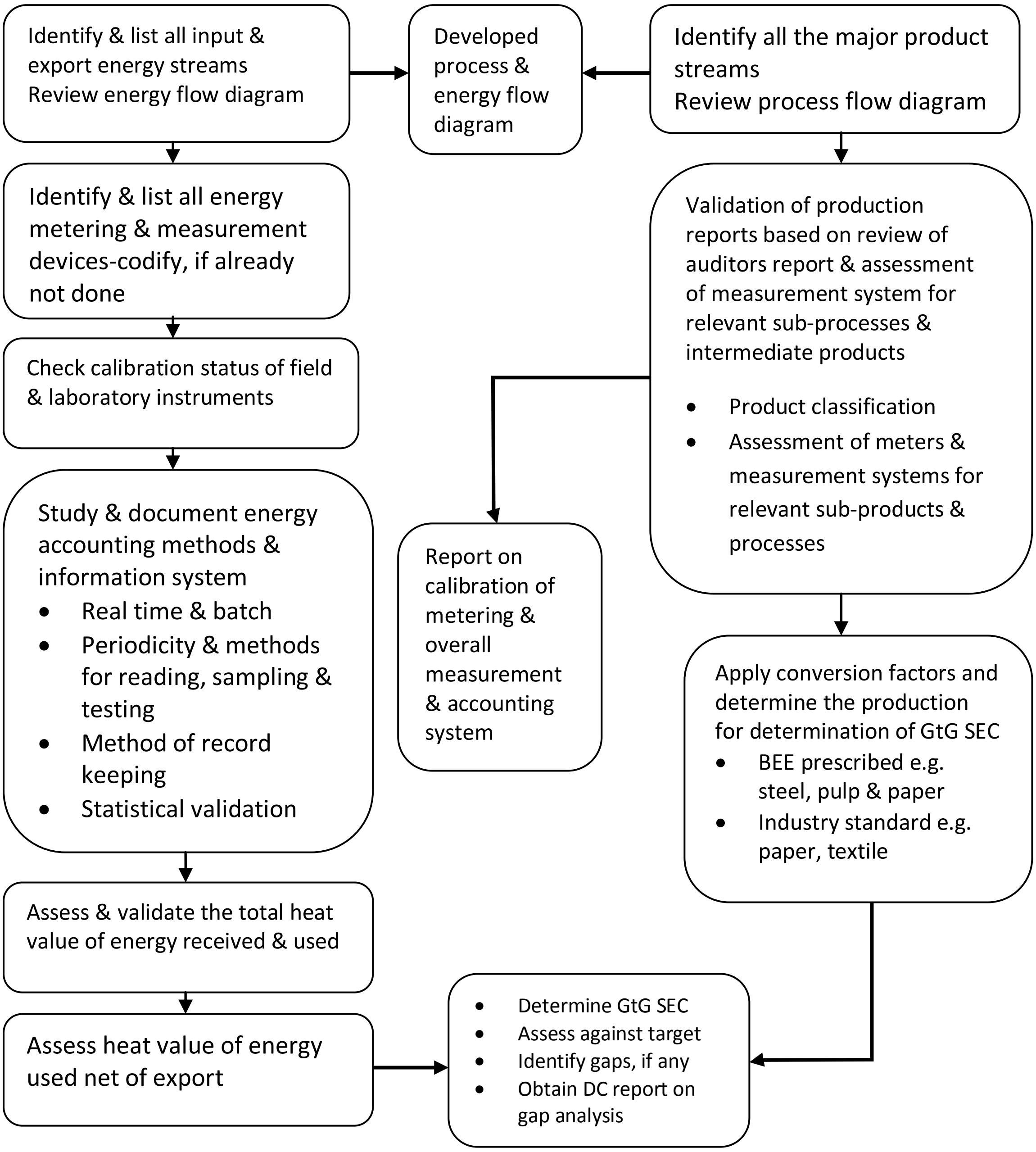
8. NORMALISATION PROCESS

The normalisation process is proposed to be carried out in three stages:

- Step-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- CHANGE IN CAPTIVE & GRID POWER MIX

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.

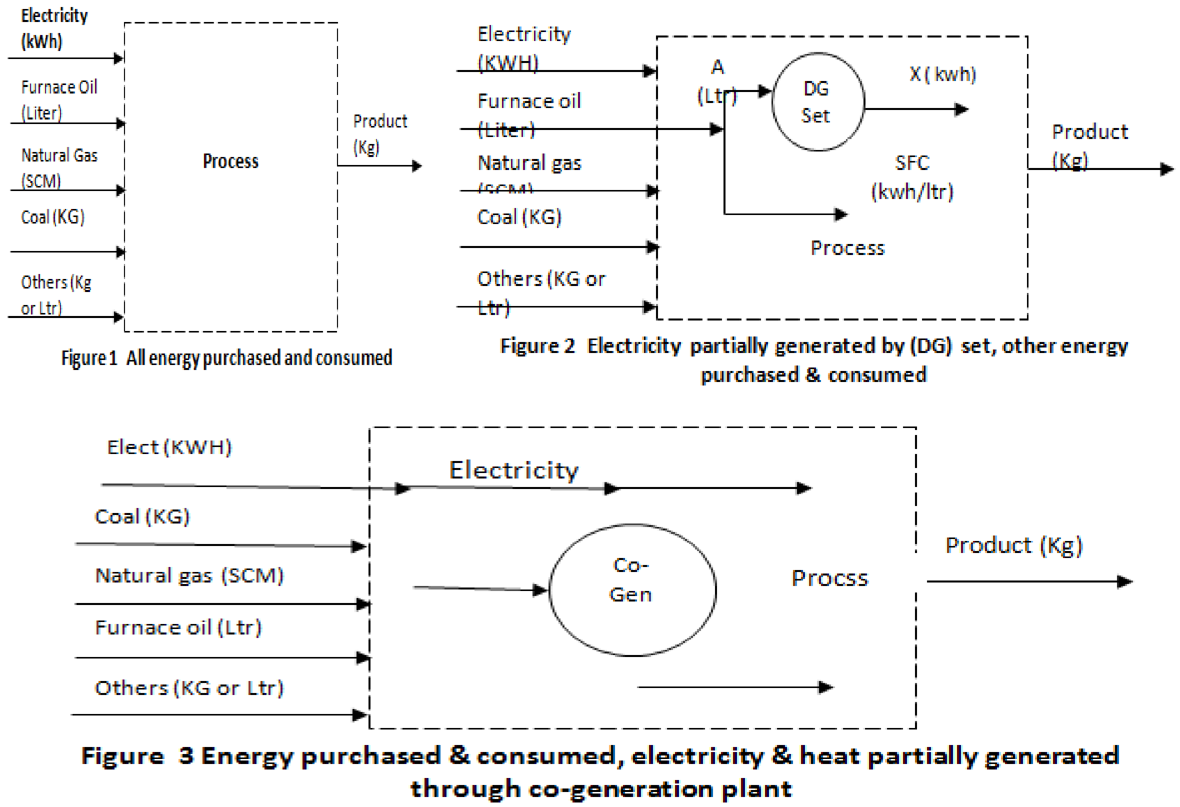


Figure 10: Gate to Gate energy consumption

Briefly the scenario cases are:

- Entire electricity is purchased from outside and fuel is used in boilers for steam generation and supply to the process
- Part of the electricity is purchased from outside and balance generated using DG set. Steam is used by burning fuel in the boilers
- 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).

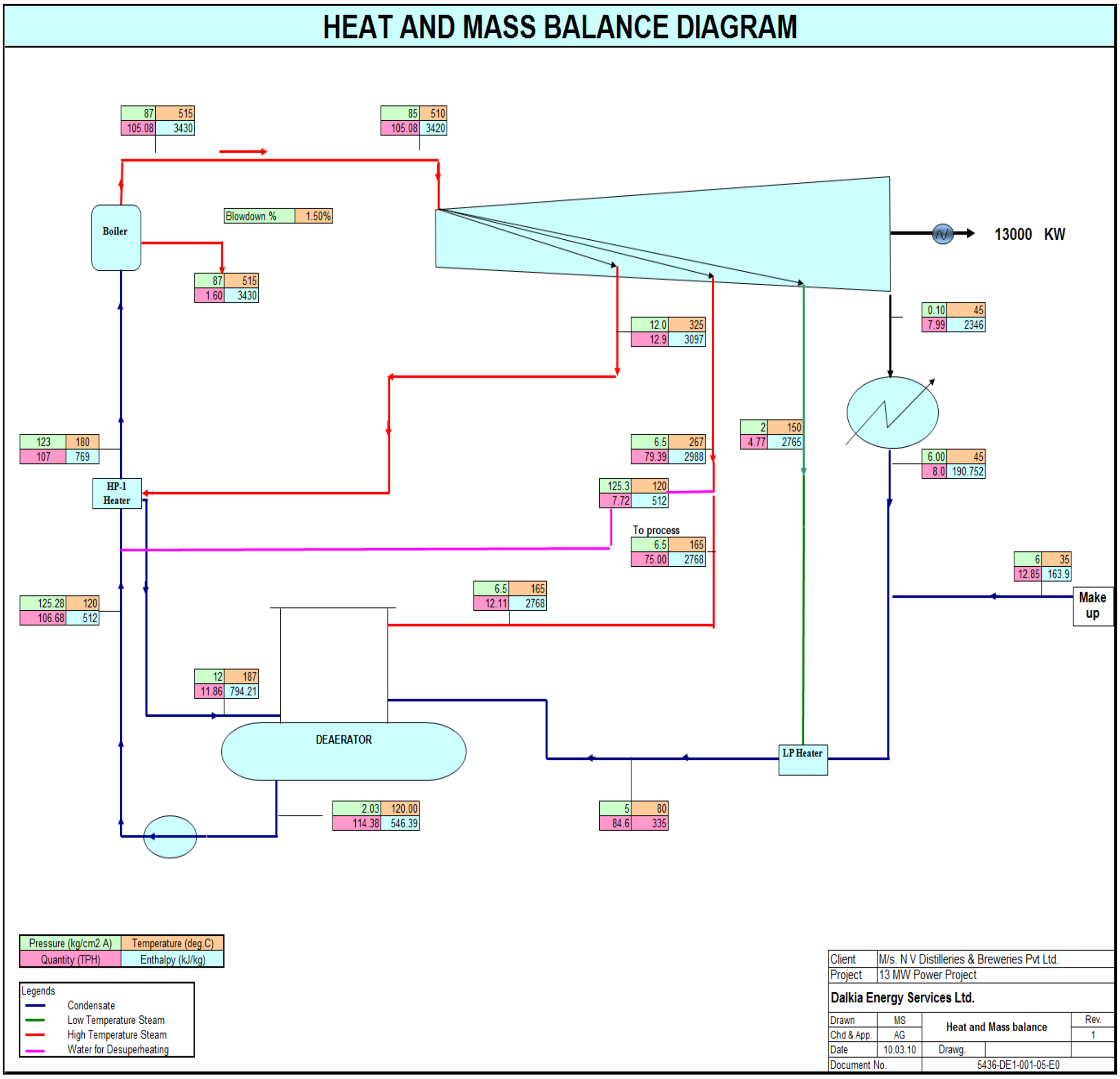


Figure 11: Heat and Mass Balance Diagram

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

Table 19: Overall energy consumption

Particulars	Units	Amount	Specific Heat kCal	Equivalent 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 2nd scenario (HMBD scenario); the fuel value captures the loss in the Rankine cycle since the Cogeneration 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 20: Heat value at real heat rate

Particulars	Units	Amount	Specific Heat kCal	Equivalent 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 as per 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 20th 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 21: 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.