M&V Protocol for Fertiliser Sector

Perform-Achieve and Trade Scheme

An initiative supported by

SHAKTI SUSTAINABLE ENERGY FOUNDATION

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ABBREVIATIONS

APM	*Administrative pricing mechanism*
ata	*Atmospheric pressure absolute*
BEE	*Bureau of Energy Efficiency*
CEA	*Central Electricity Authority*
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*
EE	*Energy efficiency*
Escert	*Energy savings certificate*
FICC	*Fertiliser industry coordination committee*
GCV	*Gross calorific value*
GtG	*Gate to gate*
Kcal	*Kilocalorie*
KLPY	*Kilo liter per year*
LTPY	*Lakh tonnes per year*
MKCal	*Million kilocalorie*
MT/T	*Metric Ton*
M&V	*Measurement & Verification*
NFL	*National Fertilizers Ltd*
NPS	*New pricing scheme*
PAT	*Perform achieve & trade*
PMT	*Panna Mukta Tapti*
RIL	*Reliance Industries Limited*
SCUM/Scm^3	*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 fertiliser 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. For the fertiliser sector, there is already a well established procedure for normalisation process including conversion factors for power units into equivalent thermal units. This system has been developed over the years as required by the FICC for administration of the subsidy scheme. The baseline report has been prepared on the basis of this existing system. The baseline reports have provided data and information based on which CU GtG impact has been analysed. These reports have also included the list of identified projects. However, impact of such projects or other variables on GtG SEC has not been analysed. DESL has carried out summary analysis to assess the probability of the DC to achieve PAT target by implementing these projects.

Few more variables having impact on GtG SEC have been identified based on review of past DESL audit reports and literature survey. There is very good corelationship between CU and GtG SEC for the fertiliser units. It should be easily possible to determine the corelationship coefficient during the validation study.

Following other key variables has been identified, which can impact the GtG SEC.

- Process technology
- Fuel/feedstock

- Plant vintage & maintainability
- Plant capacity
- Plant capacity utilisation
- EE investment

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

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

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 protocol have to be developed for every DC as the demanded accuracy can be obtained only with rigorous statistical analysis of unit specific performance data and parameters.

The fertilizer sector needs to be considered as an exceptional category from PAT perspective due to its long established process for monitoring and reporting of energy consumption as required by FICC. It is therefore, recommended that:

- GtG SEC is computed considering various conversion factors for determination of equivalent thermal energy for electricity used from different sources as per FICC norms (DESL is not recommending change as has been recommended for other sectors).
- Data & information protocol are also maintained as close to the FICC process as possible
- GtG SEC is computed on gross overall energy consumption (including for ammonia and urea)and conversion factor (ammonia to urea)used for determining GtG SEC for urea

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 for 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 'Normalisation' 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. FERTILISER SECTOR-OVERVIEW

2.1 SECTORAL PERFORMANCE-A BRIEF OVERVIEW

Starting with big push provided by Government policy in early 60s, fertiliser industry grew at rapid pace over next thirty years. However, growth started declining thereafter almost stagnating since 1999[2]. The financial performance of the industry has been continuously affected due to squeeze from both ends-increase of energy prices and inadequate subsidy to bridge the gap between cost of production and controlled selling price.

The consumption on the other hand has been growing at a reasonable rate throughout the 11th plan period [2].

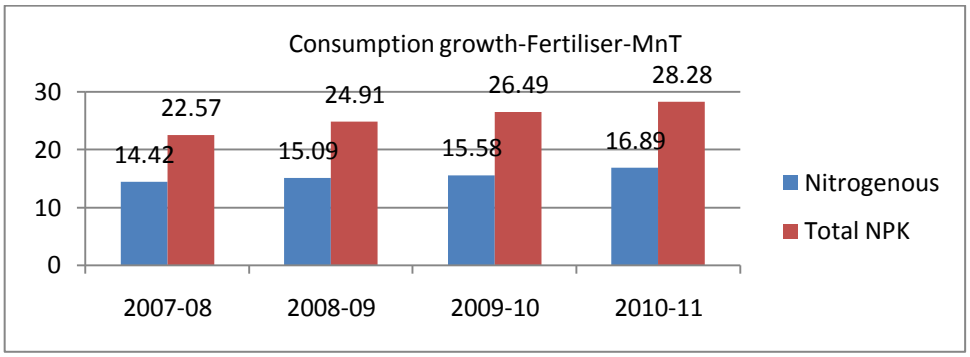


Figure 1: Consumption growth

With targeted subsidy, the share of nitrogenous fertiliser consumption has been progressively reduced from 64% in 2008-09 to about 60% in 2010-11. Even then 1.5 Million T of ammonia and 2.64 billion m^3 of gas had to be imported in 2010-2011 to meet the demand-supply and energy resource gap.

India is currently the 2nd largest producer and 3rd largest consumer of fertiliser in the world[1]. There are over 141 plants manufacturing different types of fertilisers out of which 29 units are producing ammonia and urea. These 29 units have been identified and listed as designated consumers for the current PAT cycle.

2.2 ENERGY USE IN UREA MANUFACTURE-INDIA

The urea manufacturing process comprises two major sub-processes - production of ammonia through reformation/partial oxidation of primary fuel and urea through reaction of ammonia and carbon di-oxide. Specific energy consumption is least for gas based plant followed by fuel

[2] Report of working group on fertiliser industry for the 12th plan-Government of India.

oil and coal based plants respectively. Typical ratio is 1:1.3:1.7 (Gas: Heavy oil: Coal). Electrical energy is used all the production processes whereas thermal energy is required for decomposition, drying and concentration.

As in case of cement, fertiliser sector in India too has achieved global benchmark in energy efficiency. In fact, the average specific energy consumption of the gas based plants in India is better than the global average. Apart from the feedstock, process technology and capacity utilisation are the two other major factors, which impact the SEC in urea manufacture. India has been in the forefront in adopting new technology as would be seen from the rapid stride made in reducing the SEC over the last 25 years[2].

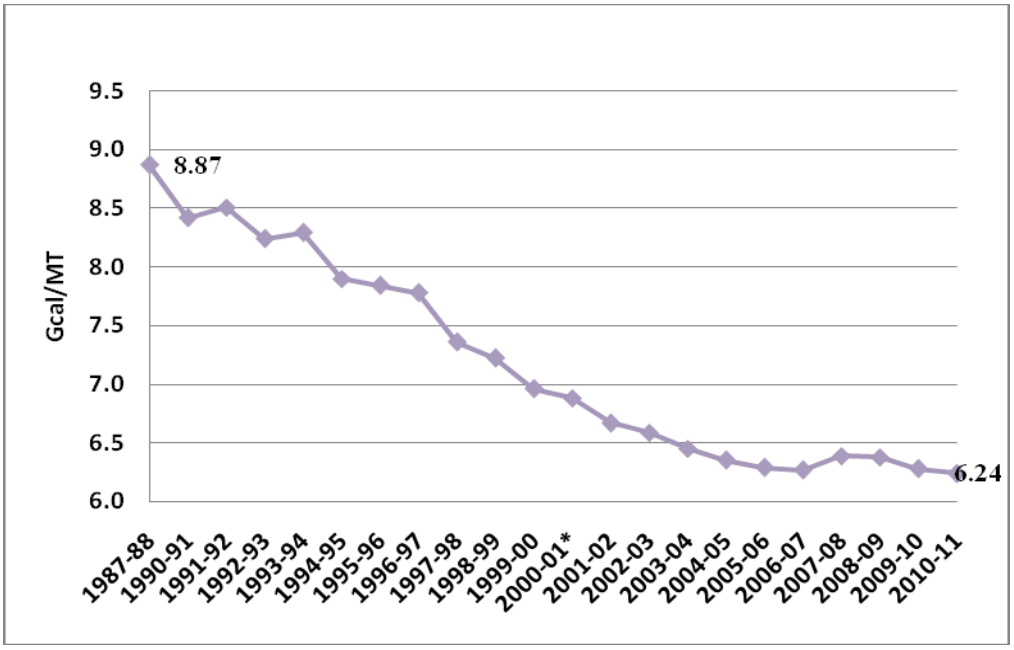


Figure 2: Declining Specific Energy Consumption

In the year 2011, 23 Urea plants have achieved higher energy efficiency compared to the NPS-III norms.

In addition to technology up gradation, maintaining high productivity has also contributed in improving the energy performance of the sector. The overall capacity utilisation has been consistently maintained at 105-110% during the 11th plan period.

3. DESIGNATED CONSUMERS-FERTILISER SECTOR

In the current PAT cycle, the fertiliser sector has been set a target for reducing the energy consumption by close to 0.5 Mn TOE representing little over 7% of the overall savings target.

The distribution of the targeted savings in individual units looks a little skewed as 3 of the 29 designated units have the aggregate savings target of over 50% of the sectoral target. Each of this unit has individual targets of close to 90000 TOE/year whereas there are twenty units having the combined target of about 45000 TOE, which is 50% of the target of the largest single entity. These units have individual target ranging from little over 1000 TOE to little over 5000 TOE each.

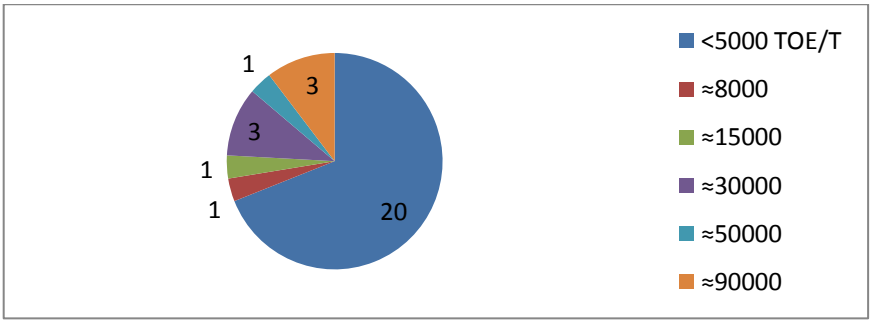


Figure 3: Units & savings targets

From the normalisation and M&V perspective, it would be desirable to have different approach and level of efforts for the 20 units having low targets and the largest three units having higher level of individual targets. This document has been prepared primarily to address to the larger units.

4. BASELINE & NORMALISATION-OVERVIEW

4.1 BEE GUIDELINES

The PAT scheme is an operating unit-specific scheme, targeting reduction of energy intensity of the products being manufactured in the unit. The energy intensity has been defined as 'Gate to Gate' specific energy consumption (GtG SEC) determined by dividing the thermal equivalent of all energy inputs within the unit boundary by the product manufactured in the target period (Text box-1)[3]. With a view to neutralize the impact of uncontrollable variables, the concept of baseline and normalisation has been introduced (Text box-2)[3].

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. However, it has also been provided that such normalisation factor would be applied if the capacity utilisation has deviated by more than 30% due to uncontrollable factors described in rule 4[4].

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.

[3] PAT Notification, July, 2012
[4] Section 1.4 © of Schedule (MOP/BEE)

Text Box 2: Baseline & normalisation

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

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

The fertiliser sector comprises of different types of manufacturing processes for production of nitrogenous and phosphatic fertilisers. For the purpose of PAT, only the 29 urea manufacturing units have been identified as DCs.

For the sector, BEE document has provided guideline for conversion of ammonia to equivalent urea, which has been identified as the major product for indexing the GtG SEC. However, the sector has well established guideline under FICC protocol for conversion of various types of energy into equivalent thermal energy for energy benchmarking.

4.2 PROPOSED METHODOLOGY

The proposed methodology has been developed considering the followings:

- BEE/EESL guidelines
- Review of the baseline audit reports
- Review of information available from DESL case studies and public domain

The production for the target period can be determined using the above methodologies. Similarly, energy consumption can be determined based on input electrical and fuel energy calculated as per FICC guideline.

Using BEE/EESL guideline

BEE document has provided clear guidelines on production and energy consumption variables 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 ((d) (ii) at text box-2) 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.

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 provided sufficient information for determination of GtG SEC and capacity utilisation on major products for Unit-1. For Unit-2, all relevant data for three years have not been provided. For this, GtG SEC has been analysed based on monthly data for the year 2009-10. Information on identified energy savings projects has also been provided. However their impact on reduction of GtG SEC has not been evaluated. No other variables has been identified and analysed.

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

Baseline reports have included adequate, though not comprehensive, information on data source and traceability. This information has been used for preparing more structured data and information format, which is recommended to be 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
- Impact of implementation of identified energy saving projects
- 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 Fertiliser sector, following important variables have been identified:

- Process technology
- Fuel/feedstock
- Plant vintage & maintainability
- Plant capacity & capacity utilisation
- EE investment

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. In case of change in feedstock/fuel, there would be major impact on energy consumption and normalisation would be required. For three plants, steep target has been set presumably based on the assumption that feedstock would change from fuel oil to gas. In case this change is not effected due to gas availability factor, it would be necessary to develop normalisation factor on fuel/feedstock account for these plants. This can be done based on existing FICC guideline and norms.

In case of major expansion of capacity baseline data would have to be revised. There is very good corelationship between CU and GtG SEC and this would be the most important normalisation factor for the sector.

5. ILLUSTRATION-BASELINE AUDIT & DETERMINATION OF GtG SEC

Two reports obtained from BEE have been perused. The broad particulars of the units are as shown in the following table.

Table 1: Particulars of the units

Parameter	Unit-1	Unit-2
Capacity		
Ammonia	9.9 Lac TPY	2.97 Lac TPY
Urea	17.05 Lac TPY	3.50 Lac TPY*
Fuel/feedstock	Gas	Gas
Electricity supply	Mainly captive	>80% grid, balance captive
Technology	Haldor Topsoe	Haldor Topsoe

*Computed at 1000 TPD @ 350 days

The process technology is same in both the plants. The baseline audit has also been carried out by the same agency following the BEE guidelines.

The process and energy flow diagram for the unit-1 is as shown in the following figure.

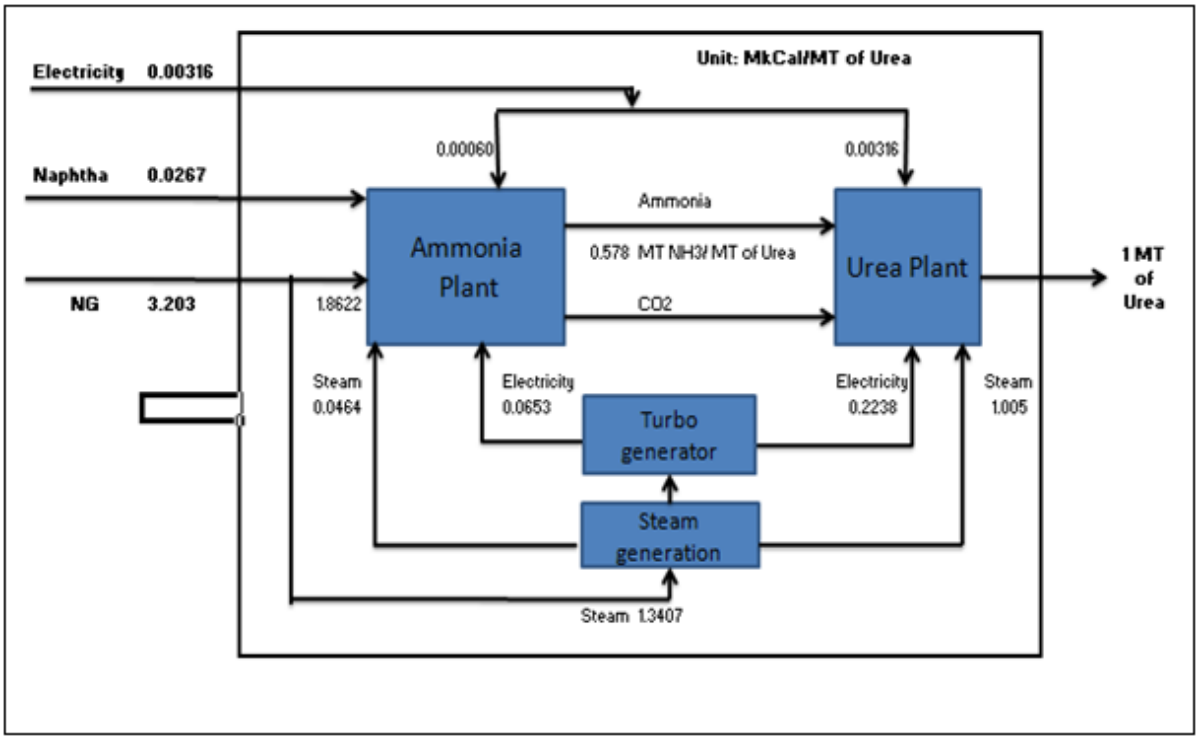


Figure 4: Process & energy flow diagram

The energy flow diagram captures the overall scenario. However, energy balance has been carried out for urea production alone as per energy accounting data obtained from the plant.

For computation of thermal energy, the following conversion factors have been used for 2009-10 as per FICC guideline as reported by the auditors.

Table 2: Conversion ratios

Particular	Unit	2009-10
Energy of steam	MKCal/MT	0.862
Heat Rate of power	MKCal/MWh	2.812
Conversion factor for grid power	MKCal/MWh	2.86
Conversion factor for ammonia to urea	Fraction	0.5787
Steam Carbon Ratio		3.36

5.1 ANALYSIS-UNIT-1

The GtG SEC figures computed by the auditors and as reported is shown in the following table.

Table 3: Reported GtG SEC-Unit-1

Parameters	Unit	2007-08	2008-09	2009-10
Gas fuel	MKCal/T (urea)	1.518	1.512	1.927
Steam	MKCal/T (urea)	1.089	1.055	1.051
Own generation	MKCal/T (urea)	0.216	0.217	0.224
Grid electricity	MKCal/T (urea)	0.0089	0.0067	0.0032
Naphtha (till May, 2009)	MKCal/T (urea)	0.534	0.504	0.027
Total	MKCal/T (urea)	3.3659	3.2947	3.2322

Methodology for allocation of fuel used for power and steam generation has not been detailed out

The baseline data reported by the auditors and the computed GtG SEC figures are as shown in the following table.

Table 4: Baseline data-Unit-1

Item	Unit	2007-08	2008-09	2009-10
Ammonia				
Installed Capacity	TPY	990000	990000	990000
Actual Production	MT	1054905	1096850	1128320
Capacity utilisation	%	106.6%	110.8%	114.0%
Actual Stream Days	Days	350.73	355.95	344.56
Urea				
Installed capacity	TPY	1705000	1705000	1705000
Production	TPY	1832334	1903521	1782171
Capacity utilisation	%	107.5%	111.6%	104.5%
Inputs as				
Feed NG to reformer APM	SM^3	397201785	377651529	30045281
RIL	SM^3	0	0	600584649
PMT	SM^3	0	0	42272419
Fuel APM to reformer, Aboil& superheater	SM^3	319027977	330123091	383665775
Fuel RIL to reformer	SM^3	0	0	52637889
Feed Naphtha to reformer	MT	226111.21	259439.31	25835.407
Fuel Naphtha	MT	92463.65	90579.35	4942.04
NG NCV APM	$Kcal/SM^3$	8684.56	8696.41	8647.69
RIL	$Kcal/SM^3$	0	0	8449.66
PMT	$Kcal/SM^3$	0	0	8415.06
Naphtha NCV	Kcal/KG	10548.29	10559.96	10556.30
Fuel Oil /LSHS NCV	Kcal /KG	--	--	--
Total Steam Import (2)	MT	157876	165118	105039
Total Power Captive	KWH	47225086	48888781	45326604
Total Power Purchased	KWH	1245292	909403	407674
Power(Captive & Purchased)	KWH	48470378	49798184	45734278
Energy of steam per MT	MKCal	0.866	0.864	0.862
Heat Rate of power /MWH	MKCal	2.617	2.689	2.812
Conversion factor for grid/MWH	MKCal	2.86	2.86	2.86
Total Energy (Fuel, steam & electricity)				
Fuel APM to reformer, Aboil & superheater	MKCal	3449523.9	3284212.9	3762593.6

Fuel RIL to reformer	MKCal	0.0	0.0	444772.4
Fuel Naphtha	MKCal	975332.98	956514.00	52169.71
Grid power	MKCal	3561.54	2600.89	1165.95
Imported steam	MKCal	136720.62	142661.95	90543.62
Total	MKCal	4565139.1	4385989.8	4351245.3
SEC-Urea	MKCal/T	2.491	2.304	2.442
	MTOE/T	0.2491	0.2304	0.2442

The computed figures are much lower than the reported figures. One of the possible reasons could be non-inclusion of additional energy used for the urea process alone separately in the baseline report and the same might have been embedded in the feed input. The CU GtG SEC relationship has therefore, been assessed on both the reported and computed figures.

GtG SEC corelationship

The GtG SEC corelationship based on the reported and computed figures are as shown in the figures 5 & 6 respectively.

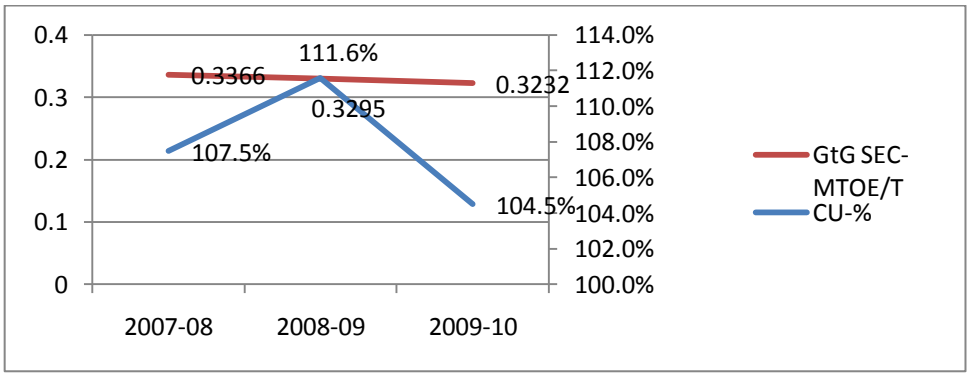


Figure 5: CU GtG SEC corelationship (reported)-Unit-1

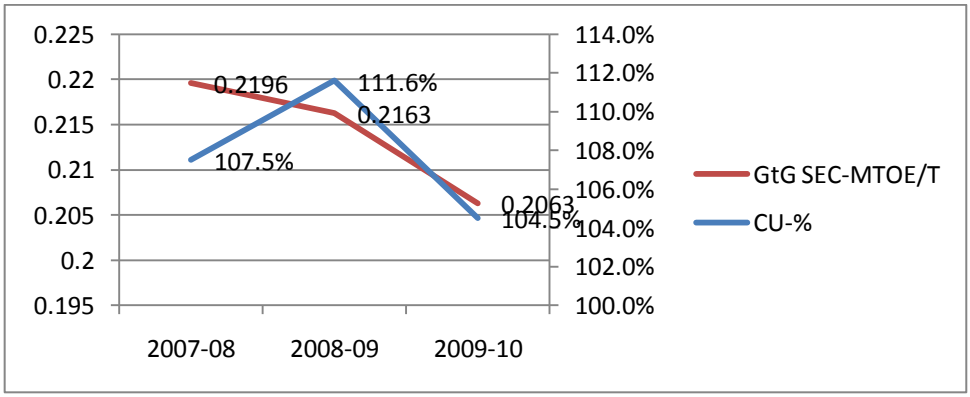


Figure 6: CU GtG SEC Corelationship (Computed)-Unit-2

The corelationship trends are similar though in case of computed figures, sharper decline is seen in SEC figure for 2009-2010. The trend shows good corelationship with reduction of SEC corresponding to the increase in CU in 2008-09. In the following year, the trend shows reduction in SEC with reduced CU. The plant has been historically using both gas and naphtha as feedstock and fuel. Use of naphtha has been totally discontinued since August, 2010. Switching over to gas has certainly favourably impacted the SEC. However, quantification of the impact would require analysis of the process for which operational data would be required for all the sub-processes.

It would be desirable to have the baseline on the basis of gas so that PAT cycle can use the same without any adjustment for naphtha. The assessment and analysis have therefore, been carried out on the basis of monthly figures for the period 2009-10. Following summary table shows the calculated capacity utilisation and GtG SEC figures.

Table 5: Capacity, CU & GTG SEC-Unit-1

2009-2010	Urea Production MT	Capacity Utilization %	SEC MKCal/T
April	94,410	66.37	7.185
May	1,43,625	100.97	6.413
June	1,56,365	109.92	6.213
July	1,60,425	112.78	6.242
August	1,59,090	111.84	6.246
September	1,60,285	112.68	6.136
October	1,50,420	105.74	6.305
November	1,55,295	109.17	6.249
December	1,54,190	108.39	6.207
January	1,57,465	110.70	6.265
February	1,42,545	100.21	6.237
March	1,56,585	110.08	6.254
Total	17,90,700	104.90	6.290

The above SEC figures provided in the baseline report include the embedded energy in the product. Segregation of fuel energy has not been provided for these datasets. The CU GtG SEC corelationship trend has therefore, been assessed on the total energy basis.

As already stated, the unit totally shifted to gas as fuel/feedstock from September 2010 onward. The CU and GtG SEC figure correlation for the period post September is as shown in the following figure.

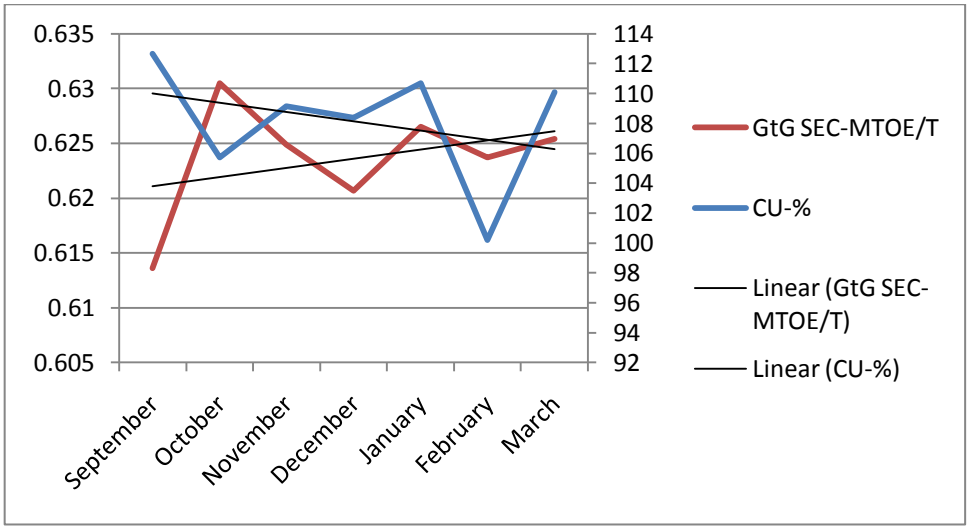


Figure 7: CU & GtG SEC relationship-Unit-1

There is good correlation between CU and GtG SEC. Though there are few spikes to contra, general trend does indicate that in this sector CU can be considered as the most important normalisation factor.

Impact of identified energy saving project

The list of energy saving project and the potential saving estimate as reported in the baseline report is shown in the following table.

Table 6: Identified energy saving projects-Unit-1

Sr. No.	Energy Conservation Option	Saving (Gcal/year)
Revamping of Ammonia Plant		
1	Replacement of Combustion preheater	446985
2	Primary Reformer Burner modification	
3	E204 coil modification	
4	Revamping of Present Co2 Removal Benfield System to a 2 Stage GV System	
5	Additional of S-50 Synthesis Converter in Series with Existing Synthesis Converter	
6	Replacement of LP Condenser Stripper with MP Condenser Stripper	
7	Revamp of Boiler Feed Water Steam Pump Turbines and CT Turbines for Steam Economy	

8	Over Hauling of TG-1 Turbine (Refilling and Machining of Guard Vane Carriers)	11941
9	Over Hauling of TG-2 Turbine (Refilling and Machining of Guard vane Carriers)	11941
10	Installation of Ammonia Preheater in Urea Plant to recover heat from LP decomposer Vapours	19628
11	Relocation of PC07 (HP Section Pressure Control Valve) outlet gases to MV-2 (Medium Pressure Decomposer) Top line	13654
Total		**504149**

The savings potential at 504149 Gcal/Year represents about 9% of the baseline years (2009-10) total consumption of 5765833 Gcal/year. Bulk of the potential saving pertains to revamping of the ammonia plant. Therefore, it would be possible for the unit to achieve the PAT target on implementation of this project.

Conclusion:

- There is reasonable corelationship between CU and GtG SEC
- The baseline report does not provide all the information based on which GtG SEC has been calculated & reported
- The unit has changed over from naphtha to gas in September 2010. It would be desirable to develop new baseline for which data has to be segregated for computation of fuel energy afresh for the new baseline period
- It has also not been clarified in the report about availability of metering and measurement system for accounting of gas as feed and fuel
- Identified energy savings project would help the unit in meeting the PAT target

5.2 UNIT-2

The GtG SEC figure has been reported for the year 2009-10 only at 0.4398 MTOE/T. Similarly, the baseline data has also been reported by the auditors for the year 2009-10 after carrying out certain corrections in the data submitted by the unit.

Table 7: baseline data-Unit-2

Item	Unit	2009-10
Ammonia V Plant		
Installed Capacity	MT	297000

Actual Production		MT	330235
Actual Stream Days		Days	350.43
Input as	Feed APM gas to reformer	'000 SCM	143318.7
	Fuel APM gas to reformer	'000 SCM	99280.9
	Feed RIL gas to reformer	'000 SCM	61008.2
	Fuel RIL gas to reformer	'000 SCM	0
	Feed PMT gas to reformer	'000 SCM	348.56
	Fuel Naphtha	MT	0
	APM NCV	Kcal/SM3	8288.427
	RIL NCV	Kcal/SM3	8408.554
	PMT NCV	Kcal/SM3	8453.007
	Total Steam Import (2)	MT	519405
	Total Power Captive (direct ,CT & allocated)	KWH	8993.384
	Total Power Purchased	KWH	40401.373
Energy of steam		MKCal/MT	0.957
Heat Rate of power		MKCal/MW	2.86
Conversion factor for grid power		Kcal / KW	2.86
Energy consumption- Ammonia	Fuel	MKCal/T	2.49
	Total Power Captive	MKCal/T	0.08
	Total Steam	MKCal/T	1.5
	Total Power Purchased	MKCal/T	0.35
	(Credits/debits)	MKCal/T	0
	Total	MKCal/T	4.42
Urea			
Installed Capacity		MT	330000

Actual Production		MT	306905
Actual Stream Days		Days	285.42
Capacity Utilization		%	93
Input as	Steam Import (2)	MT	481915
	Ammonia	MT	184276
Energy consumption-Urea	Steam	MKCal/T	1.502
	Ammonia (Total)	MKCal/T	2.656
	Total Power Captive	MKCal/T	0.044
	Total Purchased Power	MKCal/T	0.196
	Energy Credits (if any)	MKCal/T	0
	Total	MKCal/T	4.398
		MTOE/T	0.4398

In this case too, the methodology for segregation of data for ammonia and urea production has not been provided. The datasheet from the unit included in the baseline report also does not provide segregated information. From the table it would be seen that the SEC values for ammonia and urea are almost the same. This is contra to how the SECs are computed for the industry.

The CU GtG corelationship has therefore, been assessed from the reported monthly production and gross energy consumption figures.

CU GtG SEC corelationship

The monthly data available for different parameters at different sections of the report have been compiled, GtG SEC and CU figures computed for assessment of CU GtG corelationship. Following table shows the computed CU and SEC figures.

Table 8: Monthly data for 2009-10-Unit-2

2009-10	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Urea Production, MT	1081	13582	23130	23440	30420	22025	38060	28416.4	27340.6	35570	29210	34630
NH_3 Production, MT	27540	26435	27645	24560	29580	20460	31095	26875	29640	28450	27530	30425
Grid power MTOE/T Urea	0.3	0.41	0.44	0.44	0.41	0.46	0.45	0.44	0.37	0.4	0.37	0.37
Gas MTOE/T Urea	0.212	0.244	0.273	0.258	0.291	0.220	0.296	0.270	0.283	0.291	0.261	0.292
Gross MTOE/T Urea	0.512	0.654	0.713	0.698	0.701	0.680	0.746	0.710	0.653	0.691	0.631	0.662

Monthly capacity	24750	24750	24750	24750	24750	24750	24750	24750	24750	24750	24750	24750
CU	111.3%	106.8%	111.7%	99.2%	119.5%	82.7%	125.6%	108.6%	119.8%	114.9%	111.2%	122.9%

CU figure has been computed on ammonia production basis as per available data. However, GtG SEC figures have been taken for urea production. Since there is fixed corelationship between ammonia and urea productions, the relative GtG SEC trend on this basis has been used for analysis purpose. For the analysis, figures for the months of April and May have been ignored due to very low productions urea in these months.

The following figure shows the corelationship trend for the year 2009-10.

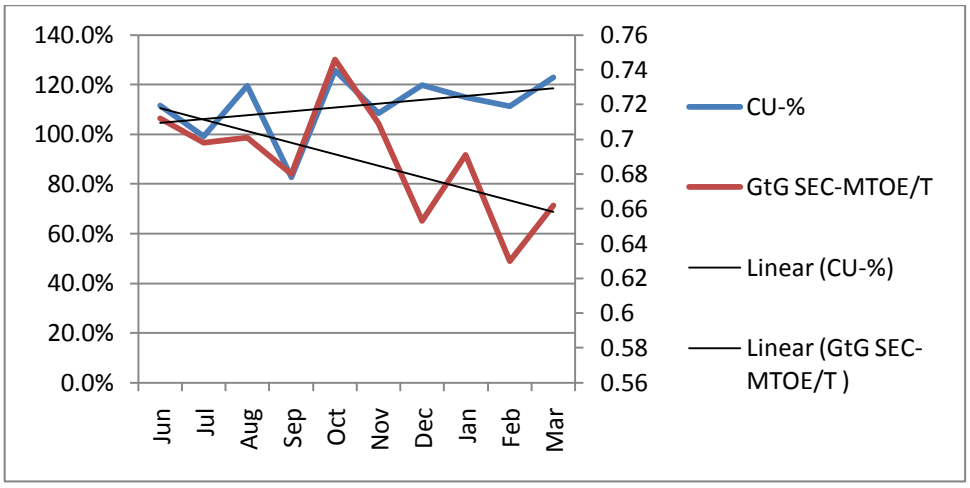


Figure 8: CU GtG corelationship-Unit-2

From the trend lines, it would be seen that in this case too, there is good corelationship between CU and GtG SEC.

Impact of identified energy saving projects

The list of identified projects and the estimated saving potential is as shown in the following table.

Table 9: Identified energy saving projects-Unit-2

	Energy Conservation Option	Saving (Gcal/Year
1	Increase in TG capacity from 12 to 15 MW	20434
2	Installation of steam driven boiler feed pump	8718
3	Improve waste heat recovery to reduce flue gas temperature from 250 to 150 oC (revamping of heat exchanger) in NH3 V plant	8485

4	Controlling burner excess air to optimize combustion air quantity & reduce flue gas losses	125
5	Instillation of modified trays in urea reactor	19779
6	Installation of VFD on cooling tower pump	
	Total	**57541**

Estimated savings potential of 57541 MKCal/Year from energy conservation projects work out to about 4.2% of the baseline years' (2009-10) consumption of 1349720 MKCal. The unit would be required to carry out more detailed study for identification of more energy conservation projects.

Conclusions:

- There is good corelationship between CU and GtG SEC consumption
- It should be possible to establish the corelationship coefficient based on reported data to the FICC
- No other variables, except CU that could impact the SEC have been reported by the auditors.
- The industry uses normative guideline for converting power from different sources to the equivalent thermal unit. This can pose some difficulty in assessment of true reduction in SEC should there be any change in the quantum of power drawn from the grid.
- The unit would have to identify more energy saving projects for meeting the PAT target

6. VARIABILITY FACTORS AND NORMALIZATION

In addition to the review of the baseline reports and own database, DESL has carried out survey of literature available in the public domain and interaction with sectoral experts to establish the variables, which can impact the energy consumption and therefore, need to be factored for the process of normalisation. The key variable impacting the SEC for the urea fertiliser sector are[5]:

- Process technology
- Fuel/feedstock
- Plant vintage & maintainability
- Plant capacity
- Plant capacity utilisation
- EE investment

6.1 PROCESS TECHNOLOGY

There are six plants, which are based on fuel other than gas[2]. Considering the present situation of gas availability, it is unlikely that these plants would switch to gas in the current PAT cycle. Thus, process technology for these projects may remain the same. Very steep target has been set for the following three plants:

- NFL, Panipat-24%
- NFL, Bhatinda-22%
- NFL, Nangal-25%

All these plants are currently based on heavy oil. It looks like major process change (including fuel shift) is envisaged for these plants. It would be desirable to provide for 'what if' scenario in case these plants are not able to make big investment envisaged and undertake only normal EE investment measures as in case of other plants. Since capacity utilisation has been identified as the major variability factor, the target for these units can be reviewed against CU, should the process and feedstock remain the same.

[5] Development of energy consumption standards/norms for ammonia/urea plant-R V Nesari, Fertiliser sector workshop, New Delhi, Sept, 2008

6.2 FUEL/FEEDSTOCK MIX

In case any plant shifts from the present source or change the mix, baseline can be adjusted using the industry acceptable formula[6]:

Gas: Naphtha: Heavy oil: Coal-1: 1.1: 1.3: 1.7

Change in fuel chemistry and GCV would also impact the SEC. However, this is not important for gas based plants as the input gas is procured in terms of calorie and as such normalisation gets carried out at the metering stage itself. However, in case of heavy oil, it would be necessary to have provision for normalisation on this account.

The coal GCV value can vary widely depending upon the ultimate analysis of coal. In any case, amongst the DCs, no plant is using coal and as such this issue need not be a consideration for development of the normalisation process.

6.3 PLANT VINTAGE & MAINTAINABILITY

Since the target has been fixed for individual units, this factor would not be a consideration for normalisation.

6.4 PLANT CAPACITY

During the process of the PAT cycle, the capacity of a particular unit may change as would be seen from the baseline report. Such expansion can impact the specific energy consumption in two different ways:

- Impact of fixed component of energy consumption for auxiliaries such as pumps, fans, lighting, HVAC etc
- Change in the capacity utilisation factor

In case of major expansion of capacity, the benefit of reduction of the SEC on the fixed component should be available as credit. The CU factor would be applicable as would be without the expansion.

6.5 PLANT CAPACITY UTILISATION

There is good corelatioship between CU and GtG SEC and as such the same should be applied for normalisation.

[6] www.emt-india.net-Fertiliser production in India

6.6 EE INVESTMENT

PAT scheme has been designed to make EE investment more attractive. This is not a factor to be considered for normalisation. However, it would be desirable for validators to include an investment analysis report to enable BEE to improve the design of the program for the next PAT cycle.

Due to various complexities involved in establishing all the variabilities and their normalisation, the validation process would require reconciliation exercise based on assessment of impact of EE projects implemented during the PAT project cycle.

The recommended normalisation process is summarised in the following table.

Table 10: Normalisation process

Parameters	Baseline report	Recommendation	Remarks
Process technology	Not considered	May require considerations for the 3 heavy oil based plants with higher levels of SEC reduction targets	
Fuel/feedstock mix	Not considered	Should be considered in case of change in the mix and normalisation carried out using the SEC impact factors	Fuel quality impact is also to be considered for heavy oil based plants Coal quality impact to be considered for plants having captive power plant
Plant vintage & maintainability	None	None	This is already factored since unit specific SEC targets have been fixed
Plant capacity	Not considered	Not considered	However, provision should be kept for review of the baseline GtG SEC in case the plant is significantly expanded
Capacity utilisation	CU figures worked out based on computed production figures	Main factor for normalisation	It should be possible to determine the corelationship coefficient without much difficulty
EE investment	List provided	Methodology for	

reconciliation developed

6.7 RECONCILIATION-IMPACT OF ENERGY SAVING PROJECTS

It is expected that in the 1st PAT cycle challenges would remain in clear identification of variables and determination of their corelationship coefficienct with GtG SEC. It is therefore, recommended to that the achieved GtG SEC figures are reconciled against reduction in energy consumption due to implementation of energy saving projects. Suggested steps are:

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

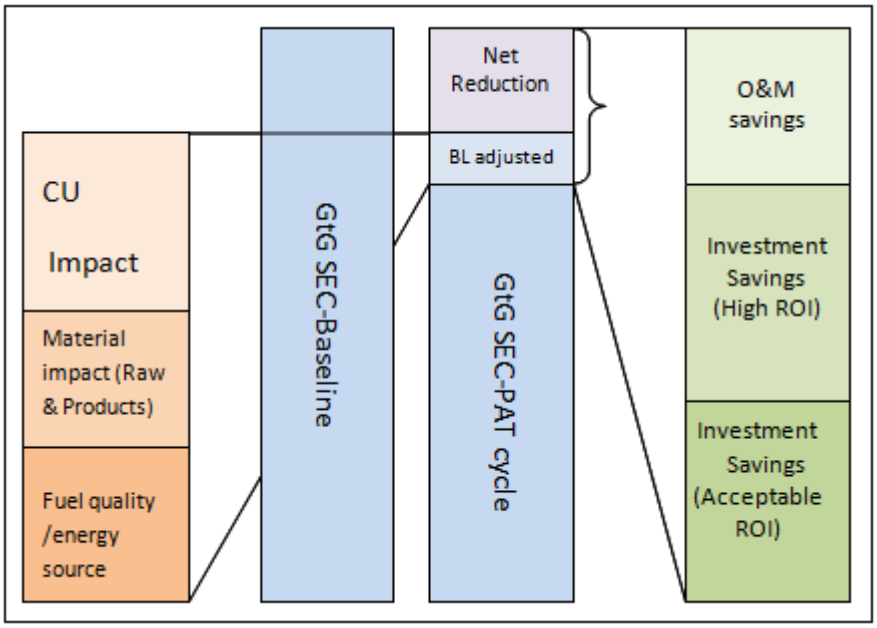


Figure 9: Normalisation & Baseline Adjustment

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. OVERALL M&V PROCESS AND PROTOCOL

7.1 METERING & MEASUREMENT

The baseline reports have used complicated methodology for determination of SEC. Individual accounting has been made for ammonia and urea system separately. This has been possible as all fertiliser plants have very robust system for metering, measurement and accounting. Separate accounting has been used for fuel, feedstock, steam and power (generated & import). This system may be necessary for integrated chemical complex where other products are also manufactured and power and steam from the same system is used in plants other the ammonia and urea. For plants having only ammonia and urea stratums, it would be better to use simple input and output methods as depicted in the following figure.

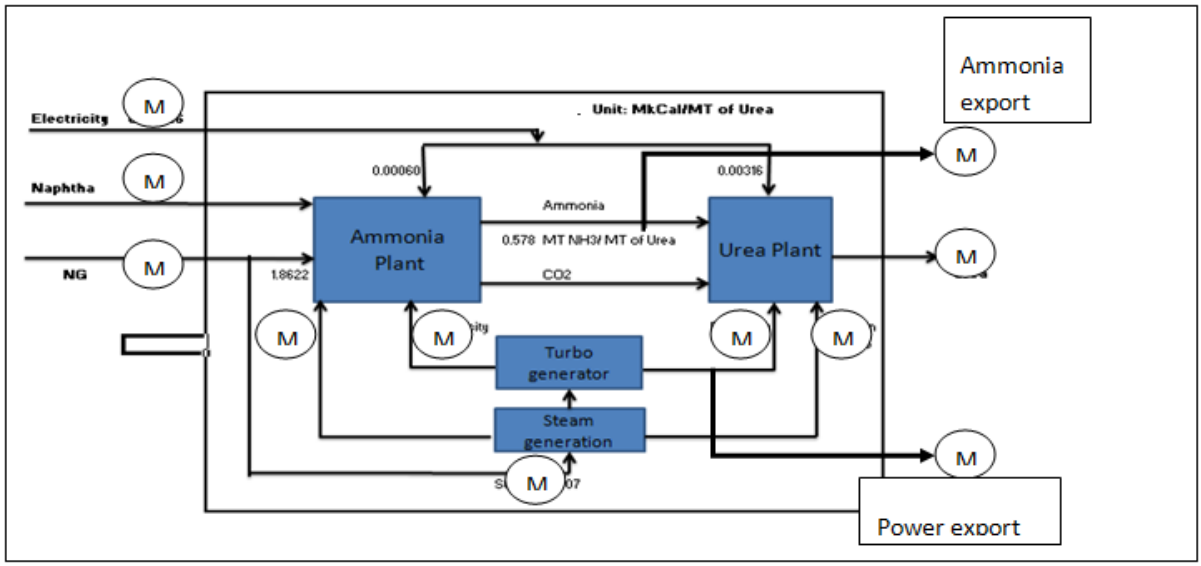


Figure 10: Metering & measurement

The metering & measurement plant would consist of primary and secondary systems:

- Primary system
  - Import of fuel/feedstock
  - Import of power
  - Export of urea
  - Export of ammonia
  - Export of power
- Secondary system

- Power to ammonia plant
- Power to urea plant
- Power to auxiliaries including off-sites
- Fuel for power plant
- Steam for ammonia
- Steam for urea

The primary system would be used for determination of GtG SEC whereas the secondary system would be used only for reconciliation.

The data and information management system has been accordingly proposed as shown at the section 7.2 below. The proposed M& V protocol for validation has been designed to address to the following specific provisions:

Statistical analysis would require lot more data than what could be made accessed during baseline audit. Data gathering system including source points, metering and measurement systems and the frequency provided in the baseline reports would be adequate for the proposed M&V system.

During the validation process the corelatioship between CU & GtG SEC need to be better established by using more data points for all variables and statistical analysis.

7.2 DATA & INFROMATION PROTOCOL

Table 11 : Data protocol

Sr No	Particulars	Unit	Source of Data (Metered, calculated, estimated-M/C/E)	Frequency of Data Record	Method of data recording (Electronic/paper
A	***Capacity & production***				
A1	Installed Capacity	MT of Urea/year	As per FICC	Annual	P
A2	Actual production	MT of ammonia/year	Mass flow meter for liquid ammonia (M/C)	Daily	E/P
		MT of Urea/year	Weighto meter (M/C)	Daily	E/P
B	***Electrically Generation & Consumption***				
B1	Electricity Purchased	kWh/year	Electricity bill (M)	Daily	E/P
B2	Electricity Generated	kWh/year	Electrical meter(M)	Daily	E/P
B3	Electricity consumed in each plant	kWh/year	Separate Energy meter for each plant which includes grid power & own generation (M/C)	Daily	E/P
B4	Heat rate for power generation	kCal/kWh	DCS HMBD Calculated	Daily	E/P
B5	Heat rate for grid power	kCal/kWh	FICC norm	Annual	P
C	***Feed***				
C1	APM gas	SM^3/year	Flow meter(M)	Daily	E/P
C2	RIL gas	SM^3/year	Flow meter(M)	Daily	E/P
C3	PMT gas	SM^3/year	Flow meter(M)	Daily	E/P

C4	Heavy oil	MT/year	Weighing system (M/C)	Daily	E/P
C5	Feed Composition	%	Daily Joint Ticket (M/C)	Daily	E/P
C6	Calorific Value-gas	kCal/SM^3	Daily Joint Ticket(M/C/E)	Daily	E/P
C7	Calorific value-FO	kCal/Kg	Daily Joint Ticket(M/C/E)	Daily	E/P
D	***Fuel consumption***				
D1	APM gas	SM^3	Flow meter(M/C)	Daily	E/P
D2	RIL gas	SM^3	Flow meter(M/C)	Daily	E/P
D3	Naphtha	SM^3	Flow meter(M/C)	Daily	E/P
D4	Heavy oil	MT	Weighing system (M/C)	Daily	E/P
D5	Fuel Composition	%	Daily Joint Ticket(C)	Daily	E/P
D6	Fuel consumption	MKCal	Daily Joint Ticket(C)	Daily	E/P
E	***Steam generation***				
E1	Pressure	ata	DCS/Pressure gauge (M)	Hourly	E
E2	Temperature	^oC	DCS/Temperature indicator (M)	Hourly	E
E3	Flow rate	TPH	DCS/Steam flow meter(M)	Hourly	E
E4	Total flow	TPM	DCS/Steam flow recorder/integrator	Monthly	E/P
F	***Steam consumption***				
F1	Pressure	ata	Pressure gauge (M)	Hourly	E
F2	Temperature	oC	Temperature indicator (M)	Hourly	E
F3	Flow rate	TPH	Steam flow meter (M)	Hourly	E
F4	Total Flow	TPM	DCS/Steam flow recorder/integrator	Monthly	E/P

F4	Energy of steam	MKCal/MT of steam	C	Daily	P
G	***Fuel, power & steam allocation-urea***				
G1	APM gas	SM^3	Daily Joint Ticket(C)	Daily	E/P
G2	RIL gas	SM^3	Daily Joint Ticket(C)	Daily	E/P
G3	PMT gas	SM^3	Daily Joint Ticket(C)	Daily	E/P
G4	Heavy oil	MT	Daily Joint Ticket(C)	Daily	E/P
G5	Fuel Composition	%	Daily Joint Ticket(C)	Daily	E/P
G6	Fuel consumption	MKCal	Daily Joint Ticket(C)	Daily	E/P
G7	Power from self generation	kWh	Meter (M/C)	Daily	E/P
G8	Grid power	kWh	Meter (M/C)	Daily	E/P
G9	Total power	MKCal	Calculated	Daily	E/P
G10	Steam	MT	DCS (M/C)	Daily	E/P
G11	Steam	MKCal	Calculated	Daily	E/P

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.

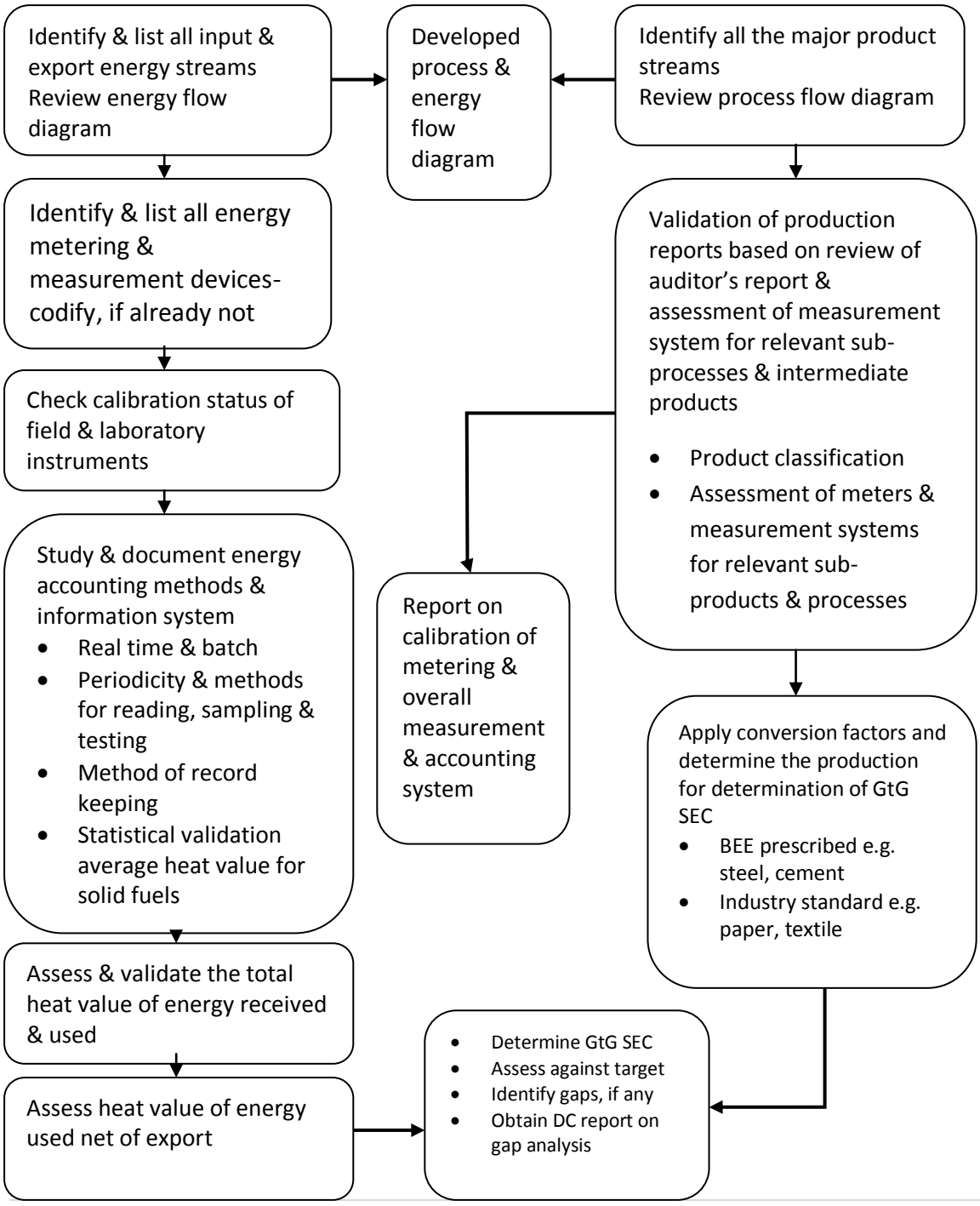
Table 7: M&V Protocol- EE Project

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

Step-1-Determination of GtG SEC



Step-2: Normalisation

Capacity utilisation impact-Statistical analysis

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

Fuel impact analysis (Fuel switch/solid fuel usage)

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

Power source change impact-Heat rate analysis

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

Impact of other variables

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

Normalised GtG SEC & Gap analysis

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

Step-3: Verification & validation

Review of audit report

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

Assessment of implementation status

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

Validation

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