M&V Protocol for Cement Sector

Perform-Achieve and Trade Scheme

An initiative supported by

SHAKTI
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FOUNDATION

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ABBREVIATIONS

BEE	*Bureau of Energy Efficiency*
CEA	*Central Electricity Authority*
CF	*Clinker factor*
CPP	*Captive power plant*
CU	*Capacity utilisation*
CUM	*Cubic meter*
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*
KLPY	*Kilo liter per year*
LTPY	*Lakh tonnes per year*
MT	*Metric Ton*
M&V	*Measurement & Verification*
OPC	*Ordinary Portland cement*
PAT	*Perform achieve & trade*
PPC	*Portland Pozzolana cement*
PSC	*Portland slag cement*
RDF	*Residue derived fuel*
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 cement 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 normalised 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.

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 outlined their impact. In case of the two reports obtained for the cement sector, various production and energy consumption data and computed GtG SEC have been provided. Information and statistical analysis of variables and GtG SEC corelationship have not been provided.

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 corelatioship between CU & GtG SEC. More in depth analysis has been carried out for determination of relationship behaviors.

BEE has provided guideline on treatment for product mix and power source variables for computing GtG SEC and normalisation process. However, under certain conditions, errors can creep in due to change in the power mix and change of heat rates. Normalisation process has been recommended to take care of such situation.

For the cement sector, reasonable corelationship has been established between capacity utilisation (CU), particularly on normalised production and GtG SEC. Following variables have been identified having influence on the GtG SEC.

- Quality of limestone
- Process technology
- Plant capacity & capacity utilisation
- Product mix
- Change in captive and grid power mix & heat rate

From the perspective of PAT, mathematical corelationship of GtG SEC to identified variables is to be established and normalisation process carried out using the corelationship 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 neutralised 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

[1] PAT consultative document

methodology to determine the normalization factors and finally development of the GtG SEC figures in line with objectives set forth in the PAT process.

2. CEMENT INDUSTRY-OVERVIEW

2.1 CEMENT INDUSTRY IN INDIA

India is the world's second largest producer of cement. Indian cement industry has outpaced the growth rates of other prominent industries in the country on the back of factors, such as rising demand from the housing sector, increased activity in infrastructure, and construction recovery. Recent industry developments and the government supportive policies are attracting global cement giants and sparking off a spate of mergers & acquisitions to spur growth.

Almost all cement majors expanded their installed capacity in the backdrop of the government backed construction projects as these projects have created strong demand for cement in the country. About 20 Million Tons (MnT)/year capacity has been added in 2011 and another 10 to 15 MnT addition is expected in the current year. Moreover, it is anticipated that the industry players will continue to increase their annual cement output in coming years and the country's cement production will grow at a CAGR of around 12% during 2011-12 - 2013-14 to reach 303 MnT[2] and further upto about 550 MnT by 2020[3].

The industry is considerably consolidated with large 125 Mills accounting for about 90% of the production and over 300 mini mills accounting for the balance 10%.

Out of the 125 larger units, 85 have been covered under the PAT scheme and target energy savings for each of the 85 units fixed.

2.2 MANUFACTURING PROCESS

Generally cement manufacturing process involves the following stages:

1. Quarrying raw materials
2. Crushing
3. Pre-homogenization and raw meal grinding
4. Pre-heating
5. Pre-calcining
6. Clinker production in the rotary kiln

[2] www.indiancementindustry.com
[3] www.iseindia.com

7. Cooling and storing
8. Blending
9. Cement grinding
10. Storing in the cement silo

Both wet and dry processes are deployed in the raw material preparation and clinkerisation sub-processes. In the wet process, raw materials other than gypsum are crushed and mixed in an appropriate ratio. Then water is added and the mixture is further made finer by a combined tube mill into slurry with a water content of 35 to 40%. The slurry is put in a storage tank with a capacity of several hundred tons, mixed to be homogenized with the corrective materials, and is sent to a rotary kiln for clinker burning. In the wet process, the slurry can be easily mixed but a large amount of energy is consumed in clinker burning due energy required for evaporation of extra water.

In the dry process, crushed raw materials are dried in a cylindrical rotary drier, mixed at per predetermined ratio, further ground and conveyed in different storage tanks. The prepared materials are further mixed as per pre-determined ratio and fed into rotary kiln for clinkerisation.

Deployment of a particular process depends upon the properties of raw materials, costs of fuel, conditions of location and others. For the wet process, plant construction cost is rather low and high-quality products are manufactured easily. But energy consumption is high. On the other hand, the dry process consumes less energy and its running cost is lower. During the 80's & 90's, technological advancements took place world over in design of cement plant equipment/systems primarily in the following areas[4]:

1. Pre-calcination
2. High pressure grinding
3. Automation in process control
4. High efficiency particle separation
5. Clinker cooling

These resulted in significant transformation of the production process globally. The Indian cement industry closely followed the international trend. In addition to reducing the energy consumption, the technology changes have helped bridge the quality gap between cements produced using the two different processes. The share of energy inefficient wet process plants had slowly decreased from 94.4% in 1960 to 61.6% in 1980. Currently, the share of wet process is only about 1% according to industry sources[4].

Depending upon the usage of clinker and other materials in the final product, marketed cement product is classified under three different categories-ordinary Portland cement (OPC), Portland Pozzolana cement (PPC) & Portland slag cement (PSC). Clinker constitutes about 95% in OPC,

[4] Indian Cement Industry-A Technology Perspective (www.nistads.res.in)

Gypsum contributing for the rest. In PPC, 15 to 20% of the clinker is substituted by pozzolonic material such as fly ash whereas in PSC about 50% clinker is substituted by blast furnace slag, Gypsum contribution in both the cases remaining at the same level of about 5%[5]. With increased availability of fly ash and its favorable contribution in improving the strength of concrete and reduction in cost of energy, share of PPC production has been continuously increasing all over the world, more so in India.

2.3 ENERGY USE IN THE CEMENT INDUSTRY

The cement plant consumes two types of primary energy: thermal energy and electricity as shown in Figure 1. The material transport, crushing and milling mainly consumes electricity whereas thermal energy is used for calcination. The secondary energy sources used in cement production are kiln exhaust gas and hot air from clinker cooler. The secondary heat contained in the hot kiln exhaust gas is utilized primarily in pre-drying and preheating the raw materials before their introduction into the kiln and raw mill. The waste heat contained in the exhaust air from the clinker cooler serves to preheat combustion air and also to dry and preheat the raw materials before they enter the raw mill and kiln. Energy flow for the manufacturing operation in the plants is shown in the following figure.

[5] Cement sustainability initiative-World Business Council for Sustainable Development

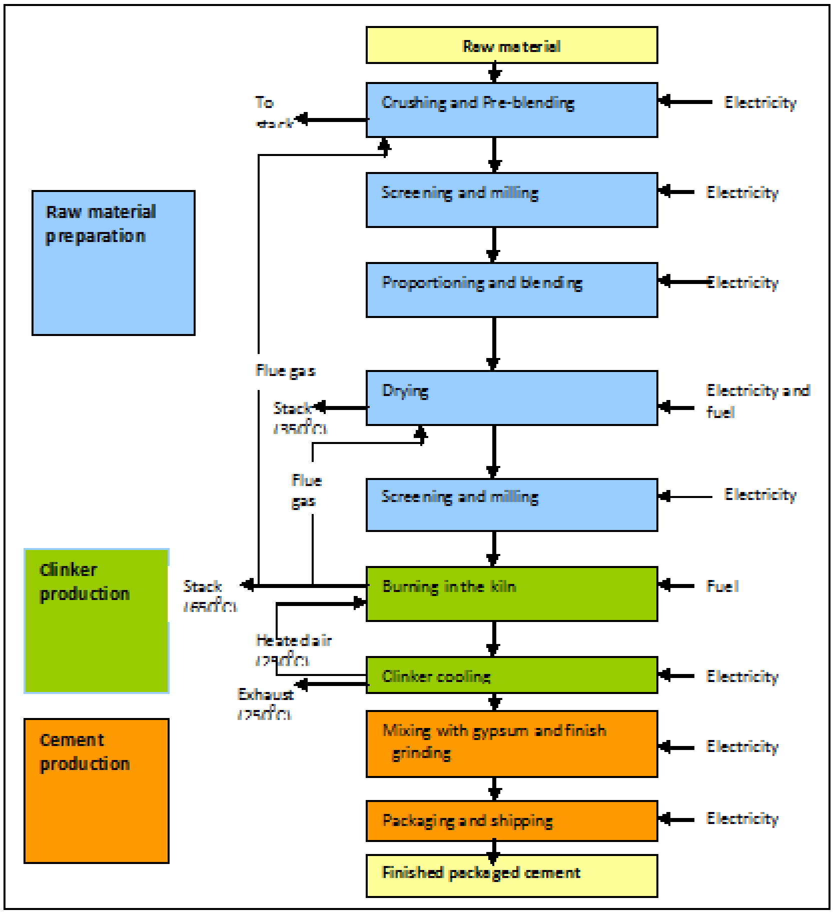


Figure 1: Energy consumption in cement industry

The specific energy consumption for fuel is calculated on clinker production whereas for electricity, it is on cement. Thus, it is possible to make proper comparative assessment of energy consumption in a mill irrespective of manufacturing processes and grade of finished product. For an OPC manufacturing plant, fuel constitutes about 90% of the overall energy consumption ranging from 650 to 700 Kcal/Kg of clinker on net energy usage basis. However, if energy content of electricity is converted on the basis of power station heat rate, the share of both types of energy would almost be equal.

Large number of mills has already shifted to captive power generations based on different types of fuel as well as waste heat. It is therefore, important to develop a proper understanding of the energy consumption in cement process considering the heat contents of energy resources at source rather than in converted form of energy.

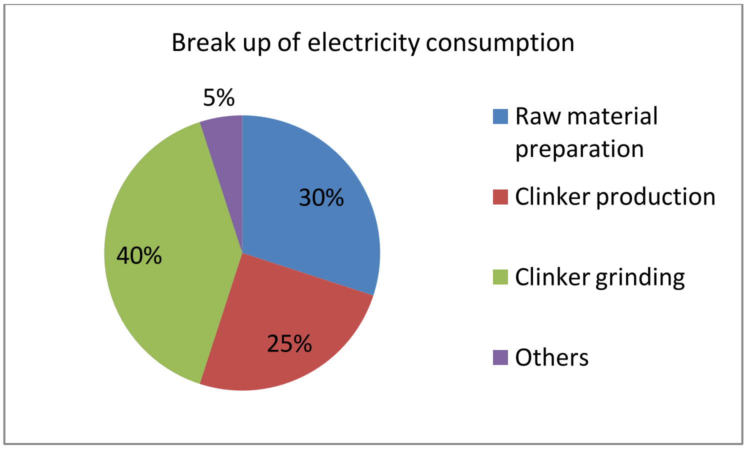


Figure 2: Break up of Electricity Consumption[6]

Almost 40% of the electricity is consumed in the clinker grinding, 30% in raw material processing and another 25% in clinker production, other auxiliaries including plant utilities constituting for the balance 5%.

Until recently, electricity and coal have been the sources of energy for most of the plants. Cost of both the energy resources have been sharply increasing putting pressure on the profitability margin even for the energy efficient units.

With a view to remaining globally competitive, Indian Cement Industry has made major strides by undertaking innovative measures for managing the energy cost. These include:

- Investment in energy efficient technologies-Cement industry in India has achieved global benchmark in specific electricity consumption at 63 kWh/T cement against next best of 65 kWh/T and very close in thermal energy consumption at 665 Kcal/Kg of clinker against global best of 663 Kcal/Kg[3].
- High efficiency captive power generation including based on waste heat recovery
- Use of non-conventional fuel like biomass, RDF (Municipal solid waste derived fuel), old tyres etc.
- Off-site renewable energy generation and wheeling through open access.

Larger players in the Cement sector have successfully institutionalised continuous improvement process through collective and individual inter-unit consultations thereby improving the energy profile of the entire sector.

[6] DESL database-global benchmark

3. DESIGNATED CONSUMERS-SAVINGS TARGET

There are 85 designated consumers in the sector covered under the PAT project cycle. The overall savings have been targeted at over 0.8 Million TOE to be achieved over the 1st cycle period of three years. Individual highest target is about 25000 TOE and the lowest one at 1520 TOE. In terms of individual savings targets, number of units is quite evenly distributed, though over 80% of the total number is having individual savings target of over 5000 TOE.

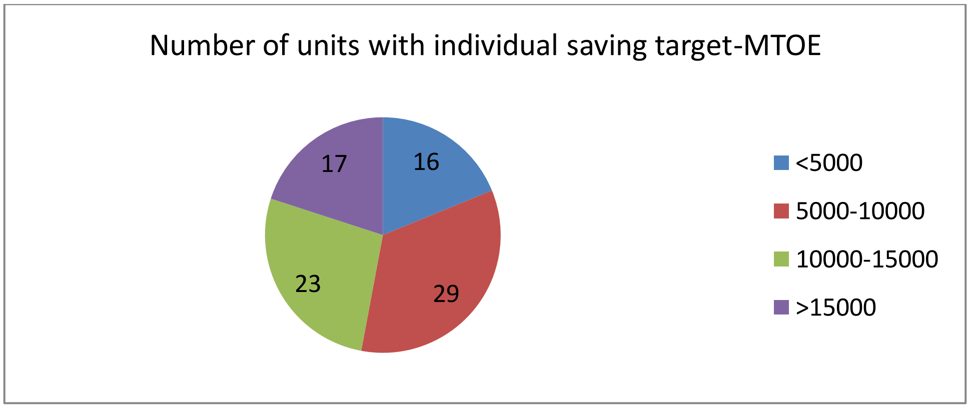


Figure 3: DCs-Size Distribution

Unlike many other sectors, the units are fairly well distributed in terms of size in the cement sector. The process of normalisation and M&V would therefore, need uniform attention irrespective of size and type of units.

4. BASELINE & NORMALIZATION-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)[7]. With a view to neutralize the impact of uncontrollable variables, the concept of baseline and normalisation has been introduced (Text box-2)[7].

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.

The principles for the normalisation process have been outlined with capacity utilisation as the key variable. 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.

[7] PAT notification, July, 2012

Text Box 2: BEE guideline- Procedure for normalisation of specific energy consumption

(a) Variable factors as described in rule 4 may affect the energy consumption and 'Normalisation Factors' shall be considered in those cases. Capacity utilisation is one of the most important parameters to have a normalisation factor.
The reported specific energy consumption (SEC) shall be normalised after incorporating the normalisation factor.
Normalized specific energy consumption = f (Reported SEC, normalization factors).

(b) The specific energy consumption shall be normalised, during baseline and target periods, based on statistical procedures.

(c) The normalisation procedure is proposed to be applied if the capacity utilisation or Plant Load Factor (PLF) has a deviation of more than thirty percent. It shall be applied only if capacity utilisation has deviated due to uncontrollable factors described in rule 4, and duly declared by the designated consumer with authentic proof or self certifications.

(d) The normalisation shall be done by performing a statistical analysis of the specific energy consumption and production data by-
- (i) Plotting the production versus energy consumption curves;
- (ii) Performing statistical analysis to represent the relationship between the production and energy consumption;
- (iii) Extrapolating the above relationship to generate capacity utilisation versus energy consumption and capacity utilisation versus specific energy consumption data for a suitable range of capacity utilisation values;
- (iv) The average capacity utilisation shall be used to identify the corresponding specific energy consumption value;
- (v) The normalised specific energy consumption shall be the value as computed in the previous step;

(e) The "capacity utilisation" referred to in clauses (c) to (d) shall be replaced by "Plant Load Factor" in case of designated consumers in the thermal power plant sector;

(f) The above calculation determines the normalised specific energy consumption for the designated consumers.

For the purpose of PAT, the cement sector has been classified under the following 6 segments

1. Portland pozzolana cement (PPC)
2. Ordinary Portland cement (OPC)
3. Portland slag cement (PSC)
4. White cement
5. Grinding
6. Clinkerisation

The methodology for computation of various products into equivalent main products has also been provided as shown in the following text box[7].

Text Box 2: Normalisation calculation-Cement

Equivalent major grade of cement production.-The various product mixes shall be converted in to equivalent major grade of cement product by the designated consumer by using the following formulae:-

(i) Conversion of Ordinary Portland Cement (OPC) production equivalent to major product

Equivalent major product = OPC produced (Lakh ton) × Conversion factor of OPC/ Conversion factor of major product

(ii) Conversion of Portland Pozzolana (PPC) production equivalent to major product

Equivalent major product = PPC produced (Lakh ton) × Conversion factor of PPC/ Conversion factor of major product

(iii) Conversion of Portland Slag Cement (PSC) or any other variety of cement production equivalent to major product

Equivalent major product = PSC or any other variety cement produced (Lakh ton) × Conversion factor of PSC or any other variety cement/Conversion factor of major product

(iv) Conversion of total exported clinker to major product

Equivalent major product = Total exported clinker (Lakh ton)/Conversion factor of major product

Where: Total exported clinker = [Clinker exported to other plants + clinker exported to clinker stock over and above the opening stock]

(v) Conversion of total imported clinker to major product

Equivalent major product = Total imported clinker (Lakh ton)/Conversion factor of major product

Where: Total Imported clinker = [Clinker Imported from other plants + clinker Imported from clinker stock, equivalent to the quantity by which the clinker opening stock gets reduced]

(vi) Total equivalent major product of cement

It can be arrived at by summing up all the different grades of cements equivalent to major product calculated above:

Total Equivalent major product of Cement = (i) + (ii) + (iii) + (iv) [Lakh ton]

Note: S.No. (v) is already accounted in major product

The unit defined conversion factors would be used for normalising the production value of each of the sub-product to the defined main product. BEE has also provided conversion factors for electrical energy to equivalent thermal energy for different sources as shown in the following text box[7].

Text Box 3: Calculation for Gate to Gate specific energy consumption (SEC)

(i) Total thermal energy consumption

Total thermal energy consumption is to be calculated as:-

= [Fuel consumed (Lakh ton) x Gross calorific value of respected fuel (kcal/kg) x 100] [Million kcal]

(ii) Total electrical energy consumption

= [{(Total electricity purchased from grid (Lakh kWh) x 860 (kcal/kWh) – electricity exported to grid (Lakh kWh) x 2717 (kcal/kWh)}/10] [Million kcal]

Where: - 2717 kcal/kWh is national average heat rate.

(iii) Notional/Normalisation energy for imported electricity from grid

Notional energy for imported electricity = [Imported electricity (lakh kWh) x (3208–860) (kcal/kWh)] / 10 [Million kcal]

Where: - 3208 kcal/kWh is weighted average heat rate of all designated consumers in cement sector.

(iv) Notional/Normalisation energy required for grinding of exported clinker

It is calculated by using following formula:

Notional energy required = {Total exported clinker to major product (Lakh ton) x Electrical SEC of cement grinding (kWh/ton of cement) x weighted average heat rate (kcal/kWh)}/10 [Million kcal]

Where: - Weighted average heat rate (kcal/kWh) = [{Imported electricity (Lakh kWh) x 3208 (kcal/kWh)} + (diesel generation (lakh kWh) x diesel generator heat rate (kcal/kWh)} + {Captive power plant generation (lakh/kWh) x Captive power plant heat rate (kcal/kWh)}]/[Imported electricity (lakh/kWh) + diesel generation (lakh kWh) + Captive power plant generation (lakh kWh)]

(v) Notional/Normalisation energy required for clinkerisation of imported clinker

It is calculated by using following formula:

Notional energy required = (Total clinker imported (Lakh ton) x {thermal SEC of clinkerization kcal/kg clinker) x 1000 + electrical SEC of clinkerization (kWh/ton of clinker) x weighted average heat rate (kcal/kWh)}/10] [Million kcal]

(vi) Gate to Gate (GtG) energy consumption

GtG energy consumption = (i) + (ii) + (iii) + (iv) + (v) [Million kcal]

(vii) Gate to Gate (GtG) specific energy consumption

$$\text{GtG SEC} = \frac{\text{GtG energy consumption (Million kCal)}}{\text{Total equivalent major product of cement (lakh ton) x 100}}$$

[Kcal/kg of equivalent cement]

Like in all cases, it has been provided that permissible error shall be ±0.05% in terms of TOE for the purpose of computation.

From the above, it would be observed that most elaborate and detailed guideline has been provided for normalisation of product and energy source variables for the sector.

4.2 PROPOSED METHODOLOGY

The proposed methodology has been developed considering the followings:

- 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 cement 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 utilisation coefficient, the guideline has provided for consideration only if deviation is by 30% or more. This issue would have to be reviewed for every DC after carrying out the statistical analysis.

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.

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 corelationship. Information provided has been used to assess if such corelationship could be established. It can be stated that there is corelationship. However, to establish the corelationship coefficient much larger number of data points would be required. With a view to avoid high cost of transactions for carrying out such analysis at individual unit level, it would be good to develop sector specific statistical models. The data and information can be picked up from the validation report and model used for automatically deriving the relationship coefficient.

Considering the evidence of corelationship, it would be necessary to review the trend more closely during the validation process. It has been that even there is significant impact on SEC even at lesser CU deviation than 30% provided in the BEE guideline. Apart from the production and energy consumption, data and information on other variables that can impact the SEC has not been provided.

Information on identified energy savings projects has also been provided. However, their impact on reduction of SEC has not been analysed and in some cases, energy reduction values have not been provided.

From the data and information provided, it appears that the performance of the captive power plant is playing more important role in influencing the GtG SEC. The GtG SEC figures can also be impacted by change in the mix of power drawn from different sources with different heat rate.

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 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 Cement sector, following important variables have been identified:

- Limestone quality-primary raw material
- Process technology
- Capacity utilisation
- Finished products
- Sources of power and usage mix

The intent of the PAT scheme is to make investment in EE and process technology. As such, no normalisation needs to be carried out on these two accounts. Variation in the moisture content in the limestone impacts the energy consumption. It is possible to develop mathematical formulae and apply the same for normalisation. BEE guideline has provided methodology for normalisation for variation in product mix and power mix. Based on the analysis carried out by DESL, it is recommended to use the baseline heat rate for grid power and actual heat rate for captive power for converting electrical energy into equivalent thermal energy. The methodology adopted for adjustment in the heat rate for thermal power plants of account of coal quality variation can be used for normalisation of heat rate for the captive power plant and the gate to gate fuel consumption normalised accordingly.

5. REVIEW OF BASELINE & DETERMINATION OF GtG SEC

Two audit reports, one each for a dry and a wet processing unit have been obtained from BEE. These reports have been reviewed from the normalisation and M&V perspective against the general outline as per BEE guideline. The finding are summarised as follows.

5.1 UNIT-1

This is a 9.6 Lakh T/Year cement manufacturing unit comprising of a 2150 TPD semi-wet process kiln. The energy need is met by use of variety of purchased fuels including coal, pet coke and some small quantity of biomass. The power demand is met mostly from 15 MW coal based captive power plant. The company has a wind firm of 9 MW capacity meeting part of the electrical load. Balance requirement is met from the grid. The relevant baseline data as captured from the audit report is as in the following table.

Table 1: Baseline data-Unit-1

Particulars	Unit	2007-08	2008-09	2009-10
Production and capacity utilization details				
Production Capacity (Clinker)	Tonne	700000	700000	700000
Production Capacity (Cement)	Tonne	960000	960000	960000
Total Clinker Production	Tonne	682105	672882	643568
Total Cement Production(All varieties)	Tonne	879771	1030524	941430
Capacity Utilization (Clinker)	%	97.4	96.1	91.9
Capacity Utilization (Cement)	%	91.64	107.35	98.07
OPC Production	Tonne	89535	137058	85435
PPC Production	Tonne	790236	893466	830923
Clinker Imported	Tonne	18540	113758	46020
Quantity of Fly Ash used	Tonne	144629	199364	194413
Quantity of Gypsum Used	Tonne	47876	44233	39789
Quantity of Slag Used	Tonne	0	500	11014
Quantity of any other Additive used	Tonne	0	1966	3868
Clinker Factor for OPC	Fraction	0.9479	0.9379	0.9079
Clinker Factor for PPC	Fraction	0.7623	0.7352	0.7229
Clinker Factor for PSC	Fraction	0	0	0.5261
Electricity Consumption				
Electricity from Grid / Other				
Gross Total Units from Grid	Lakh kWh	62.4	52.8	72.7
Purchased / Billed Units	Lakh kWh	36.31	10.98	14.5

Particulars	Unit	2007-08	2008-09	2009-10
Wind Energy (Wheeling)	Lakh kWh	26.09	41.82	58.2
Equivalent Thermal Energy (B1)	MKCal	5366	4541	6252
Own Generation-steam turbine				
Annual Gross Unit generation	Lakh kWh	1142.7	1192.2	1149.9
Imported coal for Power generation	Tonnes	1691	990	1145
GCV of coal	kCal/kg	6383	6480	6217
Petcoke for Power generation	Tonnes	0	184	1219
GCV of Petcoke	kCal/kg	8653	8698	8601
Other solid fuel for power generation	Tonnes	121037	111487	104357
GCV of other solid fuel	kCal/kg	3355	3793	3865
Thermal Energy- all fuel	MKCal	416873	430886	420943
Average Gross Heat Rate	kCal/ kWh	3648.14	3614.21	3660.69
Auxiliary Power Consumption	%	11.81	11.44	11.1
Electricity export	Lakh kWh	23.62	28.18	29.13
Equivalent Thermal Energy supplied to grid/others	MKCal	6417.55	7656.51	7914.62
Total Electricity Consumed	Lakh kWh	1181.5	1216.8	1193.5
Solid Fuel Consumption				
Coal (Indian)				
Quantity purchased	Tonnes	124988	127598	121117
Quantity for power generation	Tonnes	121037	111487	104357
GCV	kCal/ kg	3355	3793	3865
Quantity for process heating	Tonnes	0	10089	10928
GCV of coal for kiln	kCal/ kg	0	4360	3942
Total Quantity Consumed	Tonnes	121037	121576	115285
Thermal Energy Input-coal	MKCal	406079	466858	446418
Petcoke				
GCV	kCal/ kg	8653	8698	8601
Quantity purchased	Tonnes	12515	12482	20084
Quantity for power generation	Tonnes	0	184	1219
Quantity used for process heating	Tonnes	10261	13350	15053
Total Quantity Consumed	Tonnes	10261	13534	16272
Thermal Energy Input-petcoke	MKCal	88788	117719	139955
Coal(Imported)				
GCV	kCal/ kg	6383	6480	6217
Quantity purchased	Tonnes	104586	88220	82507
Quantity for power generation	Tonnes	1691	990	1145

Particulars	Unit	2007-08	2008-09	2009-10
Quantity for process heating	Tonnes	101837	80465	74109
Total Quantity Consumed	Tonnes	103528	81455	75254
Thermal Energy Input-Imp. Coal	MKCal	660819	527828	467854
Bio mass or Other purchased Renewable solid fuels e.g. saw dust, rice husk, charcoal.				
Average GCV	kCal/ kg	2200	2245	2245
Quantity purchased	Tonnes	132	846	79
Quantity for power generation	Tonnes	132	793	0
Quantity for process heating	Tonnes	0	53	79
Total Quantity Consumed	Tonnes	132	846	79
Thermal Energy Input	MKCal	290.4	1899.27	177.36
Solid Waste e.g. Rubber tyres chips, Municipal Solid waste etc.				
Quantity purchased	Tonnes	0	442	1285
Average Gross calorific value as	kCal/ kg	0	608	4782
Quantity for power generation	Tonnes	0	0	0
Quantity for process heating	Tonnes	0	442	1285
Total Quantity Consumed	Tonnes	0	442	1285
Thermal Energy Input	MKCal	0	268.74	6144.87
Total energy-solid fuel	MKCal	1155977	1114573	1060550
Diesel oil (HSD)				
Gross calorific value	kCal/ Kg	9600	9600	9600
Quantity purchased	Tonnes	1763.8	1692	1596
Average Density	kg/litre	0.86	0.86	0.86
Quantity for power	Tonnes	0	0	0
Quantity for process heating	Tonnes	120	153	165
Total Thermal Energy Input	MKCal	1152	1468.8	1584
Total-liquid fuel	MKCal	1152	1468.8	1584
Total energy-gaseous fuel	MKCal	0	0	0
Total-all Fuels	MKCal	1157129	1116042	1062134
Total of fuel & purchase elect	MKCal	1162495	1120583	1068386
	MTOE	116250	112058	106839
SEC-Cement without normalisation	MTOE/T	0.1321	0.1087	0.1135

Following graph shows the GtG SEC CU corelationship based on the reported cement CU (without normalisation) and the GtG SEC figure as per Table 5 above.

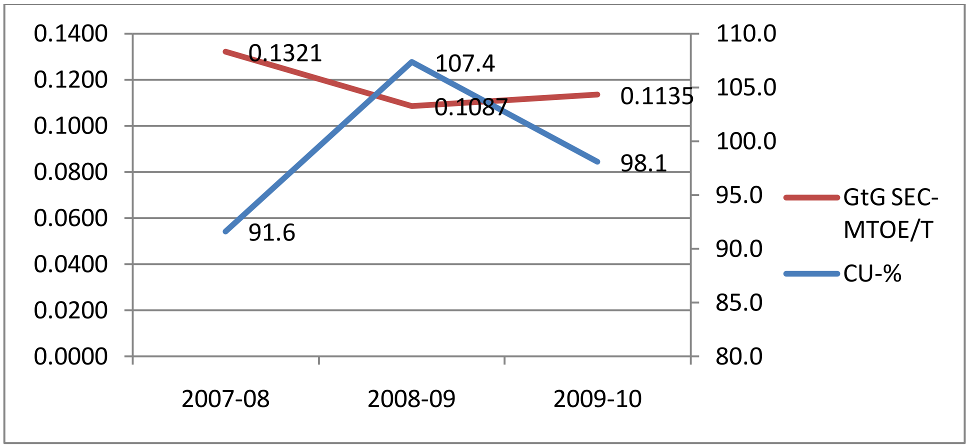


Figure 4: CU GtG corelationship-unit-1 (Without normalisation)

From the figure 4 above, it is seen that there is very clear corelationship between CU & GtG SEC even without normalisation. BEE prescribed methodology has been used for carrying out normalisation of products into an equivalent major product and conversion of electrical energy from different sources into equivalent thermal energy as shown in the following tables.

Table 2: Factors for normalization for SEC

Parameters	Converted to	Normalization factors
Clinker (imported/exported)	PPC	Clinker quantity/Clinker factor of PPC
PPC	PPC	1
OPC	PPC	OPC*CF of OPC/CF of PPC
PSC	PPC	PSC*CF of PSC/CF of PPC
Grid power-import	Kcal/year	860 Kcal/kWh
Power exported (grid heat rate)	Kcal/year	2,717 Kcal/kWh
Captive power (weighted average HMBD heat rate)	Kcal/year	3208 Kcal/kWh

Table 3 : Calculated GtG SEC (Normalized)- Unit-1

Details of Production	Unit	2007-08	2008-09	2009-10
Production of OPC	Lakh Tonnes	0.9	1.37	0.85
Production of PPC	Lakh Tonnes	7.9	8.93	8.31
Production of PSC/any other variety cement	Lakh Tonnes	0	0	0.25
Conversion Factors (CF) for Clinker to various Cement grades				
Clinker to OPC	Fraction	0.9479	0.9379	0.9079
Clinker to PPC	Fraction	0.7623	0.7352	0.7229
Clinker to PSC/any other variety cement	Fraction	0	0	0.5261
Total Thermal Energy consumed	MKCal	1157129	1116042	1062134

Details of Production	Unit	2007-08	2008-09	2009-10
Total Electricity consumed (GtG)	Lakh kWh	1181	1217	1193
Grid import	Lakh kWh	62.4	52.8	72.7
Grid export	Lakh kWh	23.62	28.18	29.13
Equivalent major grade cement Production				
OPC	Lakh Tonnes	1.11	1.75	1.07
PPC (Major)	Lakh Tonnes	7.9	8.93	8.31
PSC/any other verity	Lakh Tonnes	0	0	0.18
Exported clinker to major product	Lakh Tonnes	0	0	0
Imported Clinker to major product	Lakh Tonnes	0.24	1.55	0.64
Total Equivalent major product	Lakh Tonnes	9.25	12.23	10.2
Performance Indicators				
Thermal SEC (Clinker)	kCal/kg	1083	1013	984
Electrical SEC (clinker)	kWh/Tonne	89.6	83.9	91.2
Electrical SEC (Cement grinding)	kWh/Tonne cement	50.2	45	50.5
Calculation for Gate to Gate SEC				
Notional Energy Required for grinding of exported clinker	MKCal	0	0	0
Notional Energy Required for clinkerization of imported clinker	MKCal	26142	149701	60647
Notional Energy for grid power	MKCal	14652	12397	17070
Gate to Gate energy consumption	MKCal	1168619	1253346	1105711
GtG SEC	MTOE/T	0.1263	0.1025	0.1084

The GtG CU relationship on normalised production basis is as shown in the following figure.

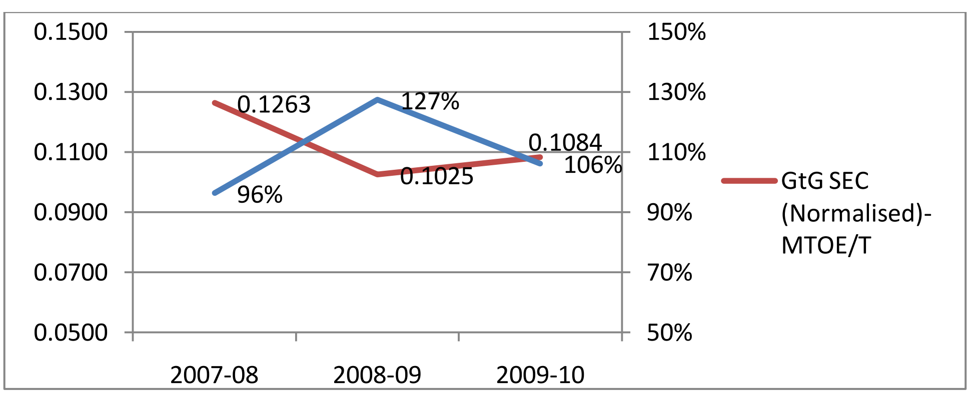


Figure 5: CU GtG SEC relationship (Normalised)

The CU GtG SEC relationship based on normalised production continues to show same trend.

This plant depends upon imported coal as primary source of energy for both power generation and heating fuel. Some small quantity of HSD has also been used both for power generation and heating mainly as standby.

The share of captive thermal power has been continuously increasing over the three years with corresponding reduction of grid power. The average drawl from captive thermal plant has been 87% during the last three years. The plant has also been using some quantity of wind power through wheeling but the drawl has gone down significantly from annual drawl of over 250 lakh units in each of the pervious to last year reducing to less than 100 lakh units for the last reported year. In case of change in ratio of drawl of power from different sources, the SEC figure derived on normative heat rate can get distorted and therefore, not correctly reflecting the impact of energy efficiency measures implemented.

The list of identified energy saving projects and their impact on reduction of overall energy consumption has been reported as in the following table.

Table 4: Energy saving projects-Unit-1

Project Description	Identified savings (MTOE/Year)	Immediate achievable (MTOE/Year)
Kiln -Improve insulation in Cyclone # 4 Raw meal pipe connecting to calciners	187	112
Reduce fines in the CM 8 separator rejects	642	385
Optimisation of VRM circuit	606	121
Installation of VFD for 7 nos cooler fans and auto operation of cooler	444	222
CFD study of total pre heater circuit for optimising KE fan energy consumption	282	0
Optimise the operation of all identified bag filters and install VFD for all bag filters	165	83
Usage of existing cement mechanical conveying system after modification	144	86
FRP fan blade for 3 nos air cooled condensers.	37	22
Reduce pressure drop across cyclones in CM 8 separator circuit. -CFD	36	0
Replace the wash water pumps with high efficiency	40	24
Usage of existing fly ash mechanical conveying system after modifications	63	0
Avoid damper loss and install VFD for CM 7 vent fan	45	23
Replace the raw water pumps in raw water pump house with high efficiency pumps	40	24

Project Description	Identified savings (MTOE/Year)	Immediate achievable (MTOE/Year)
Install VFD for Mixer basin pumps 3 & 4	38	27
Optimise CM8 Vent fan circuit	38	19
Avoid damper loss and install VFD for CM 8 separator vent fan	9	5
Optimise operation of Kiln coal firing blower in Pyro section by VFD	34	17
Replace the existing ACWP's with higher efficiency pumps	25	15
Improve the performance of settling tank water pumps	18	11
APFC panel for power factor improvement in CPP	14	11
Use of Power boss load manager for primary crusher to reduce energy consumption	14	8
Energy Savings by bypassing the Kiln side PH gas (25% of Total Flow) -directly to fan inlet	518	259
Pr. Drop reduction in CD & DDC Circuit due to ENCON 22	746	522
Arrest of False Air in Preheater Section at Crusher Dryer and Dusting Cyclone	1035	518
Total	**5220**	**2514**

The identified and achievable savings represents about 4.5% and 2.2% of the 2009-10 energy consumption level.

Conclusions:

- There is good corelationship between GtG SEC and capacity utilisation on the gross production without normaisation
- The unit would be requiring more intensive efforts to identify and implement additional energy saving projects to meet the PAT target

5.2 Unit-2

This is a 3.5 MnT/Year cement manufacturing unit comprising of one unit of 250 TPD semi-dry process and two dry processing units, one each of 3300 TPD an 3800 TPD capacity respectively. The energy need is met by use of variety of purchased fuels including coal, lignite, pet coke, furnace oil and HSD. The power demand is met mostly from coal based captive power plants of aggregate capacity of 45 MW and utility grid. For emergency, there are four number DG sets with aggregate capacity at 15 MVA.

The capacity, production and capacity utilisation figures of the three years as per the baseline study are shown in the following table.

Table 5: Baseline data-Unit-2

Particulars	Unit	2007-08	2008-09	2009-10
Production and capacity utilisation				
Production Capacity (Clinker)	Tonne	2754000	2754000	2754000
Production Capacity (Cement)	Tonne	3500000	3500000	3500000
Total Clinker Production	Tonne	2444075	2495340	2475330
Total Cement Production(All varieties)	Tonne	3293741	3373784	3114187
Capacity Utilization (Clinker)	%	88.75	90.61	89.88
Capacity Utilization (Cement)	%	94.11	96.39	88.98
OPC Production	Tonne	650541	540277	532992
PPC Production	Tonne	2530464	2732242	2461248
Other Cement Production	Tonne	112736	101265	119947
Clinker Exported	Tonne	632.91	1820.89	74931.63
Clinker Imported	Tonne	0	2815	0
Quantity of Fly Ash used	Tonne	734003	763064	662150
Quantity of Gypsum Used	Tonne	166492	152871	128740
Quantity of Slag Used	Tonne	22953	6572	0
Limestone	Tonne	720	3189	10420
Clinker Factor for OPC	Fraction	0.91	0.94	0.94
Clinker Factor for PPC	Fraction	0.66	0.67	0.69
Clinker Factor for Other Cements	Fraction	0.96	0.96	0.97
Electricity Consumption				
Electricity from Grid / Other				
Gross Total Units from Grid	Lakh kWh	559.31	350.01	40.99
Purchased / Billed Units	Lakh kWh	293.11	81.67	-56.21
Wind Energy (through wheeling)	Lakh kWh	266.1957	268.34	97.2
Equivalent Thermal Energy of purchased energy from grid	MKCal	48100	30101	3526

Particulars	Unit	2007-08	2008-09	2009-10
Own Generation				
Through DG sets				
Annual generation	Lakh kWh	99.00836	54.05	22.21
Avg. Gross Heat rate of DG Set	kCal/kWh	2463.02	2528.66	2461.71
Through Steam turbine/generator				
Annual Gross Unit generation	Lakh kWh	2009.48	2316.99	3282.62
Average Gross Heat Rate	kCal/ kWh	3070.32	3365.49	3298.08
Auxiliary Power Consumption	Lakh kWh	180.75	318.19	281.29
	%	8.99	9.11/27.38	8.34/8.88
Total Generation of Electricity	Lakh kWh	2108.49	2371.04	3304.83
Electricity Supplied to Grid/Others	Lakh kWh	0	0	680.72
Equivalent Thermal Energy supplied to grid/others	MKCal	0	0	184952
Total Electricity Consumed	Lakh kWh	2668	2721	2665
Solid Fuel Consumption				
Coal (Indian)				
Quantity for power generation	Tonnes	0	3843	0
Average GCV	kCal/ kg	0	4417	0
Total Quantity Consumed	Tonnes	0	3843	0
Thermal Energy Input	MKCal	0	16975	0
Lignite				
Average GCV	kCal/ kg	5481	5028	5013
Quantity for power generation	Tonnes	9053	14056	37243
Quantity for process heating	Tonnes	0	0	497
Total Quantity Consumed	Tonnes	9053	14056	37740
Thermal Energy Input	MKCal	49619	70674	189191
Coal(Imported) - High Grade				
Average GCV	kCal/ kg	6355	6308	6260
Quantity purchased	Tonnes	436907	387247	426659
Quantity for power generation	Tonnes	87435	88578	138010
Quantity for process heating	Tonnes	322374	318930	284750
Total Quantity Consumed	Tonnes	409809	407508	422760
Thermal Energy Input	MKCal	2604336	2570560	2646478

Particulars	Unit	2007-08	2008-09	2009-10
Coal(Imported) - High moisture (Low grade)				
Average GCV	kCal/ kg	6538	6187	5881
Quantity for power generation	Tonnes	0	12455	662
Quantity for process heating	Tonnes	0	18340	340
Total Quantity Consumed	Tonnes	0	30795	1002
Thermal Energy Input	MKCal	0	190528.7	5893
Petcoke				
Average GCV	kCal/ kg	0	8180	8260
Quantity for process heating	Tonnes	0	1796	37600
Total Quantity Consumed	Tonnes	0	1796	37600
Thermal Energy Input	MKCal	0	14691.28	310576
Total-solid fuel	**MKCal**	**2653956**	**2863429**	**3152137**
Liquid Fuel Consumption				
Furnace Oil				
Gross calorific value	kCal/ kg	10474	10461	10256
Quantity purchased	Tonnes	5104	2985	1189
Average Density	kg/litre	0.95	0.95	0.95
Quantity for power generation	Tonnes	2309	1284	516
Quantity for process heating	Tonnes	2735	1891	806
Total F. Oil Consumption as fuel	Tonnes	5044	3174	1322
Total Thermal Energy Input	MKCal	52833	33206	13558
High Speed Diesel (HSD)				
Gross calorific value	kCal/ Kg	10713	10678	10638
Quantity purchased	kilo Litre	1543.639	1135.575	268
Average Density	kg/litre	0.86	0.86	0.86
Quantity for power generation	kilo Litre	21.98	26.30	18.51
	Tonnes	18.91	22.62	15.92
Quantity for process heating	kilo Litre	189.5	45	61
	Tonnes	162.97	38.7	52.46
Total HSD Consumption as fuel	Tonnes	181.88	61.32	68.38
Total Thermal Energy Input	MKCal	1948	655	727
Total-liquid fuel	**MKCal**	**54782**	**33861**	**14286**
Total Thermal Energy-Fuels	**MKCal**	**2708737**	**2897290**	**3166423**

Particulars	Unit	2007-08	2008-09	2009-10
	MTOE	270874	289729	316642
SEC (Cement without normalisation)	MTOE/T	0.0822	0.0859	0.1017

The reported GtG CU relationship on the basis of cement production is shown in the following figure.

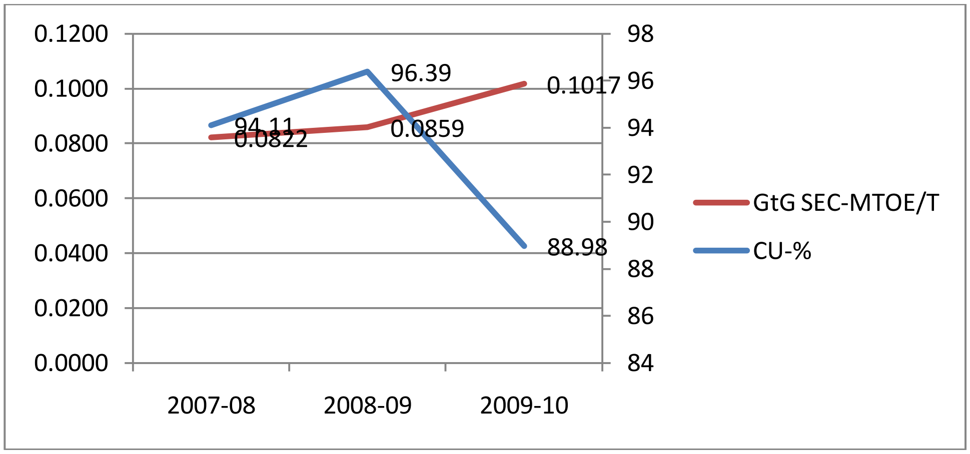


Figure 6: GtG SEC CU relationship-Unit-2

From the data of 2009-10, it can be concluded that there is good corelationship in case of significant change in the capacity utilisation.

In this case too, normalisation process has been carried out as per the BEE guidelines. Summary findings are as shown in the following table.

Table 6 : Unit-2 Normalization for SEC

Parameters	Converted to	Normalization factors
Clinker (imported/exported)	PPC	Clinker quantity/Clinker factor of PPC
PPC	PPC	1
OPC	PPC	OPC*CF of OPC/CF of PPC
PSC	PPC	PSC*CF of PSC/CF of PPC
Grid power-import	Kcal/year	860 Kcal/kWh
Power exported (grid heat rate)	Kcal/year	2,717 Kcal/kWh
Captive power (Weighted average HMBD heat rate)	Kcal/Year	3208 Kcal/kWh

The heat content of fuel has been computed by multiplying quantity of each of the individual fuel with its GCV and summing up for all the fuels used. GtG SEC has been computed by averaging three years data as follows:

(∑Kcal/year of net electricity used+ ∑Kcal/year of fuels)/ ∑ (normalised net PPC production)

The normalised figures can be computed on the basis of clinker factor for both capacity and production and production figures only. The CU figures so worked out are shown in the following table

Table 7: CU based on different methodology

Particulars	Unit	2007-08	2008-09	2009-10
OPC Production	MT/Year	650541	540277	532992
PPC Production	MT/Year	2530464	2732242	2461248
Other cement production	MT/Year	112736	101265	119947
CF-OPC	%	91	94	94
CF-PPC	%	66	67	69
CF-Others	%	96	96	97
OPC production	T/Year	6,50,541	5,40,277	5,32,992
OPC ratio	%	19.75	16.01	17.11
PPC production	T/Year	25,30,464	27,32,242	24,61,248
PPC ratio	%	76.8	80.98	79.03
Others production	T/Year	1,12,736	1,01,265	1,19,947
Others ratio	%	3.4	3	3.85
Equivalent production	Lakh T/Year	35.92	36.38	34.68
Cement capacity	Lakh T/Year	35	35	35
Normalised capacity*	Lakh T/Year	45.10	46.40	44.98
CU-capacity based	%	103	104	99
CU-normalised capacity based	%	80	78	77
GtG SEC (Normalised)	MTOE/T	.0754	.0796	.0914
*Assuming declared capacity is for OPC				

The following figure shows the CU GtG SEC relationship on the basis of normalised parameters.

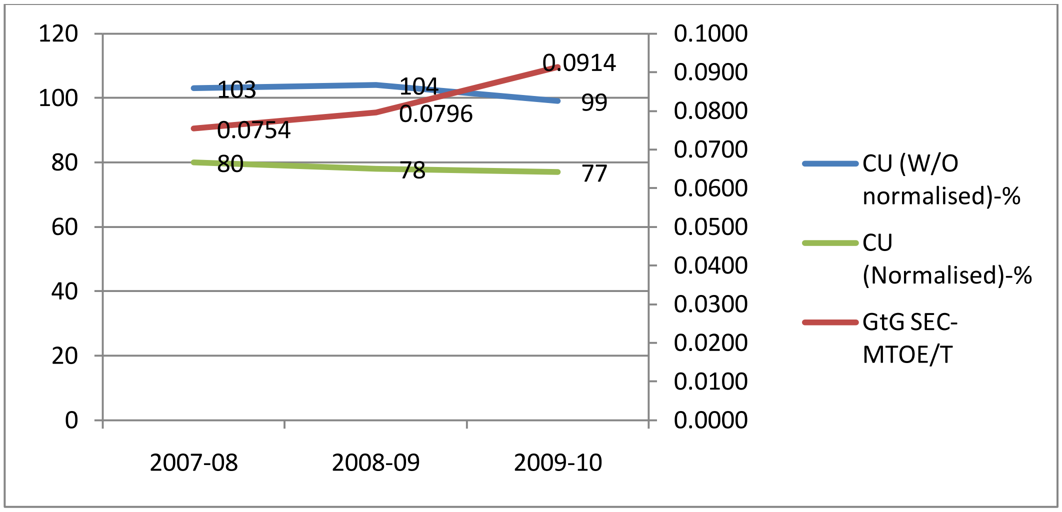


Figure 7: GtG SEC-CU relationship-unit-2 (Diff basis)

It is seen that the GtG SEC relationship is more or less similar on either basis. However, normalised basis show higher level of sensitivity as even with 1% change in CU, steeper change in GtG SEC is observed.

Effect of change in power mix and computation based on normative heat rate can change the SEC figures without reflecting the change due to energy efficiency improvement measures. This issue has been further discussed at section 6.5 of this protocol.

The identified energy saving projects as reported is as shown in the following table. In this report, the auditors have used different units of MnkWh for electricity and MT for coal against MTOE used in the report for unit-1.

Table 8 Energy Saving Project – Unit-2

Projects	Savings-Mn kWh	Savings Coal-MT
To provide level sensors in VRM I reject hopper to avoid the reject belt idle running	0.013	
In FLS plant, the raw meal ventilation fan operation to be put into auto mode	0.063	
In crusher 4 wobblers chute conventional type heater chaining with strip heater and increasing the reliability	0.015	
Transfer of fly ash from VRM-I after drying directly to CVRM-1 mill instead sending to DD silo and then pumping to CVRM-1 mill	0.011	
CVRM-II HAG (hot air generator) usage to be reduced through fresh air damper closed in CVRM II cement grinding mills.(Electrical)	0.105	
CVRM-II HAG (hot air generator) usage to be reduced through fresh air damper closed in CVRM II cement grinding mills.(Thermal)		112.52

Projects	Savings-Mn kWh	Savings Coal-MT
To provide control switch, timer at various places for plant & colony lighting	0.025	
In electrical, mechanical workshop & KHD motor godown by replacing GI sheet with transparent sheet	0.012	
Transparent sheets to be provided in ETP & central workshop roof to save power and improve illumination	0.013	
Power saving to be done by fixing the pendulum flap instead of rotary air lock in FLS cooler ESP	0.024	
Eliminating the K2NFNJ fan form silo group and connect it to the bin group to save the power, also connect the K2NFNJ fan with K2NFN& to keep the K2NFNJ fan	0.031	
Higher capacity cooling fan is to be replaced with required capacity in H7B truck loader	0.001	
Raw meal top air slide fan & RAV stops immediately when neither recirculation mode nor kiln feed mode is selected. (7.5 kW saving approx.)	0.001	
VRM 3 mill heat up mode selection logic to be made in which mill auxiliaries and the reject group and silo in the feed group will not run in the mill start-up. Only classifier and seal air fan will run along with the raw mill fan until temp reaches	0.006	
Stopping of the magnetic separator cross belt conveyor is to be interlocked with collecting belt conveyor. For switching of the electromagnet also interlock is to be made. (4kW saving approx)	0.001	
The coal reclaimer magnetic separator cross belt conveyor & electromagnet are to be interlocked with reclaimed coal transporting belt conveyor running. (4kW saving approx.)	0.001	
GRR cooling fan will stop, if the motor runs at 100% speed and the cooling fan runs if the drives runs below rated full speed.(1.5kW saving approx.)	0.0003	
In FLS cooler second grate stops for more than 10 minutes clinker transportation group stop's (45kW saving approx.)	0.008	
Total	0.3303	112.52

The impact of these projects on the overall SEC is negligible.

Conclusions:

- Clear corelationship is there between GtG SEC and CU
- The normalisation process has been carried out for the following variables
    a) Production
    b) Electricity usage from different sources
    c) Sufficient data and information are available for assessment of impact of capacity utilisation and other variables on GtG SEC and identification of other variables from normalisation perspective

d) Sufficient information is available for development of the M&V protocol for the identified variables

- The report has addressed the normalisation issue for power in an indirect manner

e) In table 6.5 of the report, the gross heat rate of the CPP has been provided. The average works out to about 2484 Kcal/kWh, indicating a thermal efficiency of about 34.5%, which is too high for a plant of this capacity

f) For calculating thermal heat value, figure of 3208 Kcal/kWh has been taken. This basis has been considered on the basis of global average heat rate value for the CPPs in the sector as per BEE guideline

g) Adequate data is available in the system by which the heat rate for CPP can be determined and that should be used as baseline

- Wind power seems to have been treated as grid power

- The listed energy saving project would not make any significant contribution towards achievement of PAT target.

6. VARIABILITY FACTORS & NORMALISATION-CEMENT

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 cement sector are:

- Limestone quality-primary raw material
- Process technology
- Capacity utilisation
- Finished products
- Sources of power & usage mix

6.1 LIMESTONE QUALITY

Moisture content, grindability and burnability are the three parameters that impact energy requirement for the preparation of the raw material and meal[8]. In case of higher moisture (usual range is 3 to 5%), more thermal energy is needed during the preparation stage for which either available surplus exist flue gas or sometime supplementary heating fuel is used. Higher power is required for grinding of harder material. In case of poor burnability, fuel consumption may increase during the clinker production process.

However, most of the cement mills have long term arrangement for procurement of limestone from the designated mines. As such, during a PAT project cycle, it is unlikely that there would be any significant change in the quality, which would impact the energy consumption. Even then it would be desirable to monitor the quality for future reference.

6.2 PROCESS TECHNOLOGY

The wet process consumed more energy. However, since the mills under wet process have been separately categorized for target setting, it would not be necessary to use any normalisation factor. In case of change of process too, normalisation need not be carried out as the investment in change can be considered as investment in EE conforming to the objective of the PAT program.

6.3 CAPACITY UTILISATION

There is good corelationship between CU and GtG SEC for cement sector. The methodology for normalisation of production figure is well established. It has been seen that the SEC relationship looks even better on the basis of normalised production and CU calculated on the basis of

[8] "Handy Document"-Cement Industry, UNIDO & MITI, Japan, 1994

normalised capacity. Considering the close corelationship, the limit of 30% variation in CU for normalisation should not be applicable for this sector.

6.4 FINISHED PRODUCT

All cement mills manufacture clinkers and different grades of cement. Import and export of clinker also takes place as per balancing requirement. The methodology for normalisation has been already standardised by BEE (Text box-3) and same is used in both audit reports. The methodology is very robust and would be easily supportable by a simple M&V protocol.

6.5 SOURCES OF POWER &USAGE MIX

Source of electricity can be either grid or captive or mix of both. Fuel is sourced for meeting the demand of captive power plant and process heat. PAT requires that all energy sources are converted to equivalent heat energy for computation of overall energy consumption in terms of Ton oil equivalent (TOE). The two sources show divergent characteristics from the perspective of measurement and accounting. Electricity is very easy to measure but requires application of thermodynamic principles and modelling for calculation of heat rate. For liquid and gaseous fuels, it is easy to both measure and compute the heat content. Solid fuel on the other hand can be measured practically only in batch mode and also requires extensive sampling and analysis for determination of total thermal energy entering the gate.

In the baseline audit report following methodologies has been used for computation of heat rates:

- Fuel-Quantity used for power generation and process heat, GCV as per various plant records
- Conversion of electrical energy to equivalent thermal energy as per BEE guideline
    - Captive-as per CPP heat rate for SEC of electricity
    - Grid power
        - 860 Kcal/kWh for import for computation of overall heat
        - 860 Kcal/kWh for import while computing notional energy equivalent for calculation of GtG SEC
        - 2717 kCal/kWh (national heat rate) for computation of credit for export of power
    - Notional energy on account of clinker export/import
        - Sector average CPP heat rate (3208 Kcal/kWh)
        - Net rate at sectoral heat rate (3208)minus grid heat rate (860)

There are both pros and cons of using this methodology. It is simple and harmonised and so can be used by all the units without getting into details of individual CPP heat rate. Major disadvantage is that the system does not technically represent the true position from thermodynamic perspective.

Further, it would be difficult to verify impact of energy efficiency enhancement measures or lack of it in the CPP. Since CPP heat rate for the plants can be determined (as has been done in both the baseline audit reports), it should be possible to determine the baseline using the same. It would also be desirable to take heat rate for power from renewable resources such as wind and solar at 860 Kcal/kWh.

With a view to capture the essence of the definitions and assess the implications, following four different scenarios have been constructed to represent the prevailing practices in the cement sector.

- Entire electricity is purchased from grid-Baseline
- Part of the electricity is purchased from grid, balance from combination of DG & coal based captive power plant-Scenario i, ii & iii
- Part of the electricity is purchased from grid, balance from combination of DG & coal based group captive power plant, considered technically outside plant boundary, hence heat rate of 860 is applied-Scenario iv
- For the hypothetical case, following additional assumptions have been made:
    a. Change in the national heat rate to 2750 kCal/kWh
    b. DG heat rate of 2650 kCal/kWh
    c. Captive coal based plant at 3200 kCal/kWh

Power sourced from waste heat recovery process has not been included for this analysis. It is proposed that this is accounted for separately. In all cases, it is assumed that fuel is purchased from outside and accounted for as direct input of thermal energy. Accordingly, GtG SEC has been computed for the four different scenarios as shown in the following table.

Table 9: GtG SEC Computation for four different scenarios

GtG Energy computation-scenario analysis		**Scenario**				
Item	Unit	Baseline	I	II	III	iv
Production	T/Year	10000	10000	10000	10000	10000
Specific electricity **consumption**	kWh/T	70	70	70	70	70
Fuel consumption for thermal	TOE/T	0.07	0.07	0.07	0.07	0.07
Total energy consumption						
Electricity	kWh/year	700000	700000	700000	700000	700000
Fuel consumption for thermal	TOE/Year	700	700	700	700	700
Source of electricity						
Grid	kWh/year	700000	100000	100000	100000	100000
DG Set	kWh/year	0	300000	0	0	0
Captive coal power plant	kWh/year	0	300000	600000	300000	300000
Captive outside GtG (treated as grid)	kWh/year	0	0	0	400000	0

Captive outside GtG (treated as captive)		0	0	0	0	300000
Heat equivalent for power @-Kcal/kWh						
Grid	860	602000000	86000000	86000000	86000000	86000000
DG Set	2650	0	795000000	0	0	0
Captive coal power plant	3200	0	960000000	1920000000	960000000	960000000
Captive outside GtG (treated as grid)	860	0	0	0	344000000	0
Captive outside GtG (treated as captive)	3000	0	0	0	0	900000000
Total heat rate including grid & captive	***Kcal/Year***	***602000000***	***1841000000***	***2006000000***	***1390000000***	***1946000000***
Elec-Oil equivalent @10000 kcal/kg)	**TOE**	**60.2**	**184.1**	**200.6**	**139**	**194.6**
GtG SEC @ grid rate 860	**TOE/T**	**0.07602**	**0.08841**	**0.09006**	**0.0839**	**0.08946**
Revised heat rate @ 2717Kcal/kWh for grid	Kcal/Year	1901900000	271700000	271700000	271700000	271700000
Total heat rate including grid & captive	***Kcal/Year***	***1901900000***	***2026700000***	***2191700000***	***1575700000***	***2131700000***
Oil equivalent @10000 kcal/kg)	TOE	190.19	202.67	219.17	157.57	213.17
GtG SEC @ grid rate 2717 Kcal/kWh	**TOE/T**	**0.0890**	**0.0903**	**0.0919**	**0.0858**	**0.0913**

It is seen that at same level of specific electricity consumption and at heat rate of 860 Kcal/kWh, GtG SEC on electricity account is varying from 60.2 TOE/Year to 200.6 TOE/year. This has impacted the overall GtG SEC varying by over 20% at the same level of overall operational performance.

The last row of the table shows the impact of the grid heat rate is taken at 2717 Kcal/kWh. The maximum variation in SEC of about 6% truly reflects the system efficiency impact.

It would therefore, be desirable to adopt the system heat rate for both grid and captive power. The system heat rate for grid power should be maintained at the baseline value for computation of SEC during the entire PAT cycle.

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
- 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

There could be another methodology adopted in total harmony with the BEE guideline as discussed below.

- All power consumptions including power from captive power plants would be treated at heat rate of 860 Kcal/kWh-A
- Fuel value of the electricity would be computed at respective heat rate-B
- Difference between the heat rate would be computed (B-A) under both baseline and validation period-C
- Notional fuel consumption would be calculated by adding the value C to the heat from fuel purchased including for thermal and power generation application
- For group captive power plant, technically treated as outside Gate, actual heat rate would be obtained from the plant for computation of value B.

GtG SEC has been recalculated using the suggested methodology as presented in the following table.

Table 10: Recomputed GtG SEC

Scenario	Unit	Baseline	i	ii	iii	Iv
Oil equivalent of electricity cons	TOE/Year	60.20	184.10	200.60	139.00	194.60
Additional notional fuel for grid power	TOE/Year	132.30	18.90	18.90	94.50	18.90
Overall energy	TOE/Year	892.50	903.00	919.50	933.50	913.50
GtG SEC	TOE/T	0.08925	0.0903	0.09195	0.09335	0.09135

The figures computed the suggested methodology show much higher level of consistency and represents the systems efficiency

6.6RECOMMENDATION ON NORMALISATION

Based on the detailed review of the baseline audit reports, literature survey and DESL database and the analysis presented above on the identified variables, recommended considerations for normalisation are presented in the following table. The requirement of data and data protocol has been provided at section 7.2.

Table 11: Normalisation process

Normalisation element	Variability factors	As per BEE Guideline/baseline audit reports	Recommendations
Limestone	Moisture content, grindability	None	None for calculation for SEC for the 1st cycle but to be monitored for future reference
Finished product	Product mix, clinker import/export	Clinker factors as detailed	Clinker factors as detailed
Capacity utilisation	Product mix	Normalised product to nominal capacity	Normalised product to normalised capacity using clinker factors
Power	Sources of power	None for CPP as it is taken care in fuel heat For imported power at (Sector CPP heat rate-860 Kcal/kWh) For power export at national grid heat rate	All power consumptions including power from captive power plants would be treated at heat rate of 860 Kcal/kWh-A Fuel value of the electricity would be computed at respective heat rate-B Difference between the heat rate would be computed (B-A) under both baseline and validation period-C Notional fuel consumption would be calculated by adding the value C to the heat from fuel purchased including for thermal and power generation application For group captive or captive power plant, technically treated as outside Gate, actual heat rate would be obtained from the plant for computation of value B. Power import from wind & solar system at 860 Kcal/kWh

6.7 ILLUSTRATIVE EXAMPLE - RECONCILIATION

It is recommended to adopt a multi 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 and impacts of other variables established.

  Even after exhaustive statistical analysis, it may become difficult to achieve the targeted accuracy level of 0.05%. as provided in the PAT document of July, 2012.It has therefore, been recommended to carry out a project based assessment and reconcile the same with derived and normalised GtG SEC

  The following process is recommended for carrying out the reconciliation process.

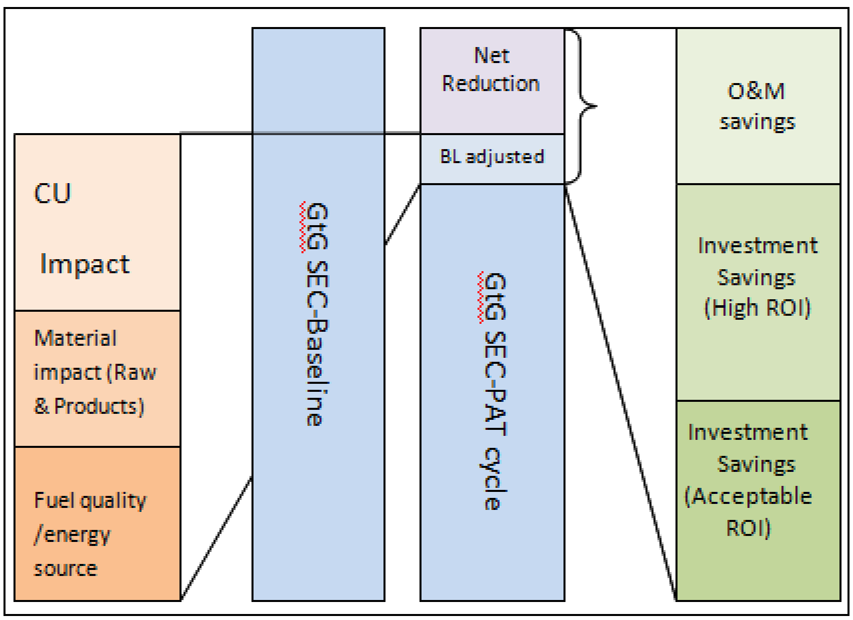


Figure 8: Normalisation & Baseline Adjustment

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 & PROTOCOLS

7.1 METERING & MEASUREMENT

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

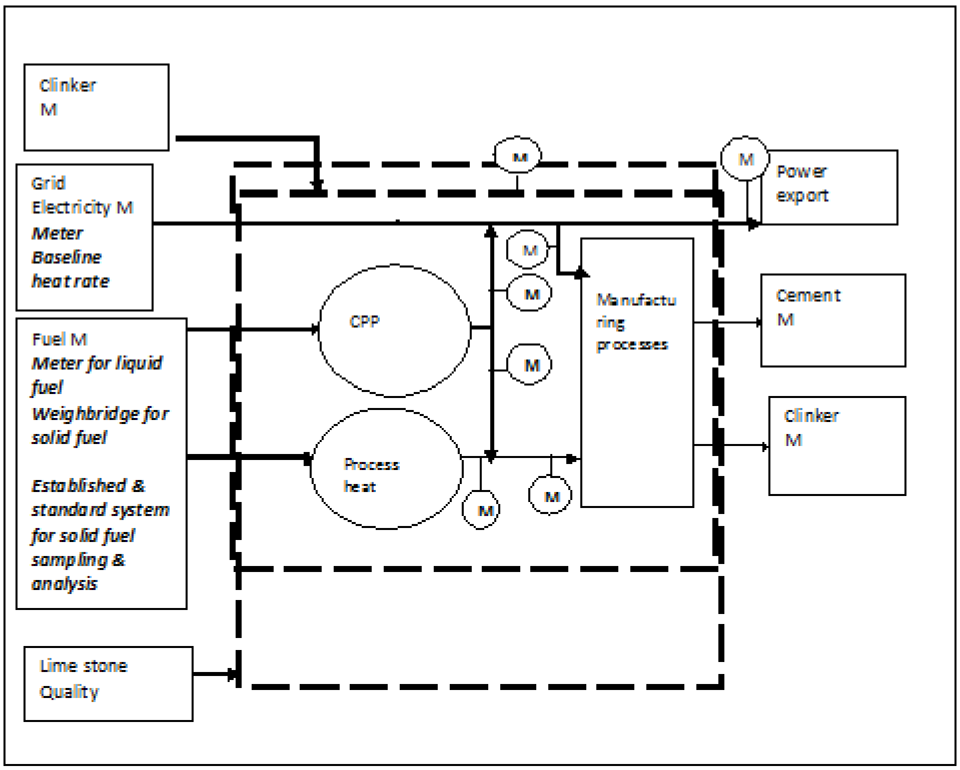


Figure 9: Metering & measurement plan

The metering & measurement plant to clearly determine:

- Production of different grade of cements
- Production, import & export of clinkers
- Fuel quantity & quality
    - Total
    - Cement production
    - Power generation
    - Auxiliary heat units for dryers, if any
- Imported & exported power

- Power from wind and solar systems
- Limestone-quality
- Power generation in CPP

The data and information management system has been 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
- 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 12: Data 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 (Clinker)	Balance sheet	Lakh Tonnes/year LTPY)	E	Annual	E/P	
A2	Production Capacity (Cement)	Balance sheet	LTPY	E	Annual	E/P	
A3	Total Clinker Production	Monthly Production report	LTPY	M/C	Daily	E/P	
A4	Total Cement Production(All varieties)	Monthly Production report	LTPY	C	Daily	E/P	
A5	Opening Clinker Stock	Cost Audit Report	Lakh Tonnes (LT)	M/C	Annual	E/P	
A6	Closing Clinker Stock	Cost Audit Report	Lakh Tonnes (LT)	M/C	Annual	E/P	
A7	Opening Cement Stock	Cost Audit Report	Lakh Tonnes (LT)	M/C	Annual	E/P	
A8	Closing Cement Stock	Cost Audit Report	Lakh Tonnes (LT)	M/C	Annual	E/P	
A9	OPC Production	Monthly Production report	LTPY	M/C	Daily	E/P	
A10	PPC Production	Monthly Production report	LTPY	M/C	Daily	E/P	
		Monthly					

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
A11	Other Cement Production	Production Log Files	LTPY	M/C	Daily	E/P	
A12	Clinker Exported	Monthly Production Log Files	LTPY	M	Daily	E/P	
A13	Clinker Imported	Monthly Production Log Files	LTPY	M	Daily	E/P	
A14	Quantity of Fly Ash used	Monthly Production Log Files	LTPY	M/C	Daily	E/P	
A15	Quantity of Gypsum Used	Monthly Production Log Files	LTPY	M/C	Daily	E/P	
A16	Quantity of Slag Used	Monthly Production Log Files	LTPY	M/C	Daily	E/P	
A17	Quantity of any other Additive used (Performance improver - Limestone)	Monthly Production Log Files	LTPY	M/C	Daily	E/P	
A18	Clinker Factor for OPC	Monthly cost audit reports	LTPY	C	Monthly	E/P	
A19	Clinker Factor for PPC	Monthly cost audit reports	LTPY	C	Monthly	E/P	
A20	Clinker Factor for Other Cements	Monthly cost audit reports	LTPY	C	Monthly	E/P	

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
B			**Power**				
B1	Annual power import	Utility bill	Million kWh (MU)	M/C	Monthly	P	
B2	Annual 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	Annual gross generation-Unit-1	DCS/Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
B5	Annual gross generation-Unit-2	DCS/Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
B6	Annual gross generation-Unit-3	DCS/Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
B7	Annual gross generation-Unit-4	DCS/Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
B8	Annual gross generation-WHR	DCS/Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
B9	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	

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
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	
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/CNG-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						

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
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	Monthly cost audit report	KLPY	M/C/E	Monthly	P/E	
D6	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	
E	Limestone-Moisture	Lab analysis report	%	M/C/E	Monthly	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 organisation EVO. For assessment of performance of EE projects, one or more of the four following methodologies can be used.

Table 13: M&V Protocol EE Projects

Option	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 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. 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 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

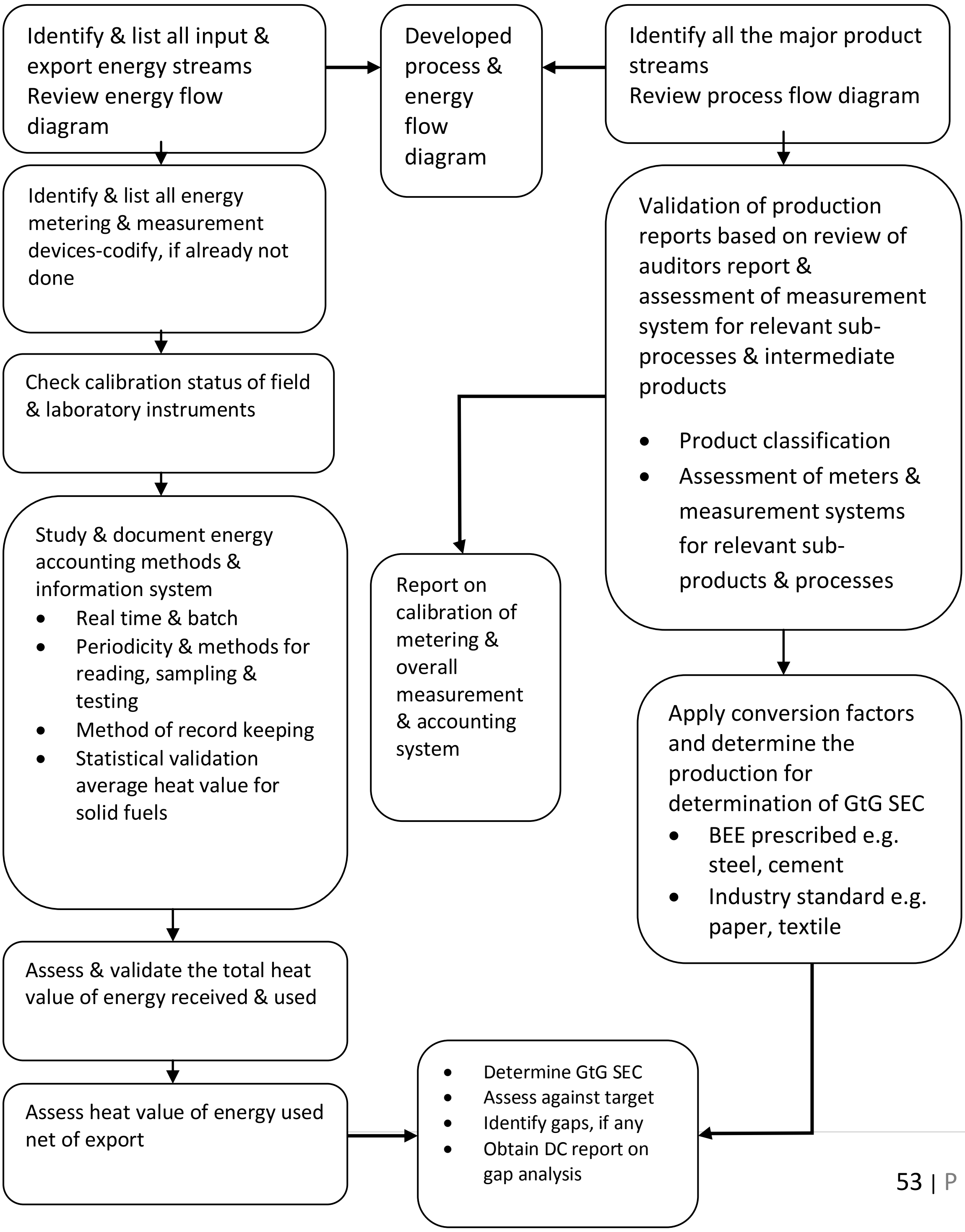
8. NORMALISATION PROCESS

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

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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

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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