सत्यमेव जयते
MINISTRY OF POWER
GOVERNMENT OF INDIA

BUREAU OF ENERGY EFFICIENCY

MONITORING & VERIFICATION GUIDELINES (REVISED) FOR MANUFACTURING SECTOR

PAT SCHEME
PERFORM, ACHIEVE & TRADE

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November, 2019

ऊर्जा जीवन है, संरक्षण करें

BEE

Energy is Life, Conserve it

BUREAU OF ENERGY EFFICIENCY

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1. Introduction

1.1 Background

Ministry of Power and Bureau of Energy Efficiency (BEE) have been implementing several programs for efficient use of energy and its conservation. This is further supplemented by the National Mission for Enhanced Energy Efficiency (NMEEE), which is one of the missions under the National Action Plan on Climate Change (NAPCC), launched by Hon'ble Prime Minister on 30th June, 2008 to ensure increase in the living standards of the vast majority of people while addressing climate change concerns.

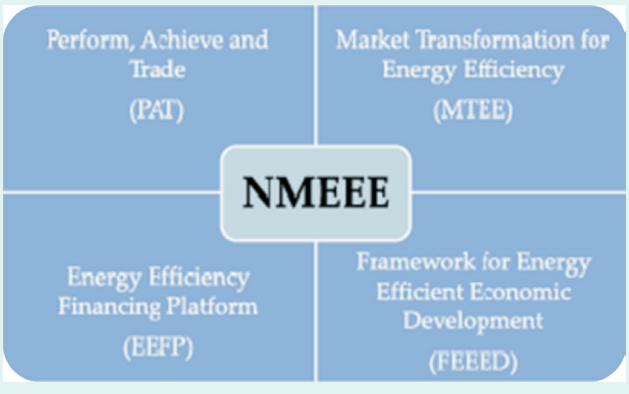


FIGURE 1: SECTION OF NMEEE

NMEEE spelt out the following four new initiatives to enhance energy efficiency, in addition to the programmes on energy efficiency being pursued. These are:

- **Perform, Achieve and Trade (PAT),** a market-based mechanism to make improvements in energy efficiency in energy-intensive large industries and to make facilities more cost – effective by certification of energy saving that can be traded.
- **Market Transformation for Energy Efficiency (MTEE)** accelerates the shift to energy-efficient appliances in designated sectors through innovative measures that make the products more affordable.
- **Energy Efficiency Financing Platform (EEFP),** a mechanism to finance demand side management programmes in all sectors by capturing future energy savings.
- **Framework for Energy Efficiency Economic Development (FEEED),** for developing fiscal instruments to promote energy efficiency.

The Perform Achieve and Trade (PAT) Scheme is one of the initiatives under the NMEEE program, which was notified on 30th March, 2012. PAT scheme is a market assisted compliance mechanism to accelerate implementation of cost-effective improvements in energy efficiency in large energy-intensive industries, through certification of energy savings that could be traded. The genesis of the PAT mechanism flows out of the provision of the Energy Conservation Act, 2001 (Amended in 2010).

The key goal of the PAT scheme is to mandate specific energy consumption reduction of the most energy intensive industries. The scheme builds on the large variation in energy intensities of different units in almost

each notified sector, ranging from amongst the best in the world and some of the most inefficient units. The scheme envisages improvements in the energy intensity of each unit covered under it. The specific energy consumption reduction target, mandated for each unit is dependent on its current specific energy consumption. The reduction target is lesser for those who are more efficient and is higher for less-efficient units.

Ministry of Power, in consultation with Bureau of Energy Efficiency prescribes the energy consumption norms and standards, in exercise of the power conferred under clause (g) and (n) of section 14 of the Energy conservation Act, 2001 (Amended in 2010) for the Designated Consumers. The 1st PAT cycle was notified vide S.O. 687 (E), dated 30.03.2012 (Containing Baseline Specific Energy Consumption, Product Output and Target Specific Energy consumption for the Designated Consumers). The said S.O. Notification was based on the Rules notified under G.S.R. 269 (E) [Energy Conservation (Energy Consumption Norms and Standards for Designated Consumers, Form, Time within which, and Manner of Preparation and Implementation of Scheme, Procedure for Issue of Energy Savings Certificates and Value of per Metric Ton of Oil Equivalent of Energy Consumed) Rules, 2012] dated 30th March, 2012, herein referred as PAT Rules, 2012. Three new sectors, namely Petroleum Refinery, Railways, and Electricity Distribution companies were notified vide S.O. 1264(E), dated 31st March, 2016. The said S.O. notification was in accordance with the PAT rules, 2012 and its subsequent amendment vide G.S.R. 373(E) dated 31st March, 2016, and G.S.R. 409(E) dated 26th April, 2018.

PAT Cycle 1 & its outcomes

PAT Cycle – I, which was operationalized in April, 2012, included 478 units, known as "Designated Consumers" (DCs), from eight energy-intensive sectors viz. Aluminium, Cement, Chlor – Alkali, Fertilizer, Iron andSteel, Pulp and Paper, Thermal Power Plant and Textile were included. The annual energy consumption of these DCs in eight sectors was around 164 m MTOE.

The overall SEC reduction target in this cycle was about 4.05% (6.686mMTOE), intend to achieve by 2014-15. With the completion of PAT Cycle -1 in 2015, The reported achievement was about 8.67m MTOE, achieving 30% more than the target. The energy savings is equivalent to saving of about 20 million tonnes of coal and avoided emissions of about 31 million tonnes of CO_2. In terms of monetary value, saving in energy consumption corresponds to Rs. 95,000 million.

PAT Cycle - I observed an exceptional performance from all the sectors in terms of reducing their energy consumption. The DCs have made commendable efforts to achieve energy efficiency targets by adopting various improvement measures in technology, operational and maintenance practices, and application of management techniques. A brief achievement of PAT is mentioned in the Table 2.

FIGURE 2PAT AS ROLLING CYCLE

Sector	Threshold Limit for Qualifying as DC (TOE)	Number of DCs	Target energy savings in PAT Cycle–I (mMTOE)	Achieved energy savings in PAT Cycle–I (mMTOE)	Achievement in excess (%)	% Share of DCs
Aluminium	7500	10	0.456	0.73	60.09%	2.09%
Cement	30000	85	0.815	1.48	81.60%	17.78%
Chlor-Alkali	12000	22	0.054	0.093	72.22%	4.60%
Fertilizer	30000	29	0.478	0.78	63.18%	6.07%
Iron and Steel	30000	67	1.486	2.1	41.32%	14.02%
Pulp and Paper	30000	31	0.119	0.289	142.86%	6.49%
Textile	3000	90	0.066	0.129	95.45%	18.83%
Thermal Power Plant	30000	144	3.211	3.06	-4.70%	30.13%
Total		**478**	**6.68**	**8.66**	**29.56%**	**-**

TABLE 1: PAT CYCLE 1 ACHIEVEMENT

With the completion of the PAT Cycle – I in 2015, the overall achievement was 8.67 mMTOE against the target of 6.686 m MTOE, thereby exceeding the target by around 30%. The energy saving of 8.67 m MTOE is equivalent to around 20 million tonnes of coal savings translating to avoided emissions of around 31 million tonnes of CO_2 equivalent. The overall energy saved corresponds to Rs. 95,000 million of monetary savings.

PAT Cycle-II

After the successful completion of PAT Cycle-I, Parliamentary Standing Committee on Energy, Executive Committee on Climate Change (ECCC) and the Group of Secretaries for energy efficiency and energy conservation, recommended to put PAT under rolling cycle.Hence, PAT cycles get notified on annual basis since 2016. This means, every year the new DCs in existing

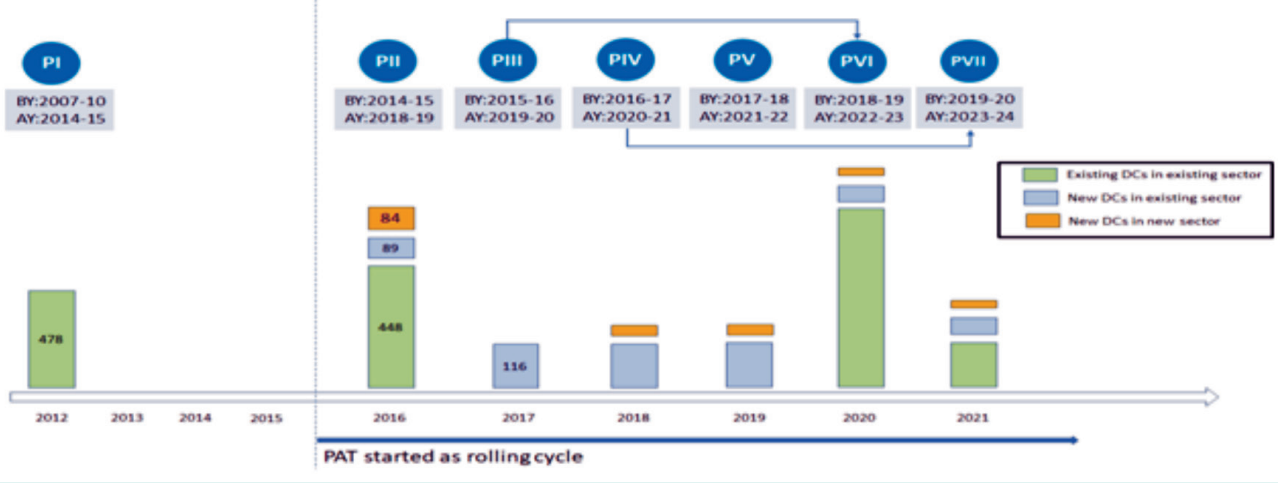


FIGURE 2: PAT AS ROLLING CYCLE

sectors will get notified, in addition to new sector as per the EC, Act. "Deepening" and "Widening" of PAT had been carried out with an objective of increasing the number of Designated Consumers under second cycle of PAT. Under the deepening initiative, 89 DCs that were identified from the existing sectors, notified under PAT Cycle II. Under widening initiative, three new sectors that is Railways, Petroleum Refineries, and Electricity DISCOMs have also been covered under PAT scheme. Total 84 Designated Consumers from these three notified sectors were included under PAT cycle II.

S. No.	Sector	No. of DCs in PAT I	Additional DC in PAT Cycle-II	Total no. of DCs PAT -II
1	Aluminum	10	2	12
2	Chlor-Alkali	22	3	24
3	Textile	90	14	99
4	Pulp & Paper	31	4	29
5	Iron & Steel	67	9	71
6	Fertilizer	29	8	37
7	Cement	85	27	111
8	Thermal Power Plants	144	22	154
9	Refinery	NA	18	18
10	DISCOMS	NA	44	44
11	Railway	NA	22	22
				621

FIGURE 3: SECTOR WISE DCS IN PAT-II

PAT in its second cycle seeks to achieve an overall energy consumption reduction of 8.869 MTOE(excluding DISCOM sector) for which energy reduction targets have been assigned and notified to DCs in these 11 sectors (eight existing sectors and three new sectors). This energy savings will translate in to avoiding of about another 32 million tonnes of CO2. The expected investment on energy efficient project and technologies, under PAT cycle-II is around 30,000 Cr. INR.

PAT Cycle –III and beyond

In continuation to the rolling cycles of PAT, the third cycle was notified on 31st March, 2017.

S. No	Sector	No of DCs	Energy Consumption (million toe)	Energy Savings (million toe)
1	Aluminium	1	1.02	0.061
2	Cement	14	1.74	0.096
3	Iron & Steel	29	7.648	0.457
4	Pulp & Paper	1	0.06	0.003
5	Textile	34	0.668	0.040
6	Thermal Power Plant	37	23.86	0.402
	Total	116	35.00	1.06

FIGURE 4: SECTOR WISE DCS UNDER PAT-III

The baseline year was taken as 2015-16, and the target year will be 2019-20. The total number of DCs notified was 116 from 6 sectors namely Thermal Power Plants, Iron & Steel, Cement, Aluminium, Pulp & Paper and textile. No new sectors were added in this cycle. The total target was given as 1.06 million tonnes of oil equivalent, which corresponds to a reduction of around 3 million tonnes of CO2.

PAT Cycle-IV

The fourth cycle of PAT has been notified on 28th March, 2018.

S. No	Sector	No of DCs	Energy Consumption (million toe)	Energy Saving Target (million toe)
1	Cement	1	0.0741	0.0040
2	Chlor Alkali	2	0.0501	0.0030
3	Commercial Buildings (Hotels)	37	0.0625	0.0037
4	Iron & Steel	35	3.2268	0.1926
5	Petrochemical	8	3.8224	0.2293
6	Pulp & Paper	2	0.1642	0.0098
7	Textile	7	0.3418	0.0204
8	Thermal Power Plant	17	10.7500	0.2370
Total		109	18.5	0.6998

FIGURE 5: SECTOR WISE DCS UNDER PAT-IV

The baseline year is taken as 2016-17 and the target year as 2020-21. A total of 109 DCs are likely to get a total reduction target of 0.6998 million tonnes of oil equivalent. These DCs are from 8 sectors consisting of 6 existing sectors and two new sectors. The new sectors are Petrochemicals and Commercial Buildings (Hotels). Under Commercial Building sector, hotels have been selected as the potential designated consumer sub-sector for this cycle. Other sub-sectors in the commercial building sector may come up in future. Under Petrochemical, naphtha crackers and gas crackers has been considered under this cycle of PAT. The total expected CO2 emission reduction from PAT-IV is around 2 million tonnes.

PAT Cycle-V

PAT cycle V has commenced with effect from 1st April, 2019. Under PAT cycle V. 110 DCs from the existing sectors of PAT i.e. Aluminium, Cement, Chlor-Alkali, Commercial Buildings (Hotels), Iron & Steel, Pulp &Paper, Textile and Thermal Power Plant have been notified. The total energy consumption of these DCs is about 15.244 million toe and it is expected to get a total energy savings of 0.5130 million toe through the implementation of PAT cycle V.

S. No	Sector	No of DCs	Energy Consumption (million toe)	Energy Saving Target (million toe)
1	Aluminium	1	1.2375	0.0739
2	Cement	12	1.6000	0.0870
3	Chlor Alkali	2	0.0282	0.0017
4	Commercial Buildings (Hotels)	31	0.0223	0.0013
5	Iron & Steel	23	2.8256	0.1687
6	Pulp & Paper	8	0.2837	0.0169
7	Textile	16	0.2267	0.0135
8	Thermal Power Plant	17	9.0200	0.1500
Total		110	15.2440	0.5130

FIGURE 6: SECTOR WISE DCS UNDER PAT-IV

1.2 Purpose of Monitoring and Verification (M&V)

A reliable monitoring, reporting and verification (M&V) system forms the backbone of assessment process of the PAT scheme. The objective of the M&V system is to streamline the activities to be carried out for verifying the energy performance achieved by the Designated Consumer in the target year.

The Assessment of performance verification involves an independent evaluation of each activity undertaken by the DCs for compliance under PAT rules. The verification plays a crucial role in maintaining the integrity of the scheme and ensuring transparent validation.

The verification process will ensure that the information and data in Form 1 and Pro- forma are free from material omissions, misrepresentations and errors.

The documents set out the requisite guidelines for M&V in the Monitoring and Verification phase under the PAT Rules. It provides practical guidance and procedures to Designated Consumers (DCs) and Empaneled Accredited Energy Auditors (EmAEA) Firm on verification requirements, and aims to establish a verification process consistent with relevant rules and regulations.

The process requires EmAEA Firm to verify the energy performance of DCs in accordance with PAT rules while taking into the considerationthe Normalization factors and any other relevant conditions as defined under PAT Rules.

The monitoring and verification of DC by EmAEA Firm and submission of performance assessment documents i.e. Form A, Form B, Verification reports along with Form 1, sector specific proforma and authentic sources of documents must be completed by DC within four months of conclusion of target year from the baseline year i.e. between 1st April to 31st Julyof that year.

This document helps to develop clarity on the verification process as it,

- Provides Designated Consumers and EmAEA a set of guidelines to establish methods for assessment of specific energy consumption
- Defines broad techniques for assessing/ determining factors that effects the performance of establishment
- Provides general terms, which are applicable to all sectors and also includes specific sector term
- Will guide as per the provisions conferred under Rule 3 of PAT Rules, 2012
- Provides support to the Designated Consumer to meet its obligation specified in Rule 7 and Rule 15 of the PAT Rules

1.3 Definition of Monitoring and Verification

The Monitoring and Verification (M&V) is a process to verify the energy performance index through verifiable means of each Designated Consumer in the baseline year and in the assessment year by an empanelled accredited energy auditor Firm. The energy performance index defined under rule 2 of PAT rules, 2012 and its subsequent amendments is indicated in Annexure-A.

The underlying principles for Monitoring and Verification include the followings:

- **Consistency:** By applying uniform criteria to meet the requirements of the sector specific methodology throughout the assessment period.

- **Transparency:** Information in the verification reports shall be presented in an open, clear, factual, neutral and coherent manner based on documentary evidence

➢ **Acceptability:** The Empanelled Accredited Energy Auditors shall base their findings and conclusions upon objective evidence, conduct all activities in connection with the validation and verification processes in accordance with the rules and procedures laid down by BEE, and state their validation or verification activities, findings, and conclusions in their reports truthfully and accurately.

➢ **Measurability:** Measurement is a fundamental starting point for any kind of data captured for energy performance index.

i. Establishment ofenergy saving from projects: The energy saving from any project is determined by comparing measured parameters before and after implementation of a project, making appropriate adjustments for changes in conditions.

ii. Verificationof parameters for data captured in Pro-forma: The parameters entered in the pro-forma shall be taken from the measured logs with supporting documentation through Computational documentation from basic measurement at field

iii. Verificationactivities in the baseline and assessment year consist of the following:

- meter installation, calibration and maintenance
- data gathering and screening,
- development of a computation method and acceptable estimates from the basic measurement at field,
- computations with measured data, and
- reporting, quality assurance

A measurement boundary is a notional border drawn around equipment and/or systems that are relevant for determining the savings achieved through implementation of Energy saving projects.

➢ **Traceability:** The documents presented for substantiating the reduction in specific energy consumption or savings from Energy Conservation and energy efficiency Measures (ECM) should be verifiable and visible.

➢ **Verifiability:** The validation of filled in data in the Pro-forma and savings from Energy Conservation and energy efficiency Measures through proper authentic documentation are to be carried out by the EmAEA firm.

1.4 Empanelled Accredited Energy Auditor Firm or Verifier

Accredited Energy Auditor firm empanelled with BEE under PAT rules will be the verifier of PAT M&V process. Given below are the key exercises, the verifier will carry out & their meaning,

"Verification" means a thorough and independent evaluation by empaneled

accredited energy auditor firm of the activities undertaken by the designated consumer for compliance with the energy consumption norms and standards in the target year compared to the energy consumption norms and standards in the baseline year and consequent entitlement or requirement of energy savings certificate.

"Certification" means the process of certifying the verification report or check-verification report by the empaneled accredited energy auditor firm to the effect that the entitlement or requirement of energy savings certificate is quantified accurately in relation to compliance of energy consumption norms and standards by the designated consumer during the target year;

"Check-Verification" means an independent review and ex-post determination by the Bureau through the empaneled accredited energy auditor firm, of the energy consumption norms and standards achieved in the target year which have resulted from activities undertaken by the designated consumer with regard to compliance of the energy consumption norms and standards.

"Compliance period" means the period starting from the last date of submission of the performance assessment document in Form A and ending on the last date of submission of status of compliance to the concerned state designated agency with a copy to Bureau in Form D.

1.4.1 Empanelled Accredited Energy Auditor (EmAEA) firm for Verification and Check-Verification

As per Rule 9 of PAT Rules, 2012 and its subsequent amendments, the Bureau has empanelled the sector wise accredited energy auditor firms for doing Monitoring and Verificationand their updated list is published on Bureau's website. The DC has to engage any one of EmAEA Firm eligible for their sector for carrying out the monitoring and verification. Every DC must ensure the presence of competent team as per their empanelment for carrying out M&V.

1.4.2 Obligation of Empanelled Accreditor Energy Auditor Firm

For the work of verification or check verification, the accredited energy auditor shall constitute a team comprising of a team head and other members including Process Experts:

Some of the Do's & Don'ts involved in Monitoring & Verification and check verification to be an EmAEA are,

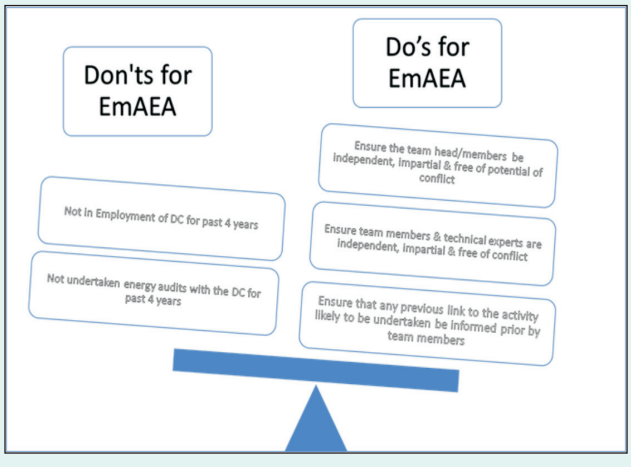


FIGURE 7: DO'S & DON'TS FOR EMAEA FIRM

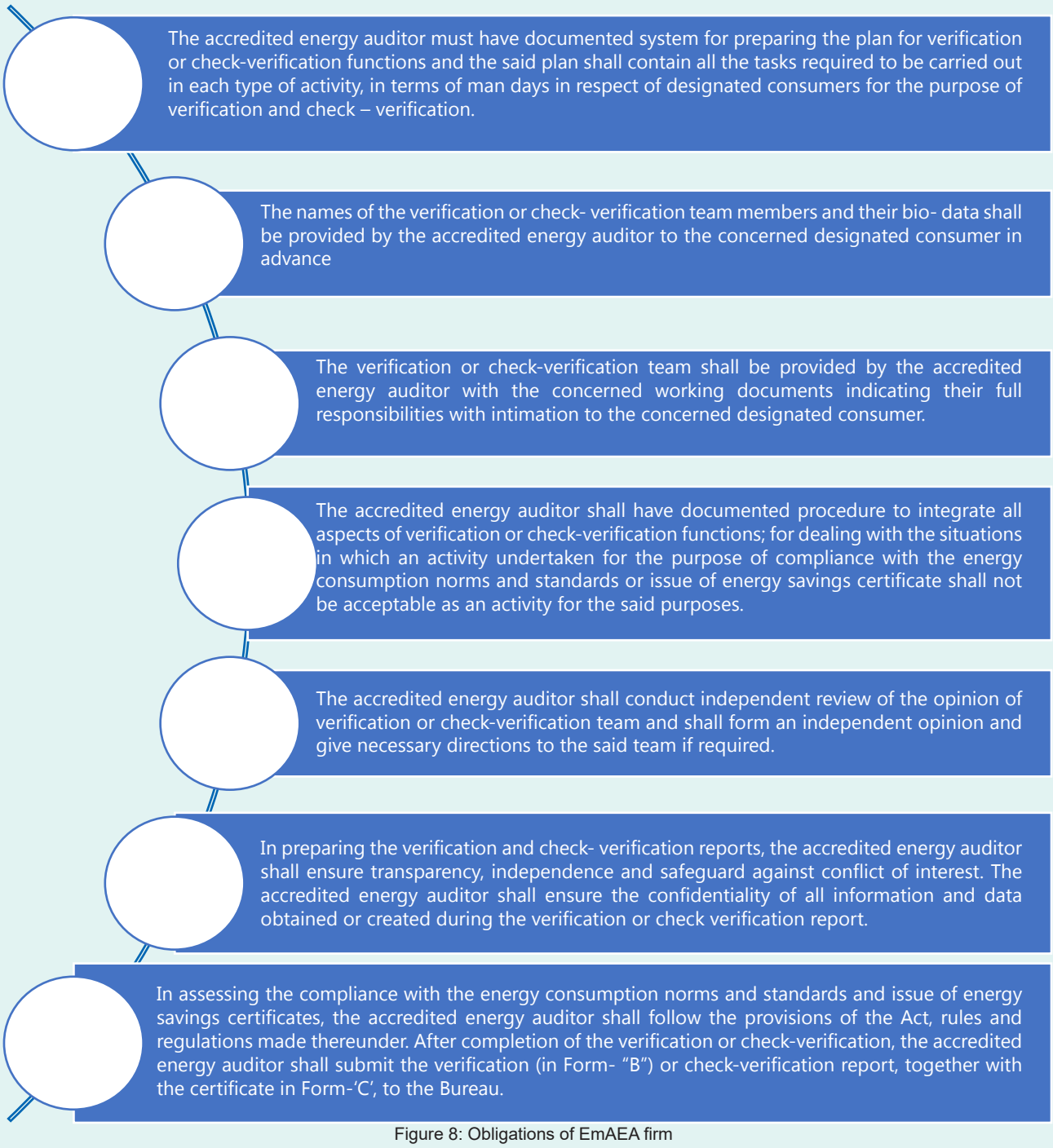


Figure 8: Obligations of EmAEA firm

1.5 Important Documents required for M&V and check verification process

I. Accepted Baseline Audit Report* (Available with BEE and DC)

II. Form 1 & Sector Specific Pro-forma

III. Form A, B, C, D as covered in PAT rules

IV. Normalisation Document and Monitoring & Verification Guidelines prepared and issued by BEE

V. Other source of documents for data provided in Pro-forma as per instruction sheet of the pro-forma

[1]Baseline report: Available with BEE & respective DC's. EmAEA to verify the consistency of the report

• This clause is not applicable to Railway Sector.

2. Broad Roles and Responsibilities of Stakeholders

The various roles to be assessed in the verification process include administration, regulation and services delivery. The key stakeholders are Ministry of Power, Bureau of Energy Efficiency, state designated agencies, adjudicator, and designated consumers and empanelled accredited energy auditor.

2.1 General

The roles and responsibilities of individuals and designated consumer are set out in Energy Conservation Rules 2012 , and its subsequent amendments in 2016 and 2018.

The roles and responsibilities of the Designated Consumer (DC), Empanelled Accredited Energy Auditor (EmAEA), Bureau of Energy Efficiency (BEE), State Designated Agencies (SDA), Adjudicator and Ministry of Power (MoP) can be summed up as under,

The Designated Consumer shall fill the data in the Sector Specific Pro-forma and Form I stating source of data in the Form, manually in Excel Sheet Pro-forma and in PATNET. The filled in Forms with the authentic source of data in terms of hard copy of document shall have to be kept ready by Designated Consumer for verification. The designated consumer in consultation with the EmAEA, shall put in place transparent, independent and credible monitoring and verification arrangement. The verifier shall ensure transparency, independence and safeguard against conflict of interest.

As part of verification process, the EmAEA shall carry out a strategic and statistical Analysis, checking of relevant and authentic document, Quarterly, Yearly and End of Cycle internal data audit reports, Performance Assessment Documents (Form A), Form I and sector specific pro-forma from DCs. After the actual verification, the EmAEA shall submit the verification report, relevant authentic supporting documents and Form B to SDA and BEE. The SDA, in turn after proper verification of Form A sent by DC may send comment to BEE for final verification based on the SDA Check List.

If the accredited energy auditor records a positive opinion in his verification report, the Bureau shall consider that all the requirements with regard to the compliance with energy consumption norms and standards, entitlement about issue or liability to purchase energy savings certificate have been met.

BEE on satisfying itself about the correctness of verification report, and check-verification report, wherever sought by it, send its recommendation under clause (aa) of sub-section (2) of section 13 to the Central Government,

[2]Energy Conservation Rules 2012: Energy Consumption Norms and Standards for Designated Consumers, Form, Time within which, and Manner of Preparation and Implementation of Scheme, Procedure for Issue or purchase of Energy Savings Certificate and Value of Per Metric Ton of Oil Equivalent of Energy Consumed) as per Notification G.S.R.269 (E) dated 30th march 2012

based on the claim raised by the designated consumer in Form `A', within two months from the last date of submission of comments on said Form `A' by the concerned state designated agency, for issuance of energy savings certificates under section 14.

2.2 Designated Consumer (DC)

The Designated Consumers have the following responsibilities with respect to End of Cycle (EOC) or mid cycle verification as per guidelines in Energy Conservation Rules, 2012:

1. To record data and submit reports in accordance with the Energy Conservation rules, 2012
2. Establish data and information management system as per Sector Specific Supporting Pro-forma for Form I, Normalization formulae etc.
3. To create M&V arrangements for energy consumption and production
4. The monitoring methodology or the Input Data Entry with Normalisation factors shall be changed if this improves the accuracy of the reported data and for taking out any errors reported by DC in the Sector Specific Pro-forma (Linking formulae, error formulae or wrong data entry)
5. The designated consumer in consultation with the accredited energy auditor, shall put in place transparent, independent and credible monitoring and verification arrangements for energy consumption and production based on the Bureau of Energy Efficiency (Manner and Intervals of Time for Conduct of Energy Audit) Regulations, 2010 for compliance with the energy consumption norms and standard, and the said arrangements shall include,

i. Preparation and Maintenance of Quarterly Data Reports to be prepared by DCs from 2015-16 onwards up to assessment year

a. On the performance of plant and production process

b. Internal Field Audit Report on Energy and Process

ii. Preparation and Maintenance of Yearly Data Reports to be prepared by DCs from 2015-16 onwards up to assessment year.

a. On the performance of plant and production process.

b. Outcome of Internal Field Audit

c. Measures to reduce energy consumption and improve energy efficiency

d. Measures taken to improve the efficiency of the production processes during each year

iii. Preparation and Maintenance of Yearly Data Reports to be prepared by DCs from 2015-16 onwards up to assessment year

a. Report on production achieved, energy consumed

b. Specific energy consumption achieved.

c. reduction achieved, measures adopted

for energy conservation and quantity of energy saved;

iv. Preparation and Maintenance of Consolidated End of Cycle (EOC) Data Reports to be prepared by DCs from 2015-16 onwards up to assessment year

a. Report on production achieved, energy consumed

b. specific energy consumption achieved, specific energy consumption

c. reduction achieved, measures adopted for energy conservation and quantity of energy saved;

6. The DC has to maintain in set tabulated format and set reports template as per above guidelines for submission to EmAEA.

7. The DC has to fill the data in the Sector Specific Pro-forma for the Normalization factors including M&V protocol for its facility in conformity with the Sectoral Normalization factor guidelines prepared by BEE.

8. The data to be filled in the latest version of MS Office Excel sheet and PATNET

9. Designated Consumers shall facilitate verification and check-verification work by the EmAEA and SDA.

10. The designated consumers shall,

a. get their compliance with the energy consumption norms and standards assessed by accredited energy auditors;

b. take all measures, including implementation of energy efficiency projects recommended by the accredited energy auditor and good practices prevalent or in use in the concerned industrial sector so as to achieve the optimum use of energy in their facility; furnish the full and complete data, provide necessary documents and other facilities required by the accredited energy auditor for the purpose of performing the function of verification and check-verification.

11. The designated consumer for the purpose of compliance with the energy consumption norms and standards during the target year, in the relevant cycle shall take the following actions and furnish the status of compliance to the state designated agency with a copy to the Bureau in Form D by the end of eight months from the last date of submission of Form `A'.

a. practise energy conservation and carry out energy efficiency measures to comply with energy consumption norms, or

b. where the energy efficiency measures implemented are found inadequate for achieving compliance with the energy consumption norms and standards, the designated consumer shall purchase energy saving certificates to meet the compliance norms in terms of metric tonne of oil equivalent.

There are certain procedures/practices that DCs need to take care of during assessment year for recordkeeping of the various operating parameters already captured in proforma (Form-I) and other related scenarios that can

impact energy performance of the plant. Following guidelines may be referred by DCs for the purpose:

A. Record keeping guidelines as per the PAT rules:

i. The designated consumer shall make necessary arrangement for taking "as fired basis" samples from auto-sampler installed at solid fuel feeding points for the purpose of fuel sampling.

ii. The designated consumer shall ensure that coal samples are picked up from the auto-sampler at least once in a month and get such samples tested at the internal lab of the designated consumer and external National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited lab for Gross Calorific Value (GCV) and proximate analysis of coal.

iii. The designated consumer shall ensure that coal samples are picked up from the auto-sampler at least once in a quarter and get the same sample tested at external National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited lab for ultimate analysis.

2.3 Empanelled Accredited Energy Auditor (EmAEA) Firm

The EmAEA Firm is responsible for verification of Energy Consumption Norms and Standards for Designated Consumers, Gate to Gate Specific Energy Consumption of baseline and assessment year as per guidelines of ECRules, 2012 and itssubsequent amendments:

1. To ensure that the verification is carried out by properly trained and competent team as per their empanelment.
2. The EmAEA firm is responsible for ensuring that the systems and processes adopted by the DC for determination of SEC/EPI from the data in Sector Specific Pro- forma along with Normalisation sheets maintained in conformity with the various notifications and information provided by BEE/SDA from time to time
3. EmAEA Firm is required to perform different roles such as technical review of processes & energy consumption/losses patterns, system variabilities and their impact on energy consumption, and on issues including application of statistical methods and finally performance of verifications including integrity of data
4. The accredited energy auditor shall independently evaluate each activity undertaken by the designated consumer for compliance with the energy consumption norms and standards and entitlement or requirement of energy savings certificate, to ensure that they meet with the requirements of these rules.

(A) The accredited energy auditor, in order to assess the correctness of the information provided by the designated consumer regarding the compliance with energy consumption norms and standards shall-

(a) Apply standard auditing techniques;

(b) Follow the rules and regulation framed under the Act;

(c) Integrate all aspects of verification, and certification functions;

(d) Make independent technical review of the opinion and decision of the verification team; also take into consideration, a situation where a particular activity may or may not form part of the activities related to the compliance with the energy consumption norms and standards, and the procedure for the assessment shall include,-

(A) Document review, involving

(i) review of data and its source, and information to verify the correctness, credibility and interpretation of presented information;

(ii) cross checks between information provided in the audit report and, if comparable information is available from sources other than those used in the audit report, the information from those other sources and independent background investigation;

(B) follow up action, involving-

(a) Site visits, interviews with personnel responsible in the designated consumers' plant;

(b) Cross-check of information provided by interviewed personnel to ensure that no relevant information has been omitted or, over or under valued;

(c) Review of the application of formulae and calculations and reporting of the findings in the verification report.

(C) The accredited energy auditor shall report the results of his assessment in a verification report and the said report shall contain,

- The summary of the verification process, results of assessment and his opinion along with the supporting documents;
- Single line diagram of the DC showing the entire process with input fuel, raw material, and product(s) on gate to gate concept, for both baseline year and assessment year
- Broad assessment of the activities/ projects undertaken by the DCs for the purpose of compliance with their energy consumption norms and standards
- The details of verification activities carried out in order to arrive at the conclusion and opinion, including the details captured during the verification process and conclusion relating to compliance with energy consumption norms and standards, increase or decrease in specific energy consumption with reference to the specific energy consumption in the baseline year;
- the record of interaction, if any, between the accredited energy auditor and the designated consumer as well as any change made in his assessment because of the clarifications, if any, given by the designated consumer.

5. EmAEA to prepare a verification report as per Reporting template to be provided by BEE

6. EmAEA to resolve errors, omissions or misrepresentations in the data/records/ calculations in consultation with the DCs prior to completing the verification report

7. EmAEA to resolve calculation errors in the Sector Specific Pro-forma in consultation with the BEE prior to completing the verification

2.4 State Designated Agencies (SDA)

All the documents like verified Sector Specific Pro-forma, Form I, Verification report of EmAEA firm and related source of documents will be routed to BEE via SDA.

1. The technical role of SDA is,

i. Inspection & enforcement for M&V related systems

ii. Assist BEE in information management process

iii. Review and validation of Sector Specific Pro-forma, Form 1, and Verification report of EmAEA and related documents before sending it to BEE.

iv. After submission of duly verified Form 'A' by designated consumer, SDA may convey its comments, if any, on Form 'A' to the Bureau within forty-five days of the last date of submission of Form 'A'.

v. BEE, in consultation with SDA may decide to undertake review on Check verification

vi. The EmAEA in-charge of check-verification shall submit the report with due certification of Form C to the BEE and the concerned SDA.

vii. The State designated agency may furnish its comments on the check-verification report within one month from the receipt of the report from the said EmAEA. In case no comments are received from the concerned state designed agency, it shall be presumed that they have no comments to offer in the matter

viii. The State designated agency within two months from the date of the receipt of the report by the Bureau referred to in sub- rule (14) of rule 8, shall initiate-

a. action to recover from the designated consumer the loss to the Central Government by way of unfair gain to the designated consumer;

b. penalty proceedings against the persons mentioned in the said report, under intimation to the Bureau;

c. register complaint for such fraudulent unfair gain if designated consumer does not pay penalty and loss to the exchequer in the specified time mentioned in the penalty proceedings.

ix. The SDA shall ensure that coal samples are picked up at random through an independent agency engaged by it from the auto coal sampler within the premises of the DC, and get the GCV and proximate analysis of coal from the internal lab of the DC as well as any NABL accredited external lab.

3. Process & Timelines

3.1 Activities and Responsibilities

The Energy Conservation Rules, 2012, and its subsequent amendments in 2016 and 2018, clearly defines the timelines of activities and responsibilities to be carried out for accomplishment of PAT scheme. Timely submission of action plan from DC to trading of ESCerts needs to be done in a definite time zone.

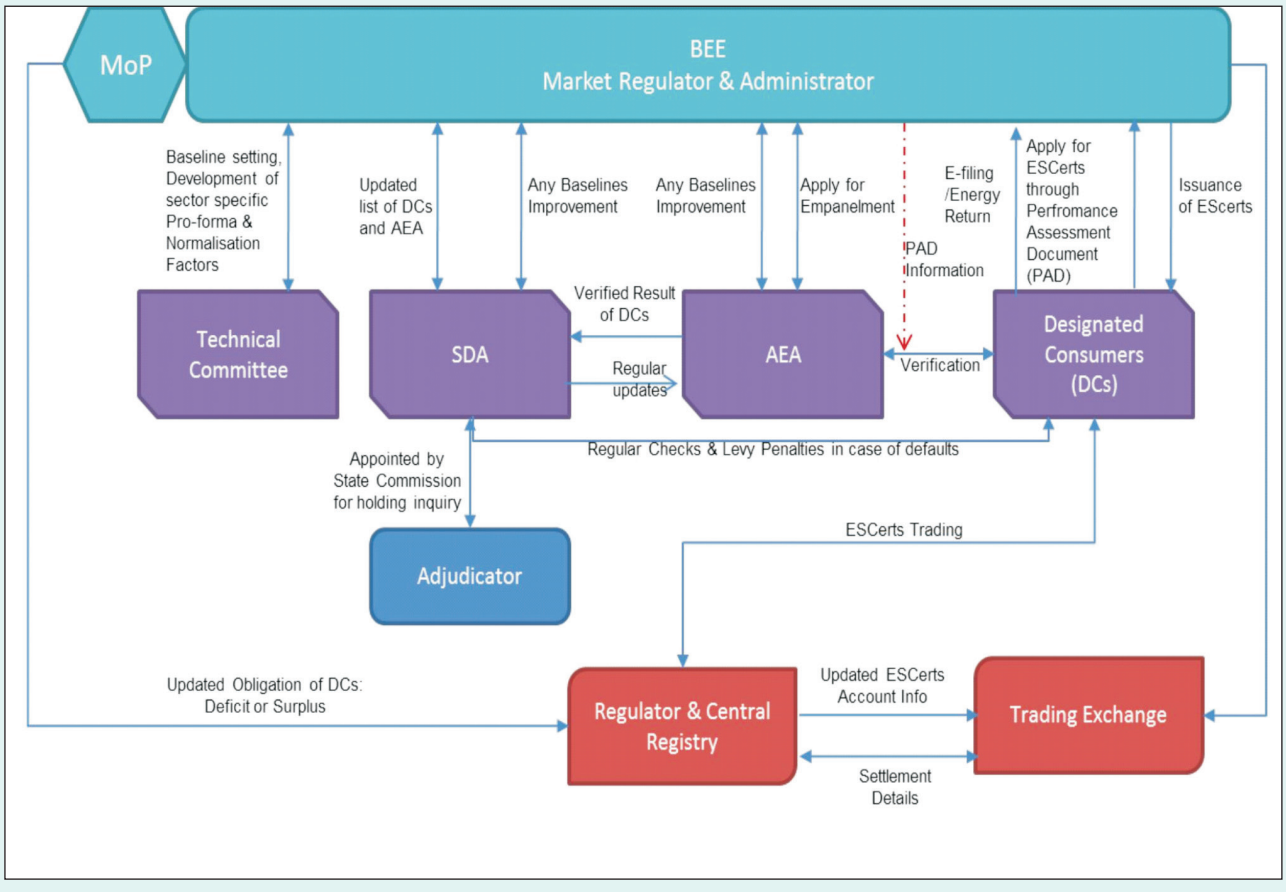


FIGURE 9: INSTITUTIONAL FRAMEWORK

Constant performance monitoring of the program by the Administrator, through parameters like total ESCerts issued & traded, complying sectors or participants, market liquidity etc., will be carried out. Delays at any point of the process-chain will be identified and timely action be taken by the Administrator/ Regulator.

Automation of processes wherever feasible will be carried out for seamless implementation of the PAT scheme.

Activity	Time Line	Description	Dates for PAT Cycles	Activity by	Where to submit
Action plan submission	3 Months	Within 3 months from Notification	30-June	DC	SDA/BEE
Form 1 and Pro-forma submission	3 Months	Yearly submission of Form 1 within 3 months from last financial year	30 June (Every Year)	DC	SDA/BEE
Form A, Form B along with other documents	4 Months	Within 4 months from conclusion of target year	31st July	DC	SDA/BEE
Submission of comments on Form A, Form B from SDA	45 Days	Within 45 days of the last date of submission of Form A	15th Sept	SDA	BEE
Recommendation of ESCerts to MoP, GOI	Two Months	Within two months from the date of the receipt of the comments from SDA	15th November	BEE	MoP
Issuance of ESCerts by MoP	45 Days	Within 45 days from the date of receipt of recommendation of ESCerts from BEE	31st December	MoP	DC
Form D Submission	Eight Months from last date of Form A	Within eight months from last date of submission of Form A by DC to SDA with a copy to Bureau	31st March	DC	SDA/BEE
Form C (check verification report and certificate)	One year	One year from the date of submission of compliance report		EmAEA	BEE

TABLE 2: ACTIVITIES AND RESPONSIBILITIES FOR PAT CYCLE

Note: Forms are available on BEE website / PATNet Portal

3.2 Process Interlinking

The complete process from notifying the targets to issuing ESC erts are inter linked among different stakeholders complying a definite time frame as defined below,

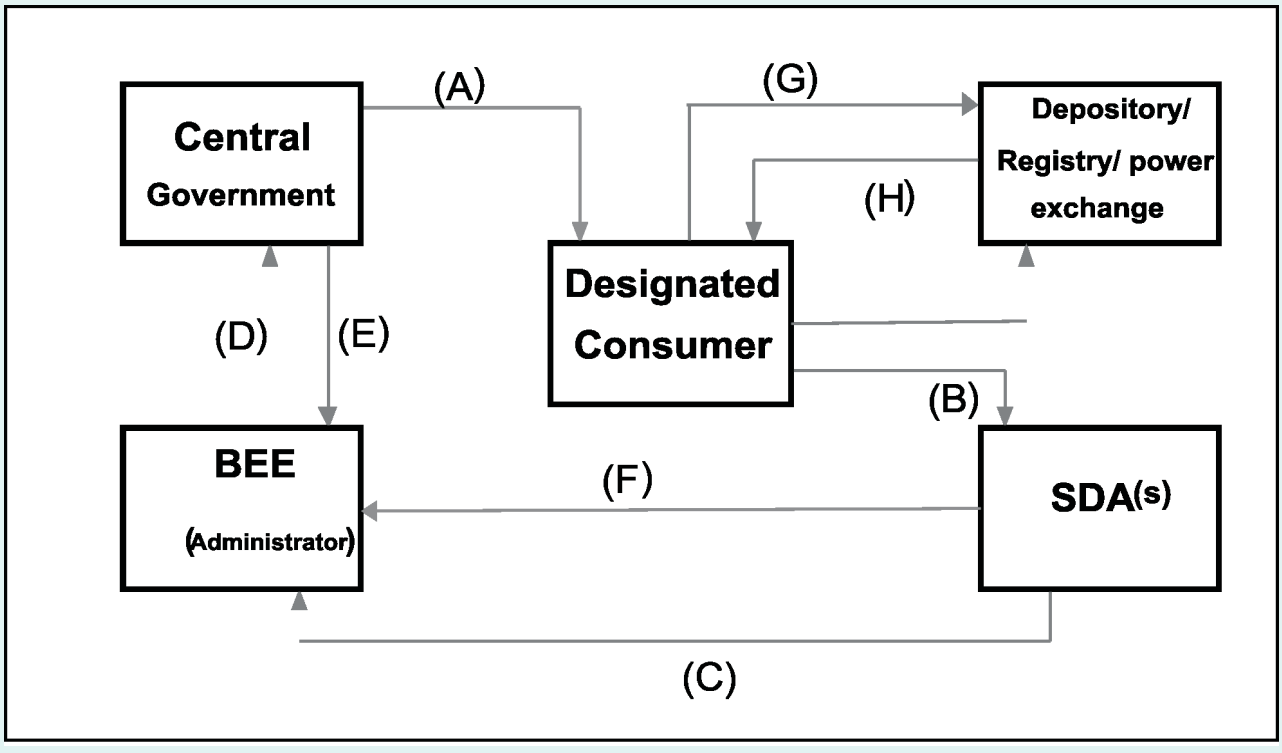


FIGURE 10: INTERLINKING STAKEHOLDERS

(A) Targets from Central Government to DCs

(B) Performance Assessment Document (Form A from DC to SDA with a copy to BEE)

(C) PAD (Form-A) with comments from SDA to BEE

(D) Recommendation of ESCerts Issuance by BEE to Central Government

(E) ESCerts Issuance Instruction from Central Government to BEE

(F) Electronic ESCerts Issuance Instruction from BEE to Depository

(G) DC Interaction with Depository A/c

(H) ESCerts credit to DC's A/c

(I) Trading of ESCerts by DCs on power exchanges

4. Verification requirements

4.1 Guidelines for Selection Criteria of EmAEA Firm by Designated Consumer

1. The EmAEA Firmshall be selected only from the latest available List of EmAEA Firm on BEE website from time to time.

4.2 Guidelines for Empanelled Accredited Energy Auditor Firm

1. For the Work of verification, EmAEA shall constitute a team in accordance to rule 9 of Energy Conservation Rules, 2012, and its subsequent amendments.
2. Where ever necessary, EmAEA firm must state any discrepancies in their final verification reports. Potential improvements to achieve more accurate reporting in line with the PAT Rules, amendments and EC Act.
3. The EmAEA firm may constitute any no's of team for verification or check-verification purpose to carry out the verification process for no's of Designated Consumer.
4. The EmAEA firm shall ensure that it has formal contractual conditions of team members including technical experts for verification and check-verification so as to act in an impartial and independent manner and free of potential conflict of interest.
5. The EmAEA firm has the sole responsibility and signing authority on Form B, Form C, and on the report.
6. The verification by EmAEA firm should be completed for onward submission to SDA and BEE before the due date.
7. The EmAEA firm should furnish a time plan and activities chart to DC after receiving valid order from the respective designated Consumer

S. No	Designation	Qualification	Experience
1	Team Head	Accredited Energy Auditor	In the Field of Energy Auditing of PAT Sectors, at least 10 years of experience in the relevant sector if any other sector expert is not a part of the team.
2	Team Member [Expert]	Graduate/ Diploma	Process or Technical Expert related to the specific sector, where verification will take place having experience of more than 10 years. In case the AEA has the 10 years sector specific experience, he may be construed as the sector expert as well.
3	Team Member	Certified Energy Auditor	In the Field of Energy Auditing
4	Team Member	Graduate/ Diploma Engineer	

TABLE 3: TEAM DETAILS (MINIMUM TEAM COMPOSITION)

8. The Designated Consumer shall inform Bureau of Energy Efficiency about the date of start of verification by EmAEA.
9. The verification shall be carried out by single EmAEA firm for the particular DC.
10. The audit report shall be certified by the EmAEA and shall be counter signed by the DCs Energy Manager and Competent Authority.
11. EmAEA to submit an undertaking that there is no conflict of interest in the team assigned as per the PAT Rules, and its subsequent amendments along with Form B.

4.3 Guidelines for Verification process

4.3.1 Sector Specific Pro-forma

The Sector Specific Pro-forma is made with the purpose of capturing the data for Production, Energy, intermediate processes, and import-export and Normalization factors under equivalent condition for the baseline and assessment year. The filled in Pro-forma is used to calculate the Notional Energy for Normalization. Once complete data is filled in the Pro-forma, the SEC after Normalization automatically comes out in the summary sheet enabling the DC to see the actual performance of the plant

1. The Energy Conservation (Form and Manner for submission of Report on the Status of Energy Consumption by the Designated Consumers) Rules, 2007 directs every designated consumers to submit the status of energy consumption in electronic form as well as hard copy, within three months, to the designated agency with a copy to Bureau of Energy Efficiency at the end of the previous financial year in Form-1.
2. The Sector Specific Pro-forma have many sections to cover all the aspects of GTG methodology as follows:

a) Instruction for Form 1 filling

b) General Information Sheet

c) Form 1

d) Sector Specific Pro-forma

I. Production and Capacity Utilization Details

II. Section wise details of different products

III. Electricity and Renewable Energy Consumption

IV. Power Generation (DG/GG/GT/ STG/Co-Gen/WHR)

V. Fuel Consumption (Solid/ Liquid/Gas/ Biomass & Others)

VI. Heat Rate of different power sources and Coal Quality

VII. Process parameters

VIII. Import-export details of energy, raw materials and products/ intermediate products

IX. Miscellaneous Data for Normalization

e) Additional Equipment installation due to Environmental Concern

f) Project Activities details

g) Summary Sheet

h) Normalization calculation sheets

3. The Form I will be automatically generated after filling the Pro-forma, which is required to be filled in the PATNET as input for final assessment of GTG SEC for the baseline and assessment year

4. Formulae cells in Pro-forma, Summary sheet and Normalisation calculation sheets are locked to ensure data security, reliability etc.

5. The Sector Specific Pro-forma will be used for mandatory submission of annual Energy return. Cells have been Colour coded for differentiating cells with formulae from empty cells to be filled. The formulae cells are locked for data security.

4.3.2 Reporting in Sector Specific Pro-forma

1. Baseline parameter and Plant boundary in Gate to Gate Concept means

➢ **Plant Boundary for Energy and Product**

- Input Raw material
- Output product
- CPP installed within premises or outside the plant demographic boundary
- Energy inputs and Outputs (Electricity/ Gas/Steam etc)

➢ **Defining Input Energy in Sector Specific Pro-forma**

- Fuel Input to the Captive Power Plants
- Fuel Input to the Process
- Bifurcation of Input Energy for Renewables/Alternate source/ Biomass etc in Captive Power Plants
- Not connected with Grid- The energy used from the Renewables/Alternate source/ Biomass will not be added in the total input energy
- Connected with Grid-The energy used from the Renewables/ Alternate source/ Biomass will be added in the total input energy
- Waste Heat Recovery
- Co-generation
- Accounting of Energy generation and Energy used inside the plant boundary.
- Raw material input and Product output
- Intermediary semi-finished Product output for market sale: the energy for making the intermediary product to be deducted from the total energy consumption
- Intermediary semi-finished Product input as raw material in between the process: the energy for making up to the semi-finished intermediate product to be added in the total energy consumption.

2. The baseline Production and Energy related data to be entered in Sector Specific Pro- forma as per Baseline Report of individual DCs. The same will be verified by EmAEA.

3. The DCs are required to fill the data as per instruction sheets in all the relevant baseline and assessment year sections with source of data.

4. The entered baseline data in the Excel Sheets may be locked for data security by BEE, and sent to the DCs for filling the assessment year details. The DC can enter data in all the fields other than locked Cells. However, in case the baseline data locked sheets are not available, the DC needs to fill the data as per the baseline verification report accepted by BEE. In either case, the EmAEA Firm needs to verify the baseline parameters also along with the assessment year data.
5. The Locked-in Sector Specific Pro-forma is to be sent to DCs for data entry.
6. The primary and secondary source of data should be kept ready in hard copies for verification by EmAEA firm as per guidelines in the instruction sheet.
7. The DCs are advised to fill the data in Excel Sheets only and return the same in Excel form to SDAs with a copy to BEE along with hard copies of Form 1, Sector Specific Pro-forma, Summary and all Normalisation sheets duly signed.

4.3.3 Verification Process

As part of the verification process, the EmAEA shall carry out the following steps:

1. The EmAEA firm after receiving the work order is advised to get the final Baseline report (Accepted by BEE) from the DC.
2. The EmAEA shall conduct a site visit on mutually agreed dates with Designated Consumer, to inspect the monitoring systems, conduct interviews, and collect sufficient information and supporting documentary evidence vide Sector Specific Pro-forma.
3. Prior to visiting the site, the EmAEA is advised to study the Baseline reports, Sector Specific Pro-forma and Sector specific Normalisation document
4. For computing SEC in Gate-to-Gate concept, the plant boundary was established such that the total energy input and the defined product output is fully captured. Typically, it is the entire plant excluding colony, residential complex and transportation system. The same boundary should be considered for entire PAT cycle as finalised for the baseline year in the final Baseline Energy Audit Report. Ideally, plant boundary should not change during the entire cycle. Any change in plant boundary limit or merger of two plants, division of operation should be duly reported. The definition of Plant boundary should be considered same as established in the baseline year.
5. The EmAEA will assign the activities among team members for verifying the data through the Pro-forma, Documented Primary and secondary sources, field reports, conducting interviews, site visits etc.
6. The filled in Baseline data for Production and Energy shall be verified through Baseline Report by EmAEA.
7. The additional Baseline data filled by DC needs to be verified based on authentic documentary evidences.
8. The baseline verified data shall be considered as final data to be filled in the sector specific pro-forma. In case of

any typographical or factual error, the same shall be taken into account during verification process subject to all factual and authentic data source is available by DC. The EmAEA may take into such cases into account while preparing the verification form B, providing proper justification and sufficient documentary evidences in the report.

9. The SEC calculation methodology as devised in the pro-forma shall be considered.

10. In case of any discrepancies observed in baseline data w.r.t. the baseline reported data, the same should be reported to BEE with proper justification from EmAEA or DC for rectification in the existing Sector Specific Pro-forma. The rectified Pro-forma from BEE will be sent to the DC through e-mail. Officials from Bureau of Energy Efficiency may visit Designated Consumers' Plant during the course of verification by EmAEA.

11. Review of assessment year data and its authentic sources:

i. The verifier shall ask the filled in Sector Specific Pro-forma with Form 1 from the Designated Consumer along with authentic documentary evidence.

ii. In case DC reports some error; Interlinking or calculation error, these are to be reported back to BEE by the EmAEA with proper justification. BEE will send the rectified Pro-forma to DC through e-mail.

iii. EmAEA shall start the verification of Pro-forma referring to the documents provided by DC

iv. The guidelines as relevant to the data source are tabulated for different sections in Table 3 below. The instruction sheet of all sector may also be referred for detailed documentation requirement.

v. EmAEA may seek other documents relevant to the process of M&V as well apart from the documents mentioned in the guidelines for his satisfaction.

vi. EmAEA should include a write up on Fuel Analysis report, internally or externally, in the Verification Report.

vii. Data sampling method could be performed on sources of data, so that Operator's Log book/Log Sheet data/ Shift Report (Basic data Entry Point particularly for Lab test/Production/ External reasons etc.) could be verified in a loop of verifying the source document. EmAEA is advised to verify random sampling of data up to the primary source for some of the major parameters, affecting SEC of the Plant, which will be included in the Verification Report

viii. In case of discrepancies between authentic document provided by DC and the Pro-forma, the same to be recorded in the EmAEA's verification report with justification, if any, from the DC and EmAEA.

FIGURE 11: STAKEHOLDERS OUTPUT

12. Review of Energy Savings Projects

i. In terms of Rule 7 of PAT Rules, 2012 on

Quarterly, Yearly and EOC internal data reports prepared by the Designated Consumer

ii. In terms of Internal Audit reports prepared and maintained by the Designated Consumer

iii. In terms of measures adopted for energy conservation and quantity of energy saved and investment made by the Designated Consumer covering the relevant cycle

iv. Through Photographs, Screenshots in support of measures implemented in each year, if feasible

v. Through Percentage improvement in energy savings achieved in every year following the baseline year until the target year

vi. Verification & validation based on evaluation of implemented EE projects through commissioning and procurement documents

vii. Site visit to some of the implemented EE projects for verification and validation

viii. Establish linkage of expected results of projects on reduction of GTG SEC

ix. Identify SEC reduction reasons in the Verification Report

13. Review of Formulae and its application

i. EmAEA to review the formulae used in the Pro-forma with Normalisation factor sheets and its applications; Errors are to be reported immediately to BEE.

ii. EmAEA to review the formulae and calculation used to arrive certain data filled in the Pro-forma by Designated Consumer and documented properly in the Verification Report

iii. Verification through Personnel Interviews, site visits and cross checking the same with the filled in data in Sector Specific Pro-forma

4.3.4 Primary and Secondary source of Documentation

1. For verification process, the DC shall provide all necessary information, supporting documents and access to the Plant site to EmAEA. It will be the responsibility of the EmAEA to maintain the confidentiality of the data collected and not to use for any other purpose except for the PAT scheme.

2. The data submitted for verification and other figures for SEC calculation of any unit has to be in line with the units declared production and consumption figures as per the statutory financial audit and declaration in their annual report.

3. EmAEA, while verifying the SEC calculation should also cross verify the input figures based on the procurement plans and physical receipts.

4. The transit and handling losses have to be within the standard norms allowable under financial audit.

5. Guidelines on sources of data for the Designated Consumer and EmAEA:

a. The general guidelines are tabulated in Table 10 below,

b. Designated Consumer and EmAEA may also refer the guidelines provided in the Instruction sheet attached with the Sector Specific Pro-forma.

6. In case of any discrepancies, EmAEA may seek further field document or Equipment/ Section Log sheets for particular data verification

Sr No	Details	Unit	Frequency of record	Primary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor	Secondary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor
Production and capacity utilisation details					
1	Production Capacity of a Plant/section/ line/unit	Tonne	Annual	1) Original equipment manufacturer (OEM) Document of line/ unit/equipment capacity 2) Environmental Consent to establish/ operate document 3) DoF Communication	1) Equipment/ Section wise capacity document from OEM 2) Capacity calculation document submitted for Environmental Consent
2	Production of a Plant/ section/line/ unit	Tonne	Continuous, Hourly, Daily, Monthly	1) Log Sheet 2) DCS/CCR/SCADA Report/ Trends 3) DPR 4) MPR 5) SAP Entry in PP/SD module 6) Excise record (ER1) 7) Annual Report 8) TOP	1) Storage Level 2) Feeding Weigh feeders 3) Belt Weigher 4) Solid flow meter 5) Counters
3	Production of Intermediate/ Semi-finished Product/Other product	Tonne	Continuous, Hourly, Daily, Monthly	1) Log Sheet 2) DCS/CCR/SCADA Report/ Trends 3) DPR 4) MPR 5) SAP Entry in PP/SD module 6) Excise record (ER1) 7) Annual Report 8) TOP	1) Storage Level 2) Feeding Weigh-feeders 3) Belt Weigher 4) Solid flow meter 5) Counters

4	Opening stock of Intermediary product	Tonne	Daily, Monthly	1) Inventory Report 2) Excise Document (ER1) 3) Stores Entry 4) SAP Entry in MM/PP/ SD module 5) Annual Financial report 6) TOP	1) Field Inventory 2) Storage Level
5	Closing Stock of intermediary product	Tonne	Daily, Monthly	1) Inventory Report 2) Excise Document (ER1) 3) Stores Entry 4) SAP Entry in MM/PP/ SD module 5) TOP	1) Field Inventory
6	Export of Intermediary Product	Tonne	Daily, Monthly	1) Excise Document 2) Stores receipt 3) SAP Entry in FI/SD Module 4) Annual Report 5) TOP	1) Internal material Transfer Records
7	Import of Intermediary Product	Tonne	Daily, Monthly	1) Excise Document 2) Stores receipt 3) SAP Entry in FI/SD Module 4) Annual Report 5) TOP	1) Internal material Transfer Records
8	Raw material consumption if any	Tonne	Daily, Monthly	1) Lab Product Test Report 2) DPR 3) MPR 4) SAP Entry in MM/PP module 5) Raw material stock entry (Stores)	1) Lab Testing Register 2) Closing and opening stock
9	Thermal Energy Consumption of section/ Unit/Product	Tonne	Daily, Monthly	1) Fuel Weigh-feeder 2) Fuel Flow Meter 3) DPR 4) MPR 5) SAP Entry in MM/PP module	1) Storage Level 2) Feeding Weigh feeders 3) Belt Weigher 4) Solid flow meter

10	Electrical Energy Consumption of section/ Unit/Product	Tonne	Daily, Monthly	1) Energy Management System 2) Equipment List Major Equipment section 3) DPR 4) SAP Entry in MM/PP module	1) Storage Level 2) Feeding Weigh feeders 3) Belt Weigher 4) Solid flow meter

TABLE 4: PRODUCTION AND CAPACITY UTILISATION DETAILS

S r No	**Details**	**Unit**	**Frequency of record**	**Primary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor**	**Secondary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor**
Major Equipment (Eqp) Capacity and Operating SEC					
1	Major Eqp-wise production in tonnes.	Tonne	Continuous, Hourly, Daily, Monthly	1) Log Sheet 2) CCR SCADA Report/ Trends 3) DPR 4) MPR 5) SAP Entry in MM/PP module	1) Storage Level 2) Feeding Weigh feeders 3) Belt Weigher 4) Solid flow meter
2	Operating Major Eqp thermal SEC (Total thermal energy consumed in Major Eqp/ total Major Eqp production) in kcal/ kg Intermediary Product.	Kcal/ kg or kcal/ Tonne	Continuous, Hourly, Daily, Monthly	1) Fuel Weigh-feeder 2) Fuel Flow Meter 3) DPR 4) MPR 5) SAP Entry in MM/PP module	1) Storage Level 2) Feeding Weigh feeders 3) Belt Weigher 4) Solid flow meter

3	Operating Major Eqp electrical SEC (Total electricity consumed in Major Eqp/ total Major Eqp production) in kWh / kg Intermediary Product.	Kwh/ Tonne	Continuous, Hourly, Daily, Monthly	1) Energy Management System 2) Equipment List Major Eqp section 3) DPR 4) SAP Entry in MM/PP module	1) Electrical Meter Record for Major Eqp section
4	Major Eqp wise annual running hours.	Hrs	Continuous, Hourly, Daily, Monthly	1) Major Eqp Log sheet 2) DPR 3) MPR 4) DCS/CCR/DCS Trends	1) Major Eqp Shift operator's Log Register 2) Breakdown report
5	Annual Hot-Hot start in Nos	Nos	Continuous, Hourly, Daily, Monthly	1) Major Eqp Log sheet 2) DPR 3) MPR 4) DCS/CCR/DCS Trends	1) Major Eqp Shift operator's Log Register 2) Breakdown report
6	Total annual Hot-Cold Stoppage Hours for Major Eqp due to external factor	Hrs	Continuous, Hourly, Daily, Monthly	1) Major Eqp Log sheet 2) DPR 3) MPR 4) DCS/CCR/DCS Trends	1) Major Eqp Shift operator's Log Register 2) Breakdown report
7	Total annual Hot-Cold Stoppage Nos for Major Eqp due to external factor	Nos	Continuous, Hourly, Daily, Monthly	1) Major Eqp Log sheet 2) DPR 3) MPR 4) DCS/CCR/DCS Trends	1) Major Eqp Shift operator's Log Register 2) Breakdown report

[3]External Factor: Market demand, grid failure (where captive power plant is not synced with the grid), raw material unavailability, natural disaster, rioting or social unrest, major change in government policy hampering plant's process system, any unforeseen circumstances beyond the plant management's control

8	Total annual Electrical Energy Consumption for Hot-Cold Stoppage for Major Eqp due to external factor in Lakh kWh	Lakh kWh	Continuous, Hourly, Daily, Monthly	1) Energy Meter Reading for Major Eqp Section 2) Major Eqp Log sheet 3) DPR 4) MPR 5) CCR SCADA Trends	1) Major Eqp Shift operator's Log Register 2) Breakdown report
9	Total annual Cold-Hot Start Hours for Major Eqp due to external factor	Hrs	Continuous, Hourly, Daily, Monthly	1) Major Eqp Log sheet 2) Major Eqp Shift operator's Log Register 3) DPR 4) MPR 5) CCR SADA Trends	1) Major Eqp Shift operator's Log Register 2) Breakdown report
10	Total annual Cold-Hot Start Nos for Major Eqp due to external factor	Nos	Continuous, Hourly, Daily, Monthly	1) Major Eqp Log sheet 2) Major Eqp Shift operator's Log Register 3) DPR 4) MPR 5) DCS/CCR/DCS Trends	1) Major Eqp Shift operator's Log Register 2) Breakdown report
11	Total annual Electrical Energy Consumption for Cold-Hot Start for Major Eqp due to external factor in Lakh kWh	Lakh kWh	Continuous, Hourly, Daily, Monthly	1) Energy Meter Reading for Major Eqp Section 2) Major Eqp Log sheet 3) DPR 4) MPR 5) DCS/CCR/DCS Trends	1) Major Eqp Shift operator's Log Register 2) Breakdown report
12	Annual Cold-Hot Start in Nos due to internal factors	Nos	Continuous, Hourly, Daily, Monthly	1) Major Eqp Log sheet 2) Major Eqp Shift operator's Log Register 3) DPR 4) MPR 5) DCS/CCR/DCS Trends	1) Major Eqp Shift operator's Log Register 2) Breakdown report

TABLE 5: MAJOR EQUIPMENT CAPACITY AND OPERATING SEC

Sr No	Details	Unit	Frequency of record	Primary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor	Secondary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor
Boiler Details (Process/Co-Gen)					
1	Type			1) OEM Document	
2	Rated Capacity	TPH	Annual	1) OEM document on Boiler Capacity 2) Predicted performance Data (PPD) for Boiler 3) Environmental Consent to Operate	1) Capacity calculation submitted for Environmental Consent
3	Total Steam Generation	Ton	Continuous, Hourly, Daily, Monthly	1) Log Sheet 2) DCS/ SCADA Trend 3) DGR 4) MGR 5) SAP Entry in PP/PM Module	1) Steam Flow Meter 2) Process steam Consumption report 3) Log Book
4	Running hours	Hrs	Continuous, Hourly, Daily, Monthly	1) Log Sheet 2) DCS/ SCADA Trend 3) DGR 4) MGR 5) SAP Entry in PP/PM Module	1) Hour Meter 2) Log book
5	Coal Consumption	Tonne	Continuous, Hourly, Daily, Monthly	1) Log Sheet 2) DCS/ SCADA Trend 3) DGR 4) MGR 5) SAP Entry in PP/PM Module	1) Weigh Feeder 2) Solid flow Meter 3) Coal Storage register 4) Storage Level

6	GCV of Coal	kcal/ kg	Daily, Monthly, Yearly	1) Daily Internal Report from Lab on Fuel Proximate Analysis performed on each lot. 2) Test Certificate from Government Accredited lab. (Plant to maintain minimum 1 sample test in a quarter for Proximate and Ultimate Analysis i.e. 4 test certificates in a year for each fuel in case of CPP/Cogen Fuel, for Process Fuel 1 sample test in a quarter for Proximate Analysis) 3) Purchase Order, where guaranteed GCV range is mentioned	1) Lab Register on Fuel Testing for Proximate Analysis 2) Calibration Record of instrument used for testing
7	Type of Fuel–2 Name : Consumption	Tonne	Continuous, Hourly, Daily, Monthly	1) DGR 2) MGR 3) CPP/Cogen Log Sheet 4) SAP Entry in MM/PP/ FI module 5) Annual Report	1) Belt Weigher before Fuel Bunker
8	GCV of any Fuel-2	kcal/ kg	Daily, Monthly, Yearly	1) DGR 2) MGR 3) Lab Test Report	1) Lab Register on Fuel Testing for Proximate Analysis 2) Calibration Record of instrument used for testing

9	Type of Fuel–3 Name : Consumption	Tonne	Continuous, Hourly, Daily, Monthly	1) DGR 2) MGR 3) CPP/Cogen Log Sheet 4) SAP Entry in MM/PP/FI module 5) Annual Report	1) Belt Weigher before Fuel Bunker
10	GCV of any Fuel-3	kcal/kg	Daily, Monthly, Yearly	1) DGR 2) MGR 3) Lab Test Report	1) Lab Register on Fuel Testing for Proximate Analysis 2) Calibration Record of instrument used for testing
11	Type of Fuel–4 Name : Consumption	Tonne	Continuous, Hourly, Daily, Monthly	1) DGR 2) MGR 3) CPP/Cogen Log Sheet 4) SAP Entry in MM/PP/FI module 5) Annual Report	1) Belt Weigher before Fuel Bunker
12	GCV of any Fuel-4	kcal/kg	Daily, Monthly, Yearly	1) DGR 2) MGR 3) Lab Test Report	1) Lab Register on Fuel Testing for Proximate Analysis 2) Calibration Record of instrument used for testing
13	Feed water Temperature	C	Continuous, Hourly, Daily, Monthly	1) DGR 2) DCS/SCADA Trends	
14	Operating Efficiency	%	Continuous, Hourly, Daily, Monthly	1) Indirect Method or Direct method calculation	

15	SH Steam outlet Pressure (Operating)	kg/ cm2	Continuous, Hourly, Daily, Monthly	1) DGR 2) DCS/SCADA Trends	1) Field Pressure Meter
16	SH Steam outlet Temperature (Operating)	^{0}C	Continuous, Hourly, Daily, Monthly	1) DGR 2) DCS/SCADA Trends	1) Field Temperature Meter
17	SH Steam Enthalpy (Operating)	kcal/ kg	Continuous, Hourly, Daily, Monthly	1) Steam Table	
18	Design Efficiency	%	Yearly	1) OEM document on Boiler Efficiency 2) Predicted performance Data (PPD) for Boiler	1) Design Calculation

Table 6: Boiler Details (Process and Co-Generation)

Sr No	Details	Unit	Frequency of record	Primary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor	Secondary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor
Electricity from Grid / Other (Including Colony and Others) / Renewable Purchase obligation/Notified Figures					
1	Annual electricity purchase from the grid	Lakh kWh	Daily, Monthly	1) Monthly Electricity Bills from Grid 2) Internal Meter reading records for grid incomer	Energy Management System
2	Renewable electricity consumption through wheeling	Lakh kWh	Daily, Monthly	1) Open Access records 2) Electricity Bills for Renewable energy 3) Renewable Purchase Obligation document	Energy Management System

3	Electricity consumption from CPP located outside of the plant boundary though wheeling	Lakh kWh	Daily, Monthly	1) Open Access records 2) Electricity Bills (for Wheeling)	Energy Management System
4	Renewable Purchase obligation of plant for the current year in % (Solar and Non-Solar).	%	Yearly	1) Renewable Purchase Obligation document	
5	Renewable Purchase obligation of plant for the current year in Lakh kWh (Solar and Non-Solar).	Lakh kWh	Yearly	1) Renewable Purchase Obligation document	
6	Renewable Purchase obligation of plant for the current year in MW (Solar and Non-Solar).	MW	Yearly	1) Renewable Purchase Obligation document	
7	Renewable Energy Generator Capacity in MW as approved by MNRE	MW	Yearly	1) 'Certificate for Registration' to the Applicant concerned as 'Eligible Entity' confirming its entitlement to receive Renewable Energy Certificates for the proposed RE Generation project	

8	Quantum of Renewable Energy Certificates (REC) obtained as a Renewable Energy Generator (Solar & Non-Solar) in terms of REC equivalent to 1 MWh	Nos	Yearly	1) Renewable Energy Certificates	
9	Quantum of Energy sold in terms of preferential tariff under REC Mechanism in MWh	Nos	Lot, Yearly	1) Power Purchase Agreement (PPA) for the capacity related to such generation to sell electricity at preferential tariff determined by the Appropriate Commission	
10	Plant connected load	kW	Monthly	1) L-Form document 2) Electrical Inspectorate record	1) Total connected Load (TCL) of Plant 2) Equipment List
11	Plant contract demand with utility i	kVA	Monthly	1) Monthly Electricity Bills from Utility	
12	DCs Notified Specific Energy Consumption in TOE/T for Baseline Year	TOE/T		1) Notification S.O.687 dated 31/03/2012	
13	DCs Target Specific Energy Consumption in TOE/T for Target year	TOE/T		1) Notification S.O.687 dated 31/03/2012	

14	Equivalent Major Product Output in tonne as per PAT scheme Notification	Tonne		1) Notification S.O.687 dated 31/03/2012	

TABLE 7: ELECTRICITY FROM GRID/OTHERS, RENEWABLE PURCHASE OBLIGATION, NOTIFIED FIGURES

Sr No	Details	Unit	Frequency of record	Primary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor	Secondary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor
Own Generation through captive power plant (CPP) (STG/GG/GT/WHRB/DG)					
1	Selection is required from the drop down list for grid connectivity with grid (Yes/ No)	Yes/ No			
2	Installed capacity of all the Units in MW.	MW	Annual	1) OEM document for capacity 2) Rating plate of Generator	1) Capacity enhancement document 2) R&M document
3	Gross unit generation of all the Units in Lakh kWh.	Lakh kWh	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) CPP main energy meter reading record 4) Energy Management System data	1) Energy Meter

4	Auxiliary power consumption (APC) in %.	%	Continuous, Hourly, daily, Monthly	1) Daily Power Report 2) Monthly Power Report 3) CPP main energy meter reading record 4) Energy Management System data	1) Energy Meter 2) Equipment List
5	Design Heat Rate of all the Units in kcal/ kWh.	Kcal/ kWh	Annual	1) OEM document on designed heat rate	1) PG test document
6	Annual running hours of all the units.	Hrs	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) Energy Management System data	1) Break down report 2) Operators Shift Register
7	Annual available hours of respective unit. Ex. If a unit commissions on 1st Oct, then available hour for the year will be 4380 hours	Hrs	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) Energy Management System data	1) Break down report 2) Operators Shift Register

8	Break down hrs due to internal, Planned and external factor for calculating Plant Availability Factor	Hrs	Hourly, daily, Monthly	1) CPP Log Sheet 2) Operators log Register 3) Daily generation Report 4) Monthly Generation Report 5) Energy Management System data 6) Refer Sr. No: N	1) Operator's Shift Register 2) CPP Break down analysis Report
9	No of hrs per annum during which Plant run on low load due to Internal Factors/ Breakdown in Plant (Average weighted hours of all the units)	Hrs	Hourly, daily, Monthly	1) CPP Log Sheet 2) Operators log Register 3) Daily generation Report 4) Monthly Generation Report 5) Energy Management System data 6) Refer Sr. No: N	1) Operator's Shift Register 2) CPP Break down analysis Report
10	No of hrs per annum during which Plant runs on low load due to Fuel Unavailability/ Market demand/ External Condition (Average weighted hours of all the units)	Hrs	Hourly, daily, Monthly	1) CPP Log Sheet 2) Operators log Register 3) Daily generation Report 4) Monthly Generation Report 5) Energy Management System data 6) Refer Sr. No: N	1) Operator's Shift Register 2) CPP Break down analysis Report

Through Co-generation					
1	Grid Connected	Yes/ No			
2	Installed Capacity	MW	Annual	1) OEM document for capacity 2) Rating plate of Generator	1) Capacity enhancement document 2) R&M document
3	Annual Gross Unit generation	Lakh kWh	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) CPP main energy meter reading record 4) Energy Management System data	1) Energy Meter
4	Auxiliary Power Consumption	Lakh kWh	Continuous, Hourly, daily, Monthly	1) Daily Power Report 2) Monthly Power Report 3) CPP main energy meter reading record 4) Energy Management System data	1) Energy Meter 2) Equipment List
5	Design Heat Rate	kcal/ kWh	Annual	1) OEM document on designed heat rate	1) PG test document
6	Running Hours	Hrs	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) Energy Management System data	1) Break down report 2) Operators Shift Register
	Inlet Steam				

7	Total Steam Flow	Tonne	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) DCS/SCADA Records	1) Makeup water Reading 2) Field Steam Flow meter reading
8	Avg. Steam Pressure	Kg/ cm2	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) DCS/SCADA Records	1) Field Pressure Meter
9	Avg.Steam Temperature	^{0}C	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) DCS/SCADA Records	1) Field Temperature Meter
10	Avg. Steam Enthalpy	kcal/ kg	Continuous, Hourly, daily, Monthly	1) Steam Table	
	Steam Extraction 1 (MP)				
11	Total Steam Flow (at the Header)	Tonne	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) DCS/SCADA Records	1) Makeup water Reading 2) Field Steam Flow meter reading
12	Avg. Steam Pressure (at the Header)	Kg/ cm2	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) DCS/SCADA Records	1) Field Pressure Meter
13	Avg. Steam Temperature (at the Header)	^{0}C	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) DCS/SCADA Records	1) Field Temperature Meter

14	Avg. Steam Enthalpy (at the Header)	kcal/ kg	Continuous, Hourly, daily, Monthly	1) Steam Table	
	Steam Extraction 2 (LP)				
15	Total Steam Flow (at the Header)	Tonne	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) DCS/SCADA Records	1) Makeup water Reading 2) Field Steam Flow meter reading
16	Avg. Steam Pressure (at the Header)	Kg/ cm2	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) DCS/SCADA Records	1) Field Pressure Meter
17	Avg. Steam Temperature (at the Header)	^{0}C	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) DCS/SCADA Records	1) Field Temperature Meter
18	Avg. Steam Enthalpy (at the Header)	kcal/ kg	Continuous, Hourly, daily, Monthly	1) Steam Table	
	Steam Condensing				
18	Total Exhaust Steam Flow	Tonne	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) DCS/SCADA Records	1) Makeup water Reading 2) Field Steam Flow meter reading
20	Exhaust Steam Vacuum	Kg/ cm2 (a)	Continuous, Hourly, daily, Monthly	1) Daily Generation Report 2) Monthly Generation Report 3) DCS/SCADA Records	1) Field Pressure Meter

Power from dedicated line					
1	Power wheeled through dedicated line in MW (average for the year)	MW	Hourly, daily, monthly	1) Energy Meter reading for nos of hours, 2) Daily Power Report	Energy Meter
2	Electricity wheeled in a year in lakh kWh	Lakh kWh		1) Separate Energy Meter Reading 2) Daily and Monthly Power Report	
3	Heat Rate of wheeled imported Electricity in kcal/kWh	kcal/ kWh	daily, Monthly	1) Power Purchase Agreement 2) DGR of Sister concern from where the power is wheeled	1) Primary document from the sister concern 2) Excise document of purchase electricity
Power Export and Colony/Others consumption					
1	Quantity of electricity sold to the grid in Lakh kWh.	Lakh kWh	Continuous, Hourly, daily, Monthly	1) Daily Power Report 2) Monthly Power Report 3) Export main energy meter reading record 4) Energy Management System data 5) Monthly Export bill receipt sent to utility	Export Energy Meter
2	Quantity of electricity consumed in colony /other in Lakh kWh.	Lakh kWh	Continuous, Hourly, daily, Monthly	1) Daily Power Report 2) Monthly Power Report 3) Colony/other main energy meter reading record 4) Energy Management System data	1) colony/Others meter

TABLE 8: OWN GENERATION THROUGH CAPTIVE POWER PLANTS

Sr No	Details	Unit	Frequency of record	Primary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor	Secondary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor
Solid Fuel Consumption					
A	**Coal (Indian) / Petcoke/ Coal (Imported) / Coal (Lignite)/Coal 1/Coal 2/Coal 3/ Coal 4 (Other Solid Fuel)/Dolachar/Coal fines/Met Coke/Coke Breeze /Nut coke/Lump Coke (Imported)**				
1	Landed cost of Solid Fuel i.e. Basic Cost+All Taxes + Freight. The landed cost of last purchase order in the financial year	Rs./ MT	Annual	1) Purchase Order for basic rates and taxes 2) Freight document for rates	
2	Gross calorific value (As Fired Basis) of solid fuel consumed for power generation	kcal/ kg	Lot, Daily, Monthly, Quarterly	1) Daily Internal Report from Lab on Fuel Proximate Analysis performed on each lot. 2) Test Certificate from Government Accredited lab. (Plant to maintain minimum 1 sample test in a quarter for Proximate and Ultimate Analysis i.e. 4 test certificates in a year for each fuel in case of CPP/Cogen/WHRB Fuel, for Process Fuel 1 sample test in a quarter for Proximate Analysis) 3) Purchase Order, where guaranteed GCV range is mentioned	1) Lab Register on Fuel Testing for Proximate Analysis 2) Calibration Record of instrument used for testing 3) Lab register 4) Lab analysis procedure documents 5) Sampling methodology document

[4]Location of sampling: As fired Fuel after the Grinding Mill
[5]Location of sampling: As fired Fuel after the Grinding Mill

3	Gross calorific value (As Fired Basis) of solid fuel consumed in the process	kcal/ kg	Lot, Daily, Monthly, Quarterly	1) Daily Internal Report from Lab on Fuel Proximate Analysis performed on each lot. 2) Test Certificate from Government Accredited lab. (Plant to maintain minimum 1 sample test in a quarter for Proximate and Ultimate Analysis i.e. 4 test certificates in a year for each fuel in case of CPP/Cogen/WHRB Fuel, for Process Fuel 1 sample test in a quarter for Proximate Analysis) 3) Purchase Order, where guaranteed GCV range is mentioned	1) Lab Register on Fuel Testing for Proximate Analysis 2) Calibration Record of instrument used for testing 3) Lab register 4) Lab analysis procedure documents 5) Sampling methodology document
4	Annual solid fuel quantity purchased	Tonne	Lot, Daily, Monthly, Yearly	1) Purchase Order 2) Stores Receipt 3) SAP Entry in MM/PP/FI module 4) Annual Report	1) Stores Receipt Register
5	Annual solid fuel moisture % (As Received Basis)	%	Lot, Daily, Monthly, Yearly	1) Daily Internal Report from Lab on Fuel Proximate Analysis performed on each lot. 2) Purchase Order, where guaranteed % moisture range is mentioned	1) Lab Register on Fuel Testing for Proximate Analysis 2) Calibration Record of instrument used for testing
6	Annual solid fuel quantity consumed in power generation	Tonne	Hourly, Daily and Monthly	1) DPR 2) MPR 3) CPP/Cogen/WHRB Log Sheet 4) SAP Entry in MM/PP/FI module 5) Annual Report	1) Belt Weigher before Coal Bunker

7	Annual solid fuel quantity consumed in process	Tonne	Hourly, Daily and Monthly	1) DPR 2) MPR 3) Major Eqp Log Sheet 4) SAP Entry in MM/PP/FI module 5) Annual Report	1) Belt Weigh Feeder 2) Solid Flow Meter
B	**Biomass and other renewable solid fuel / Solid waste**				
1	Landed cost of Solid Fuel i.e. Basic Cost+All Taxes + Freight. The landed cost of last purchase order in the financial year	Rs./ Tonne	Yearly	1) Purchase Order for basic rates and taxes 2) Freight document for rates	
2	Gross calorific value of biomass / solid waste	kcal/ kg	Lot, Daily, Monthly, Quarterly	1) Daily Internal Report from Lab on Fuel Proximate Analysis performed on each lot. 2) Test Certificate from Government Accredited lab (NABL). (Plant to maintain minimum 1 sample test in a quarter for Proximate and Ultimate Analysis i.e. 4 test certificates in a year for each fuel in case of CPP Fuel, for Process Fuel 1 sample test in a quarter for Proximate Analysis) 3) Purchase Order, where guaranteed GCV range is mentioned	1) Lab Register on Fuel Testing for Proximate Analysis 2) Calibration Record of instrument used for testing 3) Lab register 4) Lab analysis procedure documents 5) Sampling methodology document
3	Annual biomass/ solid waste quantity purchased	Tonne	Lot, Daily, Monthly, Yearly	1) Purchase Order 2) Stores Receipt 3) SAP Entry in MM/PP/FI module 4) Annual Report	1) Stores Receipt Register

4	Annual solid fuel moisture % (As Received Basis)	%	Lot, Daily, Monthly, Yearly	1) Daily Internal Report from Lab on Fuel Proximate Analysis performed on each lot. 2) Purchase Order, where guaranteed % moisture range is mentioned	1) Lab Register on Fuel Testing for Proximate Analysis 2) Calibration Record of instrument used for testing
5	Annual biomass/ solid waste Consumed in power generation	Tonne	Hourly, Daily and Monthly	1) DPR 2) MPR 3) CPP Log Sheet 4) SAP Entry in MM/PP/FI module 5) Annual Report	1) Belt Weigher before Coal Bunker
6	Annual biomass/ solid waste consumed in processing	Tonne	Hourly, Daily and Monthly	1) DPR 2) MPR 3) Major Eqp Log Sheet 4) SAP Entry in MM/PP/FI module 5) Annual Report	1) Belt Weigh Feeder 2) Solid Flow Meter

TABLE 9: SOLID FUEL CONSUMPTION

Sr No	Details	Unit	Frequency of record	Primary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor	Secondary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor
Liquid Fuel Consumption					
A	**Furnace Oil**				
1	Landed cost of Solid Fuel i.e. Basic Cost+All Taxes + Freight. The landed cost of last purchase order in the financial year	Rs/ Tonne	Annual	1) Purchase Order for basic rates and taxes 2) Freight document for rates	

[6]Government Accredited Lab: National Accreditation Board for Testing and Calibration Laboratories(NABL Labs)

2	Gross calorific value of furnace oil	kcal/ kg	Lot, Monthly, Yearly	1) Test report from Supplier 2) Internal Test Report from lab 3) Test report from Government Accredited (NABL) Lab 4) Standard Value as per Notification	Lab Register
3	Annual furnace oil quantity purchase	kL	Lot, Monthly, Yearly	1) Purchase Order 2) Stores Receipt 3) SAP Entry in MM/ PP/FI module 4) Annual Report	Stores Receipt
4	Density of furnace oil	kg/Ltr	Lot, Monthly, Yearly	1) Test report from Supplier 2) Internal Test Report from lab 3) Test report from Government Accredited (NABL) Lab 4) Standard Value as per Notification	Lab Register
5	Furnace oil quantity consumed in DG set for power generation	kL	Daily, Monthly, Yearly	1) Daily Generation Report 2) Monthly Generation Report 3) DG Log Sheet 4) SAP Entry in MM/ PP/FI module 5) Annual Report	Flow Meter, Dip measurement in day tank
6	Furnace oil quantity consumed in CPP for power generation in kilo liters.	kL	Daily, Monthly, Yearly	1) Daily Generation Report 2) Monthly Generation Report 3) CPP Log Sheet 4) SAP Entry in MM/ PP/FI module 5) Annual Report	Flow Meter, Dip measurement in day tank

7	Furnace oil quantity used in process heating (including Pyro-processing and Product mill Hot Air Generator) in kilo litres.	kL	Daily, Monthly, Yearly	1) DPR 2) MPR 3) Major Eqp Log Sheet 4) Product Mill Log Sheet 5) SAP Entry in MM/ PP/FI module 6) Annual Report	Flow Meter, Dip measurement in day tank
B	**LSHS/HSHS**				
1	Landed cost of Solid Fuel i.e. Basic Cost+All Taxes + Freight. The landed cost of last purchase order in the financial year	Rs/ Tonne	Annual	1) Purchase Order for basic rates and taxes 2) Freight document for rates	
2	Gross calorific value of LSHS/ HSHS	kcal/ kg	Lot, Monthly, Yearly	1) Test report from Supplier 2) Internal Test Report from lab 3) Test report from Government Accredited Lab 4) Standard Value as per Notification	Lab Register
3	Annual LSHS/ HSHS quantity purchase	Tonne	Lot, Monthly, Yearly	1) Purchase Order 2) Stores Receipt 3) SAP Entry in MM/ PP/FI module 4) Annual Report	Stores Receipt
4	LSHS/HSHS quantity consumed in DG set for power generation	Tonne	Daily, Monthly, Yearly	1) Daily Generation Report 2) Monthly Generation Report 3) DG Log Sheet 4) SAP Entry in MM/ PP/FI module 5) Annual Report	Flow Meter, Dip measurement in day tank

5	LSHS/HSHS quantity consumed in CPP for power generation	Tonne	Daily, Monthly, Yearly	1) Daily Generation Report 2) Monthly Generation Report 3) CPP Log Sheet 4) SAP Entry in MM/ PP/FI module 5) Annual Report	Flow Meter, Dip measurement in day tank
6	LSHS/HSHS quantity consumed in process heating.	Tonne	Daily, Monthly, Yearly	1) DPR 2) MPR 3) Major Eqp Log Sheet 4) Product Mill Log Sheet 5) SAP Entry in MM/ PP/FI module 6) Annual Report	Flow Meter, Dip measurement in day tank
C	**HSD/LDO**				
1	Landed cost of Solid Fuel i.e. Basic Cost+All Taxes + Freight. The landed cost of last purchase order in the financial year	Rs./ Tonne	Annual	1) Purchase Order for basic rates and taxes 2) Freight document for rates	
2	the gross calorific value of HSD/LDO	kcal/ kg	Lot, Monthly, Yearly	1) Test report from Supplier 2) Internal Test Report from lab 3) Test report from Government Accredited Lab 4) Standard Value as per Notification	Lab Register
3	Annual HSD/ LDO quantity purchase	kL	Lot, Monthly, Yearly	1) Purchase Order 2) Stores Receipt 3) SAP Entry in MM/ PP/FI module 4) Annual Report	Stores Receipt

4	Density of HSD/LDO	kg/Ltr	Lot, Monthly, Yearly	1) Test report from Supplier 2) Internal Test Report from lab 3) Test report from Government Accredited Lab 4) Standard Value as per Notification	Lab Register
5	HSD/LDO quantity used in DG set for power generation	kL	Daily, Monthly, Yearly	1) Daily Generation Report 2) Monthly Generation Report 3) DG Log Sheet 4) SAP Entry in MM/ PP/FI module 5) Annual Report	Flow Meter, Dip measurement in day tank
6	HSD/LDO quantity used in CPP for power generation	kL	Daily, Monthly, Yearly	1) Daily Generation Report 2) Monthly Generation Report 3) CPP Log Sheet 4) SAP Entry in MM/ PP/FI module 5) Annual Report	Flow Meter, Dip measurement in day tank
7	HSD/LDO quantity used in Transportation, if any	kL	Daily, Monthly, Yearly	1) Vehicle Log book 2) Stores Receipt 3) Fuel Dispenser meter reading 4) Work Order for Internal Transportation	
8	HSD/LDO quantity used in process heating	kL	Daily, Monthly, Yearly	1) DPR 2) MPR 3) Major Eqp Log Sheet 4) Product Mill Log Sheet 5) SAP Entry in MM/ PP/FI module 6) Annual Report	Flow Meter, Dip measurement in day tank

D	**Liquid Waste**				
1	Landed cost of Solid Fuel i.e. Basic Cost+All Taxes + Freight. The landed cost of last purchase order in the financial year	Rs/ Tonne	Annual	1) Purchase Order for basic rates and taxes 2) Freight document for rates	
2	Gross calorific value of liquid waste	kcal/ kg	Lot, Monthly, Yearly	1) Test report from Supplier 2) Internal Test Report from lab 3) Test report from Government Accredited Lab 4) Standard Value as per Notification	Lab Register
3	Annual liquid waste quantity purchase	kL	Lot, Monthly, Yearly	1) Purchase Order 2) Stores Receipt 3) SAP Entry in MM/ PP/FI module 4) Annual Report	Stores Receipt
4	Density of liquid waste	kg/Ltr	Lot, Monthly, Yearly	1) Test report from Supplier 2) Internal Test Report from lab 3) Test report from Government Accredited Lab 4) Standard Value as per Notification	Lab Register
5	Liquid waste quantity consumed in DG set for power generation	kL	Daily, Monthly, Yearly	1) Daily Generation Report 2) Monthly Generation Report 3) DG Log Sheet 4) SAP Entry in MM/ PP/FI module 5) Annual Report	Flow Meter, Dip measurement in day tank

6	Liquid waste quantity consumed in CPP for power generation	kL	Daily, Monthly, Yearly	1) Daily Generation Report 2) Monthly Generation Report 3) CPP Log Sheet 4) SAP Entry in MM/ PP/FI module 5) Annual Report	Flow Meter, Dip measurement in day tank
7	Liquid waste quantity consumed in process heating	kL	Daily, Monthly, Yearly	1) DPR 2) MPR 3) Major Eqp Log Sheet 4) Product Mill Log Sheet 5) SAP Entry in MM/ PP/FI module 6) Annual Report	Flow Meter, Dip measurement in day tank

TABLE 10: LIQUID FUEL CONSUMPTION

Sr No	Details	Unit	Frequency of record	Primary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor	Secondary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor
	Gaseous Fuel Consumption				
A	**Natural Gas (CNG/NG/PNG/LNG)**				
1	Landed cost of Solid Fuel i.e. Basic Cost+All Taxes + Freight. The landed cost of last purchase order in the financial year	Rs./ Tonne	Annual	1) Purchase Order for basic rates and taxes 2) Freight document for rates	

2	Gross calorific value of NG	kcal/ SCM	Lot, Monthly, Yearly	1) Test report from Supplier 2) Test report from Government Accredited Lab 3) Standard Value as per Notification	
3	Annual NG quantity purchase	Million SCM	Lot, Daily, Monthly, Yearly	1) Purchase Order 2) Stores Receipt 3) SAP Entry in MM/PP/ FI module 4) Annual Report	Gas Meter Reading, Bullet Pressure Reading
4	NG quantity consumed in power generation	Million SCM	Continuous, Daily, Monthly, Yearly	1) Daily Generation Report 2) Monthly Generation Report 3) GG Log Sheet 4) SAP Entry in MM/PP/ FI module 5) Annual Report	Gas Meter Reading, Bullet Pressure Reading
5	NG quantity consumed in transportation	Million SCM	Daily, Monthly, Yearly	1) Vehicle Log book 2) Stores Receipt 3) Fuel Dispenser meter reading 4) Work Order for Internal Transportation	Gas Meter Reading, Bullet Pressure Reading
6	NG quantity consumed in process heating	Million SCM	Daily, Monthly, Yearly	1) DPR 2) MPR 3) Major Eqp Log Sheet 4) Product Mill Log Sheet 5) SAP Entry in MM/PP/ FI module 6) Annual Report	Gas Meter Reading, Bullet Pressure Reading

B	**Liquefied Petroleum Gas (LPG)**				
1	Landed cost of Solid Fuel i.e. Basic Cost+All Taxes + Freight. The landed cost of last purchase order in the financial year	Rs./ Tonne	Annual	1) Purchase Order for basic rates and taxes 2) Freight document for rates	
2	Gross calorific value of LPG in kcal/kg.	kcal/kg	Lot, Daily, Monthly, Yearly	1) Test report from Supplier 2) Test report from Government Accredited Lab 3) Standard Value as per Notification	
3	Annual LPG quantity purchase	Million kg	Lot, Daily, Monthly, Yearly	1) Purchase Order 2) Stores Receipt 3) SAP Entry in MM/PP/ FI module 4) Annual Report	Gas Meter Reading, Bullet Pressure Reading
4	LPG quantity consumed in power generation	Million kg	Daily, Monthly, Yearly	1) DPR 2) MPR 3) GG Log Sheet 4) SAP Entry in MM/PP/ FI module 5) Annual Report	Gas Meter Reading, Bullet Pressure Reading
5	LPG quantity consumed in process heating	Million kg	Daily, Monthly, Yearly	1) DPR 2) MPR 3) Major Eqp Log Sheet 4) Product Mill Log Sheet 5) SAP Entry in MM/PP/ FI module 6) Annual Report	Gas Meter Reading, Bullet Pressure Reading

TABLE 11: GASEOUS FUEL CONSUMPTION

Sr No	Details	Unit	Frequency of record	Primary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor	Secondary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor
Quality Parameters					
A	**Raw Material Quality**				
1	Raw Material Quality (Sector Specific Raw Material Quality testing)	%	Lot, Monthly	1) Internal Test Certificate 2) External Test Certificate from related Sector Govt Accredited Lab	1) Lab Test Report Register
B	**Coal Quality in CPP (As Fired Basis)**				
1	the Ash % in coal used in CPP/Cogen/ WHRB	%	Lot, Daily, Monthly, Quarterly	1) Daily Internal Report from Lab on Fuel Proximate Analysis performed on each lot. 2) Test Certificate from Government Accredited lab. (Plant to maintain minimum 1 sample test in a quarter for Proximate and Ultimate Analysis i.e. 4 test certificates in a year for each fuel in case of CPP/Cogen/WHRB Fuel, for Process Fuel 1 sample test in a quarter for Proximate Analysis) 3) Purchase Order, where guaranteed GCV range is mentioned	1) Lab Register on Fuel Testing for Proximate Analysis 2) Calibration Record of instrument used for testing

2	the Moisture % in coal used in CPP/ Cogen/WHRB				
3	the Hydrogen % in coal used in CPP/ Cogen/WHRB				
4	the GCV value of coal used in CPP/ Cogen/WHRB				

TABLE 12: DOCUMENTS FOR QUALITY PARAMETER

Sr No	Details	Unit	Require ment	Frequency of record	Primary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor	Secondary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor
Miscellaneous Data						
A. Additional Equipment installation after baseline year due to Environmental Concern						
(i)	Electrical Energy Consumption with list of additional Equipment installed due to Environmental Concern after baseline year in Sheet! AddlEqp List-Env.	Lakh kWH	List of Equipment to be filled up	Daily, Monthly, Annual	Energy Meter Readings and Power consumption details of each additional equipment installed from 1st Apr to 31st March	1) EMS 2) Energy Meter 3) Addition Equipment List with capacity and running load 4) Purchase Order document 5) SAP Data in MM module

(ii)	Thermal Energy Consumption with list of additional Equipment installed due to Environmental Concern after baseline year in Sheet! AddlEqp List-Env.	Million kcal	List of Equipment to be filled up	Daily, Monthly, Annual	Solid/Liquid/ Gaseous Fuel consumption of each additional equipment installed from 1st Apr to 31st March	1) Fuel Flow Meter 2) Weigh Feeder 3) Purchase Order document 4) SAP Data in MM module
B	**Biomass/ Alternate Fuel availability**					
(i)	Details of replacement of Bio-mass with fossil fuel due to un-availability. This is required in fossil fuel tonnage in terms of equivalent GCV of Bio-mass (Used in Process)	Tonne	Fossil Fuel: Coal/ Lignite/ Fuel Oil	Monthly	1) Authentic Document in relation to Bio-Mass/ Alternate Solid Fuel/ Alternate Liquid Fuel availability in the region. 2) Test Certificate of Bio-mass from Government Accredited Lab for GCV in Baseline and assessment year 3) Test Certificate of replaced Fossil Fuel GCV	

(ii)	Details of replacement of Alternate Solid Fuel with fossil fuel due to un-availability. This is required in fossil fuel tonnage in terms of equivalent GCV of Alternate Solid Fuel (Used in Process)	Tonne		Monthly		
(iii)	Details of replacement of Alternate Liquid Fuel with fossil fuel due to un-availability. This is required in fossil fuel tonnage in terms of equivalent GCV of Alternate Liquid Fuel (Used in Process)	Tonne		Monthly		

C	Project Activities (Construction Phase)					
(i)	Electrical Energy Consumption with list of Project Activities and energy consumed during project activities treated as Construction phase in Lakh kwh Ref: Sheet Project Activity List	Lakh kWH	List of Equipment to be filled up	Daily, Monthly	Energy Meter Readings of each project activity with list of equipment installed under each activity from 1st Apr to 31st March	1) EMS 2) Energy Meter 3) Addition Equipment List with capacity and running load 4) Purchase Order document 5) SAP Data in MM module
(ii)	Thermal Energy Consumption with list of Project Activities and energy consumed during project activities treated as Construction phase in Million kcal converted from different fuel Ref: Sheet Project Activity List	Million kcal	List of Equipment to be filled up	Daily, Monthly	Solid/Liquid/ Gaseous Fuel consumption of each project activity with list of equipment under each activity installed from 1st Apr to 31st March	1) Fuel Flow Meter 2) Weigh Feeder 3) Purchase Order document 4) SAP Data in MM module

[7]The Electrical Energy which is not included in colony/others

D	New Line/Unit Commissioning					
(i)	Electrical energy consumed in Lakh kWh during its commissioning till it attains 70% of the new line capacity utilisation	Lakh kWH		Daily, Monthly	1) Rated Capacity of new Process/ line from OEM 2) Energy Meter Readings and Power Consumption record of process/line with list of equipment installed from 1st Apr to 31st March	1) EMS 2) Energy Meter 3) Addition Equipment List with capacity and running load
(ii)	Thermal energy consumed in Million kcal during its commissioning till it attains 70% of the new line capacity utilisation. The energy is calculated after converting from the different fuel GCV used in the new process/line	Million kcal		Daily, Monthly	1) Rated Capacity of new Process/ line from OEM 2) Thermal Energy Consumption record with list of equipment from DPR/ Log book/ SAP Entry in PP module	1) Fuel Flow Meter 2) Weigh Feeder

(iii)	Final/ Intermediary Product production during its commissioning up to 70% of new line/ process capacity utilisation in Tonne	Tonne		Daily, Monthly	1) Rated Capacity of new Process/ line from OEM 2) Production record from DPR/Log book/SAP Entry in PP module	1) Weigh Feeder
(iv)	Date of achieving 70% capacity utilisation of new process/ line	Dates			1) Record/ Document from SAP Entry/Log Book Entry/ DPR/MPR	Operator's Shift Register
(v)	Electrical Energy consumed in Lakh kWh from external source during its commissioning till it attains 70% of the new unit capacity utilisation in Power generation	Lakh kWH		Daily, Monthly	1) Rated Capacity of new unit from OEM 2) Energy Meter Readings and Power Consumption record of unit from external source with list of equipment installed from 1st Apr to 31st March	1) EMS 2) Energy Meter 3) Addition Equipment List with capacity and running load

(vi)	Thermal energy consumed in Million kcal during its commissioning till it attains 70% of the new unit capacity utilisation. The energy is calculated after converting from the different fuel GCV used in the new unit in Power generation	Million kcal		Daily, Monthly	1) Rated Capacity of new unit from OEM 2) Thermal Energy Consumption record with list of equipment from DPR/ Log book/ SAP Entry	1) Fuel Flow Meter 2) Weigh Feeder
(vii)	Net generation in Lakh kwh from the new unit in power generation, used in the Product Plant till the new unit achieved 70% of Capacity Utilisation	Lakh kWH		Daily, Monthly	1) Record/ Document from SAP Entry/Log Book Entry/ DPR/MPR	1) EMS 2) Energy Meter
(viii)	Date of achieving 70% capacity utilisation of new unit in Power generation	Dates			1) Record/ Document from SAP Entry/Log Book Entry/ DPR/MPR	

E	Unforeseen Circumstances					
(i)	Electrical Energy Consumption with list of unforeseen circumstances consumed in Lakh kWh claimed for Normalisation	Lakh kWH	Unforeseen Circum-stances: Situation not under direct or indirect control of plant man-agement		1) Relevant document on Unforeseen Circumstances beyond the control of plant 2) Energy Meter Readings and Power Consumption during the said period of unforeseen circumstances	
(ii)	Thermal Energy Consumption with list of unforeseen circumstances consumed in Million kcal claimed for Normalisation	Million kcal			1) Relevant document on Unforeseen Circumstances beyond the control of plant 2) Thermal Energy Consumption record during the said period of unforeseen circumstances from DPR/ Log book/SAP Entry	

TABLE 13: DOCUMENTS RELATED TO ENVIRONMENTAL CONCERN, BIOMASS/ALTERNATE FUEL AVAILABILITY, PROJECT ACTIVITIES, NEW LINE COMMISSIONING, UNFORESEEN CIRCUMSTANCES

Sr No	Details
	Document related to external factor
(i)	**Market Demand**
	1) Product storage full record from product mill log book 2) SAP entry in SD and FI module 3) SAP entry in PP module 4) Document related to sales impact of market
(ii)	**Grid Failure**
	1) SLDC Reference No. for planned Stoppages from respective Substation 2) Log book record of Main Electrical Substation of Plant 3) DPR 4) MPR 5) SAP entry in PM module of Electrical department
(iii)	**Raw Material un-availability**
	1) Material order copy and denial document from mines owner 2) SAP entry in MM/FI module on raw material order 3) DPR 4) MPR
(iv)	**Natural Disaster**
	1) Supporting authentic document from Local district Administration 2) Major Eqp Log Sheet 3) Major Eqp operators Report book 4) DPR 5) MPR
(v)	**Major change in government policy hampering plant's process system**
	1) Government notification or statutory order 2) Authentic document from plant on effect of major eqp production due to policy change 3) DPR 4) MPR 5) SAP Entry on production change
(vi)	**Unforeseen circumstances/Labour Strike/Lockouts/Social Unrest/Riots**
	1) Relevant documents on unforeseen circumstances beyond the control of plant 2) Energy meter readings and power consumption during the said period of unforeseen circumstances 3) Thermal energy consumption record during the said period of unforeseen circumstances from DPR/Log book/SAP Entry
(vii)	**Note:**
	The hard copy/Printouts is to be signed by Authorised signatory, if SAP data is used as documents
(viii)	**Availability of documentation**
	1) For Normalisation factors, which became applicable due to external factors, authentic documents to be produced by DC for the baseline as well for the assessment year. In absence of these authentic documents, no Normalisation Factor will be applied/Considered. 2) While selecting "No" from the drop down list, the inbuilt calculation automatic treat the Normalisation for particular factor as zero. However, DC needs to submit an undertaking from the Authorized Signatory on non-availability of document

TABLE 14: DOCUMENTS RELATED TO EXTERNAL FACTOR

5. Normalization

"Normalization" means a process of rationalization of Energy and Production data of Designated Consumer to take into account changes in quantifiable terms that impact energy performance under equivalent conditions.

There are several factors that need to be taken into consideration in the assessment year such as planned shutdowns, new project commissioning, disruption of fuel supply, changes in product quality, import/export of power etc. influenced by externalities i.e., factors beyond the control of Plant, while assessing the Specific Energy Consumption (SEC) of the plant.

In order to incorporate and address the changes happening in the DCs from Baseline Year to Assessment year, Bureau has formulated Sub- Technical Committees under the Technical Committee for each sector. The sub-Technical committees include representatives from DCs, research associations, Concerned Ministries, expert bodies from government and private sector etc. The Sub-committee identified and prepared the normalization factors with consensus from the DCs.

The operating parameters in the Assessment year have to be normalized w.r.t Baseline year so as to avoid any favourable or adverse impact on the specific energy consumption of the plant. This will also assist in quantifying and establishing the benefits of the energy efficiency projects implemented by the plant

5.1 Specific Issues

1. The complete Normalization Process with equations and calculations have been dealt separately in sector specific Normalization documents. EmAEA needs to study the document to carry out the verification process.
2. The details of data furnished in Form I shall be drawn from the sector-specific Pro-forma, referred to in the guidelines, relevant to every designated consumer and the said sector-specific Pro-forma, duly filled in, shall also be annexed to Form I
3. The Sector Specific Pro-forma have built-in calculations of Normalization with specific Energy Calculation in the summary sheet. The notified Form 1 will be generated automatically from the Pro-forma, once filled in all respect.
4. The normalization will be given to DCs only upon submission of valid/authentic supporting documents for both baseline year as well as assessment year. Failing which, the DC will not be eligible for normalizations.
5. The operating parameters for which normalization is eligible/has been provided, but not being claimed, the DC should submit the valid reason for the same.
6. The new DCs, which are not notified under PAT scheme shall also fill up the Sector Specific Pro-forma for the verification of their total energy consumption.

7. Notional/Normalized Energy will not to be considered in Total Energy Consumption, while deciding whether a plant falls under the designated consumer category or not. Normalization energy is considered only in the calculation of Gate to Gate Specific Energy Consumption.

8. External factors definition: The factors over which an individual DC does not have any control but that can impact the SEC are classified as uncontrollable factors.

a. External Factors should be scrutinized carefully for Normalization applicability

b. The defined external factors in the document are to be supported by external authentic documentary evidences

c. Any other undefined external factor, which may affect production or energy of a DC should be brought in the Verification Report by EmAEA with authentic documentary evidences

d. The external factors identified are as follows:

i. Natural Disaster (Flood, Earthquake etc.)

ii. Major change in Government policy (affect plant's process system)

iii. Unforeseen Circumstances (Labor Strike/ Lockouts/Social Unrest/Riots/Others etc.)

9. Boundary Limit:

a. Establishment of plant GTG boundary is required with clear understanding of raw material input, Energy input, Power Import/Export, Intermediary product Import/Export, Colony Power, Construction/Others Power, Power supplied to other Ancillary unit outside the plant boundary

b. Inclusion and exclusion from the plant boundary is maintained as established in the baseline year

c. Section wise Screen shot of SCADA from CCR/DCS is to be included in the verification report

d. Single line diagram of the DC showing the plant boundary, entire process with input fuel, raw material, and product(s) on gate to gate concept, for both baseline year and assessment year

e. Raw material input in the Plant boundary to be recorded for inclusion in the verification report

5.2 Fuel

1. Fuel Testing

i. Validation of Fuel quality testing from external and internal lab for same sample for each solid fuel used

ii. Test Certificate from external NABL Accredited Lab:

- Coal samples for testing must be picked from auto-coal-sampler
- CPP Fuel: Plant to maintain minimum 1 sample test certificate in a month for Proximate and 1 in a quarter for Ultimate Analysis
- Process Fuel: 1 sample test certificate in a month for Proximate Analysis

iii. Liquid /Gaseous Fuel Testing: As per Table in previous section

iv. Reproducibility Limit of same sample: The means of the result of duplicate determinations carried out in each of two laboratories on representative portions taken from the same sample at the last stage of sample preparation, should not differ by more than 71.7 kcal/ kg as per ISO 1928: 1995(E). If the difference is greater than 71.7 kcal/kg, the difference will be added to the GCV value of the test result obtained in DC's Lab for that particular quarter

v. Daily Proximate analysis record of all types of Coal to be maintained at Lab for ongoing submission as document related to fuel analysis

2. Note on Proximate and Ultimate Analysis of Coal

If the ultimate analysis has not been carried out in the baseline year for getting H% result, following conversion formulae from Proximate to Ultimate analysis of coal could be used for getting elemental chemical constituents like %H.The relationship is as shown,

Proximate to Ultimate Analysis Relation
%C = 0.97C+ 0.7(VM+0.1A) – M(0.6-0.01M)
%H2=0.036C+0.086(VM-0.1xA)–0.0035M2(1-0.02M)
%N2=2.10 -0.020 VM
Where
C= % of fixed carbon
A=% of ash
VM=% of volatile matter
M=% of moisture

3. The basis of Fuel sample testing i.e., As Received Basis (ARB), As Fired Basis (AFB), As Dried Basis (ADB) for calculating or measuring GCV in assessment year will be same as made during baseline year. However, the location of Fuel sample testing and weight measurement should remain identical. This will be identified in the Pro-forma under Remarks column, if the basis is other than As Fired.

4. The status quo to be maintained in the assessment year for the basis of measuring GCV of Fuel (For Ex. As Received Basis, As Fired Basis, As Dried Basis etc.) as followed in the baseline year i.e., if DC has submitted GCV value on "as received basis", the basis will be same in the assessment year as well. The DC has to write in the remarks/source of data field on basis of GCV taken in the assessment year. However, the EmAEA is requested to report the Fuel GCV "As fired basis" in the verification report, which may become baseline for subsequent PAT cycles.

5. Standard applicable IS Norms should be followed for Fuel (Solid, Liquid, Gas) sampling for internal or external lab from different location

6. Internal Coal Testing method to be elaborated as per IS Norms and to be included as document in the EmAEA report.

7. Gross Calorific Value or High Heat Value:

a. It is advised to measure the GCV of coal with the help of Bomb Calorimeter only in the assessment year and record the value daily in the LAB register for ongoing submission as document related to fuel analysis.

b. The calculation method for calculating GCV/NCV from Proximate and Ultimate Analysis in the assessment year will remain same as made during baseline year.

c. In the absence of formulae for calculating GCV, the following Dulong's formulae may be used for Gross Calorific Value (GCV) or High Heat Value (HHV) calculation

Q = 81 x C + 342.5 x [H - O/8) + 22.5 x S Where Q is GCV in kcal/kg C=% of carbon by weight H=%ofHydrogenbyweight O = %ofOxygenbyweight S=% ofSulphurby weight

Dulong's Formulae (Value from Ultimate Analysis) for GCV covers basic principle, that there are only 3 components in a fuel which generate heat i.e., Carbon, Hydrogen and Sulphur, as per the following equation.

98. Net Calorific Value (NCV) or Low Heat Value (LHV):

NCV = GCV - 5.87 x (9 x H + M) Where NCV = Net Calorific Value (kcal/kg) GCV=GrossCalorificValue(kcal/kg) H=%ofHydrogenbyweight M=%ofMoisturebyweight

The NCV includes the Steam- condensing latent heat, the NCV is defined as the gross calorific value minus the latent heat of condensation of water (at the initial temperature of the fuel), formed by the combustion of hydrogen in the fuel. The latent heat of steam at ordinary temperature may be taken as 587kcal/kg. The expression is as shown.

5.3 Normalization Condition and calculation

1. Plant should maintain the records of the number of outages during the baseline and assessment year.
2. Plant needs to maintain proper Energy Meter Reading/Records due to external factors for baseline as well as for assessment year.
3. Section wise Energy metering (Electrical and Thermal) is required for making Equivalent Product in Textile sub-sectors. Proper calculation document should be maintained, if energy figures are arrived by calculation method
4. Plant to maintain Frequency of calibration and records of Energy monitoring equipment.
5. Calibration records of all weighing and measurement system with frequency of calibration to be included in the verification report.
6. The documents maintained by DCs should clearly show the direct reasons of the shutdown along with time and duration in hours and Energy consumed with quantity of Feed to reach the pre-shutdown production level for each such break-down or shutdown.
7. Additional Nos of Equipment details in Pro-forma:

a. Additional Product/Section detail: The Designated Consumer may furnish additional Product/Section details as per sectional format in a separate Excel Sheet for insertion in the existing Pro-forma if sectional input data format is full. Otherwise, Total energy of additional section or product could be converted into the last product or section through SEC of both the product/section and feed the same in the last product/

section format for baseline as well as for assessment year.

b. Additional Boiler detail (Process/ Cogen): Additional Nos of Process or Co-gen boiler will be annexed in a separate Excel sheet as per the format provided in the Pro-forma for Boilers.

8. Lump CPPs: Information for all parameters of CPPs in Weighted Average terms w.r.t Gross Unit Generation in the CPP section, except for Design Heat Rate DHR (1,2) = DHR1 x C1+DHR2 x C2+…/ (C1+C2….)

9. Lump Co-Gen (Extraction cum Condensing): The total numbers of Co-Gen should be treated as lump power source and accordingly details to be filled in the Pro-forma as per following example in Table No #14 separately for Extraction cum Condensing Turbine

10. Lump Co-Gen (Back Pressure): The total numbers of Co-Gen should be treated as lump power source and accordingly details to be filled in the Pro-forma as per below,

Sr No	Description	Formulae	Unit	Remarks
(i)	Install Capacity (C1…. Cn)13	C1+C2+…Cn	MW	Sum of capacity
(ii)	Annual Gross Unit generation (AGG1… AGGn)	AGG1+AGG2+…AGGn	Lakh kWh	Sum of Generation
(iii)	Auxiliary Power Consumption (APC1…. APCn)	APC1 +APC2…APCn	Lakh kWh	Sum of APC
(iv)	Design Heat Rate	DHR (1,2…n) = DHR1 x C1+DHR2 x C2+…. / (C1+C2…. Cn)	kcal/ kWh	Weighted Average of Design Heat Rate w.r.t to Installed Capacity
(v)	Running Hours	(RH1xAGG1+RH2xAGG2+ ……. RHnxAGGn)/ (AGG1+AGG2+… AGGn)	Hrs	Weighted Average of Running Hours w.r.t to Annual Generation
(vi)	Auxiliary Power Consumption	(ii) x 100/(iii)	%	APC%
(vii)	Total Thermal energy used in Process	TEPr1+TEPr2+…TEPrn	Million kcal	Sum of Total Thermal Energy used in Process
(viii)	Total Thermal energy used in Power	TEPo1+TEPo2+…TEPon	Million kcal	Sum of the total energy used in power
(ix)	Heat Rate of Co-Gen	HR1xAGG1+…+HRn x AGGn/ (AGG1+…+AGGn)	kcal/kwh	Weighted average of heat rate

TABLE 15: LUMP CO-GENERATION TREATMENT

11. In case a DC commissions a new line/ production unit before or during the assessment/target year, the production and energy consumption of new unit will be considered in the total plant energy consumption and production volumes once the Capacity Utilisation of that line has touched / increased over 70%. However, the energy consumption and production volume will not be included till it attains 70% of Capacity Utilisation. Energy consumed and production made (if any) during any project activity during the assessment year, needs to be exclusively monitored and will be subtracted from the total energy and production in the Assessment year. Similarly, the same methodology will be applied on a new unit installation for power generation (CPP) within the plant boundary. The Capacity Utilisation will be evaluated based on the OEM document on Rated Capacity or Name plate rating on capacity of New Line/ Production Unit and the production of that line/unit as per DPR/ Log sheet.

5.4 Normalisation General Issue

1. Normalisation Environmental Concern: Any additional equipment installed to comply with the Environmental standards as applicable in the baseline, will not qualify for this Normalization i.e., If any Plant after the baseline year has deviated from the Environmental Standards imposed in the baseline year and additional equipment have been installed after the baseline year to comply with these Standards, the plant is not eligible for Normalization.

2. Unavailability of biomass/Alternate fuel in assessment year as compared to the baseline year due to external factor. The normalization for Unavailability for Biomass or Alternate Fuel takes place only if sufficient evidence in-terms of authentic document is produced. Plant to furnish the data replacement of fossil fuel from Biomass/ Alternate Fuel (Solid/ Liquid) in the assessment year w.r.t. baseline year. The energy contained by the fossil fuel replacement will be deducted in the assessment year

3. If a captive power plant or cogeneration plant caters to two or more DCs for the electricity and/or steam requirements. In such scenario, each DC shall consider such captive power plant or cogeneration plant in its boundary and energy consumed by such captive power plant or cogeneration plant shall be included in the total energy consumption. However, electricity in terms of calorific value (as per actual heat rate) and steam in terms of calorific value (as per steam enthalpy) exported to other plants shall be subtracted from the total energy consumption.

4. Normalisation for Start Stop: The Designated Consumer has to furnish the Electrical and Thermal Energy Consumption by taking into account the saleable or intermediate production made during Hot-Cold Stop and Cold-Hot Start.

a. Hot to Cold Stop: The Plant ceases to halt after abrupt tripping of main equipment due to external factor.

b. Cold to Hot Start: The Plant is restarted after a brief halt / stoppage to reach the normal production

5. For the Start/Stop Normalization following factor may be considered:

a. At the time of Hot to Cold stop, due to external factors, electric energy consumed in the major section/plant to maintain essential loads of the plant shall be deducted from the total energy consumption.

b. At the time of Cold to Hot start after Hot to Cold stop due to external factors, specific energy consumption of the major section/major equipment shall be multiplied with the actual production during this time and added to the total energy consumption.

c. The actual equivalent production shall also be added to the total production. For the purpose of clarity, equivalent production means the amount of production of that major section/ equipment converted into the major product output.

6. For Normalization factors, which became applicable due to external factors, authentic documents to be produced by DC for the baseline as well for the assessment year. In absence of these authentic documents, no Normalization Factor will be applied/ Considered.

7. Investment for year 2015-16,2016-17, 2017-18 and 2018-19 will be included in the assessment year of sector specific pro- forma

8. Any factor, which has not been considered in the document and Form 1, the Empanelled Accredited Energy Auditor will report it separately with possible solution for the same and Annexed to the Form B (Verification Form)

9. Sector specific Pro-forma, Normalization document and aforementioned guidelines are the major elements of the M&V process, and additional Sector Specific M&V guidelines are provided in Annexure I-VIII.

10. Some of the information sought under this annexure could be considered as supporting information/documents, which may help EmAEA in submitting the Form B.

11. Plant to maintain Frequency of calibration and records of Energy monitoring equipment.

12. Calibration records of all weighing and measurement system with frequency of calibration to be included in the verification report.

13. The documents maintained by DCs should clearly show the direct reasons of the shutdown along with time and duration in hours and Energy consumed with quantity of Feed to reach the pre-shutdown production level for each such break-down or shutdown.

Quick Pointers for PAT-II DCs

1. SEC improvement from baseline period 2014-15 to assessment period 2018-19, should be cross checked and verified by EmAEA during M&V Audit based on best operating practices, Energy efficiency & conservation measures or any other relevant measures taken up by plant during the cycle. The same verification details should be incorporated in M&V Report.
2. Establish and report the plant Mass & Energy balance on Gate-to-Gate basis for entire plant and also for each plant/ mill section.
3. Submission of minutes of meeting (MoM) for plant visit duly signed by every team member of EmAEA agency and plant officials is mandatory to ensure the presence of the members. BEE will interact with that only team members who had visited the plant while verification & finalization of the report, not with the others.
4. EmAEA should report the process technology based on product-wise with respect to the operational characteristics of each process. The same should be incorporated in M&V Audit Report.
5. Identify and report the major energy intensive processes and equipment inside the plant boundary where the total energy consumption of the plant is accounted. Also please ensure to include the additional facilities related to environmental compliance, if any.
6. Observe and compile various Energy Conservation (ENCON) measures implemented by the plant.

7. Evaluate and project the energy saving potential in terms of "Metric Ton of Oil Equivalent (MTOE)" available in the plant in the next three calendar years by means of analysing the plant performance in previous PAT cycles which would occur due to process change, efficiency improvement, retrofitting or fine tuning of operational parameters, etc.
8. The report should also include future/projected energy conservation plans/measures/investments in consultation with the management of the DC.

Mandatory:

1. With reference to the (a) Energy Conservation Rule, 2012 (GSR 269 (E), dt. 30/3/2012) and its amendment rule, 2016 (GSR 373 (E), dt. 31/3/2016); **kindly complete the "Monitoring & Verification" of your plant within FOUR MONTHS time period w.e.f. 1st April, 2019** and submit the verification report along with all relevant performance assessment documents & supporting documents as per given rule. The last date for entire M&V process completion is 31st July 2019 (Wednesday).
2. DC must ensure the presence of EmAEA agency's team member (Lead AEA, 3 Energy Auditors & relevant Sector Expert) at site during M&V Period. EmAEA agency team member details are given in updated list of EmAEA as on dated 15.4.2019 who are empanelled for PAT Cycle-II M&V Audit. Absence of any member should be reported to BEE and SDA immediately

Abbreviations

1. ARU – Amine Recovery Unit
2. ASU – Air Separation Unit
3. BBL – Billion Barrels
4. BBU – Bitumen Blowing Unit
5. CCR – Continuous Catalytic Reforming
6. CDU – Crude Distillation unit
7. CFBC – Circulating Fluidized Bed combustion
8. CPP – Captive power plant
9. CRU – Catalytic Reformer Unit
10. DCS – Distributed control System
11. DHDS – Diesel Hydrodesulphurization
12. DHDT – Diesel Hydrotreating
13. DISCOM – Distribution Company
14. GCV – Gross calorific value
15. ISOM – Isomerization Unit
16. LPG – Liquified Petroleum Gas
17. MMBTU – Metric Million British Thermal Units
18. MMTPA – Million Metric Tonnes per Annum
19. MSQ – Motor Spirit Quality
20. MTBE – Methyl Tert-Butyl Ether
21. MTOE – Metric Tonnes of Oil Equivalent
22. NCV – Net calorific value
23. NHR – Net Heat rate
24. NHT – Naphtha Hydrotreater Unit
25. NRGF – Energy Factor
26. NSU – Naphtha Splitter unit
27. PDU – Propane De-asphalting Unit
28. PLC – Programmable Logic controller
29. PSA – Pressure Swing Adsorption
30. SRFT – Standard Refinery Fuel Tonnes
31. SRU – Solvent Recovery Unit
32. VBU – Vis-breaker Unit
33. VDU – Vacuum Distillation Unit
34. VGO – Vacuum Gas Oil
35. VRU – Vacuum Residue Unit

Annexure I: Thermal Power Station

1. Auxiliary Power Consumption (APC)

   EmAEA may verify the section/equipment wise motor ratings. The sections/equipment shall include

a. Boilers and Auxiliaries

TABLE 16: AUXILIARY POWER CONSUMPTION DETAILS (A, B, C)

S. No.	Equipment	Power Rating (kW)	Current Rating (Amperes)
1.	Coal Grinding Mills		
2.	Coal Feeders		
3.	Boiler Re-Circulation Pump		
4.	Primary Air(PA) Fans		
5.	Secondary Air(SA) Fans		
6.	Induced Draught (ID) Fans		
7.	Seal Air fans		
8.	Scanner air fans		
9.	Air Pre-Heater (APH)		
10.	Miscellaneous/ Missed out equipment		

b. Turbine and auxiliaries

S. No.	Equipment	Power Rating (kW)	Current Rating (Amperes)
1.	Condensate Extraction Pump (CEP		
2.	Boiler Feed Pump (BFP)		
3.	Boiler Feed-booster Pump (BFBP)		
4.	Closed Circuit Cooling Water (CCCW) Pump/ De-Mineralised Cooling Water (DMCW) Pump		
5.	Auxiliary Cooling Water (ACW) Pumps		
6.	Condensate Polishing Unit (CPU)		
7.	Lube Oil Pumps		
8.	Seal Oil Pumps		
9.	Miscellaneous equipment		
10.	Miscellaneous equipment		

c. Balance of Plant

S. No.	Equipment		Power Rating (kW)	Current Rating (Amperes)
1.	Compressed Air System			
	a)	Instrument Air Compressor		
	b)	Service Air Compressors		
2.	Cooling Water (CW) Pumps			
3.	Cooling Tower (CT) Fans			
4.	Water Treatment Plant (WTP)			
	a)	Clarifiers		
	b)	Filters		
	c)	Pumps		
	d)	Ion Exchangers		
	e)	Miscellaneous/Missed out equipment		
5.	Coal Handling Plant			
	a)	Wagon Unloading System		
	b)	Crushers		
	c)	Belts Conveyors		
	d)	Stacker Reclaimer		
	e)	Miscellaneous/ Missed out equipment		
6.	Ash handling System			
	a)	Pumps		
	b)	Dry Ash Handling System		
	c)	Wet Ash Handling System		
	d)	Miscellaneous/ Missed out equipment		
7.	Fire Fighting System			
8.	Air Conditioning System			
9.	Lighting			
10.	Transmission System			
11.	Miscellaneous equipment			

This data shall be produced by the DCs for verification of section wise APC. If any item has been missed out in the table above, it shall be inserted by the DC.

The DC shall submit all design documents, manufacturers' data sheet, etc. in support of the equipment ratings if required.

2. Coal Handling Plant

a. Coal Input

The DC shall submit a copy of fuel supply agreement (FSA) in which the coal quality shall appear. Also, the DC shall submit the transportation agreement/ contract indicating the amount and quality of coal procured.

a. Scheme

The DC shall provide a schematic representation of the coal handling plant indicating the flow of coal from wagons to boilers. The description shall include hours of operation and number of equipment in running and standby conditions.

b. Coal Quality

The DC shall submit the ultimate and proximate analysis report of coal from NABL as per rules along with internal lab test report. The coal sample shall be taken from the auto coal sampler installed either at coal unloading, stacking and bunker feeding. The lab report in this regard shall be accepted

3. Heat Rate

The DC shall give the fully traceable calculation for turbine heat rate, gross heat rate and net heat rate. The values taken for heat rate calculation shall be backed by evidences, which can be a screen shot of the distributed control system (DCS) for the particular parameter.

4. Parameter verification

DCs shall make the log books and daily generation report (DGR) available as and when needed.

5. Fuel Oil

DCs shall submit the liquid oil supply contract mentioning the properties of oil. Also, the consumption shall be backed by calculation and pictures/ screen shots of level indicators/flow counter, etc.

6. Balance diagrams

a. DCs shall submit the heat mass balance diagrams showing the complete cycle.

b. Water balance diagrams shall also be submitted.

7. Fuel mix normalisation in gas based thermal power plant

Due to change in fuel mix i.e. % of consumption of gas and oil/other fuel in the assessment year with reference to the baseline year, the variation in boiler efficiency is evident. The same needs to be normalised as per total generation from gas and oil/other fuel and design boiler efficiency at 100% for gas and oil/ other fuel.

8. General

a. The scheme/layout diagram of all sub-systems, e.g., coal handling plant (CHP), ash handling plant (AHP), water treatment plant (WTP), etc. shall be

submitted by DCs. This shall facilitate in identifying the boundary condition of systems/plant.

b. DCs shall submit the maintenance history of systems/equipment.

9. Plant Boundary

a. The plant boundary shall consist of the boiler, turbine and generator island, water treatment plant, effluent treatment plant (ETP), coal handling plant, ash handling plant, cooling water system, compressed air system, fire fighting system, transmission system, etc. A typical sample of a plant boundary is represented below

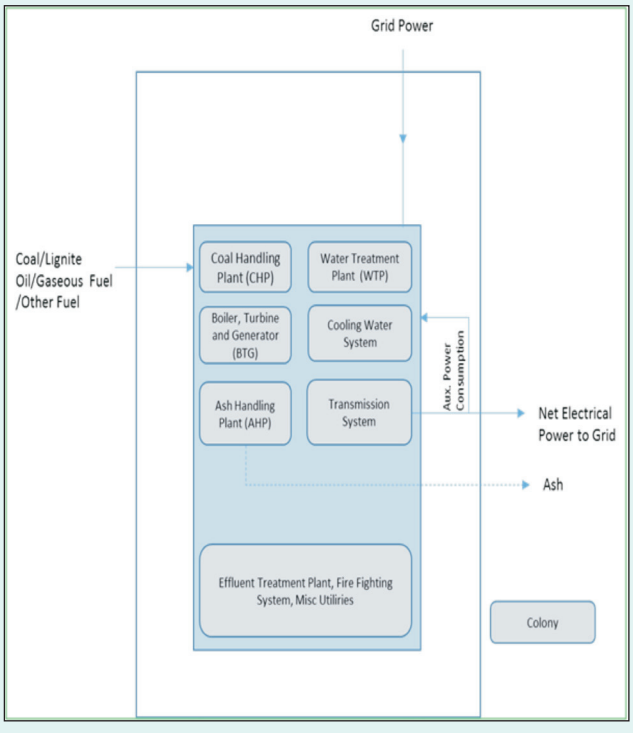


FIGURE 12: EX-GTG BOUNDARY FOR THERMAL POWER PLANT

The residential colony does not form a part of the plant boundary and hence it is kept outside in the above figure. The DC shall submit the latest plot plan of the station indicating all the systems/sub-systems.

The residential colony does not form a part of the plant boundary and hence it is kept outside in the above figure. The DC shall submit the latest plot plan of the station indicating all the systems/sub-systems.

b. The station energy balance diagram to be included in the verification report: A typical sample of the diagram is shown below for coal/lignite/oil/gas based power plant and combined cycle gas turbine

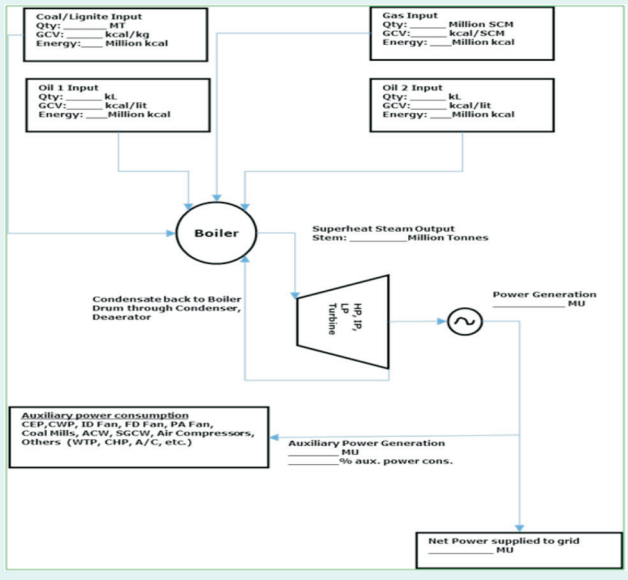


FIGURE 13: EX-COAL/LIGNITE/OIL/GAS BASED THERMAL POWER PLANT ENERGY BALANCE DIAGRAM

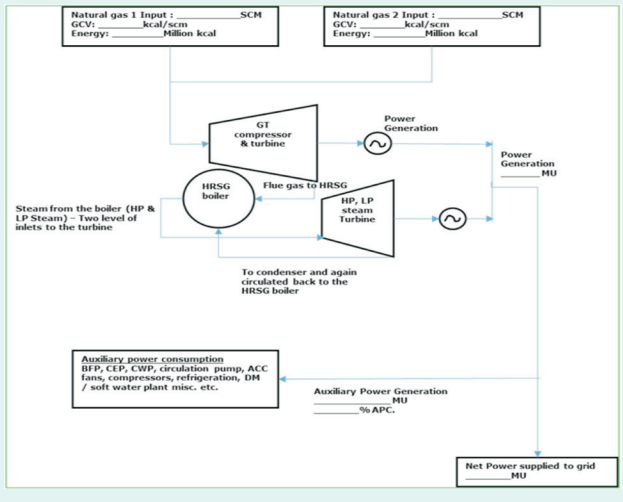


FIGURE 14: EX-CCGT ENERGY BALANCE DIAGRAM

Annexure II: Iron and Steel

A: Integrated Steel Plant

1. The data submitted for verification and other figures for SEC calculation of any unit has to be in line with the unit's declared production and consumption figures as per the statutory financial audit and declaration in their annual report.
2. The EmAEA, while verifying the SEC calculation, should also cross-verify the input figures based on the procurement plans and physical receipts.
3. The transit and handling losses have to be within the standard norms allowable under financial audit.
4. Crude steel is the product output of an integrated steel plant (ISP). The term is internationally used to mean the 1st solid steel product upon solidification of liquid steel. In other words, it includes ingots (in conventional mills) and semis (in modern mills with continuous casting facility). The PAT scheme considers crude steel as the major product output for ISPs.
5. The energy impact of any basic input such as pellet, sinter, DRI, oxygen, nitrogen, argon, which has been either imported and/or discontinued during assessment or baseline years, the upstream/notional energy impacts have to be apportioned in the SEC as the case may be.
6. Import of any finished or semi-finished fuel input say coking coal vs coke, which has been either imported and/or discontinued during assessment or baseline years, the upstream/notional energy impacts have to be apportioned in the SEC as the case may be
7. For verification process, the DC shall provide all necessary information, supporting documents and access to the plant site to the EmAEA. It will be the responsibility of the EmAEA to maintain the confidentiality of the data collected and not to use for any other purpose except for PAT.
8. Quality of raw material for the purpose of normalisation needs to be maintained as per the frequency of monitoring of the particular raw material and has to be maintained and submitted to the EmAEA by the plant, duly signed by the authorised signatory of the designated consumer.
9. In case of normalisation benefit, the unit has to provide metering and measurement of energy inputs for all the energy parameters, for which normalisation is claimed.
10. All the energy input calorific values for purchased energy and inputs that impact the energy performance of a unit shall be submitted based on suppliers' documented analysis and contractually agreed and signed documents by the competent authority. It is mandatory that all these documents are counter-signed by the auditor. A third party determination of calorific value carried out by the government accredited laboratory (NABL) of each fuel used in the plant is to be submitted for each quarter.
11. Yield of Mills shall not be greater

than 1. EmAEA needs to verify the yield for abnormal changes between baseline year and assessment year. The justification with calculation needs to be incorporated in the verification Report of EmAEA.

12. Coke Nut and Coke breeze is a part of BF grade Coke. EmAEA to take a note for the same in the verification Report of EmAEA.

13. Process route change Normalisation is applicable for change in major process due to external factor.

B: Sponge Iron Sub-Sector

1. The entire sub-sector is divided into7 groups on similarity of product

2. The major product in the 7 groups is as per the table below

Sr No	Sub-Sector Group	Major Product
1	Sponge Iron	Sponge Iron
2	Sponge Iron with Steel Melting Shop	Sponge Iron
3	Sponge Iron with Steel Melting Shop and Others (Ferro Chrome, FeMn, SiMn, Pig Iron, Ferro Silicon, Rolling Mills etc)	Sponge Iron
4	Ferro Alloy	SiMn
5	Ferro Chrome	Ferro Chrome
6	Mini Blast Furnace (MBF)	Pig Iron
7	Steel Processing Unit (SPU)	Steel

TABLE 17: SPONGE IRON SUBSECTOR MAJOR PRODUCT DETAILS

3. The energy consumption as well as production of a pellet plant shall be included in the assessment year as well as in the baseline year. The calculation for the pellet plant is included in the summary sheet of the Pro-forma.

4. For inclusion of a pellet plant in GtG Specific Energy Consumption, the DC needs to specify the same so that the summary sheet is modified.

5. Calibration records of all weighing and measurement system with frequency of calibration to be included in the verification report

6. Section-wise SCADA screen-shots if required to be included in the verification report by EmAEA.

7. Section-wise energy consumption needs to be recorded and included in the verification report.

8. The heat rate for purpose of estimating and granting credit for electricity generation only through WHRB to a Designated Consumer shall be based on design data provided by the DC upon verification by Accredited Energy Auditor or certified by EmAEA. However, in absence of this data, no credit shall be granted.

9. In case, Plant is having Rolling mills with steel melting shop then Output of steel melting shop is the major product and remaining all the products i.e. rolling mill convert to the equivalent product w.r.t. steel melting shop.

10. Quantity of Exported Dolachar is not be higher than the quantity of Dolacharinhouse produced.

11. SEC improvement from baseline period 2014-15 to assessment period 2018-19, should be cross checked and verified by EmAEA during M&V Audit based on best operating practices, Energy efficiency & conservation measures or any other relevant measures taken up by plant during the cycle. The same verification details should be incorporated in M&V Report.
12. Establish and report the plant Mass & Energy balance on Gate-to-Gate basis for entire plant and also for each plant/ mill section.
13. Submission of minutes of meeting (MoM) for plant visit duly signed by every team member of EmAEA agency and plant officials is mandatory to ensure the presence of the members. BEE will interact with that only team members who had visited the plant while verification & finalization of the report, not with the others.
14. EmAEA should report the process technology based on product-wise with respect to the operational characteristics of each process.The same should be incorporated in M&V Audit Report.
15. Identify and report the major energy intensive processes and equipment inside the plant boundary where the total energy consumption of the plant is accounted. Also please ensure to include the additional facilities related to environmental compliance, if any.
16. Observe and compile various Energy Conservation (ENCON) measures implemented by the plant.
17. Evaluate and project the energy saving potential in terms of "Metric Ton of Oil Equivalent (MTOE)" available in the plant in the next three calendar years by means of analyzing the plant performance in previous PAT cycles which would occur due to process change, efficiency improvement, retrofitting or fine tuning of operational parameters, etc.
18. The report should also include future/ projected energy conservation plans/ measures / investments in consultation with the management of the DC.
19. The equivalent product is calculated based on the product mix calculation in the Pro-forma. A typical process flow along with the location of major product is shown in the diagram. The same shall be included in the verification report for different sections of the sponge iron sub-sector.

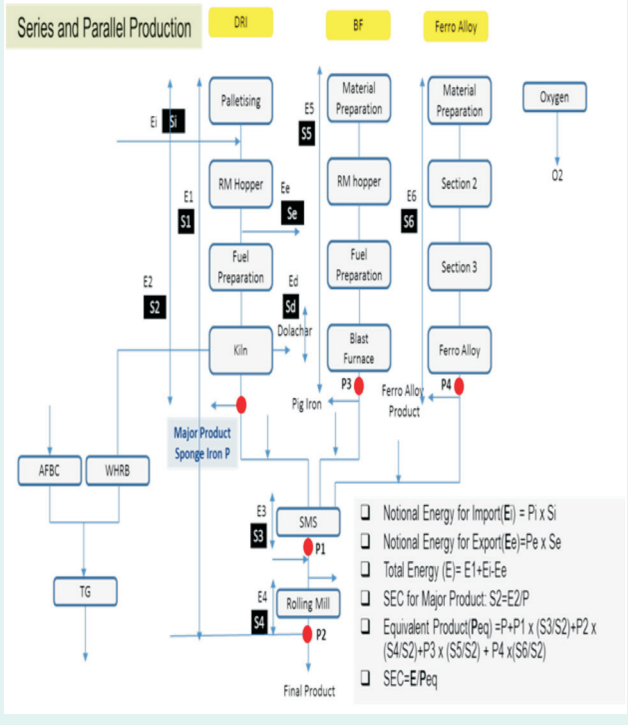


FIGURE 15: PRODUCT MIX DIAGRAM

20. Demarcation of plant boundary is required with clear understanding of raw material input, energy input, power import/export, intermediary product import/export, colony power, construction/others power, power supplied to other ancillary unit outside the plant boundary. A typical sample of plant boundary condition is represented below:

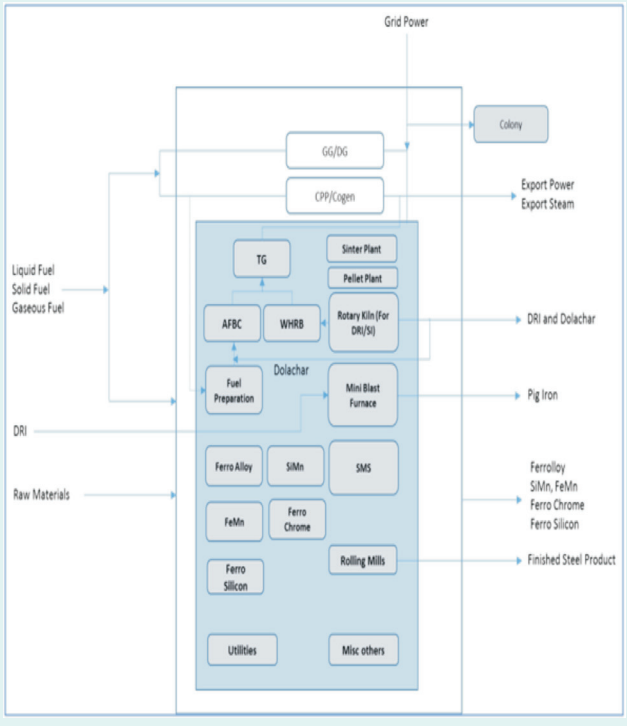


FIGURE 16: EX-GTG BOUNDARY FOR SPONGE IRON SUB-SECTOR

21. The energy and mass balance calculation is required to be included in the verification report

The ideal condition need to be assumed to find out the theoretical mass & heat balance of the kiln and its specific energy requirements. Once this is established, the actual mass & heat balance shall be worked out with SEC.

Comparison of actual SEC V/s. theoretical SEC shall give the kiln efficiency

a. Theoretical Heat Balance (Ideal Case)

To prepare the heat balance, "Hess's Law of constant Heat summation" is applied, which states "For a given chemical process the net heat charge will be same weather the process occurs in one or several stages.

Adding all reactions

$2Fe_2O_3 + 6C + 3O_2 = 4Fe + 6CO_2 + \Delta Hr$(Final reaction)

Standard heat of formation of Fe_2O_3& CO_2 are -825.5 & -393.5 KJ/mole respectively. Heat of formation of element is taken zero.

The final reaction after applying thermodynamics principal.

$\Delta Hr = \sum \Delta H$ product - $\sum \Delta H$ reactants

Negative sign indicates exothermic reaction or heat release and positive sign indicates requirement of heat

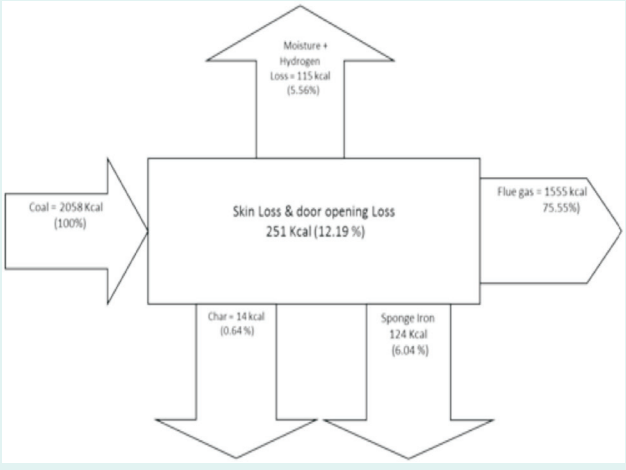
Iron ore	1.43 Kg.	Heat Supplied = 2058 Kcal	Sponge iron	1 Kg.
Coal	0.64 Kg.	⇌	Char	0.064 Kg.
Air	5.20 Kg.	-251 Kcal (Excess heat)	Flue Gas	6.20 kg.
Total Input	7.270 Kg		Total Output	7.264 Kg.

In Heat balance of ideal kiln (100% coal used as reducing agent and no coal is used as fuel)

S. No	Component	Heat Value (Kcal)
1	Sponge iron sensible heat, assuming Δt 1045° C	+124
2	Char sensible heat, assuming Δt 1045° C	+13
3	Flue gas sensible heat, assuming Δt 1045° C	+1555
4	Heat loss due to moisture present in the coal	+66
5	Heat Loss due to vapor formed from Hydrogen of fuel	+49
6	Heat of iron reduction reaction (exothermic)	-758
7	Heat gain from burning of VM of coal	-1300
8	Net heat surplus in overall	-251
9	Total Additional heat/coal requirement to produce 1 Kg Sponge Iron	Nil

b. Sankey diagram of Kiln (Ideal condition)

EmAEA is required to include the heat balance report of Kiln as per actual condition of Plant operation



c. Ideal Mass balance condition

To produce 1 kg of Sponge Iron in ideal condition i.e. with no excess air (flue gas without O_2 & CO).

Input: 0.64 kg coal, 1.43 kg Iron Ore, 5.20 Kg of Air

Output: 6.206 Kg flue gas, 0.064 Kg (Ash of Coal), 1 kg sponge iron.

Annexure III: Cement

1. Preservation power for stopped kiln: A kiln which goes under stoppages due to external factors requires a certain quantity of power for safety and certain operations, which need to be maintained. The normalisation for this power will be considered, provided the DC has the baseline and assessment year data. This difference of preservation power in the baseline as well as the assessment years shall be subtracted from the total energy consumed.

2. Frequency of lab analysis from NABL accredited laboratories for providing normalisation for raw material quality in the subsequent cycles:

2.1. Burnability analysis for raw mix – Once in each quarter

2.2. Limestone Bond index – Once in a year

3. Normalisation due to non-availability of fly ash due to external factors: DC to submit in support of claim on unavailability of fly ash during assessment year to the EmAEA with sufficient data and documentation. EmAEA to establish the facts whether in the vicinity of the particular DC, other plants/DCs are getting fly ash or not.

4. Status quo to be maintained in the assessment year for the basis of measuring GCV of fuel (for example, As Received Basis, As Fired Basis, As Dried Basis, etc.) as followed in the baseline year i.e., if the DC has submitted GCV value on an "as received basis", the basis will be same in the assessment year as well. The DC has to write in the remarks/ source of data field the basis of GCV in the assessment year. However, the EmAEA is requested to report the fuel GCV "As fired basis" in the verification report, which may become the baseline for subsequent PAT cycles.

5. Plant stoppages and start due to high clinker stock or silo full to be considered as external factor: Necessary documentation to be provided by DC as per the instructions given in the cement sector Pro-forma.

6. Normalisation on use of wet fly ash due to non-availability of dry fly ash: DC has to submit proper authentic documents to establish the increase in energy during the assessment year due to usage of wet fly ash due to external reason. EmAEA to establish the facts whether in the vicinity of the particular DC, other plants/DCs are getting dry fly ash or not

7. Normalisation for claiming Bond Index: DC has to submit the authentic lab test reports for claiming Bond Index Normalisation from NABL accredited laboratories.

8. Some of the information sought under this annexure could be considered as supporting information / documents, which may help the EmAEA in submitting the Form B.

9. Demarcation of plant boundary is required with clear understanding of raw material input, energy input, power import / export, intermediary product import / export, colony power, construction / others power, power

supplied to other ancillary unit outside the plant boundary. A typical sample of plant boundary condition is represented below:

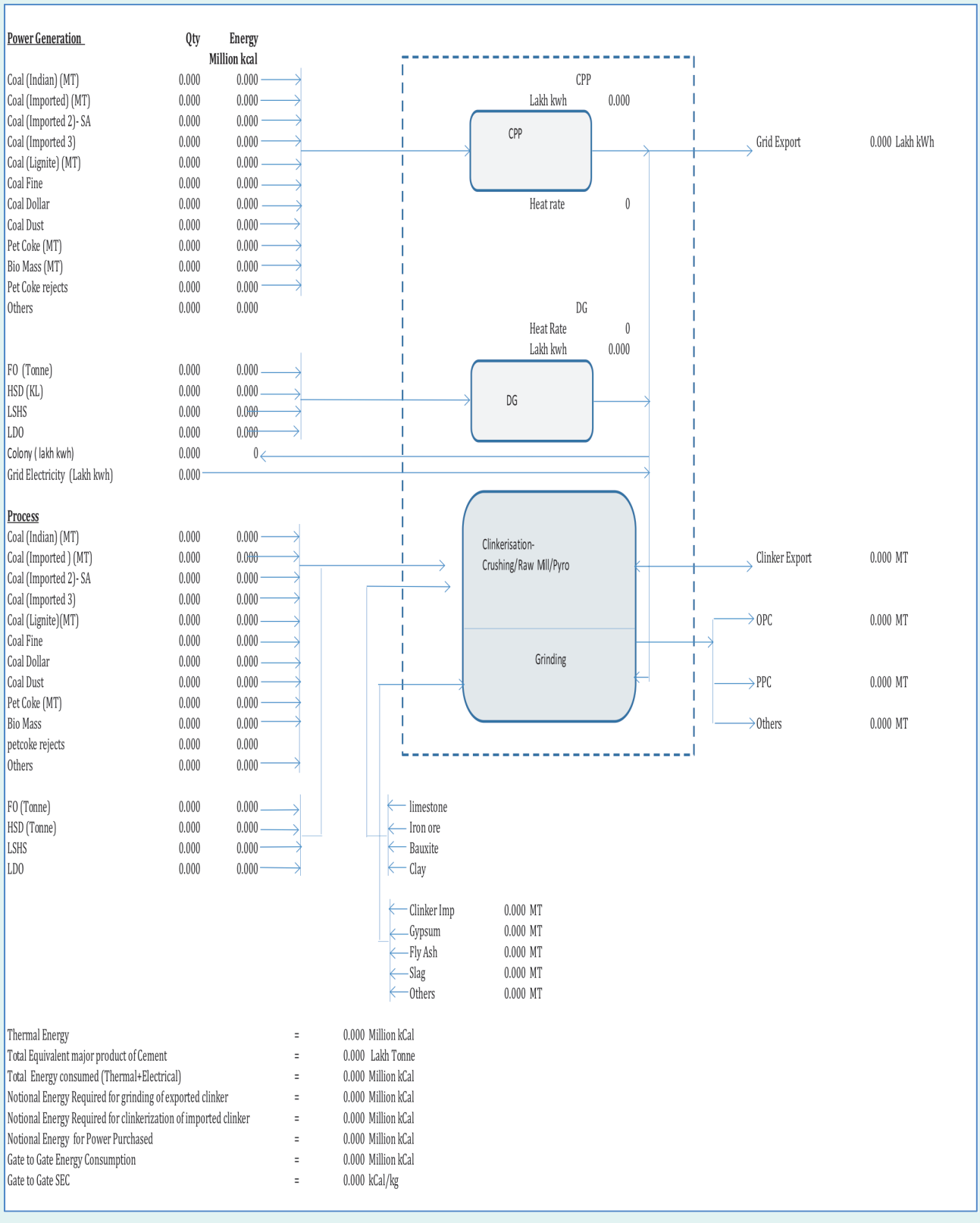


FIGURE 17: FIGURE 18: EX-GTG BOUNDARY FOR CEMENT SECTOR

10. Review of section-wise specific power consumption (line-wise)

Sr No	Section	kWh/ tonne of Material	Conversion Factor to Clinker	kWh/ tonne of Clinker	kWh/ tonne of Cement	Remarks
1	Crusher					
2	Raw Mill					
3	Kiln					
4	Coal/Petcoke Mill					
5	Cement Mill					
6	Packing					
7	Utilities					
8	Misc					
Sum						

TABLE 18: SECTION-WISE SPECIFIC POWER CONSUMPTION DETAILS

11. Mass and energy balance verification

The clinker balance verification is carried out by comparing the cement produced and clinker factor with actual clinker produced by taking into account the clinker stock difference and clinker import-export. Similarly energy balance up to clinkerisation could be verified as per the tabulated formulae

Sr No	Description	Unit	2014-15	2018-19	Remarks
A	Equivalent clinker from total cement produced: [OPC x CFOPC]+[PPC x CFPPC)]+[PSC x FPSC)]+[Composite Cement x CFComposite Cement]	Lakh tonnes			
B	Clinker Produced: Total Clinker Produced + (Clinker Imported-Clinker Exported)+(Opening Clinker Stock-Closing Clinker Stock)	Lakh tonnes			
	% Variation	(A-B) x 100/A			
C	Final SEC (Before Normalisation)	kcal/kg equivalent cement			

D	(Thermal SEC for clinkerisation * PPC Clinker Factor) + (Electrical SEC for clinkerisation in thermal equivalent * PPC Clinker Factor) + (Electrical SEC for Cement grinding in thermal equivalent)	kcal/kg equivalent cement			
	% Variation	(C-D) x 100/C			

TABLE 19: MASS AND ENERGY BALANCE

12. Section-wise screen-shots of SCADA from CCR/DCS are to be included in the verification report.
13. Raw material input in the plant boundary to be recorded for inclusion in the verification report.
14. Heat balance of kilns (kiln-wise) for the assessment year is required to be included in the verification report with boundary and understanding on the basis of calorific value, that is, NCV or GCV of fuel.
15. Calibration records of all weighing and measurement systems with frequency of calibration to be included in the verification report.
16. Clinker Factor Verification

    The clinker factor calculation is to be documented and produced in the verification report; the verification could be done by taking the following factors into account from the Pro-forma A1-A20

Item	Unit	Year1	Year2	Year3	Year 4	Remarks
Gypsum % in Cement	%					
Clinker used for PPC	tonne					
Clinker used for OPC	tonne					
Clinker used for PSC	tonne					
Clinker Used for Cement	tonne					
Gypsum used in OPC	tonne					
Gypsum used in PPC	tonne					
Gypsum used in PSC	tonne					
Clinker factor for PPC	factor					
Clinker Factor for OPC	factor					
Clinker Factor for PSC	factor					

TABLE 20: CLINKER FACTOR CALCULATION

17. Establishment of clear inclusion and exclusion from the plant boundary is maintained as in the baseline year.
18. The EmAEA is required to report separately some of the factors, which are not covered in the cement sector Pro-forma.

Annexure IV: Fertilizer Sector

Ammonia/Urea

The fertiliser industry maintains an elaborate system of measurement and reporting of production and energy data in the form of "Technical Operating Data (TOP)", as per the guidelines of Fertiliser Industry Coordination Committee (FICC), Department of Fertilisers. The TOP data is also audited by a cost accountant. TOP data can be accepted as such. In case of multi-product plants, distribution of raw materials, power, steam and other utilities to be segregated and quantities allocated for urea production are to be brought out distinctly.

1. Measurement & recording

In the following table, items have been identified, which are required for calculating material and energy balance at battery limit of the complex. Against each item, the following information is to be furnished:

a) Measuring device: Name, tag number, model, location

b) Accuracy level of measurement or date of last calibration. Correction factors (if any)

c) Type of record: Data logger/ digital recorder, charts, direct reading/log book/log sheet, etc.

d) Frequency of reading: Hourly, shift wise, daily, periodically

e) Whether the quantities are ascertained by material balance

f) Stock verification

Sr. no.	Item	Unit	Meas-uring device Name/ tag no/ model/ location	Accuracy level / correction factors (if any)	Records Type/ Location	Frequency of reading	Remarks
1.0 Final/intermediate products							
1.1	Urea production	MT					
1.2	Ammonia						
1.2.1	Production	MT					
1.2.2	Consumption for urea	MT					
1.2.3	Consumption for other products	MT					
1.2.4	Sent to storage	MT					

1.2.5	Received from storage	MT					
1.2.6	Export	MT					
2.0 Input raw materials							
2.1	Natural gas						
2.1.1	Properties						
a	GCV	Kcal/					
SCM							
b	NCV	Kcal/					
SCM							
2.1.2	Total receipt						
a	Main receiving station	MMSC-MD					
2.1.3	Distribution						
a	Reformer feed	MMSC-MD					
b	Reformer fuel	MMSC-MD					
c	Gas turbine	MMSC-MD					
d	HRU	MMSC-MD					
e	Boilers	MMSC-MD					
f	Others	MMSC-MD					
2.2	Naphtha						
2.2.1	Properties						
a	Sp. Gravity	gm/cc					
b	GCV	Kcal/kg					
c	NCV	Kcal/kg					
2.2.2	Total receipt						
a	Volume	Kl					

b	Weight	MT					
2.2.3	Distribution						
a	Reformer feed	MT					
b	Reformer fuel	MT					
c	Others	MT					
2.3	Diesel						
2.3.1	Properties						
a	Sp. Gravity	gm/cc					
b	GCV	Kcal/kg					
c	NCV	Kcal/kg					
2.3.2	Total receipt						
a	Volume	Kl					
b	Weight	MT					
3.3	Distribution						
a	DG Sets	Kl					
b	Others						
2.4	Furnace oil / LSHS etc.						
2.4.1	Properties						
a	Sp. Gravity	gm/cc					
b	GCV	Kcal/kg					
c	NCV	Kcal/kg					
2.4.2	Total receipt						
	Volume	Kl					
	Weight	MT					
2.4.3	Distribution						
a	Boiler	MT					
b	Other furnaces (specify)	MT					
c	Misc (if any)						

2.5	Coal						
2.5.1	Properties						
a	GCV	Kcal/kg					
b	NCV	Kcal/kg					
2.5.2	Total receipt						
a	Weight	MT					
2.5.3	Distribution						
a	Boilers(1+2+3)	MT					
b	Others (specify)	MT					
c	Stock variation						
2.6	Any other fuel						
3.0	**Steam**						
	Pressure	Bar					
	Temperature	Deg. C					
	Enthalpy	Kcal/Kg					
	Note: Steam production / consumption at different levels of pressure, shall be converted to equivalent quantity at highest pressure.						
3.1	Production						
3.1.1	Boiler (Individual)						
3.1.2	GTG/HRU						
3.1.3	Service/auxiliary boiler						
3.1.4	Others						
3.2	Consumption						
3.2.1	Steam turbo generator						
3.2.2	Ammonia plant						
3.3.3	Urea plant						
3.3.4	Others						

TABLE 21: MATERIAL AND ENERGY BALANCE OF FERTILISER SECTOR

2. Material balance of all inputs at battery limit of entire complex

The following information is to be filled in as follows:

(i) Illustrative figures for a day

(ii)One month with the best operation

(iii) For financial year, as per TOP

Sr. No.	Item	Unit	Received at plant battery limit	Allocated for urea production	Allocated for other products	Difference if any	Remarks
1.0 Purchased items							
1.1	Purchased power	MWh					
1.2	Natural gas	MMSC-MD					
1.3	Naphtha						
a	Volume	Kl					
b	Weight	MT					
1.4	Diesel	Kl					
1.5	Furnace oil / LSHS etc.						
a	Volume	Kl					
b	Weight	MT					
1.6	Coal	MT					
1.7	Any other fuel						
2.0 Steam							
2.1	Production						
2.1.1	Boiler (Individual)	MT					
2.1.2	GTG/HRU	MT					
2.1.3	Service/auxiliary boiler	MT					
2.1.4	Others	MT					

2.2	Consump-tion	MT					
2.2.1	Steam turbo generator	MT					
2.2.2	Ammonia plant	MT					
2.2.3	Urea plant	MT					
2.2.4	Others	MT					
3.0 Power							
3.1	Generation	MWh					
3.1.1	GTG	MWh					
3.1.2	Others	MWh					
3.2	Consump-tion						
3.2.1	Ammonia plant	MWh					
3.2.2	Urea plant	MWh					
3.2.3	Others	MWh					

TABLE 22: MATERIAL BALANCE OF ALL INPUTS IN FERTILISER SECTOR

3. Pro-forma

a. Pro-forma (Original)

Under the PAT scheme, all DCs are required to fill in and submit to BEE, the Pro-forma, which is mandatory, with the following salient features:

i. Plant capacity, production and capacity utilisation

- Installed capacity
- Production
- Capacity utilisation

ii. Purchased electricity – Purchased quantity, cost, consumption

iii. Generated electricity through DG/turbo gen/gas turbine/co-generation

iv. Fuels – Gaseous (NG, LNG), Liquid (Naphtha, fuel oil, diesel) solid (coal, coke) – Purchased quantity, calorific value (GCV).

v. Consumption of energy input for

- Power generation
- Process raw material
- Process heating

vi. Using waste as fuel

vii. Use of non-conventional energy (solar, wind, etc)

i. Total energy input at baseline

b. Sector Specific Pro-forma

Keeping in view the special requirements in the fertiliser sector, the Pro-forma has been modified with the following changes:

i. Plant capacity is reported in following formats:

1. **Name plate capacity:** The original name plate capacity at the time of installation of plant.
2. **Re-assessed capacity:** As revised by the Fertiliser Industry Coordination Committee (FICC) in 2002.
3. **Baseline production:** As worked out (for urea product only) under PAT cycle -1 scheme, it is an average of production for three baseline years, 2007-08, 08-09, 09-10. For PAT cycle – 2, actual performance data for assessment year 2014-15 is to be taken as baseline data.
4. **Re-vamp capacity:** Subsequent to baseline period, i.e. 2007-10, some plants carried out major revamp to further enhance capacity. The capacity is as reported by DCs to the Department of Fertilisers.

ii. Calorific value of fuel

In the fertiliser sector, all the energy calculations are based on net calorific value (NCV) of fuel. The NCV will also be furnished along with GCV.

iii. Total inputs at plant battery limit

In the existing Pro-forma, only the inputs, which are allocated for urea production, are furnished. The modified Pro-forma, provides for furnishing total inputs at plant battery limit in addition to the inputs allocated for urea.

iv. Quantity of natural gas

At present fertiliser plants obtain natural gas from a number of sources. Instead of giving the quantity of natural gas received from each source separately, thetotal quantity shall be furnished at only one place. However, a break-up of this quantity may be furnished for feed and fuel along with respective NCVs. Other fuels which are not in use in the fertiliser sector have been removed.

4. Annexure to Pro-forma

The Pro-forma being of generic nature does not contain information specific to the fertiliser sector. Therefore, additional technical information is furnished through the Annexure to Pro-forma. Information furnished in this annexure is as the following:

A. Installed capacity, production, CU, on-steam days for ammonia/urea for base 5 years.

B. Installed capacity has been substituted with re-assessed capacity.

C. Inputs to Ammonia Plant

- NG/RLNG/LNG/PMT (Feed, fuel)– Quantity, NCV
- Naphtha (Feed, fuel) – Quantity, NCV
- Steam / power – Quantity, conversion factor
- Credits / debits – DM Water heating, LP steam export etc.
- Ammonia production

D. Inputs to Urea Plant

- Ammonia consumption for urea
- Power/steam
- Credits/debits– DM Water heating, LP steam export etc.

E. Conversion factor for power generated.

F. Heat value of steam generated.

G. Information available in log sheets, log books, data logger print-outs and other plant documents need to be verified with appropriate references.

5. Plant battery limit block diagram

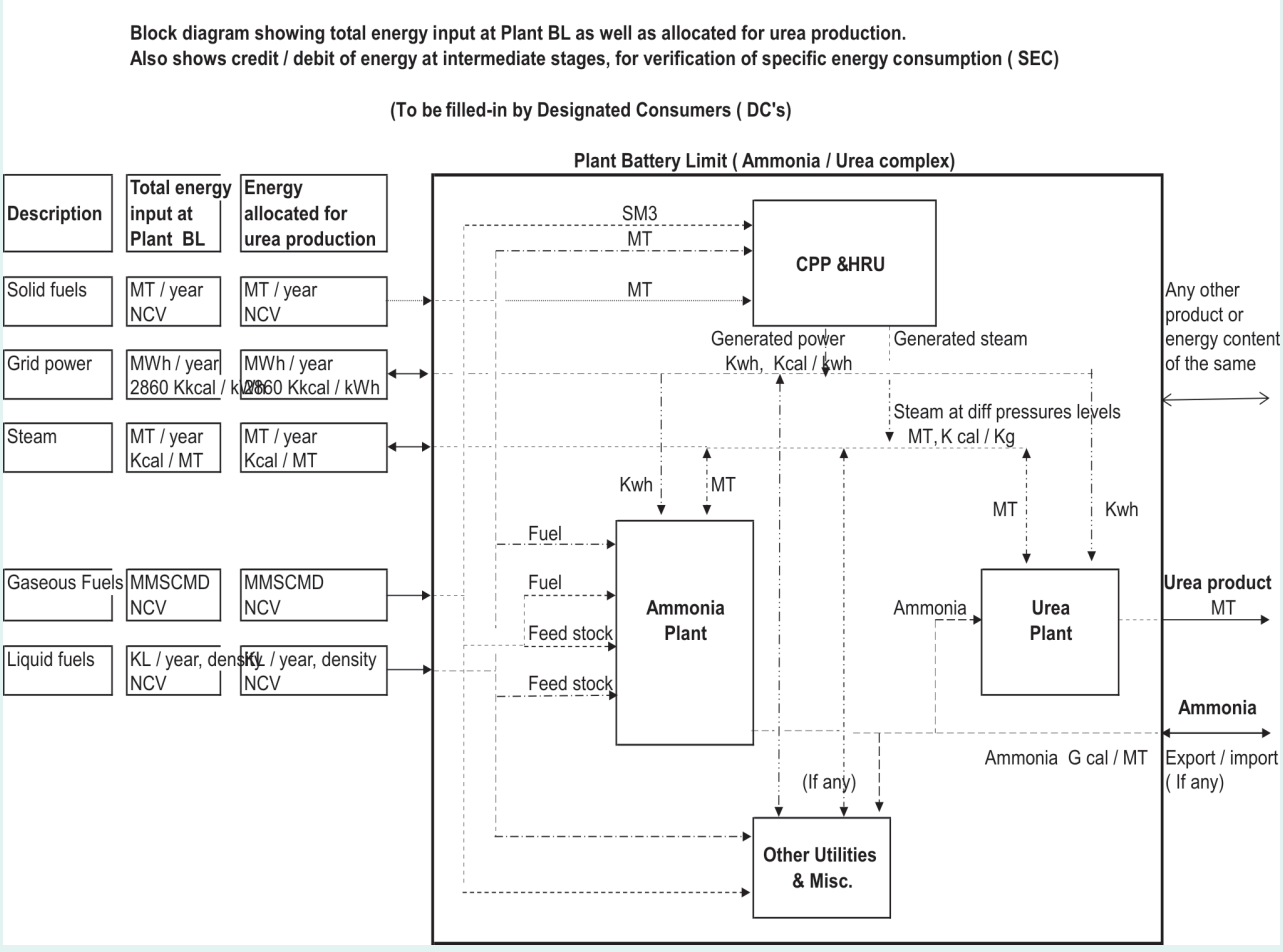


FIGURE 19: FERTILISER PLANT BATTERY LIMIT BLOCK DIAGRAM

6. Data not available in Pro-forma and Annexure – 1

- Fuel input to boilers
- Waste gases available from ammonia/ urea plants and fed to boilers.
- Quantity of steam produced.
- Other energy inputs like pre-heated DM water
- Calculations for conversion factors of steam/power.

a. Additional information in Block diagram

The illustrative block diagram in section 1.05 above, when, filled adequately, incorporates missing information.

i. It depicts all inputs at plant battery limit, which may be consumed for production of urea as well as other products.

ii. It also depicts all inputs allocated for urea production.

iii. Gives details on various imports/exports, debit/credit etc.

iv. One set of sample calculations of gate-to-gate energy balance to be furnished

v. Basis of calculations, conversion factors, assumptions, import/export, credit/ debit etc; to be mentioned specifically.

7. Procedure for calculation of specific energy consumption (SEC)

In general specific energy consumption (SEC) is calculated by dividing total energy input at battery limit by the final product. However, in case of ammonia/ urea complex, part of the input energy is utilised for manufacturing ammonia wherein carbon dioxide (CO2) is also produced as a by-product. Ammonia and CO2 are then reacted to produce urea. Part of the steam/power energy is consumed in the urea plant. Further, the full quantity of ammonia produced is not necessarily consumed for urea manufacture. Part of the ammonia may go to storage or export. Similarly, part of steam/power may be either exported or imported. Therefore, in the fertiliser sector, SEC of urea cannot be calculated directly by dividing total energy input by urea product.

The following procedure is to be adopted for calculating SEC:

a. Allocation of fuel for production of ammonia, power/steam and other products/facilities (wherever applicable).

b. Calculation of conversion factor for power generated (Kcal/Kwh) and its distribution.

c. Conversion factor for purchased power (taken as 2860 Kcal/Kwh).

d. Calculation of heat value of steam produced (Kcal/Kg) and its distribution.

e. Calculation of SEC for ammonia by considering the following:

i. Feed & fuel energy input to ammonia plant directly

ii. Allocation of steam/power to ammonia plant along with conversion factors

iii. Credit/debit of energy at ammonia plant battery limit like pre-heating of DM water, burning off-gases in boiler furnace, etc.

f. Calculation of SEC for urea by considering the following:

i. Allocation of ammonia, separately as manufactured or purchased, for urea production.

ii. Allocation of steam/power to ammonia plant along with conversion factors.

iii. Credit/debit of energy by way of export of steam, burning vent gases, etc.

SR. NO.	DESCRIPTION	UNIT	ILLUSTRATIVE FIGURES	ACTUAL FOR 2018-19	REMARKS
1.0 OVERALL PLANT BATTERY LIMIT					
1.1	INPUTS				
1.1.1	NATURAL GAS (NG)				
A	QUANTITY	MMSCM			
B	NCV OF NG	KCAL/ SCM			
1.1.2	NAPHTHA				
A	QUANTITY	KL			
B	NCV OF NAPHTHA	KCAL/LIT			
		KCAL/KG			
C	DENSITY OF NAPHTHA	GM/CC			
1.1.3	GRID POWER	MWH			
1.1.4	STEAM	MT			
1.1.5	AMMONIA	MT			
1.2	OUTPUT				
	UREA	MT			
	POWER EXPORT	KWH			

2.0 CPP/HRU					
2.1	INPUT				
2.1.1	NATURAL GAS	MMSCM			
2.2	OUTPUT				
2.2.1	POWER	MKWH			
	HEAT RATE	KCAL/ KWH			
2.2.2	STEAM	MT			
	HEAT CONTENT	KCAL/KG			
3.0 AMMONIA PLANT					
3.1	INPUT				
3.1.1	NG FEED	MMSCM			
3.1.2	NG FUEL	MMSCM			
3.1.3	NAPHTHA FEED	KL			
3.1.4	NAPHTHA FUEL	KL			
3.1.5	STEAM	MT			
3.1.6	POWER	MKWH			
3.2	OUTPUT				
3.2.1	AMMONIA PRODUCT	MT			
4.0 UREA PLANT					
4.1	INPUT				
4.1.1	AMMONIA	MT			
4.1.2	STEAM	MT			

4.1.3	POWER	MKWH			
4.2	OUTPUT				
4.2.1	UREA PRODUCT	MT			
5.0 SERVICE BOILER / UTILITIES					
5.1	INPUT				
5.1.1	NG FUEL	MMSCM			
5.1.2	NAPHTHA FUEL	KL			

8. Gate to Gate specific energy consumption (SEC)

i. Overall material & energy balance

An illustrative material & energy flow diagram of an ammonia/urea fertilizer complex is given below

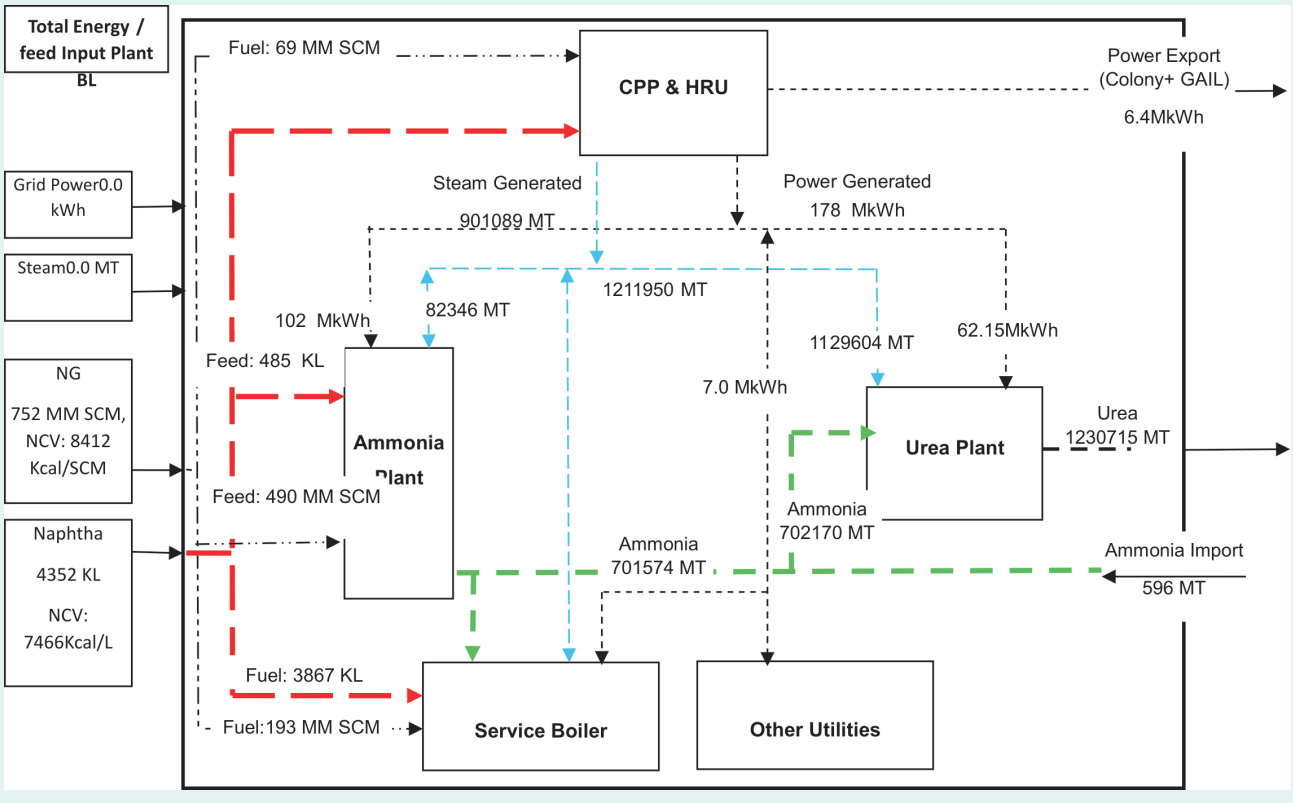


FIGURE 20: OVERALL MATERIAL AND ENERGY BALAANCE

II. CALCULATION OF SPECIFIC ENERGY CONSUMPTION (SEC) OF AMMONIA

(a) Material balance of Natural Gas

DESCRIPTION	QUANTITY (MM SCM)	NCV (KCAL/ SCM)	HEAT CON-TENT (GCAL)2 X 3	REMARKS
1	2	3	4	5
TOTAL INPUT				
	752	8412	6325824	
DISTRIBUTION				
CPP/HRU	69	8412	580428	
REFORMER FEED	490	8412	4121880	
REFORMER FUEL	193	8412	1623516	

(b) Material balance of naphtha

DESCRIPTION	QUANTITY (KL)	NCV (KCAL/ L)	HEAT CON-TENT (GCAL)2 X 3	REMARKS
1	2	3	4	5
TOTAL INPUT				
	4352	7466	32492	
DISTRIBUTION				
REFORMER FEED	485	7466	3621	
SERVICE BOILER	3867	7466	28871	

c) Energy balance in Ammonia Plant

ITEM	UNIT	QUANTITY	NCV/ HEAT VALUE	TOTAL ENERGY GCAL	SPECIFIC ENERGY CONSUMPTION
AMMONIA PRODUCTION	MT				
NG FEED	MM SCM				
NG FUEL	MM SCM				
NAPHTHA FEED	MT				
NAPHTHA FUEL	MT				
STEAM	MT				
POWER	MKWH				

TOTAL FEED ENERGY					
TOTAL FUEL ENERGY					
POWER + STEAM					
TOTAL SEC	GCAL/ MT				
NON PLANT ENERGY	GCAL/ MT				
SEC INCLUDING NON- PLANT ENERGY	GCAL/ MT				

(d) Energy balance in Urea Plant (Refer ToP data)

ITEM	UNIT	QUANTITY	NCV/ HEAT VALUE	HEAT CONTENT GCAL	SPECIFIC ENERGY CONSUMPTION
UREA					
PRODUCTION	MT	1230715			
AMMONIA FEED	MT	701574	7.691	5395806	4.384
STEAM	MT	1129604	743	839295	0.682
POWER	MkWh	62150	511	31759	0.026
TOTAL ENERGY	GCAL			6266860	
TOTAL SEC	GCAL/MT				5.092
NON PLANT ENERGY	GCAL/MT				0.079
SEC INCLUDING NON PLANT ENERGY	GCAL/MT				5.171

9. Computing Baseline Data

(i) Under PAT Cycle -1

Under the first cycle of the PAT scheme, the baseline period constitutes the years 2007-08, 08-09 and 2009-10. Urea has been taken as the basis for calculating the specific energy consumption.

a. Production

Baseline production of urea is obtained by averaging urea production for three baseline years i.e. 2007-08, 08-09, 09-10. Production during target year (2014-15) is reported in the following table.

Sr. No.	Description	Unit	Baseline data				Assess-ment year
			2007-08	2008-09	2009-10	Aver-age	2014-15
1.0	Urea product						
1.1	Installed capacity	MT				n.a.	
1.2	Actual production	MT					
1.3	Capacity Utilisation	%				n.a.	

(ii) For PAT Cycle - 2

Sr. No.	Description	Unit	Baseline data	Assessment-year
			2014-15	2018-19
1.0	Urea product			
1.1	Installed capacity	MT		
1.2	Actual production	MT		
1.3	Capacity Utilisation	%		

b. Specific energy consumption (SEC)

Baseline SEC of urea is obtained by weighted average for three baseline years i.e. 2007-08, 08-09, 09-10. The SEC during the target year (2014-15) is reported in the following table:

a. PAT Cycle – 1

Sr. No.	Description	Unit	Baseline data				Assessment year
			2007-08	2008-09	2009-10	Total	2014-15
1.0	Urea Produc-tion	Tonnes					
1.1	SEC	Gcal/ MT					
1.2	Total energy	Gcal					
1.3	Weighted aver-age	Gcal/MT					

b. PAT Cycle – 2

Sr. No.	Description	Unit	Baseline data 2014-15	Assessment year 2018-19
1.0	Urea Production	Tonnes		
1.1	SEC	Gcal/ MT		
1.2	Total energy	Gcal		
1.3	Weighted average	Gcal/MT		

10. Normalisation factors

PAT procedure provides for normalisation of reported data based on capacity utilisation factor, when the plant load factor (PLF) has a deviation of more than 30%. The PAT procedure also provides for normalisation by statistical analysis methods. In the fertiliser sector, apart from capacity utilisation, there are some other important factors number of forced shut-down of the plant, use of naphtha due to unavailability of natural gas, quality of coal and commissioning period after major revamp of the plant, which also affect the specific energy consumption of the product. Identified un-productive energy consumption on account of factors, which are beyond the control of the plant, is as follows:

(i) Forced shut-down of the plant and subsequent cold start-up

(ii) List of critical equipment, which on failure, cause forced shut-down

(iii) Plant operation at low load

(iv) Reduction of ammonia synthesis and CO shift catalyst

(v) Use of naphtha due to non-availability of gas

(vi) Deterioration in quality of coal

Formats were developed showing illustrative calculations for calculating the unproductive energy consumption against individual factors.

a. Low capacity utilisation

In addition to the reasons for lower capacity as given in the PAT document, lower capacity utilisation due to the reasons given below has also been considered for normalisation.

(i) shortage of raw material including feed, fuel, water, electricity etc

(ii) high cost of inputs leading to unviable urea production beyond certain capacity

(iii) major equipment failure

(iv) force majeure

Factors like shortage of raw materials (mainly the gas), decline in market demand, change in government policy, etc. are beyond the control of DCs. These factors may force the plant to operate at a lower capacity, thus causing an adverse effect on energy consumption. In such cases, normalisation shall be allowed as follows.

b. Calculation of unproductive energy

During any month, unproductive energy consumed in the plant may be segregated in two categories i.e.

a) Due to factors like low capacity utilization, plant shut down/ cold start up, where normalization is admissible.

b) Due to inefficient plant operation, attributable to plant management where unproductive energy is not compensated.

Total unproductive energy shall be segregated in these two categories.

1. Methodology for calculation of unproductive energy

Following methodology will be adopted for calculating unproductive energy consumption on account of low capacity utilization as well as forced shut of the plant / cold start up.

a. Best operating months : Identify months of best operation i.e. all days at 100% CU or very close to it.

b. Take weighted average of SEC for all the best operated months.

c. Take SEC of the affected month in which low CU has taken place.

Similarly, take SEC of the affected month in which forced shut down / cold start up has taken place.

d. Difference of b and c gives total unproductive energy as SEC , during that particular month.

Un-productive energy = (Monthly Energy per MT of Ammonia/ Urea during the month – Weighted Average Monthly Energy Consumption per MTAcid for the months with 100% on-stream days) *Monthly Acid production for the month of Cold Start up

e. Calculate maximum allowable unproductive energy on account of (i) Low capacity utilization (ii) forced shut down / cold start up by using methodology given in respective sections.

f. Impact of Lower Capacity utilization shall be worked out as follows:-

Maximum permissible value (Gcal/ MT urea) = (95 - % Capacity utilization) * NF

g. The lower value of d & e will be allowed as normalization factor.

h. The Designated Consumer shall declare what portion of such unproductive consumption during the month is due to cold shutdown and start up activity.

i. Normalization on account of forced shut down and low CU, will not overlap.

j. For one shut down in a year, no adjustment is required.

i. Pre-requisites for Normalisation

1. A DC shall furnish detailed and convincing reasons with supporting documents for reduction in capacity utilisation, due to factors, beyond their control.

2. The following criteria shall be adopted:

a) No compensation shall be allowed if the

capacity utilisation of the urea plant on annual basis is 95% or above.

b) Compensation shall be allowed for capacity utilisation between 70-95%.

c) Below 70%, the data may be discarded.

3. The claim will be based on technical operating data (TOP), which is being reported to the Fertilizer Industry Coordination Committee (FICC) of the Department of Fertilisers, Government of India.

4. Normalisation due to low capacity utilisation will be considered only in one of the plants i.e. either ammonia or urea.

5. Subsequent to the baseline year, i.e. 2007-10, some DCs have carried out major revamp of their plant for capacity enhancement in line with the new investment policy for urea notified by the government in 2008. The government recognised enhanced capacity, while reimbursing cost of production under the pricing policy. The enhanced capacity shall be considered, while calculating capacity utilisation for normalisation, subject to confirmation from the Department of Fertilisers, Government of India and also verification certificate issued by an Accredited Energy Auditor to DC which seeks to declare their enhanced installed capacities, production and energy use. The cost of this audit will be borne by the DC. Check tests of such verification could be carried out by BEE, if needed.

6. Some plants have ammonia plant capacity higher than the quantity of ammonia required for urea production and thus divert surplus ammonia for production of other products or direct sales. In such cases, due to government policy and/or market conditions, consumption of surplus ammonia for production of other products becomes unviable and under these circumstances, the ammonia plant is operated at lower capacity, thus resulting in higher energy consumption per MT of ammonia, which also get transferred to urea, even if the urea plant is operated at full load; normalisation shall be allowed in such cases.

7. In case the ammonia capacity of the ammonia/urea complex matches with urea production, capacity utilisation of the urea plant shall be considered.

ii. Calculation of normalisation factor

1. Based on the operating data collected from plants at 100%, 85% and 70% plant load, average normalisation factor works out to be 0.02 Gcal per MT of urea per percentage reduction in plant load below 95% up to 70%.

2. Impact of lower capacity utilisation shall be worked out as follows:

a. Maximum permissible value (Gcal/MT urea) = (95 - % Capacity utilisation) *0.02

b. Actual unproductive energy (Gcal/MT urea) = Annual Energy, Gcal/MT of Urea - Weighted Average of Monthly Energy Consumptions for the months with Capacity Utilisation of 100% or more

c. Lowest of either (a) or (b) shall be considered for allowing the impact of

lower capacity utilisation.

3. Impact of lower capacity utilisation of plants where ammonia is surplus of what is required for urea production, shall be worked out as follows:

a. Maximum permissible value (Gcal/MT ammonia) = (95 - % Capacity utilisation of ammonia plant) *0.03Gcal.

b. Actual unproductive energy (Gcal/ MT urea) = Annual Energy, Gcal/MT of ammonia - Weighted Average of Monthly Energy Consumptions for the months with ammonia plant Capacity Utilisation of 100% or more

c. Lowest of the above two shall be considered for allowing the impact of lower capacity utilisation. In such cases, normalisation due to low capacity utilisation (i.e. <95%) will be allowed only in one of the plants i.e. either ammonia or urea.

4. Capacity utilisation for urea plant will be calculated based on baseline urea production.

iii. Supporting data/documentation

Data shall be maintained in the following formats:

A. Month-wise production & energy consumption during the year

Sr. No	Month	Ammonia				Urea			
		On stream	production	CU	SEC	On stream	produc-tion	CU	SEC
		days	MT	%	Gcal/ MT	days	MT	%	Gcal/ MT
1	April								
2	May								
3	June								
4	July								
5	August								
6	September								
7	October								
8	November								
9	December								
10	January								
11	February								
12	March								

B. Data for best operating months

Sr. No.	Best operating month	Ammonia production	CU	Urea production	CU	SEC Ammonia	SEC Urea	Reference
		MT	%	MT	%	Gcal/ MT	Gcal/ MT	

(i) Take the month in which plants have run for all the calendar days.

(ii) Capacity utilisation during the month should be equal to or above 100%.

c. Cold start-up of the plant after forced shut-down

In case of sudden failure of a critical equipment as per the list below, or external factors (as notified), an ammonia plant undergoes a forced shut-down. Restarting the plant from cold conditions (cold start-up), consumes unproductive energy and shall be normalised.

i. Pre-requisites for normalisation

A. The list of critical equipment failure which leads to complete shut-down of plant and consequent cold start-up, allowed under this normalisation factor is given below :

1. Primary Reformer
2. Secondary Reformer
3. Heat Exchange Reformer
4. Reformed Gas Boiler
5. Carbon dioxide absorber and stripper
6. Air, Refrigeration and synthesis compressors
7. Synthesis converters
8. Synthesis Gas Waste Heat Boilers
9. High pressure urea reactor, stripper and carbamate condenser
10. Carbon dioxide compressor
11. Utility boiler furnace
12. Gas turbine/HRSG
13. Cooling Tower
14. Major Fire leading to complete shutdown of plant and cold start-up
15. Turbo generator along with GTG
16. Purifier
17. CO Shift Converter

B. The designated consumer shall furnish a detailed report on failure of such equipment and its impact on energy consumption.

C. The designated consumer shall declare with back-up documentation, what portion of such unproductive consumption during the month is due to cold shut-down and start-up activity.

D. This actual energy loss due to shut-down and cold start-up in Gcal/MT of Urea shall be compensated, subject to

maximum of 0.03 Gcal/MT of Urea.

ii. Calculation of normalisation factor

A. Energy loss during the month(s) for which additional cold start-up is being claimed shall be calculated as follows:

(i) (Monthly Energy per MT of Ammonia during the month – Weighted Average Monthly Energy Consumption for the months with 100% on-stream days) X Monthly Ammonia production for the month of start-up.

(ii) This Energy Loss shall be divided by Annual Urea Production to identify total unproductive loss in a month.

(iii) The designated consumer shall declare what portion of such unproductive consumption during the month is due to cold shut-down and start-up activity.

(iv) This actual energy loss due to shut-down and cold start-up in Gcal/MT of Urea shall be compensated, subject to maximum of 0.03 Gcal/MT of Urea.

(v) The failure of critical equipment leading to complete shutdown of plant and consequent cold start up, allowed under this normalisation factor is given in the Annexure -

iii. Documentation

a. PAT cycle -1

Sr. No.	Description	Unit	2007-08	2008-09	2009-10	2014-15
1	Ammonia production	MT				
2	Urea production	MT				
3	Total no of cold start up	Nos				
4	Cold start up due to failure of major equipment	Nos				
5	For each start up					
a	Duration	Hours				
b	Energy consumed	Gcal				

Note: For each shut-down/cold start-up, information to be filled in separately.

b. PAT cycle -2

Sr. No.	Description	Unit	2014-15	2018-19
1	Ammonia production	MT		
2	Urea production	MT		
3	Total no of cold start up	Nos		
4	Cold start up due to failure of major equipment	Nos		
5	For each start up			
a	Duration	Hours		
b	Energy consumed	Gcal		

d. Use of naphtha

A. Using part naphtha involves additional energy consumption as follows:

a) For each start-up of facilities to use naphtha as feed including pre-reformer

b) For the period of use of naphtha as feed

c) For the period of use of naphtha as fuel

B. DCs shall furnish detailed and convincing reasons with supporting documents for use of naphtha due to non-availability of gas on account of factors, beyond their control.

i. Pre-requisites for normalisation

A. As per the directives from the Department of Fertilisers, use of naphtha is to be discontinued in a phased manner. As such, the use of naphtha is not foreseen. However, provision is being made, in case naphtha has to be used due to shortage of natural gas in future, with permission from DoF.

B. In case of use of naphtha, the DC will furnish details regarding non-availability of gas, leading to the use of naphtha.

ii. Calculation of normalisation factor

A. The following formula shall be used

Energy loss (Gcal/MT Urea) = (185*S + 0.625 * Nfeed + 0.443 * Nfuel) / urea production in MT

S= 1 if naphtha is used as feed in startup

S= 0 if naphta is not used as feed in startup

NFeedc= quantity of naphtha used as feed in MT.

NFuelc= quanity of naphtha/LSHS/FO used as fuel in MT.

iii. Documentation

a. PAT cycle -1

Sr. No.	Description	Unit	2007-08	2008-09	2009-10	2014-15
1	Ammonia production	MT				
2	Urea production	MT				
3	NG consumption	MMSCMD				
4	Shortfall in NG	MMSCMD				
5	Equivalent naphtha	Kl				
6	Actual naphtha used	Kl				

b. PAT cycle -2

Sr. No.	Description	Unit	2014-15	2018-19
1	Ammonia production	MT		
2	Urea production	MT		
3	NG consumption	MMSCMD		
4	Shortfall in NG	MMSCMD		
5	Equivalent naphtha	Kl		
6	Actual naphtha used	Kl		

e. Catalyst reduction

Fresh catalyst is in an oxidised form and needs to be reduced with synthesis gas, wherein hydrogen reacts with oxygen and gets converted into water. The whole plant is operated at 60%-80% load for around 48 to 120 hours, depending upon the type and quantity of catalyst. Thus, replacement/reduction of ammonia synthesis and CO shift catalysts consumes large amount of unproductive energy. Therefore, normalisation due to replacement/reduction of these catalysts will be allowed.

i. Pre-requisites for normalisation

In case of ammonia synthesis catalyst, in the older plants, oxidised form of the catalyst is used which takes around 4-5 days for reduction, causing corresponding un-productive energy consumption. Pre-reduced catalyst is also available, which is expensive but takes around 48 hours for reduction, thus consuming lesser un-productive energy. This aspect will be taken into account while calculating the normalisation factor.

B. This will be considered subject to certification by DCs, furnishing to BEE information as follows:

(a) Year in which the catalyst were last changed along with copies of the purchase order, last placed with the vendor, time taken in commissioning of catalyst, facts and figures clearly indicating and quantifying rise in the energy consumption of plant due to the replacement of this catalyst.

(i) (b) Copies of purchase orders placed by units with the vendors for supply of fresh catalysts.

ii. Calculation of normalisation factor

Adjustment shall be allowed on the basis of actual plant data, subject to a maximum of 0.04 Gcal/MT of Urea.

e. Deterioration in quality of coal

The quality of indigenous coal has been deteriorating gradually, thus affecting boiler efficiency adversely. The reduction in boiler efficiency due to poor quality of coal shall be compensated.

i. Pre-requisites for normalisation

Weighted average of three years' data shall be worked out. In case there is significant variation, then the normalisation factor shall be applied based on the actual impact due to the variation.

ii. Calculation of normalisation factor

A. Quality of coal affects boiler efficiency, which shall be calculated by following empirical formula:

Boiler Efficiency = 92.5 – ((50*A+630(M+9H)) / GCV.

Where

A = Ash content of coal (%)

M = Moisture (%)

H = Hydrogen (%)

GCV = Kcal/Kg

B. Boiler efficiency shall be converted into specific energy consumption, as follows:

Additional Energy Consumption, Gcal/MT of Urea = Energy of Coal per MT of Urea in Target Year, Gcal/MT of Urea * (Boiler Efficiency in Base Year – Boiler Efficiency in Target Year) / Boiler Efficiency in Target Year.

iii. Documentation

A. Coal consumption and analysis

a. PAT cycle -1

Sr. No.	Parameters	Unit	2007-08	2008-09	2009-10	2014-15
1	Quantity of coal used	MT				
2	GCV (Weighted average)	Kcal/kg				
3	NCV (Weighted average)	Kcal/kg				
4	Proximate analysis					
A	Fixed carbon	%				
B	Volatile matter	%				
C	Moisture	%				
D	Ash	%				
5	Ultimate analysis					
A	Carbon	%				
B	Hydrogen	%				
C	Sulphur	%				
D	Nitrogen	%				
E	Oxygen	%				

b. PAT cycle - 2

Sr. No.	Parameters	Unit	2014-15	2018-19
1	Quantity of coal used	MT		
2	GCV (Weighted average)	Kcal/kg		
3	NCV (Weighted average)	Kcal/kg		
4	**Proximate analysis**			
A	Fixed carbon	%		
B	Volatile matter	%		
C	Moisture	%		
D	Ash	%		
5	**Ultimate analysis**			
A	Carbon	%		
B	Hydrogen	%		
C	Sulphur	%		
D	Nitrogen	%		
E	Oxygen	%		

f. Additional provisions

i. Normalisation factors to be applied during assessment year, shall also be applied on baseline data for 2007-10.

B. Provision of normalisation factors is intended solely to save plants from penalties for non-achieving energy saving targets, for reasons which are beyond the control of DCs. However, availing of any of the normalisation factors shall render the DC ineligible for issuance of E-certificates under PAT scheme.

C. Auditors designated by BEE will examine DC's claim based on the technical operating data (TOP), which is being reported to FICC.

Fertilizer Sector (Complex Fertilizer)

1. Heat Rate of Steam

i) Steam generated by burning fuel is to be taken at actual heat rate based on fuel consumption.

ii) Imported steam is to be taken at "Enthalpy" of steam as per steam tables.

iii) Heat rate of steam generated from process heat recovery is to be taken as per "Enthalpy" of steam as per steam tables.

iv) Wherever, steam generated from different sources is fed to the common steam header, weighted average of heat rate will be taken.

2. Heat Rate of Power

i) Purchased power is to be taken at 860 Kcal/kWh.

ii) Power generated by burning fuel is to be taken at actual heat rate based on fuel consumption.

iii) In case of power generated from steam "Imported" from common steam header, weighted average of heat rate is to be taken.

iv) Overall power heat rate shall be weighted average of (i), (ii) & (iii) above.

3. Ammonia plant

i) In case of DCs, having ammonia/urea plants as well as complex fertilizer plants, the normalized SEC of ammonia shall be used.

ii) In case of DCs, having ammonia plant and complex fertilizer plants but not having urea plant, SEC of ammonia shall be normalized in the similar way as in case of ammonia/urea plants.

4. Design (Rated) Production Capacity

i) Most of the plants over a prolonged time period, have undergone a number of revamps /retrofits, thereby, resulting in significant increase in the rated plant capacity as compared to the name plate capacity. Therefore, the actual plant capacity will be established by considering the production in the last five years and taking average of highest production for two years.

ii) Higher value of the capacity as worked out at (i) or the nameplate / revamp capacity shall be considered.

5. Capacity Utilization (CU)

The capacity utilization (CU) is calculated based on plant loading factor (PLF), in excel sheet "CU".

6. Normalization factors

The normalization shall be applicable to both baseline data as well as assessment year.

6.1 Methodology for working out unproductive energy

i) During any month, unproductive energy consumed in the plant may be segregated in two categories i.e.

(a) Due to factors like low capacity utilization, plant shut down/ cold start up, which are beyond the plant control, where normalization is admissible.

(b) Due to inefficient plant operation attributable to plant activities, unproductive energy is not to be compensated.

ii) Detailed methodology for calculating unproductive energy is given below:

(a) Best operating months: Identify months of best operation i.e. all days at 100% CU or very close to it (Ref: Excel sheet "Best monthly SEC".

(b) Take weighted average of SEC for all the best-operated months.

(c) Take SEC of the affected month in which low CU or forced shut down / cold startup has taken place.

(d) Difference of b and c gives total unproductive energy as SEC, during that particular month.

Un-productive energy = (Actual monthly Energy per MT of Acid during the month – Weighted Average Monthly SEC for the months with 100 % CU) X Monthly production for the affected month.

(e) Calculate maximum allowable unproductive energy on account of (i) Low capacity utilization (ii) forced shut down / cold start up by using methodology given in respective sections i.e.

(e.1) Maximum permissible value (SEC) against low CU = (95 - % Capacity utilization) * NF

(e.2) Maximum permissible value (SEC) against forced shut down / cold start up = No of cold start up*NF

(f) The lower value of d & e will be allowed as normalization factor.

(g) The DC will declare what portion of such unproductive energy consumption during the month is due to reasons other than the specified ones.

(iii) Normalization on account of forced shut down and low CU, should not overlap.

(iv) Wherever applicable, stream wise data shall be recorded and got audited.

(vi) For one shut down in a year, no adjustment is admissible.

6.2 Power Mix

Maintain same ratio of purchased power and generated power in assessment year as that for the baseline period.

6.3 Fuel Mix: No normalization is admissible.

6.4 Variation in ratio of purchased / manufactured inputs

(i) For the input materials i.e. ammonia, sulphuric acid, nitric acid, phosphoric acid purchased from outside the plant battery limit, specific energy consumption (SEC) will be taken at zero.

(ii) Maintain same ratio of purchased and manufactured inputs in assessment year as that for the baseline period. These inputs are mainly ammonia, sulphuric acid, phosphoric acid, nitric acid and power.

6.5 Quality of Rock Phosphate

No normalization is admissible.

6.6 Variation in product mix

(i) Energy consumption shall be considered only for those products, which are, produced both during baseline as well as assessment years. Any product which was produced during baseline year but not produced during assessment year shall not be considered. Similarly, any new product produced during assessment year but not produced during baseline period, shall be excluded.

(ii) Maintain same ratio of products in assessment year as that for the baseline period.

6.7 Normalization against low capacity utilization (Based on PLF)

(i) No compensation will be allowed if the capacity utilization is > 95%.

(ii) Compensation shall be allowed for capacity utilization between 70-95%.

(iii) Below 70%, each case will be considered on merit.

(iv) Based on the data collected from plants, maximum limit of normalization has been works out as given below :-

(a) Sulphuric Acid Plant: NF (Provisional) is 0.004 Gcal per MT of acid per % reduction in CU. This includes impact of steam / power import.

(b) Nitric acid plant: NF is 0.005 Gcal per MT of nitric acid per % reduction in CU. This includes impact of steam / power import.

(c) Phosphoric acid plant: Normalization is not admissible.

(d) Complex fertilizer plant: Normalization is not admissible.

6.8 Normalization factors for Forced shut down / cold start up

a. Normalization is admissible only for forced shut down and cold startup of plant due to failure of specified equipment /machinery and non-availability of raw materials, water, and electricity and market conditions due to reasons beyond the control of plant management.

b. Maximum limit of normalization has been works out as given below:-

(i) Sulphuric Acid Plant: NF of 0.0015 Gcal/ MT for one shut down and start up.

(ii) Nitric Acid Plant: NF of 0.0015 Gcal/MT for one shut down and start up.

(iii) Phosphoric Acid Plant: NF is not admissible.

(iv) Complex Fertilizer Plant: Since a complex fertilizer plant has multi-streams and there is a provision of one shut down every day for cleaning and maintenance, the normalization is not admissible.

Annexure V: Aluminium

1. The energy required to transport mined bauxite to refining operations within the plant boundary, alumina to smelting operations, ingots to metal processors, and scrap from collection to melting is accounted as inside transportation. It is considered as energy used in the plant.
2. Plant stoppages and start due to external factors: The DC has to provide the necessary documents.
3. Proper documents on Bauxite Quality for the purpose of normalisation have to be maintained and submitted to EmAEA.
4. Refinery Mass Balance (Bauxite to alumina ratio): The DC has to provide necessary calculation document to EmAEA during M&V for verification of alumina product ratio.
5. Smelter Mass Balance (alumina to molten aluminium ratio): The DC has to provide necessary calculation document to EmAEA during M&V for verification of molten aluminium product ratio.
6. In the smelter plant the EmAEA has to verify BusBar voltage drop and anode-cathode distance in reduction cell.
7. The DC needs to submit the heat mass balance diagram (HMBD) of the turbine system or the characteristics curve between load and turbine heat rate PLF normalisation. Equivalent capacity HMBD or characteristics curve shall be used, if OEM data is not available with the designated consumer.
8. In case of addition of new potline, a DC shall submit all relevant design data to the EmAEA for inclusion in the verification report.
9. The baseline SEC factor used for product equivalent will be used for the assessment year product equivalent. The major product of the baseline period will be considered in the assessment year. In case any new product is introduced in the assessment year the SEC factor of the assessment year will be used for converting to equivalent major product for the assessment period.
10. For import or export of carbon anode, the DC shall be required to fill the Pro-forma the type of anode (i.e., green anode, baked anode or rodded anode) exported or imported in the Remarks column. The SEC shall be for the type of carbone anode i.e., SEC up to the type of carbon anode produced. Generally for importing or exporting anodes, the energy shall be booked till the energy of baked anodes.

1. Refinery

11. Review of section-wise Specific Energy Consumption

S. No	Section	Thermal energy Consumption	Electrical Energy Consumption	kWh/ tone of Alumina	kWh/ tone of Aluminium	Remarks
1	Grinding					
2	Digestion					
3	Clarification					
4	Precipitation					
5	Calcination					

TABLE 23: SECTION-WISE ENERGY CONSUMPTION DETAILS

12. Plant Boundary

Demarcation of the plant boundary is required with clear understanding of raw material input, energy input, power import/export, intermediary product import/export, power needed for the residential colony, for construction, power supplied to other ancillary units outside the plant boundary. Typical plant boundary conditions are produced below.

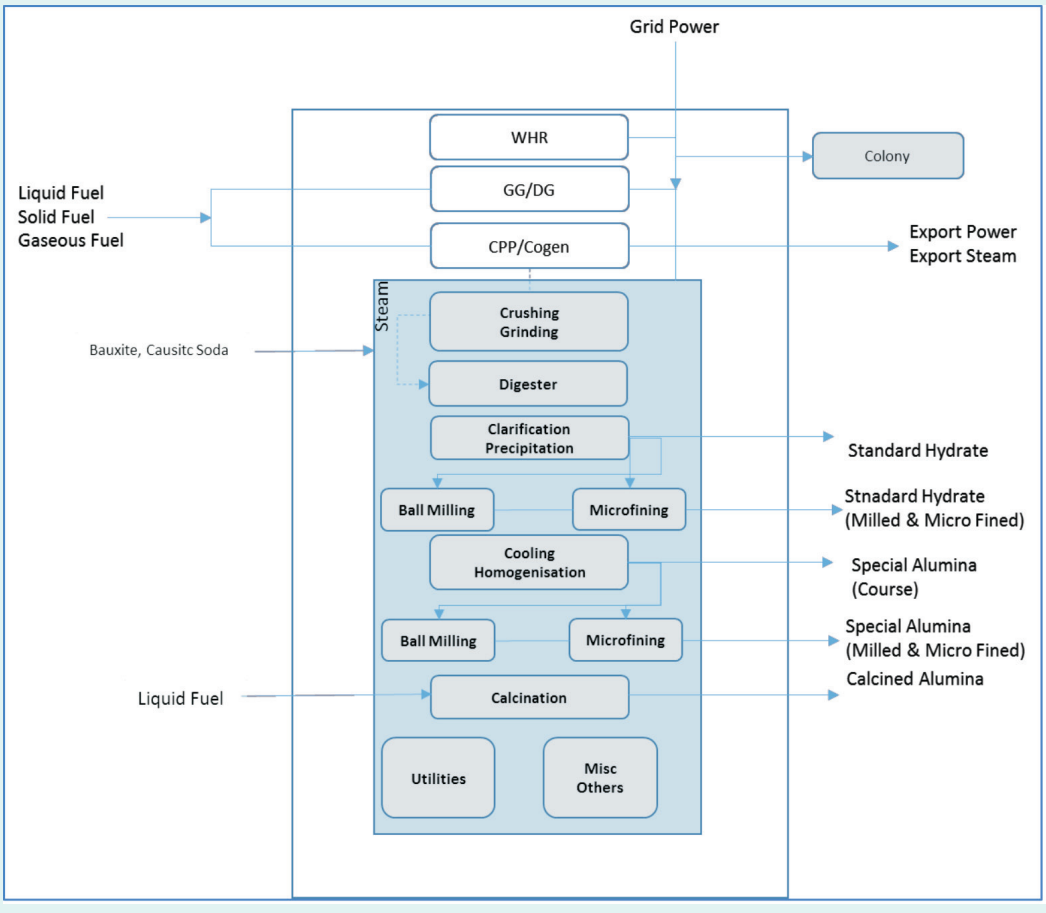


FIGURE 21: EX- GTG BOUNDARY FOR ALUMINIUM (REFINERY SUB-SECTOR)

B. Smelter

13. Carbon anode to molten aluminium ratio: The DC has to provide necessary documents to the EmAEA during M&V. Approximately, 0.45 kg of carbon anode are needed to produce one kg of aluminium.
14. The smelter energy consumption shall be taken up to molten alumina in the Pro-forma.
15. The additional cast house product shall be converted into one product and inserted in the "other" details section of the product in the Pro-forma.
16. The energy used in smelter for imported scrap/cold metal for production of finished products shall be considered for product equivalent hot metal SEC calculation.

S. No	Section	Thermal Energy Consumption	Electrical Energy Consumption	kWh/tone of Anode	kWh/ tone of Aluminium	Remarks
1	Pitch					
2	Coke					
3	Baking					

TABLE 24: SECTION-WISE ENERGY CONSUMPTION DETAILS

17. Electrolytic reduction energy consumption:

S. No	Reduction Cell (Section wise)	Voltage Distribution
1	External	
2	Anode	
3	Polarisation	
4	Bath	
5	Reaction	
6	Cathode	
7	Other	

TABLE 25: VOLTAGE DISTRIBUTION

18. Plant Boundary

Demarcation of the plant boundary is required with clear understanding of raw material input, energy input, power import/export, intermediary product import/export, power need for the residential colony, for construction, power supplied to other ancillary units outside the plant boundary. Typical plant boundary conditions are produced below.

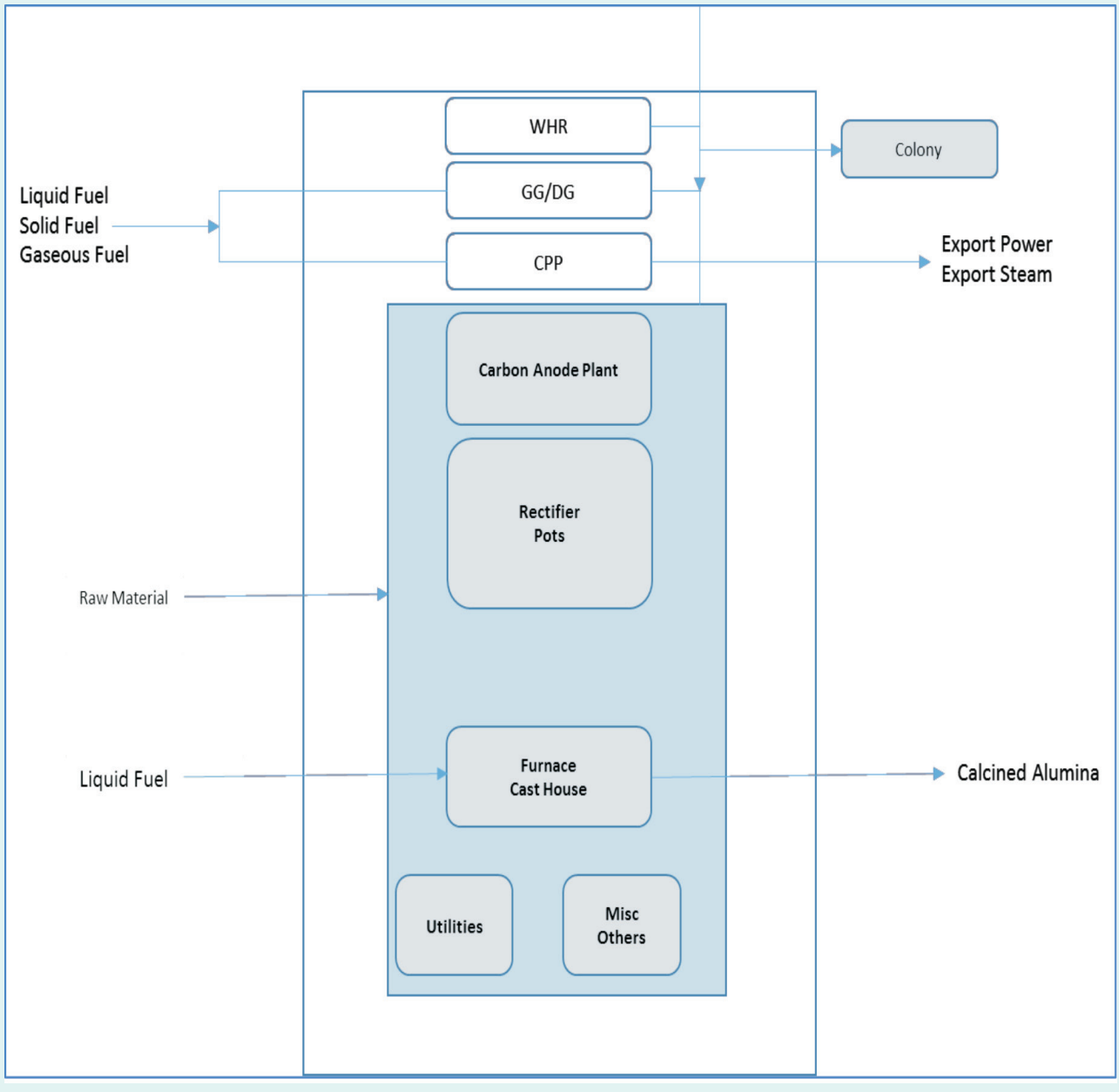


FIGURE 22: EX- GTG BOUNDARY FOR ALUMINIUM (SMELTER SUB-SECTOR)

C. Cold Sheet

19. The DC needs to provide the necessary documents as per the instruction in Form 1 to the EmAEA for verification of section-wise energy consumption and Specific Energy Consumption.

20. The product equivalent of other cold rolled products shall be calculated offline to single cold rolled product through conversion from SEC of different cold rolled products.

21. Plant Boundary

Demarcation of the plant boundary is required with clear understanding of raw material input, energy input, power import/export, intermediary product import/export, power needed for the residential colony, for construction, power supplied to other ancillary units outside the plant boundary. Typical plant boundary conditions are produced below.

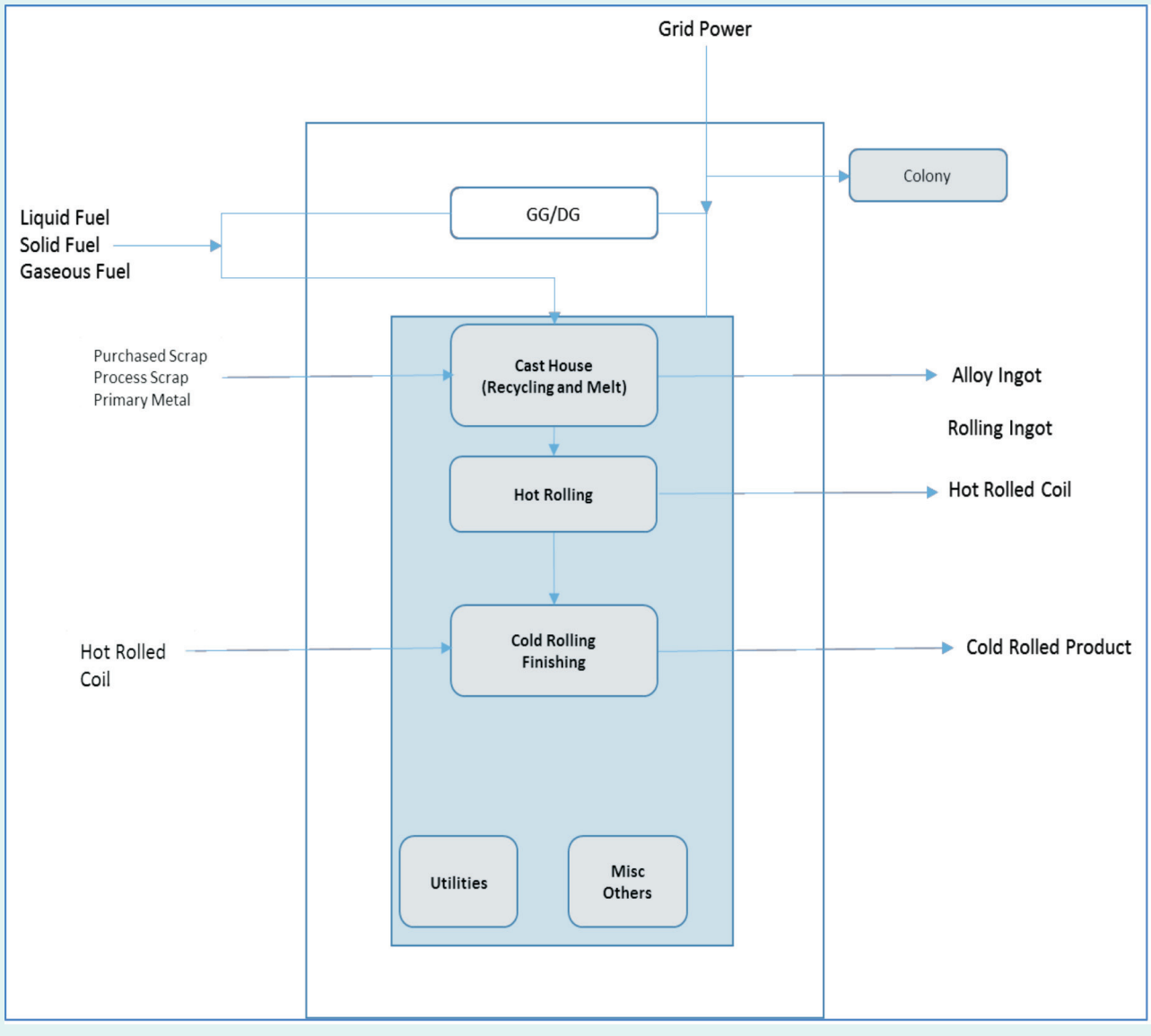


FIGURE 23: EX- GTG BOUNDARY FOR ALUMINIUM (COLD SHEET SUB-SECTOR)

Annexure VI: Pulp & Paper

1. The boundary can be drawn virtually by including CPP or co-gen plant in the boundary limit of DCs, if a number of DCs exists within the same boundary limit.
2. The captive power plant or co-gen plant will be taken into the virtual boundary of each DC and accordingly import and export of power and steam will be treated as per Pro-forma data entry system.
3. If a captive power or co-generation plant caters to two or more DCs for electricity and/or steam requirements, each DC shall consider that plant to be within its boundary and the energy consumed by the plant shall be included in the total energy consumption. However, electricity in terms of calorific value (as per actual heat rate) and steam in terms of calorific value (as per steam enthalpy) exported to other plants shall be subtracted from the total energy consumption.
4. It is to be noted that the same fuel input needs to be considered in case CPP is being taken into the boundary limit. By import and export of energy, the energy consumption from the CPP is automatically left out for the particular DC for SEC calculation.
5. Mill-wise verification data are required to be included in the verification report.

A. Wood Based Mills:

a. The auditors may collect details required in M&V format by mentioning the source and document from where data is collected. Subsequently the data may be verified from the, data provided by the DC in sector specific Pro-forma for normalisation.

b. The information required is shown in the flow chart for wood-based pulp and paper mill.

c. List of documents required for monitoring and verification.

A.1 Raw Material Details

Type of Wood:

Sr No	Name of the raw material	Moisture, %	Quantity, tonne/ annum	Source/ document
1				
2				
3				
4				
5				

TABLE 26: GENERAL DETAILS REQUIRED IN WOOD-BASED PULP AND PAPER MILLS

A.2 Wood Pulp Mill (Including Raw material, Chipper, Digester, WSC, ODL, Bleach Plant, Recovery, WTP, and ETP)

i) Pulping Processes Used

Sr No	Type of pulping	Capacity tonne/ annum	Production tonne/ annum	Total Yield (Including screening losses)	Source / Document
1	Chemical				
2	Semi Chemical				
3	Chemi Thermo Mechanical				
4	Other				

ii) Extended Delignification (ODL)

Sr No	Item	Unit	Value	Source / Document
1	Capacity	tonne/ annum		
2	Date of Installation of ODL Plant	Date		

iii) Bleaching

Sr No	Item	Chemical Pulp	Semi Chemical	Chemical Thermo Mechanical Pulp
1	Type of Bleaching	ECF/conv.	ECF/conv.	ECF/conv.
2	Sequence Used			
3	Bleaching Losses %			
4	Bleached Pulp Yield %			
5	Brightness of pulp, %			

Sr No	Item	Unit	Value	Source / Document
1	Capacity	Tonne/ annum		
2	Date of Installation of ECL Plant	Date		

iv) Energy Consumption in Pulp Mill

Sr No	Item	Qty	Source/ Document
1	Steam Consumption, LP/a		
2	Steam Consumption, MP/a		
3	Power Consumption, kWh/a		

v) Pulp Dryer

Sr No	Item	Unit	Qty	Source / Document
1	Capacity	Tonne/annum		
2	Production of saleable pulp, t/a	Tonne/annum		
3	Energy Consumption in pulp dryer	kcal		
4	LP Steam Consumption	Tonne/annum		
5	MP Steam Consumption	Tonne/annum		
6	Power Consumption	kWh/annum		

vi) Chemical Recovery

Sr No	Item	Unit	Data	Source / Document
1	Type of chemical recovery	Conventional/ Non-Conventional		
2	Total Black liquor Solids generated	Tonnes		
3	In Lime Kiln Installed	Yes/No		
4	Date of Installation of Lime Kiln I	Date		
5	Date of Installation of Lime Kiln II	Date		
6	Date of Installation of Lime Kiln III	Date		

vii) Over-all Energy consumption in pulp mill

Sr No	Item	Qty	Source / Document
1	LP Steam consumption, t/a		
2	MP Steam consumption, t/a		
3	Power consumption, kWh/a		

A.3 Paper Machine (including stock preparation, chemical preparation/addition plant, finishing house)

(i) Paper Machine Details

Number of Paper Machines

Item	PM-1	PM-2	PM-3	PM-4	PM-5	Source/ document
Type of paper machine						
Capacity, t/a						
Type of paper produced						
Production, t/a						
Annual weight average GSM						
Energy Consumption in paper machine (including Stock Preparation, chemical addition and finishing house)						
LP Steam consumption t/a						
MP Steam consumption, t/a						
Power consumption, kWh/a						

(ii) Coating / Value addition

Coating If any Yes /No

Type of coating online / offline

Item	Qty	Source/ document
Capacity of offline coating plant, t/a		
Production of coated paper/board, t/a		
LP Steam consumption,t/a		
MP Steam consumption, t/a		
Power consumption, kWh/a		

(iii) Over-all Energy consumption in paper machine, stock preparation, chemical preparation and addition plant , finishing house and offline coating plant add (i+ii)

Item	Qty	Source/ document
LP Steam consumption,t/a		
MP Steam consumption, t/a		
Power consumption, kWh/a		

A.3 The Information required is shown in the Flow Chart for Wood Based Pulp and Paper Mill

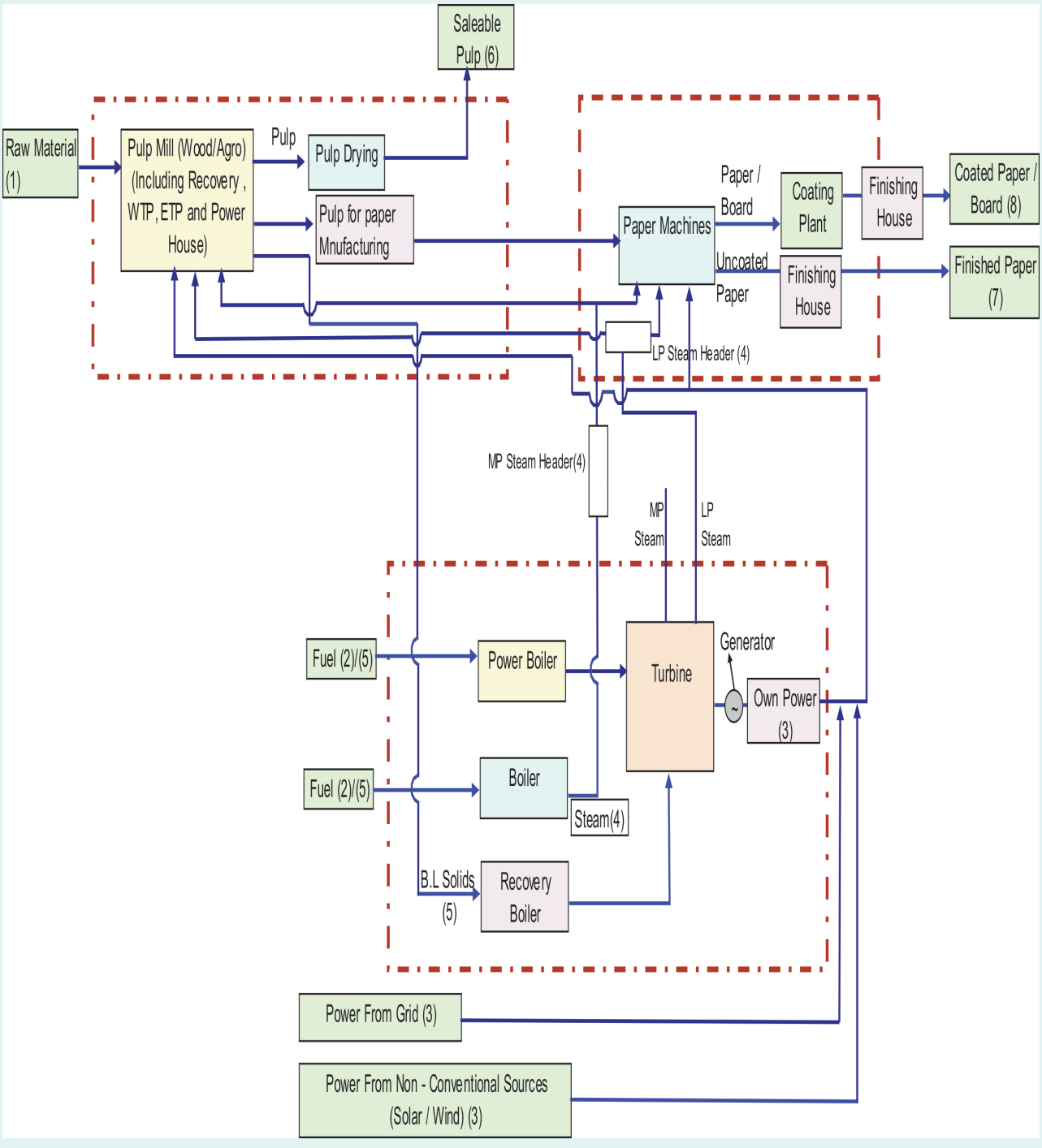


FIGURE 24: EX-GTG BOUNDARY AND METERING DETAILS FOR WOOD-BASED PULP AND PAPER MILL

S . No.	Details of input and output	Source / Type of document required	Details of the Source / document and frequency
1	Raw Materials	Lab Report	Report on moisture(%), Ash (%) and other analysis of the raw materials used by the mill Frequency: Daily/ weekly/ monthly/ annual lab reports may be produced for different types of raw materials used by the mills.
		Purchase Document From Purchase Department	Purchase documents providing details of raw material purchased by the mill Frequency: Daily/ weekly/ monthly/ annual purchase documents may be produced for purchase of different types of raw materials used by the mills
		Raw Material Consumption Reports	Consumption reports giving details of raw material consumed by the mill. The report may be for raw material chip production, digester loading etc. from the department concerned. Frequency: Daily / weekly / monthly / annual consumption documents may be produced for different types of raw materials used by the mill in chipper/digesters house.
		Annual Report	Annual report showing details of raw materials consumed on annual basis by the mill. Frequency: Annual consumption of raw materials by the mill.
2	Purchased Fuels	Fuel Purchase report/ documents	Purchase documents providing details of fuel purchased by the mill. Frequency: Daily/weekly/monthly/annual purchase documents may be produced for purchase of different types of fuels used by the mills.
		Lab report for GCV moisture and Ash	Lab report on GCV, moisture(%), Ash (%) and other analysis (proximate and ultimate) density etc, of the fuel used by mill. Frequency: Daily/weekly/monthly/annual lab reports may be produced for different types of fuels used by the mills.

		Fuel Consumption Report	Consumption reports giving details of fuel consumed by the mill in boilers, DG sets etc. The consumption report may be from the department concerned showing details of fuel consumption. Frequency: Daily / weekly / monthly / annual fuel consumption documents may be produced for different types of fuels used by the mill in boiler/DG sets etc.
		Annual Report	Annual report showing details of fuels consumed on annual basis by the mill. Frequency: Annual consumption of fuels by the mill.
3	Power	Electricity Purchased from Grid	Bill for electricity purchased from state electricity board providing details of the electricity the mill purchased. Frequency: Mills may produce monthly/annual bills for electricity purchased.
		Own power generation	Details of own power generation from different sources such as turbines (gas, steam etc), DG sets. Frequency: Daily / weekly / monthly / annual own generation reports may be produced by the mills. These reports may be the log sheets/production reports from power house.
		Production of power from non-conventional sources, e.g. solar/wind power	Details of power generation from different Non-conventional sources such as Solar / wind turbines, bio gas etc. Frequency: Daily / weekly / monthly / annual power generation reports may be produced by the mills. These reports may be the log sheets/production reports from power houses/departments concerned
		Annual Report	Annual report showing details of power purchased from grid, own power generation, power from non-conventional sources etc. Frequency: Annual report of power purchased, own generation, generation from non- conventional sources etc.by the mill.
4	Steam	Steam generation by the mill	Details of Steam generation from different boilers, extraction of steam from turbines, steam generation from waste heat recovery and non-conventional sources (solar steam generators) Frequency: Daily / weekly / monthly / annual steam generation reports may be produced by the mills. These reports may be the log sheets/production reports for steam generation from boiler house, etc.

		Steam consumption by the mill	Details of Steam consumption in different sections of the mill such as pulp mill, chemical recovery, paper machine, power house and other plants of the mill. Frequency: Daily / weekly / monthly / annual steam consumption reports may be produced by the mills. These reports may be the log sheets/ consumption reports for steam consumption by individual section of the mill or power boiler house.
		Annual Reports	Annual report showing details of Steam Generation and consumption from various sources. The generation and consumption of steam may be in individual departments as well as for the whole mill, boilers, extraction steam, steam from non-conventional sources etc. Frequency: Annual report of steam generation and consumption by the mill.
5	Internally Generated Fuels (Black liquor solids, pith, chipper dust)	Generation report of Black liquor, pith, chipper dust, etc	Details of generation of black liquor, pith, chipper dust or any other combustible waste by the mill from different sections such as chipper house, pulp mill, other plants. Frequency: Daily / weekly / monthly / annual Black liquor, dust, etc generation reports may be produced by the mills. These reports may be the log sheets/production reports for Black liquor and pith generation from boiler house etc.
		Lab reports for GCV, solids, moisture, ash etc.	Lab report on GCV, solids (%) moisture(%), Ash (%) and other analysis (proximate) of the Black liquor, pith, dust etc. used by the mill. Frequency: Daily / weekly / monthly / annual lab reports may be produced for different types of Black liquor, pith, dust etc. used by the mill.
		Annual Report	Annual report showing details of Black liquor generation, dust and pith generation, from various sources such as pulp mill, chippers, etc. Frequency: Annual report of Black liquor, pith and dust generation by the mill.
6	Saleable Pulp	Opening and closing stock of saleable pulp	Documents providing details of opening and closing of saleable pulp records by the mill. Frequency: Daily / weekly / monthly / annual opening and closing records of the saleable pulp stock may be produced for different types of pulps produced by the mill.

		Saleable pulp production	Documents providing details of production of saleable pulp from different raw materials by the mill. Frequency: Daily/weekly/monthly/annual production records/documents providing details of saleable pulp from different types of raw materials produced by the mill.
		Annual Report	Annual report showing details of saleable pulp production from different raw materials and its consumption etc. Also the annual stock closing and opening of the saleable pulp from annual report may be produced Frequency: Annual report of saleable pulp production, consumption and stock (opening/closing) by the mill.
7	Uncoated paper / board, Newsprint, Specialty grade	Opening and closing stock reports	Documents/records providing details of opening and closing of Uncoated paper/board, Newsprint, Specialty grade paper products by the mill. Frequency: Daily/weekly/monthly/annual opening and closing records of Uncoated paper/board, Newsprint, Specialty grade paper products, produced by the mill.
		Paper production report / documents	Documents providing details of production of Uncoated paper/board, Newsprint , Specialty grade paper products, produced by the mill Frequency: Daily/weekly/monthly/annual production records/documents providing details of Uncoated paper/board, Newsprint, Specialty grade paper products, produced by the mill.
		Annual Report	Annual report showing details of Uncoated paper/board, Newsprint, Specialty grade paper products, produced by the mill. Also the annual stock closing and opening of the Uncoated paper/board, Newsprint, Specialty grade paper products, produced by the mill may be produced from the annual report. Frequency: Annual report of Uncoated paper/board, Newsprint, Specialty grade paper products, produced and stock (opening/closing) by the mill.
8	Coated Paper/ board	Opening and closing stock reports	Documents/records providing details of opening and closing of Coated Paper/board by the mill. Frequency: Daily/weekly/monthly/annual opening and closing records of Coated Paper/board, produced by the mill.

		Paper production report / documents	Documents providing details of production of Coated Paper/board produced by the mill. Frequency: Daily/weekly/monthly/annual production records/documents providing details of Coated Paper/ board produced by the mill.
		Annual Report	Annual report showing details of Coated Paper/board, produced by the mill. Also the annual stock closing and opening of the Coated Paper/board, produced by the mill may be produced from the annual report. Frequency: Annual report of Coated Paper/board, produced and stock (opening/closing) by the mill.

TABLE 27: DOCUMENTS REQUIRED WOOD-BASED PULP AND PAPER MILLS

B. Agro Based Mills:-

a. The auditor may collect details required in M&V by mentioning the source and document from where data is collected. Subsequently the data may be verified from the data provided by the DC in pro-forma for normalization.

b. The information required is shown in the flow chart for Agro based pulp and paper mill.

c. List of documents required for various monitoring and verification

B.1 Raw Material Details

Type of Agro Paper

Name of the raw material	Moisture, %	Quantity, t/a	Source/ document

Whether Depithing at Mill Site Yes / No

B.2 Depither Details

Item	Unit	Qty	Source/ document
No. of Depithers	Nos		
Capacity	Tonne/annum		
Type of depithing,	Wet/dry		
Moisture	%		
Pith removal	%		

B.3 Agro-pulp Mill (Including Raw material, Pulper, Digester , WSC, ODL , Recovery, Bleach Plant, WTP, and ETP)

i) Pulping Process Used

Type of pulping	Capacity t/a	Production t/a	Total Yield (Including screening losses)	Source / Document
Chemical				
Semi Chemical				
Chemi Thermo Mechanical				
Other				

ii) Refining Details

Items	Unit	Qty	Source / Document
Type of refiners			
Capacity of Refiner, t/a	Tonne/annum		
Pulp Yield, %	%		

iii) Extended Delignification (ODL)

Item	Unit	Qty.	Source / Document
Extended Delignification (ODL)	Yes/No		
Capacity	Tonne/annum		
Date of Installation of ODL Plant	Date		

iv) Bleaching

Item	Chemical Pulp	Semi Chemical	Chemical Thermo Mechanical Pulp
Type of Bleaching	ECF/conv.	ECF/conv.	ECF/conv.
Sequence Used			
Bleaching Losses %			
Bleached Pulp Yield %			
Brightness of pulp, %			

Item	Date	Source / Document
Date of Installation of ECF Bleach Plant		

v) Energy Consumption in Pulp Mill

Item	Qty	Source/ Document
LP Steam Consumption, t/a		
MP Steam Consumption, t/a		
Power Consumption, kWh/a		

vi) Pulp Dryer

Sr No	Item	Unit	Qty	Source / Document
1	Capacity	Tonne/annum		
2	Production of saleable pulp	Tonne/annum		
3	Energy Consumption in pulp dryer	Kcal		
4	LP Steam Consumption	Tonne/annum		
5	MP Steam Consumption	Tonne/annum		
6	Power Consumption	kWh/annum		

vii) Chemical Recovery

Sr No	Item	Unit	Data	Source / Document
1	Type of chemical recovery	Conventional / Non-Conventional		
2	Total Black liquor Solids generated	Tonnes		
3	In Lime Kiln Installed	Yes/No		
4	Date of Installation of Lime Kiln I	Date		
5	Date of Installation of Lime Kiln II	Date		
6	Date of Installation of Lime Kiln III	Date		

viii) Over-all Energy consumption in pulp mill

Item	Qty	Source / Document
LP Steam consumption, t/a		
MP Steam consumption, t/a		
Power consumption, kWh/a		

B.4 Paper Machine (including stock preparation, chemical preparation / addition plant, finishing house)

(i) Paper Machine Details

Number of Paper Machines

Item	PM-1	PM-2	PM-3	PM-4	PM-5	Source/ document
Type of paper machine						
Capacity, t/a						
Type of paper produced						
Production, t/a						
Annual weight average GSM						
Energy Consumption in paper machine (including Stock Preparation, chemical addition and finishing house)						
LP Steam consumption t/a						
MP Steam consumption, t/a						
Power consumption, kWh/a						

(ii) Coating / Value addition

Coating If any Yes /No

Type of coating online / offline

Item	Qty	Source/ document
Capacity of offline coating plant, t/a		
Production of coated paper/board, t/a		
LP Steam consumption, t/a		
MP Steam consumption, t/a		
Power consumption, kWh/a		

(iii) Over-all Energy consumption in paper machine, stock preparation, chemical preparation and addition plant , finishing house and offline coating plant add (i+ii)

Item	Qty	Source/ document
LP Steam consumption, t/a		
MP Steam consumption, t/a		
Power consumption, kWh/a		

B.5 The information required is shown in the flow chart for Agro-based Pulp and Paper Mill

TABLE 28: GENERAL DETAILS REQUIRED IN AGRO-BASED PULP AND PAPER MILLS

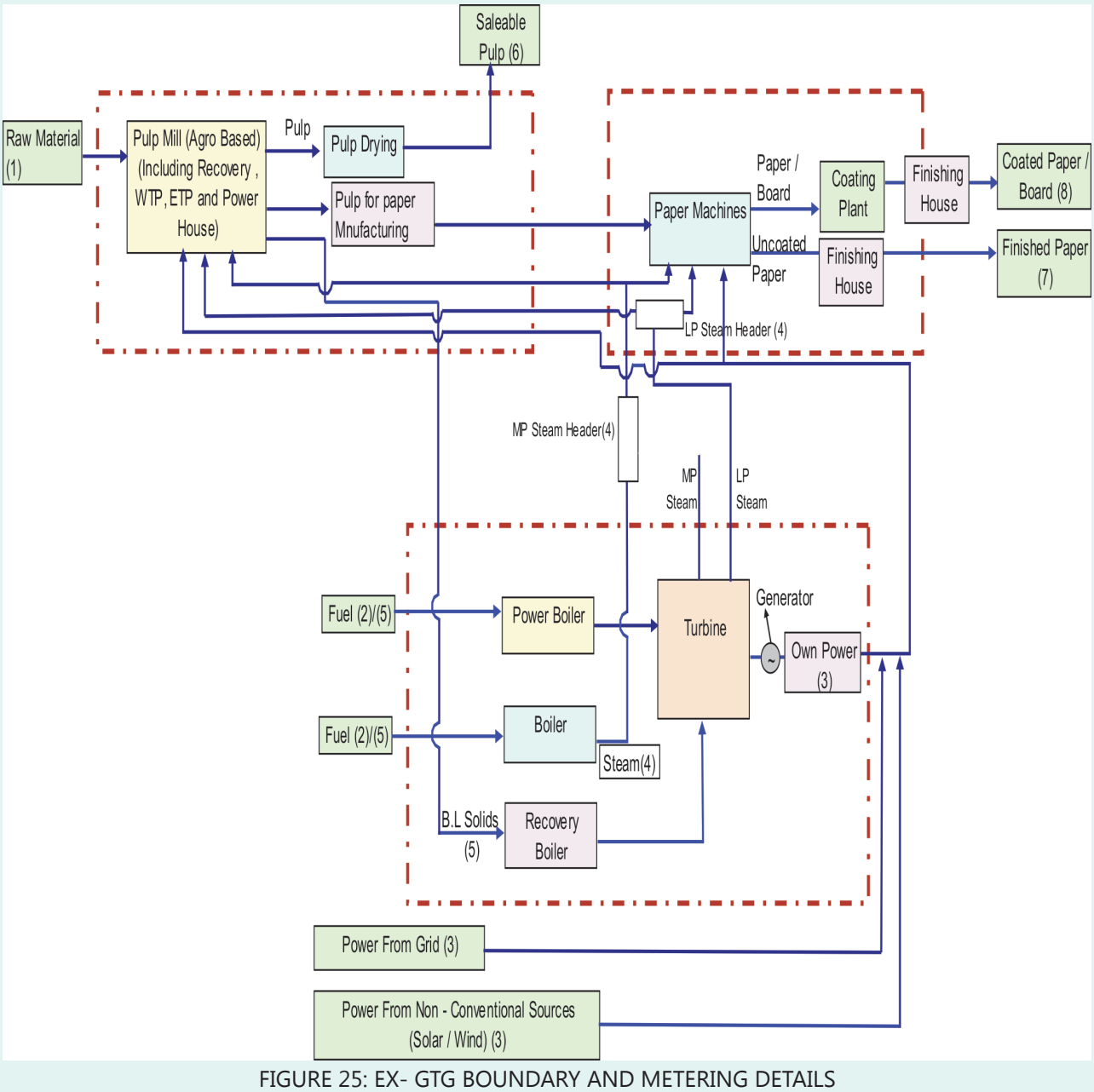


FIGURE 25: EX- GTG BOUNDARY AND METERING DETAILS FOR AGRO-BASED PULP AND PAPER MILL

S. No.	Details of input and output	Source / Type of document required	Details of the Source / document and frequency
1	Raw Materials	Lab Report	Report on moisture(%), Ash (%) and other analysis of the raw materials used by the mill Frequency: Daily / weekly / monthly / annual lab reports may be produced for different types of raw materials used by the mills.
		Purchase Document From Purchase Department	Purchase documents providing details of raw material purchased by the mill Frequency: Daily / weekly / monthly / annual purchase documents may be produced for purchase of different types of raw materials used by the mills
		Raw Material Consumption Reports	Consumption reports giving details of raw material consumed by the mill. The report may be for raw material chip production, digester loading etc. from the department concerned. Frequency: Daily / weekly / monthly / annual consumption documents may be produced for different types of raw materials used by the mill in chipper/digesters house.
		Annual Report	Annual report showing details of raw materials consumed on annual basis by the mill. Frequency: Annual consumption of raw materials by the mill.
2	Purchased Fuels	Fuel Purchase report / documents	Purchase documents providing details of fuel purchased by the mill. Frequency: Daily / weekly / monthly / annual purchase documents may be produced for purchase of different types of fuels used by the mills.
		Lab report for GCV moisture and Ash	Lab report on GCV, moisture(%), Ash (%) and other analysis (proximate and ultimate) density etc, of the fuel used by mill. Frequency: Daily / weekly / monthly / annual lab reports may be produced for different types of fuels used by the mills.

		Fuel Consumption Report	Consumption reports giving details of fuel consumed by the mill in boilers, DG sets etc. The consumption report may be from the department concerned showing details of fuel consumption. Frequency: Daily/weekly/monthly/annual fuel consumption documents may be produced for different types of fuels used by the mill in boiler/ DG sets etc.
		Annual Report	Annual report showing details of fuels consumed on annual basis by the mill. Frequency: Annual consumption of fuels by the mill.
3	Power	Electricity Purchased from Grid	Purchased electricity bill from state electricity board providing details of the electricity purchased by the mill. Frequency: monthly/annual purchased electricity bills may be produced by the mills.
		Own power generation	Details of own power generation from different sources such as turbines (gas, steam etc), DG sets. Frequency: Daily/weekly/monthly/annual own generation reports may be produced by the mills. These reports may be the log sheets/ production reports from power house.
		Production of power from non-conventional sources, e.g. solar/wind power	Details of power generation from different Non-conventional sources such as solar/wind turbines, bio gas etc. Frequency: Daily/weekly/monthly/annual power generation reports may be produced by the mills. These reports may be the log sheets/production reports from power houses/departments concerned
		Annual Report	Annual report showing details of Power purchased from grid, own power generation, power from non-conventional sources etc. Frequency: Annual report of power purchased, own generation, generation from non- conventional sources etc.by the mill.

4	Steam	Steam generation by the mill	Details of Steam generation from different boilers, extraction of steam from turbines, steam generation from waste heat recovery and non-conventional sources(Solar steam generators) Frequency: Daily/weekly/monthly/annual steam generation reports may be produced by the mills. These reports may be the log sheets/production reports for steam generation from boiler house etc.
		Steam consumption by the mill	Details of Steam consumption in different sections of the mill such as pulp mill, chemical recovery, paper machine, power house and other plants of the mill. Frequency: Daily/weekly/monthly/annual steam consumption reports may be produced by the mills. These reports may be the log sheets/ consumption reports for steam consumption by individual section of the mill or power boiler house.
		Annual Reports	Annual report showing details of Steam Generation and consumption from various sources. The generation and consumption of steam may be in individual departments as well as for the whole mill, boilers, extraction steam, steam from non-conventional sources etc. Frequency: Annual report of steam generation and consumption by the mill
5	Internally Generated Fuels (Black liquor solids , pith , chipper dust)	Generation report of Black liquor, pith, chipper dust, etc	Details of generation of black liquor, pith, chipper dust or any other combustible waste by the mill from different sections such as chipper house, pulp mill, other plants. Frequency: Daily/weekly/monthly/annual Black liquor, dust etc generation reports may be produced by the mills. These reports may be the log sheets/production reports for Black liquor and pith generation from boiler house etc.
		Lab reports for GCV, solids, moisture, ash etc.	Lab report on GCV, solids (%) moisture(%), Ash (%) and other analysis (proximate) of the Black liquor, pith, dust etc. used by the mill. Frequency: Daily/weekly/monthly/annual lab reports may be produced for different types of Black liquor, pith, dust etc. used by the mill.

		Annual Report	Annual report showing details of Black liquor generation, dust and pith generation, from various sources such as pulp mill, chippers, etc. Frequency: Annual report of Black liquor, pith and dust generation by the mill.
6	Saleable Pulp	Opening and closing stock of saleable pulp	Documents providing details of opening and closing of saleable pulp records by the mill. Frequency: Daily/weekly/monthly/annual opening and closing records of the saleable pulp stock may be produced for different types of pulps produced by the mill.
		Saleable pulp production	Documents providing details of production of saleable pulp from different raw materials by the mill. Frequency: Daily / weekly / monthly / annual production records/ documents providing details of saleable pulp from different types of raw materials produced by the mill.
		Annual Report	Annual report showing details of saleable pulp production from different raw materials and its consumption etc. Also the annual stock closing and opening of the saleable pulp from annual report may be produced Frequency: Annual report of saleable pulp production, consumption and stock (opening/ closing) by the mill.
7	Uncoated paper / board, Newsprint, Specialty grade	Opening and closing stock reports	Documents/records providing details of opening and closing of Uncoated paper/board, Newsprint, Specialty grade paper products by the mill. Frequency: Daily / weekly / monthly / annual opening and closing records of Uncoated paper/ board, Newsprint, Specialty grade paper products, produced by the mill.
		Paper production report / documents	Documents providing details of production of Uncoated paper/board, Newsprint , Specialty grade paper products, produced by the mill Frequency: Daily / weekly / monthly / annual production records/ documents providing details of Uncoated paper/board, Newsprint, Specialty grade paper products, produced by the mill.

		Annual Report	Annual report showing details of Uncoated paper/ board, Newsprint, Specialty grade paper products, produced by the mill. Also the annual stock closing and opening of the Uncoated paper/board, Newsprint, Specialty grade paper products, produced by the mill may be presented from the annual report. Frequency: Annual report of Uncoated paper/ board, Newsprint, Specialty grade paper products, produced and stock (opening/ closing) by the mill.
8	Coated Paper / board	Opening and closing stock reports	Documents/records providing details of opening and closing of Coated Paper/board by the mill. Frequency: Daily/weekly/monthly/annual opening and closing records of Coated Paper /board, produced by the mill.
		Paper production report / documents	Documents providing details of production of Coated Paper/board produced by the mill Frequency: Daily / weekly / monthly / annual production records/ documents providing details of Coated Paper/board produced by the mill.
		Annual Report	Annual report showing details of Coated Paper/ board, produced by the mill. Also the annual stock closing and opening of the Coated Paper/board, produced by the mill may be presented From the annual report. Frequency: Annual report of Coated Paper/board, produced and stock (opening/closing) by the mill.

TABLE 29: DOCUMENT REQUIRED FOR AGRO-BASED PULP AND PAPER MILLS

C. RCF Based Mills:-

a. The auditor may collect details required in M&V format by mentioning the source and the document from which data has been collected. Subsequently, the data may be verified with data provided by the DC in the Pro-froma for normalisation.

b. The information required is shown in the flow chart for RCF based pulp and paper mill.

c. List of documents required for various monitoring and verification.

A.1 Material Details

Type of Waste Paper

Name of the raw material	Moisture, %	Quantity, t/a	Source/ document

A.2 RCF Pulp Mill (Including Pulper, Pulp Cleaning and Screening, Deinking, Bleaching, WTP, and ETP)

i) Pulper / Pulp Cleaning and Screening Process Used

No. of Unit	Capacity t/a	Production t/a	Source / Document
Pulper			
HD Cleaner			
Screening			
Cleaning and screening rejects, t/a			
No. of Deinking loops			

ii) Deinking / Bleach Process

Item	Qty.	Source / Document
Capacity , t/a		
Pulp yield, %		
Fibre Loss, %		
Ink removal Efficiency, %		
Bleaching Stages Yes/No		
Bleaching losses, t/a		

iii) Refining

Item	1	2	3	Source / Document
Type of Refiners				
No. of Refiners				
Initial Pulp Freeness oSR /CSF				
Final Freeness oSR /CSF				

iv) Energy Consumption in Pulp Mill

Item	Qty	Source / Document
LP Steam consumption, t/a		
MP Steam consumption, t/a		
Power consumption, kWh/a		

v) Pulp Dryer

Sr No	Item	Unit	Qty	Source / Document
1	Capacity	Tonne/annum		
2	Production of saleable pulp, t/a	Tonne/annum		
3	Energy Consumption in pulp dryer	kcal		
4	LP Steam Consumption	Tonne/annum		
5	MP Steam Consumption	Tonne/annum		
6	Power Consumption	kWh/annum		

vi) Over-all Energy consumption in pulp mill

Item	Qty	Source / Document
LP Steam consumption, t/a		
MP Steam consumption, t/a		
Power consumption, kWh/a		

A.3 Paper Machine (including stock preparation, chemical preparation / addition plant , finishing house)

(i) Paper Machine Details

Number of Paper Machines

Item	PM-1	PM-2	PM-3	PM-4	PM-5	Source/ document
Type of paper machine						
Capacity, t/a						
Type of paper produced						
Production, t/a						
Annual weight average GSM						
Energy Consumption in paper machine (including Stock Preparation, chemical addition and finishing house)						
LP Steam consumption t/a						
MP Steam consumption, t/a						
Power consumption, kWh/a						

(ii) Coating / Value addition

Coating If any Yes/No

Type of coating online / offline

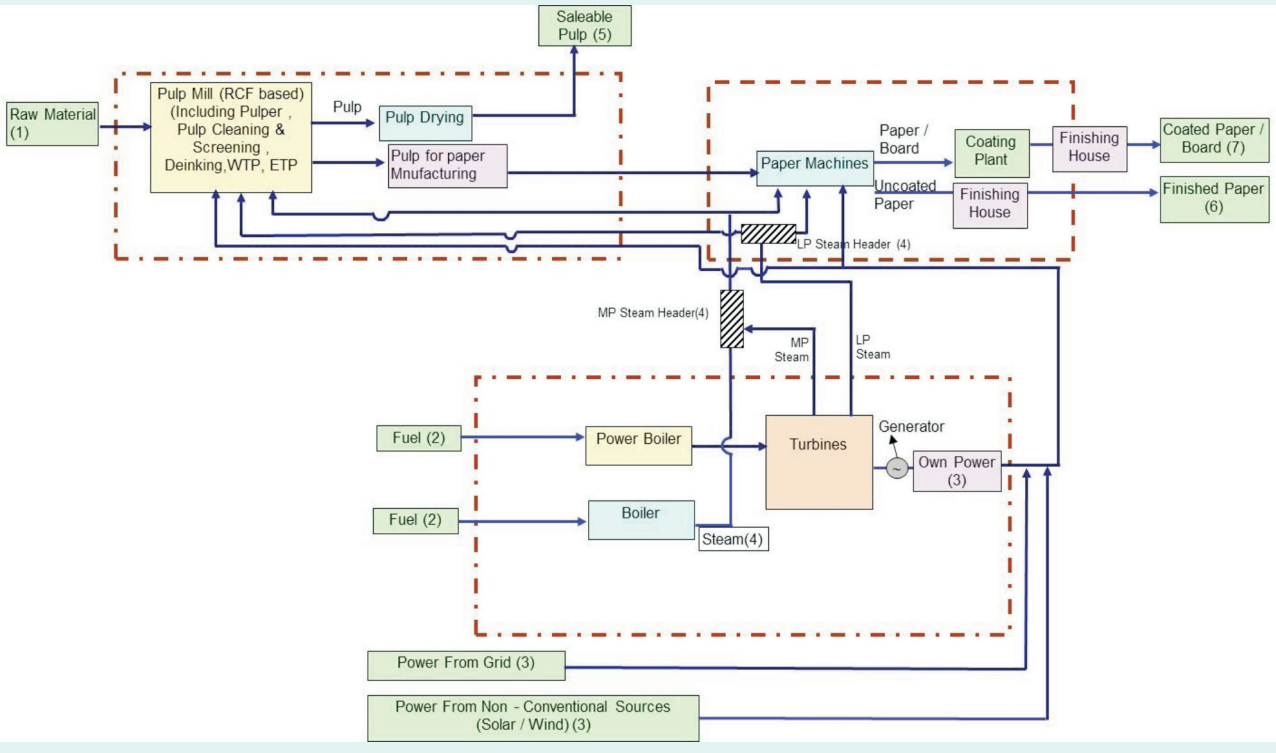
Item	Qty	Source/ document
Capacity of offline coating plant, t/a		
Production of coated paper/board, t/a		
LP Steam consumption, t/a		
MP Steam consumption, t/a		
Power consumption, kWh/a		

(iii) Over-all Energy consumption in paper machine, stock preparation, chemical preparation and addition plant , finishing house and offline coating plant add (i+ii)

Item	Qty	Source/ document
LP Steam consumption, t/a		
MP Steam consumption, t/a		
Power consumption, kWh/a		

TABLE 30: GENERAL DETAILS REQUIRED IN RCF-BASED PULP AND PAPER MILLS

A.4 The Information required is shown in the Flow Chart for RCF Based Pulp and Paper Mill



S. No.	Details of input and output	Source / Type of document required	Details of the Source / document and frequency
1	Raw Materials	Lab Report	Report on moisture(%), Ash (%) and other analysis of the raw materials used by the mill Frequency: Daily / weekly / monthly / annual lab reports may be produced for different types of raw materials used by the mills.
		Purchase Document From Purchase Department	Purchase documents providing details of raw material purchased by the mill Frequency: Daily / weekly / monthly / annual purchase documents may be produced for purchase of different types of raw materials used by the mills
		Raw Material Consumption Reports	Consumption reports giving details of raw material consumed by the mill. The report may be for raw material chip production, digester loading etc. from the department concerned. Frequency: Daily / weekly / monthly / annual consumption documents may be produced for different types of raw materials used by the mill in chipper/digesters house.
		Annual Report	Annual report showing details of raw materials consumed on annual basis by the mill. Frequency: Annual consumption of raw materials by the mill.
2	Purchased Fuels	Fuel Purchase report / documents	Purchase documents providing details of fuel purchased by the mill. Frequency: Daily / weekly / monthly / annual purchase documents may be produced for purchase of different types of fuels used by the mills.
		Lab report for GCV moisture and Ash	Lab report on GCV, moisture(%), Ash (%) and other analysis (proximate and ultimate) density etc, of the fuel used by mill. Frequency: Daily / weekly / monthly / annual lab reports may be produced for different types of fuels used by the mills.

		Fuel Consumption Report	Consumption reports giving details of fuel consumed by the mill in boilers, DG sets etc. The consumption report may be from the department concerned showing details of fuel consumption. Frequency: Daily / weekly / monthly / annual fuel consumption documents may be produced for different types of fuels used by the mill in boiler/DG sets etc.
		Annual Report	Annual report showing details of fuels consumed on annual basis by the mill. Frequency: Annual consumption of fuels by the mill.
3	Power	Electricity Purchased from Grid	Purchased electricity bill from state electricity board providing details of the electricity purchased by the mill. Frequency: monthly / annual purchased electricity bills may be produced by the mills.
		Own power generation	Details of own power generation from different sources such as turbines (gas, steam etc), DG sets. Frequency: Daily / weekly / monthly / annual own generation reports may be produced by the mills. These reports may be the log sheets/production reports from power house.
		Production of power from non-conventional sources, e.g. Solar / wind power	Details of power generation from different Non-conventional sources such as solar/ wind turbines, bio gas etc. Frequency: Daily / weekly / monthly / annual Power generation reports may be produced by the mills. These reports may be the log sheets/ production reports from power houses/departments concerned
		Annual Report	Annual report showing details of Power purchased from grid, own power generation, power from non-conventional sources etc. Frequency: Annual report of power purchased, own generation, generation from non- conventional sources etc. by the mill.
4	Steam	Steam generation by the mill	Details of Steam generation from different boilers, extraction of steam from turbines, steam generation from waste heat recovery and non-conventional sources (solar steam generators) Frequency: Daily / weekly / monthly / annual steam generation reports may be produced by the mills. These reports may be the log sheets/ production reports for steam generation from boiler house etc.

		Steam consumption by the mill	Details of Steam consumption in different sections of the mill such as pulp mill, chemical recovery, paper machine, power house and other plants of the mill. Frequency: Daily / weekly / monthly / annual steam consumption reports may be produced by the mills. These reports may be the log sheets/consumption reports for steam consumption by individual section of the mill or power boiler house.
		Annual Reports	Annual report showing details of Steam Generation and consumption from various sources. The generation and consumption of steam may be in individual departments as well as for the whole mill, boilers, extraction steam, steam from non-conventional sources etc. Frequency: Annual report of steam generation and consumption by the mill
5	Saleable Pulp	Opening and closing stock of saleable pulp	Documents providing details of opening and closing of saleable pulp records by the mill. Frequency: Daily/weekly/monthly/annual opening and closing records of the saleable pulp stock may be produced for different types of pulps produced by the mill.
		Saleable pulp production	Documents providing details of production of saleable pulp from different raw materials by the mill. Frequency: Daily / weekly / monthly / annual production records/documents providing details of saleable pulp from different types of raw materials produced by the mill.
		Annual Report	Annual report showing details of saleable pulp production from different raw materials and its consumption etc. Also the annual stock closing and opening of the saleable pulp from annual report may be produced Frequency: Annual report of saleable pulp production, consumption and stock (opening/closing) by the mill.
6	Uncoated paper / board, Newsprint , Specialty grade	Opening and closing stock reports	Documents/records providing details of opening and closing of Uncoated paper/ board, Newsprint, Specialty grade paper products by the mill. Frequency: Daily/weekly/monthly/annual opening and closing records of Uncoated paper/board, Newsprint, Specialty grade paper products, produced by the mill.

		Paper production report /documents	Documents providing details of production of Uncoated paper/board, Newsprint, Specialty grade paper products, produced by the mill Frequency: Daily / weekly / monthly / annual production records/ documents providing details of Uncoated paper/board, Newsprint, Specialty grade paper products, produced by the mill.
		Annual Report	Annual report showing details of Uncoated paper/board, Newsprint, Specialty grade paper products, produced by the mill. Also the annual stock closing and opening of the Uncoated paper/board, Newsprint, Specialty grade paper products, produced by the mill may be presented from the annual report Frequency: Annual report of Uncoated paper/ board, Newsprint, Specialty grade paper products, produced and stock (opening/ closing) by the mill.
7	Coated Paper / board	Opening and closing stock reports	Documents/records providing details of opening and closing of Coated Paper/board by the mill. Frequency: Daily / weekly / monthly / annual opening and closing records of Coated Paper /board, produced by the mill.
		Paper production report / documents	Documents providing details of production of Coated Paper/board produced by the mill Frequency: Daily / weekly / monthly / annual production records/ documents providing details of Coated Paper/board produced by the mill.
		Annual Report	Annual report showing details of Coated Paper/board, produced by the mill. Also the annual stock closing and opening of the Coated Paper/board, produced by the mill may presented from the annual report Frequency: Annual report of Coated Paper/ board, produced and stock (opening/ closing) by the mill.

TABLE 31: DOCUMENTS REQUIRED IN RCF-BASED PULP AND PAPER

Annexure VII: Textile

1. Details of Plant, Process Description, Address (Plant & regd. Office) & Energy Manager
2. Section-wise energy metering (electrical and thermal) is required for making equivalent product in textile sub-sectors. Proper calculation documents should be maintained, if energy figures are arrived at by calculation.
3. SCADA screen-shots are required for major and auxiliary systems.
4. Inclusions and exclusions should be clearly marked in the gate-to-gate boundary diagram.
5. It is essential to express quantities of different product types in a single unit for calculation of specific energy consumption from gram per linear metre (GLM). DC to furnish back-up calculation of conversion to EmAEA.
6. Energy and Mass balance is required to be furnished in the verification report.
7. EmAEA is advised to convert other special product or value added product in to the major equivalent product through energy consumption and the calculation is to be included in the verification report.
8. Energy conservation measures taken, savings achieved, investment made, detailed information with calculation sheet & photographs of ENCONs if available.
9. Details of Addition or Deletion of Equipment. Details of Project activity If any.
10. Details of Power Export and Colony consumption with its reports and supporting Documents.
11. SEC improvement from baseline period 2014-15 to assessment period 2018-19, should be cross checked and verified by EmAEA during M&V Audit based on best operating practices, Energy efficiency & conservation measures or any other relevant measures taken up by plant during the cycle. The same verification detailsshould be incorporated in M&V Report.
12. Submission of minutes of meeting (MoM) for plant visit duly signed by every team member of EmAEA agency and plant officials is mandatory to ensure the presence of the members. BEE will interact with that only team members who had visited the plant while verification & finalization of the report, not with the others.
13. EmAEA should report the process technology based on product-wise with respect to the operational characteristics of each process.The same should be incorporated in M&V Audit Report.
14. Evaluate and project the energy saving potential in terms of "Metric Ton of Oil Equivalent (MTOE)" available in the plant in the next three calendar years by means of analyzing the plant performance in previous PAT cycles which would occur due to process change, efficiency improvement, retrofitting or fine tuning of operational parameters, etc.

15. The verification report, Sector specific proforma, Form-1,Form-A,Form-B and the supporting authentic documents with proper sequencing and refrence shall be provided for checking the correctness of the report with the supporting documents.
16. The proof for timely submission of the Form-1, Form-2, Form-3 along with its copy shall be attached in the M&V report.
17. The summary of total energy consumption, the total equivalent production within the plant, opinion and the basis for the recommendation of the Energy saving certificates shall be mentioned in the Executive summary of the report.
18. The report shall be free from misrepresentation, without any error and properly verified by the verification agency as well by the plant before submission to the Bureau.
19. Spinning Sub-Sector

a. Count of yarn is one of the important parameters. Change in the count of the yarn may result in the change in the UKG of the plant. So normalisation for count of yarn is important. Hence, all products need to be converted to 40s count as per SITRA guidelines for UKG calculation. The calculation for conversion shall be an integral part of the verification report.

b. The open-end yarn to be converted to 10s count for UKG calculation.

c. Section-wise energy consumption to be provided for backup calculation as per sample table. EmAEA is required to insert or delete the section as per the requirement.

TABLE 32: SECTION-WISE ENERGY CONSUMPTION

Sr No	Item	Electrical SEC (kwh/kg)	Thermal SEC (kcal/kg)	Remarks
1	Blow Room			
2	Carding			
3	Combing			
4	Draw Frame			
5	Speed Frame			
6	Ring Frame			
7	Winding			
8	TFO			
9	AutoConer			
10	Doubling			
11	Singing and Sizing			
12	Humidification			
13	Lighting			
14	Utilities			
15	Misc Others			

d. The calculation used to convert other type of yarn (Like PV, Worsted, etc) into the singular yarn in the baseline year will remain same in the assessment year. EmAEA is advised to use the same formulae as per the baseline year report.

e. All special product yarn (Melange/Fibre dyed Yarns, High value blended yarns mixed with Wool, Silk, Modal, Nylon, etc, Slub Yarns, Compact yarns, TFO doubled yarns, Jaspe yarns, Jaspeslub yarns, Nep effect yarns) need to be converted into single major products. The conversion formulae for baseline and assessment years will be the same.

f. Production and capacity to be equated with reference to the number, speed, weight and running hours of ring frame and autoconer.

g. Mention clear bifurcation of energy in major product (GtG boundary as per PAT) and other products as per boundary limit example.

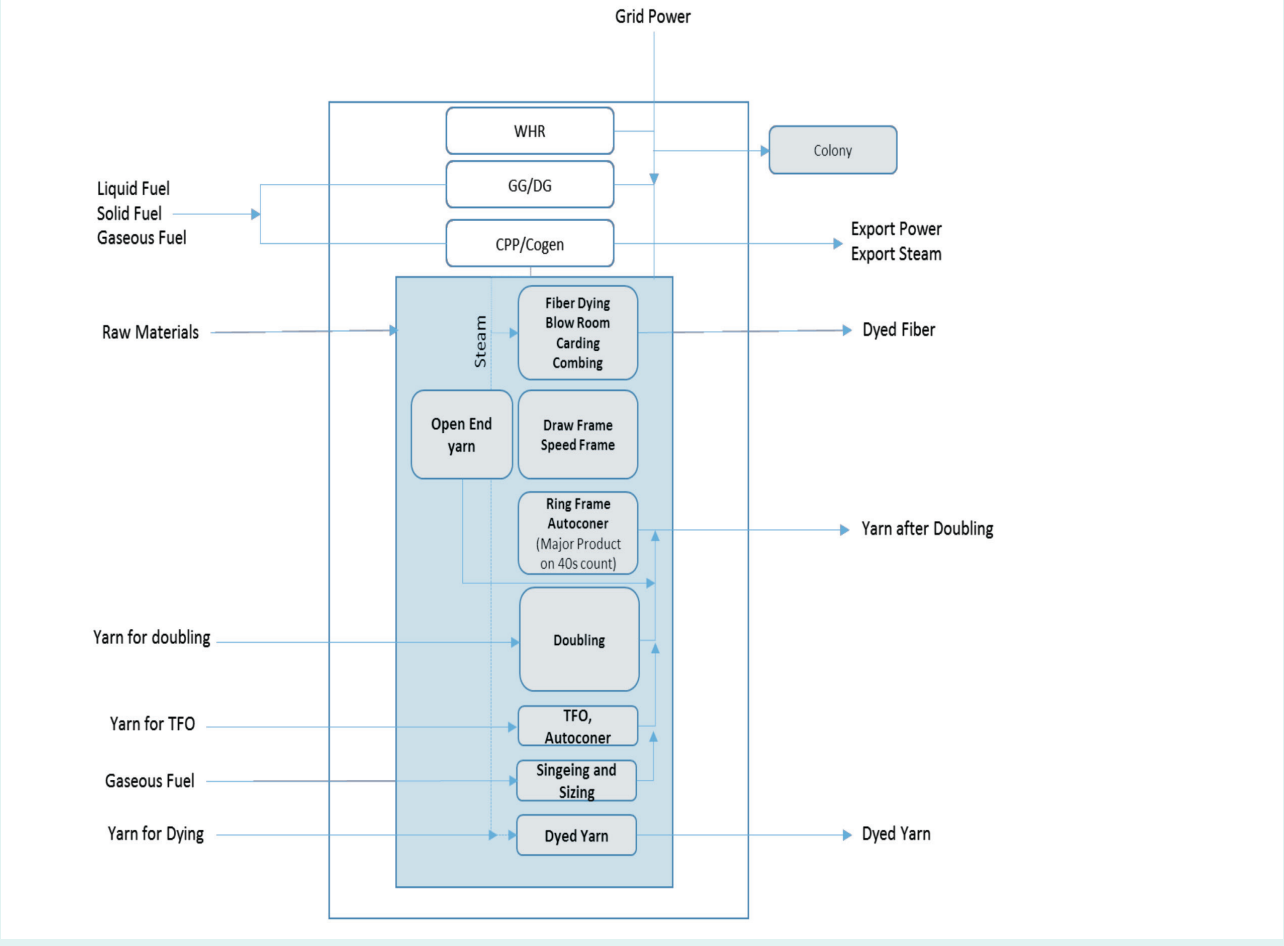


FIGURE 26: EX- GTG BOUNDARY FOR TEXTILE (SPINNING SUB-SECTOR)

20. Composite and Processing Sub-sector

a. There are five finished products defined in the composite sub-group; all other special or value-added products shall be converted into any of these five major products through energy consumption. The calculation of conversion is to be included in the verification report of the EmAEA.

The final five finished products in the composite sub-group are:

i. Cotton

ii. Polyester Cotton

iii. Lycra

iv. Non Cellulosic Product (100% Synthetic)

v. Wool-based product

b. In order to streamline weaving products of all the DCs 60 PPI (picks per inch) should be taken as the standard value; DCs should convert their weaving production at different picks to 60 PPI. EmAEA to include the conversion calculation in the verification report.

c. Similarly for knitting. The conversion factors shall be in terms of Wales on weight basis.

d. Mass and energy balance calculation is required to be included in the verification report by EmAEA.

e. Steam balance diagram is required to be included in the verification report by EmAEA.

f. Section-wise specific energy consumption is required to be specified as per the table below.

g. The yarn sold to market quantity is required to be converted into 40s count and 10s count respectively for Ring Frame and Open End Yarn.

h. Grey yarn or dyed yarn Purchase from the market for weaving or Knitting is required to specify in the report with its quantity.

i. The quantity of Yarn purchased or out sourced Fabric is used in the plant production is required to mention in the report.

Sr No	Item	Electrical SEC (kwh/kg)	Thermal SEC (kcal/kg)	Remarks
Spinning				
1	Blow Room			
2	Carding			
3	Combing			
4	Draw Frame			
5	Speed Frame			
6	Ring Frame			
7	Winding			

8	TFO			
9	AutoConer			
10	Doubling			
11	Singing and Sizing			
Knitting /Weaving				
1	Warping			
2	Sizing			
3	Knotting			
4	Weaving			
Processing				
1	Singeing			
2	Desizing			
3	Mercerizing			
4	Bleaching			
5	Sueding			
6	Dying			
7	Printing			
Misc and Others				
1	Humidification			
2	Lighting			
3	Utilities			
4	Others			

TABLE 33: SECTION-WISE ENERGY CONSUMPTION

EmAEA is required to add the section as per the requirement.

j. Demarcation of the plant boundary is required with clear understanding of raw material input, energy input, power import/export, intermediary product import/export, power for the residential colony, for construction and others requirements, power supplied to other ancillary units outside the plant boundary. A typical sample of plant boundary condition is represented below.

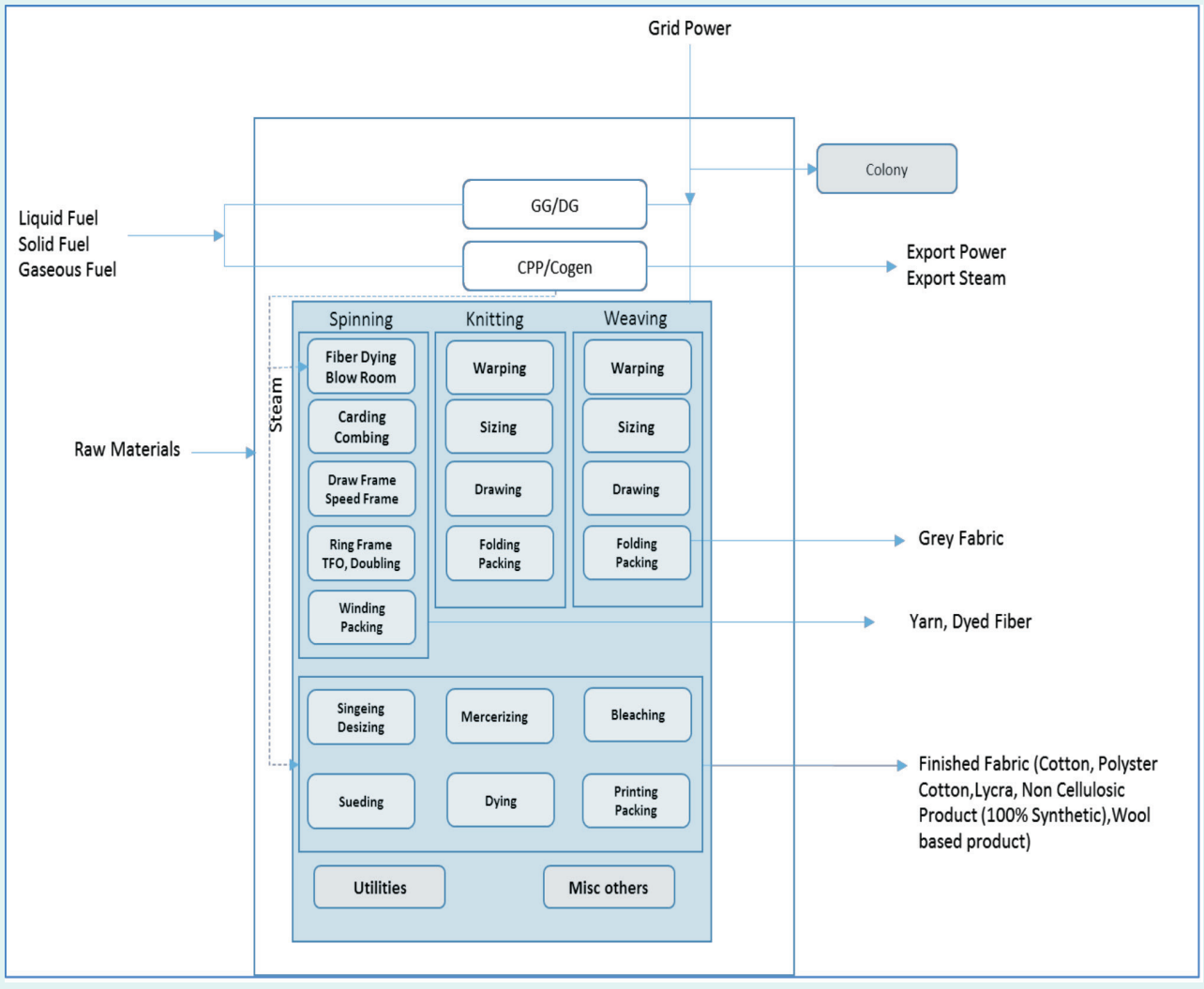


FIGURE 27: EX- GTG BOUNDARY FOR TEXTILE (COMPOSITE/PROCESSING SUB-SECTOR)

21. Fibre Sub-Sector

a. Section-wise production and Energy performance is required for each Fibre product

b. The products and sections are different in Fibre sub-sector, hence the Pro-forma of the sub-sector specifies the major product and other products from 1-5.

c. EmAEA to specify the product details with sectional process flow diagram in the verification report.

d. Mass balance calculation with reference to input raw material and output product is required to be produced.

e. Fuel used as raw material should not be considered from the input energy and reported in the verification report by EmAEA.

f. DCs have to submit weighted average denier value for their products. Plant has to submit production value in single denier by converting all the denier value.

g. DCs have to convert all of their products in single major product equivalent by taking ratio of the SEC of the other products to the main product.

h. EmAEA to include the details of major products and other products as mentioned in Pro-forma as per the following table.

Sr No	Item	Name	Unit	Remarks
1	Raw Material			
2	Major Product			
3	Product 1			
4	Product 2			
5	Product 3			
6	Product 4			
7	Product 5			
8	Denier			

TABLE 34: PRODUCT NAME IN FIBRE SUB-SECTOR

i. Steam balance diagram of the plant from steam generation to steam consumption is required to be included in the verification report.

j. Product-wise, sectional (sub-process) yearly thermal and electrical energy details are required as per the following sample table for Product 1.

Sr No	Item	Electrical SEC (kwh/kg)	Thermal SEC (kcal/kg)	Remarks
1	Polymerisation Process			
2	Spinning Process			
3	Draw line Process			
4	Utilities			
5	Misc Others			

TABLE 35: SECTION-WISE ENERGY CONSUMPTION

k. Boundary Condition

Mention clear bifurcation of energy in major product (GtG boundary as per PAT) and other products as per boundary limit example.

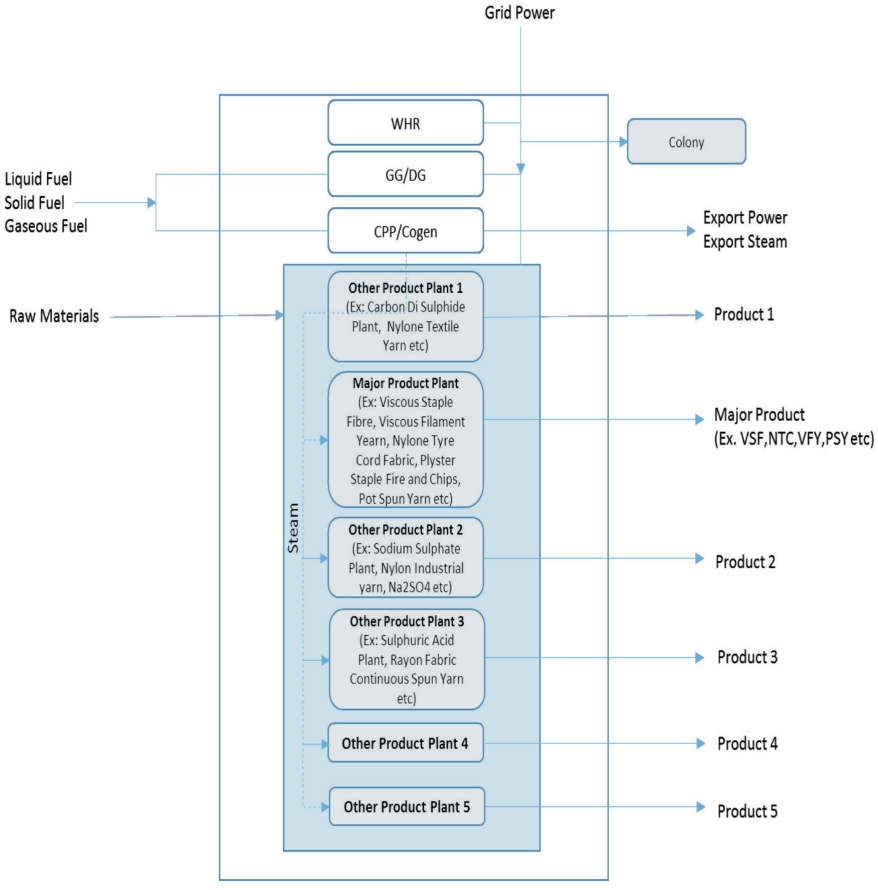


FIGURE 28: EX- GTG BOUNDARY FOR TEXTILE (FIBRE) SUB-SECTOR

Annexure VIII: Chlor Alkali

1. Section-wise Details

Section-wise specific power consumption and specific thermal consumption shall be specified and provided to EmAEA as per the following format. EmAEA can add sections if required.

Sr No	Section	SPC kwh/ tonne	SEC kcal/ tonne	Remarks
1	Primary Brine Plant.			
2	Secondary Brine Plant.			
3	Membrane Cell Plant, Caustic Soda			
4	ChlorineLiquefactions Plant			
5	Hydrogen Bottling Plant			
6	Caustic Concentration units.			
7	Caustic Evaporation units.			
8	KOH Cell Unit			
9	HCl /Sodium Hypo Plants.			
10	Utilities Plant.			
11	Waste Water Treatment Plant.			

TABLE 36: SECTION WISE ENERGY DETAILS

2. Product Mix: Same factor to be use as used in PAT cycle – 1.
3. Notional/Normalisation Energy for imported electricity from Grid in case of DC with CPP

   Notional energy for imported electricity = [Imported electricity (lakh kWh) x (3394-860) (kcal/kWh)]/10[Million kcal]

   Where: - 3394 kCal/kWh is weighted average heat rate of all designated consumers in Chlor-Alkalisector
4. Electricity exported to Grid/others will at the Generation Weighted Net Heat Rate.
5. Membrane change verification: Details regarding membrane change for each cell shall be provided along with the membrane configuration.
6. Maximum allowable capacity of chlorine storage in the DC shall be specified and provided to the EmAEA to furnish in report.
7. Cathode-anode coating verification: Details regarding cathode-anode coating shall be provided along with the membrane configuration.
8. EmAEA shall ensure and verify production of caustic soda lye (33% & 49% concentration) and hydrogen

as per quantity of chlorine produced during the electrolysis process. EmAEA shall also ensure that these productions should not exceed the stoichiometric limit.

9. DC shall provide the increase in annual power consumption kWh/Ton due to ageing of membrane and electrodes with proper justification supported by authenticated

10. If a captive power or co-generation plant caters to two or more DCs for electricity and/or steam requirements, each DC shall consider that plant to be within its boundary and the energy consumed by the plant shall be included in the total energy consumption. However, electricity in terms of calorific value (as per actual heat rate) and steam in terms of calorific value (as per steam enthalpy) exported to other plants shall be subtracted from the total energy consumption.

11. Boundary Condition

    Mention clear bifurcation of energy in the caustic soda plant (GtG boundary as per PAT) and other products as per boundary limit example.

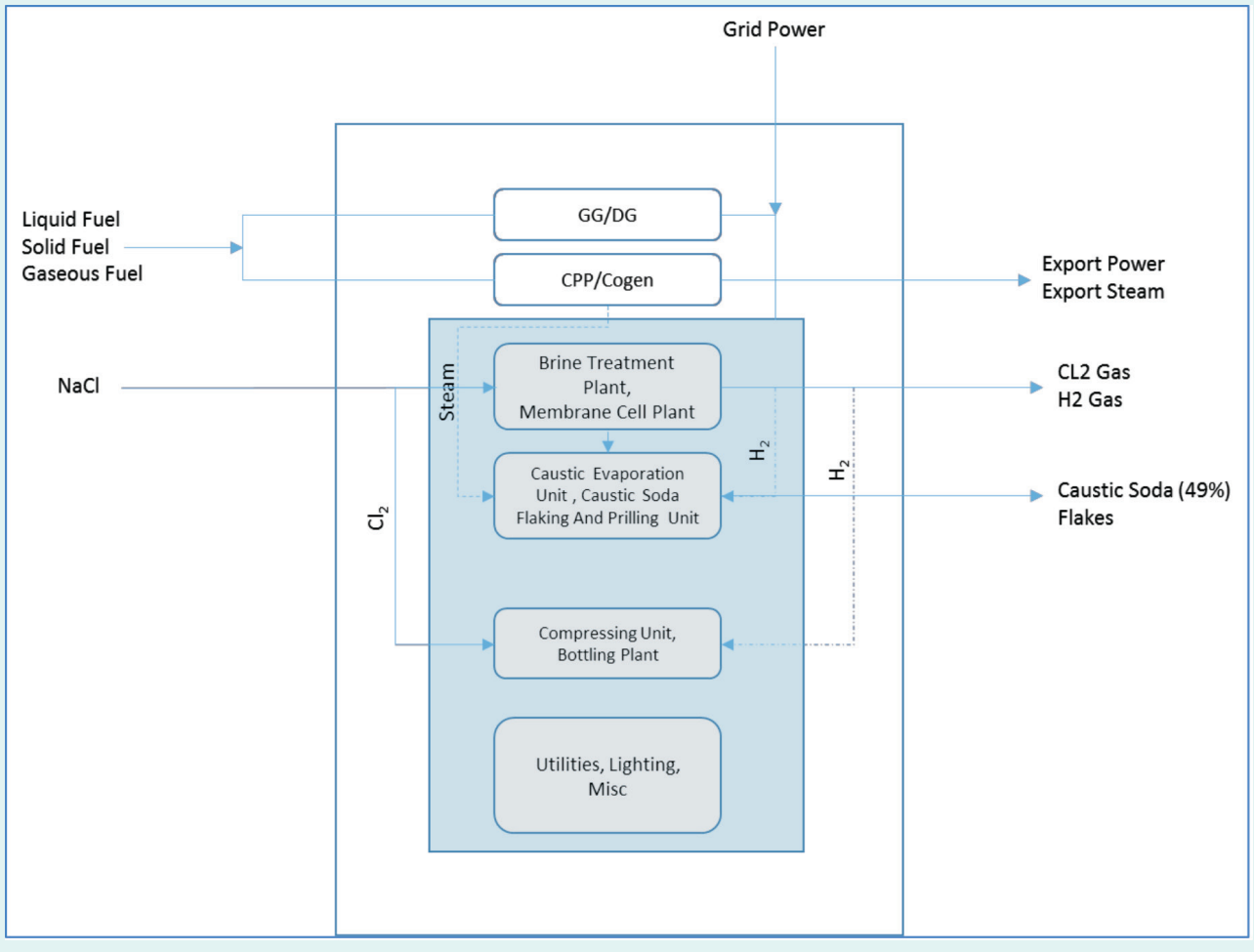


FIGURE 29: EX-GTG BOUNDARY FOR CHLOR-ALKALI SECTOR

Annexure IX – Petroleum Refineries

Refinery Process & Description

A petroleum refinery is a chemical plant that processes crude oil and produces several valuable products. A refinery contains many different types of process units that perform different operations to extract the main products and other valuable by-products. The main goal is to take the undesirable components of the crude oil and upgrade them into more valuable products, such as gasoline, diesel, and jet fuel and other low value by-products, such as fuel oils and lubricants, which are sometimes sold at a loss. The list below describes different types of units found in a refinery, followed by a complete system overview of a typical refining process.

Separation Units

A separation unit takes an incoming stream and separates it into different components. No chemical reactions occur in these units.

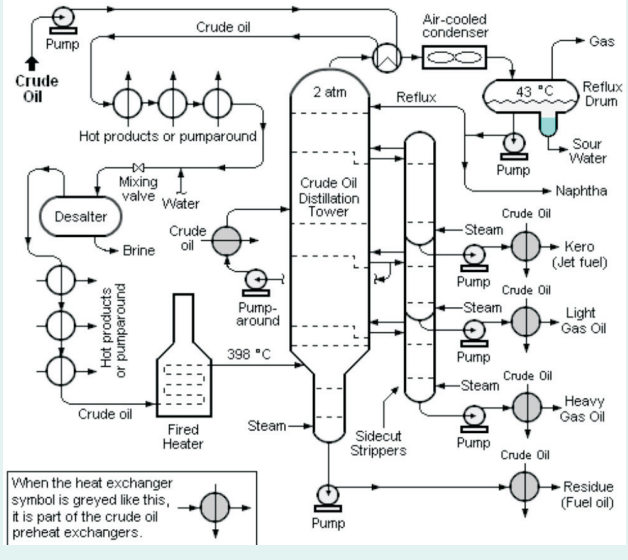


FIGURE 30: SCHEMATIC OF ADU

a) Desalter: Salt ions in the crude oil can corrode the pipes in the refinery and may also deactivate the catalysts. Thus, it is important to remove these salts from the crude before any other process is started. In order to remove the salt, water is injected into the crude oil feed stream. This pulls out the salts and prevents corrosion.

b) Atmospheric Distillation: The distillation is performed at atmospheric pressures. The outputs of the distillation unit include light ends, kerosene, diesel, heavy gas oil, and atmospheric residue.

c) Vacuum Distillation: This unit distils the atmospheric residue and produces light vacuum gas oil, heavy vacuum gas oil, and vacuum residue. In this process, the pressure inside the distillation column is decreased to nearly zero, allowing the components of the atmospheric residue to boil at a lower temperature.

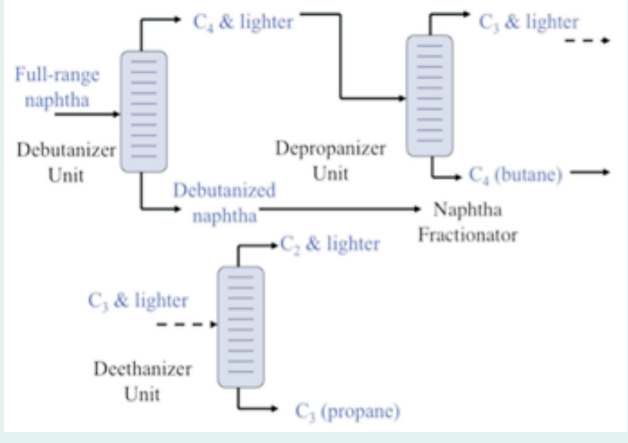


FIGURE 31: LIGHT END FRACTIONATING UNITS

[8]https://www.e-education.psu.edu/fsc432/content/atmospheric-and-vacuum-distillation-units

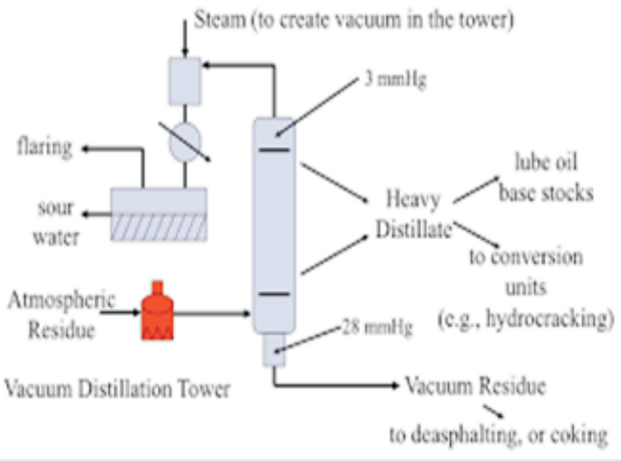


FIGURE 32: VDU SCHEMATIC

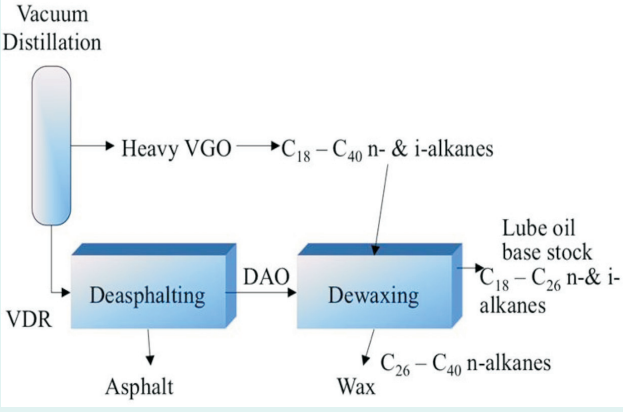


FIGURE 33: DEASPHALTING & DEWAXING UNIT

d) Light Ends Unit : The light ends unit consists of many different fractionators that separate different components of the light ends fraction from atmospheric distillation. The separated components consist of methane and ethane, which are used as fuel for heating requirements in various operations in the refinery, propane and butane, which are mixed and compressed to be sold as Liquid Petroleum Gas (LPG), light straight run (LSR) naphtha (C5 and C6), which is used in gasoline pools, and heavy straight run (HSR) naphtha, which is used as a feed stock for the catalytic reformer.

e) De-asphalter: This unit takes the vacuum residue and pulls out all of the heavy particles leaving heavy gas oil that can be further refined or used as fuel oil, and asphalt, which is used in paving.

f) De-waxer: This unit precipitates long n-paraffins out of heavy vacuum gas oil creating lubricating oils that will withstand low temperatures without solidifying.

Finishing Units

These units add final touches before the product can be sold. Few chemical reactions may occur, but none significantly alter the final product.

g) Hydrotreater: Most crude oils today have high sulphur content. Sulphur is a strong pollutant and must be removed to meet emission standards. Also, sulphur can deactivate catalysts in further refining units. Hydrogen gas is pumped into a stream resulting in a reaction with the sulphur molecules in the stream. The reaction results in extraction of the sulphur in form of hydrogen sulphide

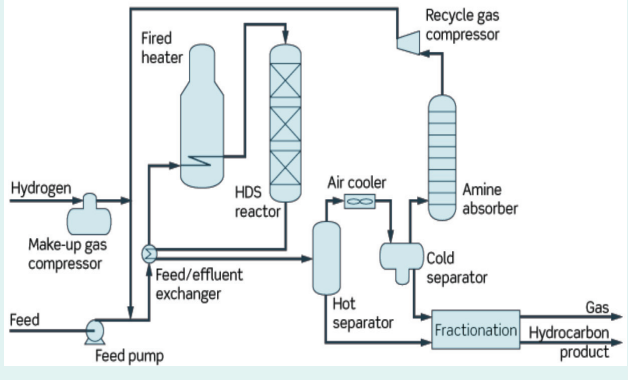


FIGURE 34: HYDROTREATING UNIT

CONVERSION

These units change the composition of input streams through chemical reactions. In the

[9]https://www.e-education.psu.edu/fsc432/sites/www.e-education.psu.edu.fsc432/files/Lesson3/Lesson3Fig3a.png
[10]https://www.e-education.psu.edu/fsc432/content/dewaxing

reactors, a low-grade product is converted into a higher-grade product.

h) Catalytic Reformer: This unit takes HSR naphtha and un saturates the hydrocarbons to produce aromatic rings and other various olefins. These aromatic rings and olefins have high octane numbers and are used in premium gasolines.

i) Catalytic Cracker : This unit transforms heavy gas oil into light distillates, such as gasoline, LPG, and light cycle oil. The unit utilizes a catalyst to take long chain hydrocarbons and break (crack) them into shorter, more valuable hydrocarbons.

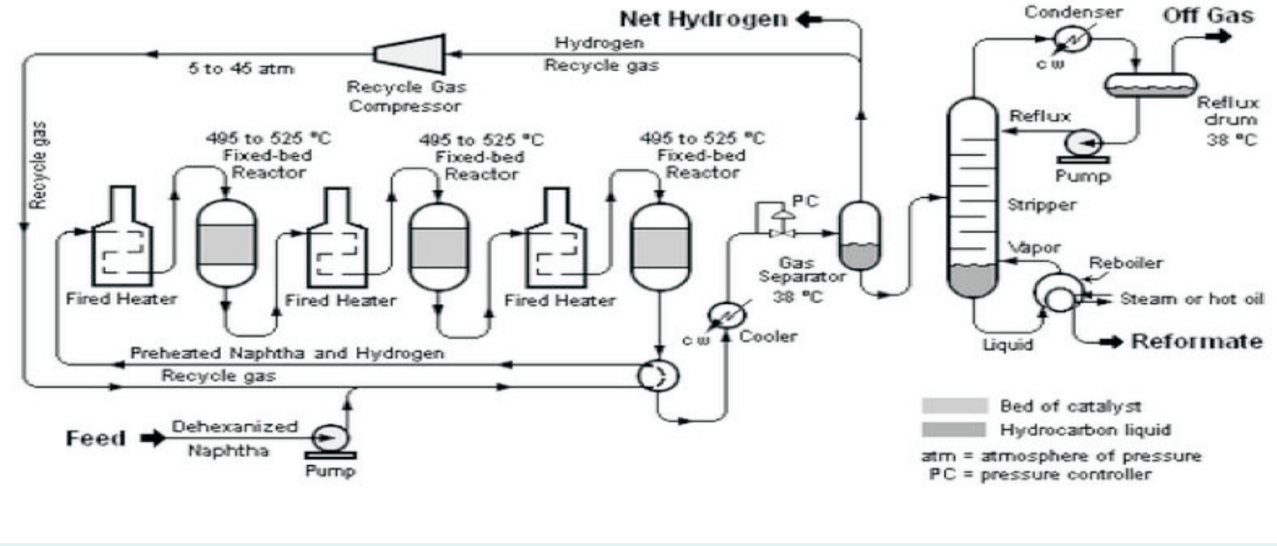


FIGURE 35: REFORMER UNIT

j) Hydrocracker: This unit performs the same operation as a catalytic cracker, but uses hydrogen gas in presence of a catalyst to break long hydrocarbon chains. Also, the feedstock is light and Heavy vacuum gas oil and the products are light and middle distillates.

k) Visbreaker: This unit employs a mild version of thermal cracking to convert vacuum residue into light and middle distillates, fuel oil, and coke or heavy gas oil into slightly lighter fuel oil.

l) Alkylater: This unit converts short olefins (ethylene, propylene, and butenes) and isobutane chains into branched C7 and C8 chains via strong acids and heat.

m) Delayed Coker: This unit uses thermal-cracking process to convert vacuum residue into light and middle distillates, and coke.

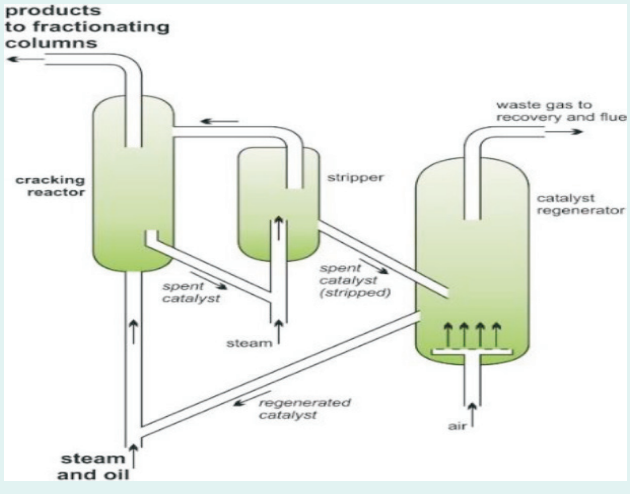


FIGURE 36: CATALYTIC CRACKING

[11]http://www.essentialchemicalindustry.org/processes/cracking-isomerisation-and-reforming.html
[12]https://en.wikipedia.org/wiki/Catalytic_reforming

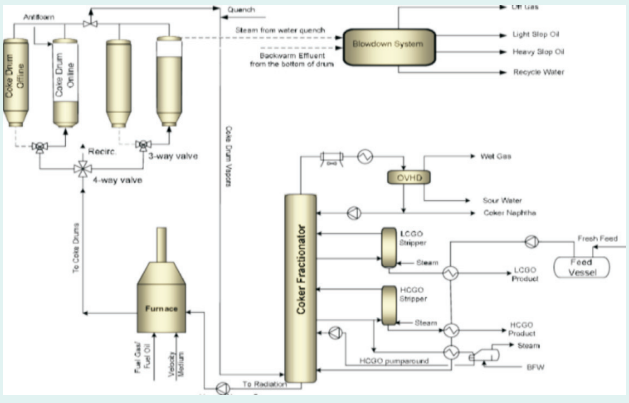


FIGURE 37: DELAYED COKER & VISBREAKER

Power and Utilities

The power and utilities unit form an integral part of the refinery sector in terms of delivering the necessary primary/auxiliary support for ensuring continuous and reliable refinery operations. Energy, either in the form of thermal, electrical or chemical, has become basic necessities in the refinery sector for meeting the demand for power and process steam.

Power usually refers to electricity, generated from an open/combined cycle gas turbine (CCGT) power plants (also referred as cogeneration units) and thermal driven steam turbines, or imported from the grid. Fuels are utilized extensively directly or indirectly for refinery and non-refinery operations, such as power generation, process heating and steam generation. In the context of steam generation and distribution, process steam is exclusively used as a stripping agent in distillate columns, fuel vaporization, hydrocarbon flaring system, storage tank heating, hydrocarbon flushing/dispersing, vacuum jets/barometric condensers, heat exchangers, regeneration of catalysts and also powering turbines, compressors and pumps.

The requirement for power finds applications for driving motors in process units (pumps, compressors, blowers, Fans etc.), process heaters, electronic systems (DCS, PLC, etc.), lighting, etc. A typical schematic of a combined cycle gas turbine power plant is shown in Figure 18. The CCGT power plant utilizes the waste heat from the gas turbine exhaust to heat the incoming feed water and convert to steam, which is used to power the steam turbine. In the case of a thermal power plant, the required thermal energy is obtained by combusting one or combination of fuels such as coal, petcoke, lignite, etc.

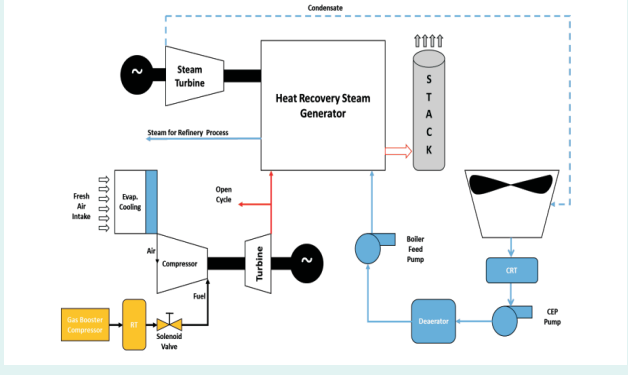


FIGURE 38: SCHEMATIC OF A COGENERATION PLANT - COMBINED CYCLE GAS TURBINE (CCGT)

The amount of thermal energy (kcal) utilized to generate one unit (kWh) of electrical output, which is defined as heat rate (kcal/kWh), is the metric that evaluates the efficiency of a power plant. For instance, lesser heat rate indicates that more electricity is generated with minimal heat input to the power plant. The calculations for heat rate only consider the thermal energy supplied to generate steam, which is further utilized for power generation. Hence, any quantity of thermal energy supplied for process steam must be deducted and the heat rate must be derived. The resulting heat rate is termed as the Gross Heat Rate (GHR) of the power plant/station.

Similarly, if the power consumed by the auxiliary equipment of the power plant is deducted, the resulting heat rate is the Net heat rate. Auxiliary equipment in the power plant majorly includes Boiler Feed Pump (BFP), Condensate Extraction Pump (CEP), Auxiliary Cooling Water (ACW) pumps, Induced Draft (ID) fans, Primary Air (PA) fans, Secondary Air (SA)/ Forced Draft (FD) fans, Air Cooled Condenser (ACC) fans, lighting, cooling towers, , conveyors, pumps for condensate polishing unit (CPU), RO & DM, auxiliary power in Control room, DCS, lighting, Fuel pump for boilers, Lube oil pumps, stator water cooling pumps, etc. Other auxiliary sources of power include wagon unloading system, crushers, stacker reclaimer, coal handling & ash handling plants & ESP's

A typical heat rate calculation sheet for a refinery is shown in Figure 19

Typical heat exchanges that need to considered for the heat rate calculation is schematically represented as in Figure 20,

Heat Rate Calculation for co-generation plant

Name of Refinry : **Typical calculation**

Year 2018-19

Enthalpy of steam at Boiler generating Pressure & Temp= 816.00 kcal/kg

Fuel Fired				Net Steam exiting Battery limit of CPP							Electricity out of CPP			
	Qty	NHV	Fired Energy	Steam pr	team Tem	Enthalpy	Steam qty	Corr steam qt	Equiv SRFT	Energy	Generated	Aux cons	PRT gen	Net Elec gen
Fuel type	TMT	Kcal/kg	MMKCal	Kg/cm2g	Deg C	Kcal/kg	MT	MT		MMKcal	MWH	MWH	MWH	MWH
NG/RLNG	329.45	12028.11	3962672.745	125	519	815	1265063.12	1263512.80			1189503.40	19524.43	37188	1207166.97
Naphtha	49.70	9460.00	470118.5472	45	371	750	1505893.57	1384093.35					KWH	1207166969
IFO	0	10406	0	16	300	725	336591.64	299055.07						
Diesel	1.69	10500	17787	5	200	680	188657.38	157214.48						
Petcoke			0					3103875.70	231269.17	2312692				
380.84	Total		4450578.292											

Net Heat Rate	Kcal/kwh	1771
	KBTU/KWH	**7.02**

Basis for Steam/ Std Fuel ratio

Basis		
Fuel quantity	SRFT	1.00
Standard Fuel NHV	Kcal/kg	10000.00
Steam Pressure	kg/cm2g	125.00
Steam Temperature	deg C	525.00
Boiler Efficiency	%	90.00
Enthapy of steam at above condition	kcal/kg	816.00
Enthalpy of Boiler feed water	kcal/kg	132.00
Quantity of steam generated	MT	13.16
Qty of steam generated considering 2% blow down	MT	**13.42**

Note :

1. Calculated steam /Fuel ratio corresponds to Boiler operating at indicated Pressure & Temp (Reference Pressure & Temp).
2. Steam at any other Pressure and Temperature exiting Battery limit are corrected for above reference steam condition.
3. For Coal and petcoke, GCV to be used. For liquid and gas fuels, only LHV (NHV) to be used.
4. Input data at Yellow background only.

Average NHV of fuel fired	Kcal/kg	11686.2

FIGURE 39: CALCULATION FORMAT FOR ESTIMATING THE HEAT RATE OF TPS/CPP/COGEN

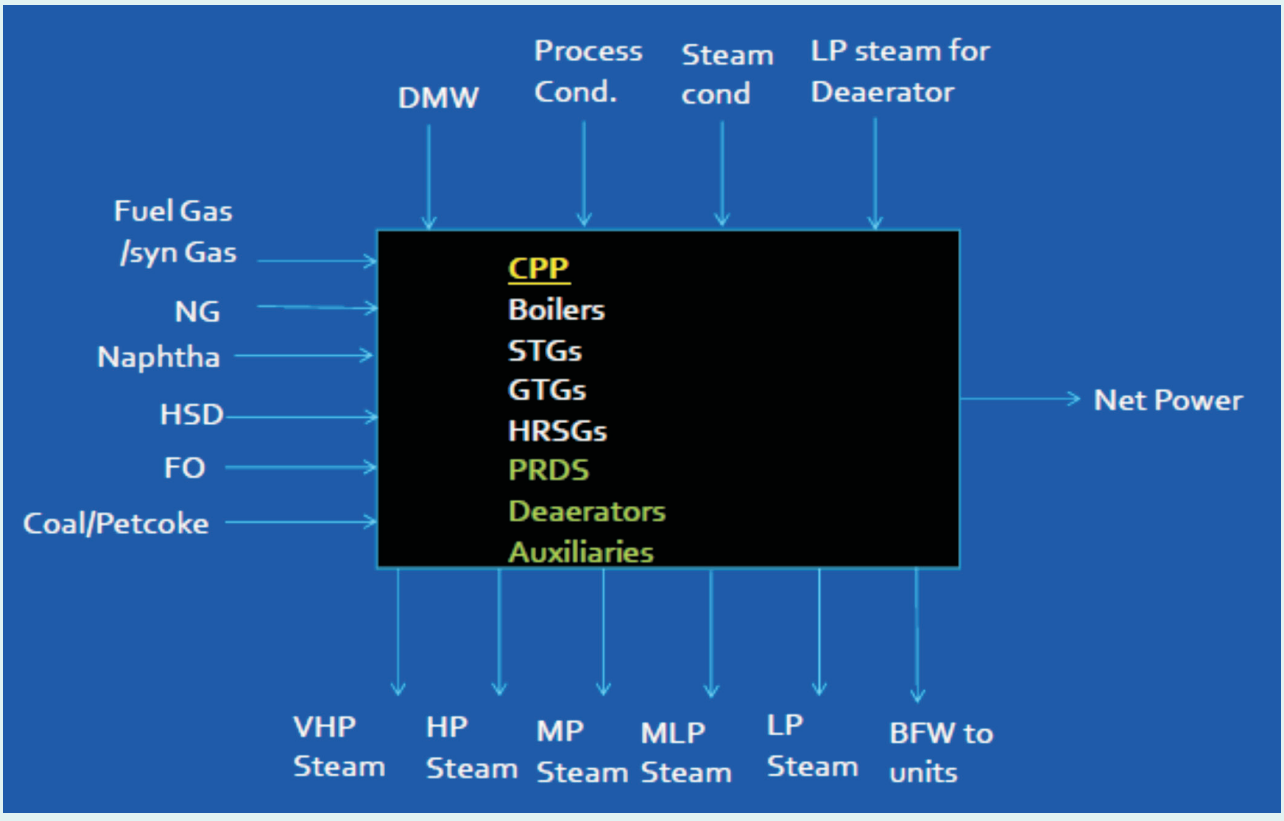


FIGURE 40: INPUT & OUTPUT STREAMS TO CPP

The procedure to calculate the Net heat rate is as given below,

- Calculation of Thermal energy in Steam:
  - To convert steam to equivalent SRFT, steam to Fuel ratio is calculated assuming 90% Boiler efficiency for oil/gas fired Boilers and 85% for CFBC Boilers
  - Steam leaving CPP Battery limit at different pressure levels is converted to steam equivalent at maximum pressure level at CPP Battery limit
  - Divide steam equivalent quantity by the steam to Fuel ratio to get the SRFT

Note: Steam to Fuel ratio to be calculated at the maximum pressure level in CPP Battery limit and not at the Boiler operating pressure

Power generated is the net power generated in CPP (Total Power generated - Auxiliaries consumption)

- Net heat rate = Net Thermal energy (MBTU) / Net Power generation (kWh)
- List of equipment included in Auxiliary power consumption,
  - Co-Generation (Turbine & auxiliaries)
  - Condensate Extraction Pump (CEP)
  - Boiler Feed Pump (BFP)
  - TPS cooling tower (dedicated- Full; common CT- proportional to CW flow to CPP/TPS)
  - DM Plant /RO plant
  - Auxiliary Cooling Water (ACW) Pumps
  - Condensate Polishing Unit (CPU)
  - Lube Oil Pumps

- Seal Oil Pumps
- Stator Water Cooling Pumps
- Raw water pumps inside Refinery
- Auxiliary power (Control room/DCS/ Lighting etc.)
- Fuel pumps for boilers
- Other units like,
  - Coal Handling Plant
  - Wagon Unloading System
  - Crushers
  - Electrostatic precipitator
  - Stacker Reclaimer
  - Miscellaneous/ Missed out equipment
  - Ash handling System

Therefore, for calculation of the net heat rate of a power plant, the following conditions are to be noted:

1. The boundary for calculating heat rate including the electricity generating equipment and boilers/utility boilers situated within TPS/CPP must be fixed.

   In case, if a utility boiler is physically located outside TPS/CPP and supplying steam only to processing units, it must be excluded from the boundary for heat rate calculation.

2. All the fuels used in GTs, Boilers and UBs within the above boundary to be considered for heat rate calculation with corresponding NHVs.

3. If the parameters of the steam are at different pressure/temperature levels (with corresponding enthalpies), then convert those parameters to quantity equivalent of the highest-pressure steam leaving battery limit and its corresponding enthalpy.

4. Calculate the Steam-Fuel ratio corresponding to highest pressure and temperature of the steam leaving TPS/ CPP at the battery limit.

5. The following efficiencies to be considered for various types of boilers, as mentioned below:

   - 90% efficiency for boilers using oil/gas as fuel
   - 85% efficiency for CFBC boilers

6. The net electricity is calculated as the difference of electricity generated (combined generation of STGs, GTs and any micro generator in CPP) and the consumption by auxiliary equipment.

7. The net energy consumption for power supplied from CPP is the difference between energy release from fuels and the fired thermal equivalentof energy carried by steam at CPP battery limit.

8. NHR is calculated as the ratio of net energy consumption and net electricity leaving CPP, kcal/kWh or MBTU/kWh = kcal/kWh *9/2269)

9. Calculation format is as shown in Figure 19. Refineries are required to use the excel sheet with inbuilt formulae for calculation.

Methodology of MBN Calculation

MBN as an indicator for specific energy consumption

Refineries includes many types of process units & operations like distillation, fractionating, Thermal or Catalytic cracking, Reforming, hydrotreating, hydrocracking etc.

& other related units through which the main products and other valuable by-products are extracted. Based on the product requirement the refinery may be complex or simple. Even in a refinery with relatively less complexity, there is no single major product as output from the refinery. Hence it is difficult to quantify energy consumption in a refinery in terms of its output. The feed input, however in every plant is a single quantity i.e. crude oil. The crude oil processed by the refinery (known as refinery throughput) represents the refinery capacity. Therefore, SEC calculation in refinery will be expressed in terms of crude throughput rather than on product fractions.

SEC or energy consumption per unit of input, however, is a misleading indicator of the energy performance of refineries as it does not account for differences in complexities, output states, or type of crude processed. A simple topping unit, for example, will always have a lower specific energy consumption than a complex refinery — sometimes one-fourth as much — but may not be able to produce blended gasoline or to remove sulphur from final products. In India, the energy performance of refineries is expressed in terms of specific energy consumption, measured in thousand British Thermal Units (MBTU)per barrel per Energy Factor (MTBU/ BBL/NRGF). This unit, commonly referred to as MBN, was developed by the Centre for High Technology (Ministry of Petroleum & Natural Gas) to provide a basis for comparing energy performance of refineries of different configurations and accounting of the throughput of secondary units

Calculation of NRGF

The NRG factor (NRGF) is the indicator of the level of complexity of a refinery. A composite NRGF of the refinery is arrived at by multiplying the throughputs of individual units with their individual energy factors and dividing the sum of all the equivalent throughputs by the crude throughputs. For example,

Energy factor of CDU * Throughput of CDU = Equivalent throughput of CDU

Energy factor of DCU * Throughput of DCU = Equivalent throughput of DCU

Energy factor of CRU * Throughput of CRU = Equivalent throughput of CRU

Therefore,

$$Composite\ NRGF = \frac{Sum\ of\ equivalent\ throoughput\ of\ all\ units}{Crude\ throughput\ of\ refinery}$$

Addition of secondary units in refineries for improvement in Gross Refinery Margin, producing quality specs of fuels, for reduction in heavier residues have increased their complexities. As the complexity of the units increase, the fuel & loss% on the crude will also increase. Therefore, using fuel & loss% as an indicator of specific energy will lead to a wrong indication.

In order to take into account these variations, MBN was introduced. The PAT targets that have been set for refineries is based on the MBN concept. Higher the baseline MBN, more will be target that is set,

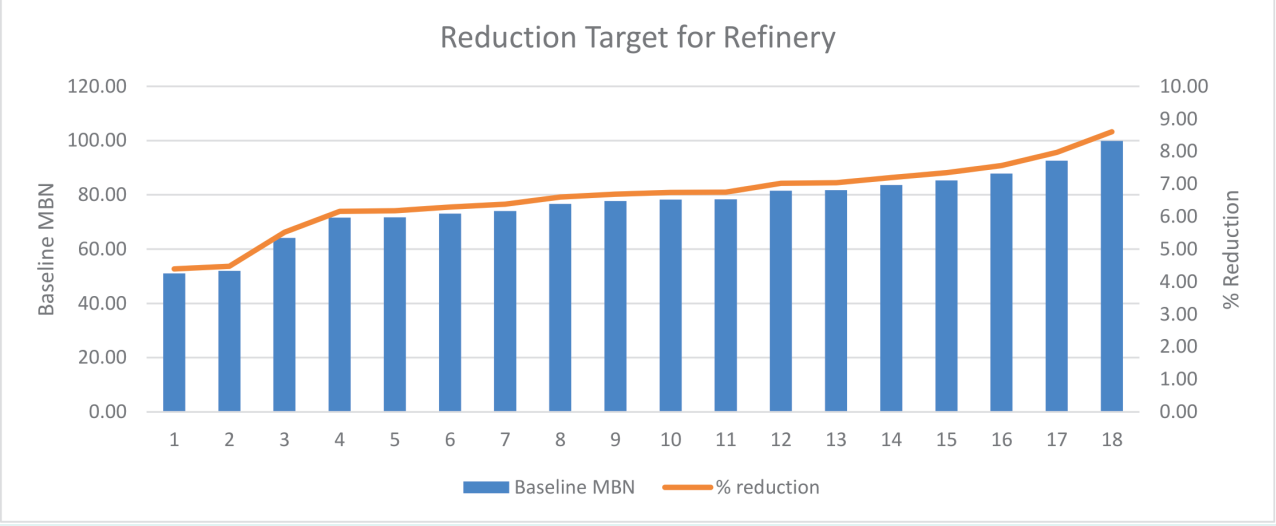


FIGURE 41: MBN VS NRGF FOR REFINERIES

Methodology of MBN Calculation

The methodology adopted for MBN calculation is as shown,

1. Set the boundary of the operation as per gate-to-gate concept
2. Identify the sources of energy
3. Data collection from refinery
4. Account for energy consumption in different scenarios
5. Calculate refinery NRGF
6. Calculate refinery MBN

Set the boundary of operation as per Gate-to-gate concept

The boundary of operation will be set to encompass all the energy consumption points within the refinery. The boundary will typically include the following components:

- All primary and secondary processing units in the refinery
- Captive power plant of the refinery
- DG sets
- Administrative buildings, canteens, etc

Non-refinery operations should be excluded from the boundary. Typical examples of such include the following:

- Refinery township
- Bank
- Project construction site
- Pipeline pumping station (cross country pipelines)
- Marketing terminal
- CISF & Railway colony
- Hospital under CSR

Identification of energy sources

All the energy sources within the boundary of operation needs to identified and measured. The energy sources include:

- Solid fuels (generated as well as imported)
- Liquid fuels (produced)
- Gaseous fuels (generated as well as imported across the boundary)

[13] Source: Developing methodology for baseline energy consumption for petroleum refinery subsector – Shakti Document

- Electricity (Own generation as well as imported)
- Steam (imported)
- Hydrogen imported

Data collection from the refinery

The baseline MBN will be calculated on the basis of the refinery's historical performance. For this purpose, data for the most recent three years needs to be collected from the refinery. The data collection template will include the following:

- Monthly value of quantum of fossil fuel consumed within the boundary by type (in kg)
- Monthly calorific value of fossil fuel consumed within the boundary by type (in kcal/kg)
- Monthly value of quantum of electricity purchased from grid or other sources (in kWh)
- Monthly value of quantum of electricity sold to grid or other sources (in kWh)
- Captive power plant station heat rate (in kcal/kWh)
- Monthly throughput of the refinery (in barrels)
- Monthly throughput across each unit in the refinery (in tonnes)
- Complexity factor of each unit in the refinery

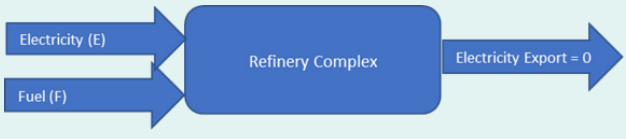
The following data needs to be segregated and excluded from data considered for baseline MBN calculation:

- Energy consumed from renewable sources
- Energy consumed in construction activities within the refinery

Accounting for energy consumption under different scenarios.

Based on the data provided by the refinery, the total energy input to the refinery will be calculated. The algorithm for calculation will change on case to case basis depending upon the scenario of energy consumption in the refinery.

- **Case 1: Electricity/Fuel from grid with no export:** Here power is taken from grid, fossil fuels are consumed for thermal usage as well as for captive power generation. No power is exported. Hydrocarbon losses are involved in the process



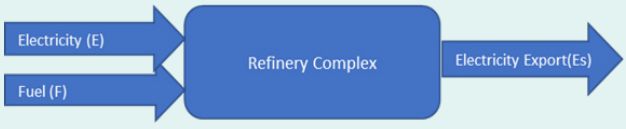
The associated energy consumption is given by,

$E_n = \{E \times 2269 + \sum F_i \times GCV_{Fi}\}$ *kcal,* where i refers to the different fossil fuels considered

It is to be noted that hydrocarbon losses occurring in the refinery has been kept outside the purview of the calculation methodology. As the PAT scheme deals with energy consumption only and hydrocarbon losses impact the feed consumption and productivity of the refinery, hence it has not been considered,

- **Case 2: Electricity/Fuel from grid with export:** The above scenario represents a refinery where electricity is purchased from the grid, different fossil fuels are consumed within the operational

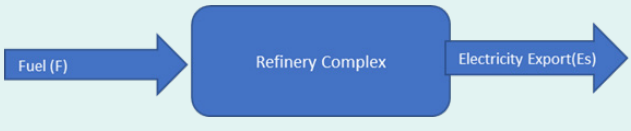
boundary, power is generated in the refinery captive power plant and electricity is exported to grid. In such a scenario, the total energy consumption is given by,



$E_n = \{E \times 2269 + \sum F_i \times NCV_{Fi} - E_s \times SHR_{CPP}\}$ *kcal,* where i refers to the different fossil fuels considered

The amount of power exported should be discounted from the energy associated with generation. For this purpose, the station heat rate of the captive power plant of the refinery is required. In case the station heat rate is not available, the same may be sourced from CEA based on capacity and the primary fuel used in the captive power plant.

- **Case 3: Fuel consumed & export to grid:** The above scenario represents a refinery where no electricity is purchased from the grid or from any other 3rd party, different fossil fuels are consumed within the operational boundary, power is generated in the refinery captive power plant. The electricity is exported to grid or sold to any 3rd party. In such a scenario, the total energy consumption is given by,



$E_n = \{\sum F_i \times GCV_{Fi} - E_s \times SHR_{CPP}\}$ *kcal,* where i refers to the different fossil fuels considered,

The input energy consumed thus calculated in kcal is converted to BTU by multiplying with a factor of 1000/252. NRGF for CDU & for all the other units it is considered as per CHT's methodology. For some units, it is calculated based on severity of the operation & quality whereas for some units it is fixed. Energy factors considered for different refineries as provided in the proforma is as shown below,

Sr. No.	Name of the Unit	NRGF
1	UDEX	1.254
2	VBU	1.533
3	BBU	0.120
4	CRU (NHT)	0.975
5	ISOM(NHT)	0.975
6	ISOM (NSU-1)	0.766
7	Splitter	1.258
8	DHDS	0.975
9	DHDT	0.975
10	VGOHDT	1.115
11	DCU	2.787
12	MSQ (CCR)	4.120
13	MSQ (2 Column Splitter)	1.258
14	ARU	1.393
15	SRU-3	21.800
16	MTBE	5.574
17	C3/C4 SPLITTER	0.697
18	Butene-1	3.270
19	FGH	0.975
20	PDS	1.115
21	ASU (NRGF * product oxygen in Knm3)	12.379
22	PSA-2 ROG PSA	1.651
23	MSQ PSA	1.651

24	Hexane	1.254
25	TAME	5.574
26	SHP	0.975
27	BT separation column	1.254
28	Food grade hexane	0.975
29	VG0-HDT (hydro desulphurization)	1.045
30	Coker HGO (HDT)	1.115
31	Prime-G	1.045
32	PDA -ROSE	3.205
33	Wax-HFU (parafin wax)	1.254
34	WAX-HFU (MCW)	1.254
35	Lube Hydrofinishing	1.393
36	Catalytic ISO-dewaxing	1.811
37	CCU	9.767
38	Solvent Unit (liquid liquid extraction of benzene and toulene)	2.090
39	Mixed Xylene	2.090
40	Rafinete purification unit (purification of C8+)	1.420
41	Alkylation unit	5.574
42	Butamer	1.393
43	SARU	7.326
44	Di olefin saturation unit	0.975
45	ISOS IV	1.393
46	Alkali splitter	0.766
47	DIB unit	1.881
48	Desalination unit	1.522
49	TGRU	47.967
50	GSU	3.345
51	LRU	4.489
52	Propane/ propylene splitter (polymer grade)	2.508
53	Propane/ propylene splitter (chemical grade)	2.090

TABLE 37: NRGF TABLE

Calculate the refinery MBN

On the basis of energy consumption of the refinery in MBTU the throughput of the refinery measured in BBL's and the composite NRGF of the refinery, the MBN of the refinery is calculated on a monthly basis.

Refinery MBN = Energy consumption (MBTU)/throughput (BBL)/NRGF

Factors considered to calculate MBN

1. Solid, Liquid & Gaseous Fuels are taken into account

- NHV of Refinery Fuel gas is taken as average of Lab results.
- NHV of RLNG is taken as average of reported figs by Gas transporter/ Lab results.
- NHV of each liquid fuel is calculated from the API gravity using correlations/ Lab report.

2. Coke burnt in Catalytic Crackers by Refinery

- NHV of Coke in FCCU is taken as 9500 Kcal/kg.

3. Heat release from PSA off gas from Hydrogen Generation Units

- NHV of PSA off gases is taken as 3600 kcal/kg

4. Non-Refinery steam consumption is converted to equivalent SRFT based on steam/fuel ratio, calculated for the refinery

5. Imported electrical energy used for Refinery operations is added to Net Energy.

- Heat rate applied is 9 MBTU/KWH, if net Imported power is more than NRO quantity
- Heat rate applied is actual calculated for the Refinery, if Net imported quantity is lower than NRO quantity

Calculation steps involved in MBN Calculation

The calculations are tabulated below,

Fuel Type	UOM (MT)	NHV (kcal/kg)	SRFT (MT)
Liquid	M_1	H_1	=(M1xH1/10000)
	M_2	H_2	
	M_3	H_3	
Gas	M_4	H_4	=(M4xH4/10000)
	M_5	H_5	
Purge Gas	M6	3600	=(M6x3600/10000)
Coke	M7	9500	=(M7x9500/10000)
NG	M8	H8	
Coal	M9	H9	
		Gross Fuel (SRFT)	GF = ∑ (Mi x Hi/10000)

* SRFT = Standard Refinery Fuel Tons

10	UOM (MT)	S/F Ratio	MWh	Grid HR (MTBU / kWh)	CPP NHR (MTBU/ kWh)	SRFT
Steam-NRO	M10	R10				=M10/R10
Power Net-Imp			E11			
Power-NRO			E12			
Power for Refy Opns (+ve)			(E11-E12)	9		=(E11-E12) x 9 x 252/10000
Power for Refy Opns (-ve)			(E11-E12)		NHR	=(E11-E12) x NHR x 252/10000
				Net Fuel (SRFT)		=Gross Fuel (SRFT) – NRO steam (SRFT)+Imp. Power for Refy Opns (SRFT)

[14]a) For Multiple CDU's, BBL is calculated for each CDU,
b) Density used for any CDU is the weighted average density of crude fed to CDU.This is important as CDU's are designed for processing crudes with varyingdensities and feed composition.

Description	UOM (MT)	SRFT	Energy MMBTU
H/C Loss	M13	M13	
Net F&L		=Net Fuel + M13	
Net F&L			Net F&L x 10000/252

1. For each Fuel type, multiply quantity in TMT with NHV (Kcal/kg) and divide by 10000 Kcal/kg to arrive at SRFT.
2. Add SRFT for each internal fuel type- Gaseous Fuels (Refinery Fuel gas, RLNG, PSA off gas), liquid Fuels (Furnace oil, HSD, Naphtha) as well as solid Fuels (Coke in FCCU and coke in CFBC Boilers).
3. Add the SRFT equivalent of imported Fuel streams (generally RLNG) to arrive at imported Fuel consumption in SRFT.
4. Add the internal fuel & imported fuel to get Gross Fuel consumption in SRFT.
5. Non-Refinery steam consumption is converted to SRFT using the steam/ Fuel ratio calculated for the Refinery (typically 1 SRFT=13.5 MT steam)
6. Convert Net Imported Electrical Energy used for Refinery operations by subtracting the energy used for Non-Refinery operations from Net Imported energy & convert it into SRFT using MBTU/kWh calculated for refinery
7. Net fuel consumption in SRFT = Gross Fuel Consumption in SRFT – Fuel eq. of non-refinery steam consumption in SRFT + Fuel eq. of net imported electrical energy used for refinery operations in SRFT

a. This value to be converted into MMBTU by multiplying with (10000/252).

8. Convert the reported hydrocarbon loss in TMT to SRFT. Convert this to MMBTU
9. Add energy & loss in MMBTU
10. Calculate the composite energy factor for the refinery from the throughput & energy factor of each individual unit

Then,

Overall NRGF for n units =

$$\sum_{k=1}^{n} \frac{[Throughput\ of\ unit\ k\ in\ M3\ X\ Energy\ Factor\ of\ Unit\ k]}{Crude\ throughput\ in\ M3}$$

Calculate MBN by dividing Net Energy plus loss (MMBTU) by crude processed in (Million Barrels) and calculated NRGF for the Refinery.

Note:

1. Energy Factors represent the relative severity of energy consumption in secondary and treatment units w.r.t stand-alone Crude distillation unit (energy factor =1.0). Energy factors in use till 2014-15 were as per the revised energy factors jointly developed by CHT/ EIL
2. Customized worksheets are developed by CHT for each Refinery for calculation of MBN
3. CHT checks, evaluates & maintains record of energy performance of Refineries
4. New NRGF calculation which takes care of effect of feed quality & operating conditions to make MBN calculation more robust has been introduced by

CHT from 2014-15 onwards. The same has been adopted by BEE for PAT

Revised NRGF features:

- MBN Calculation done as per the worksheet customized for each Refinery
- CDU and VDU are treated as separate units and Individual energy factors are assigned even for integrated units also.
- Energy factors for CDU and VDU are calculated based on Feed density, bottom %, Flash zone Temp & Flash Zone pressure
- Energy factor for Catalytic cracking unit is calculated based on Feed CCR and % coke yield
- Energy factor for Hydrocracker is calculated based on Feed Temp and % conversion
- Energy factor for Hydrogen unit is calculated based on LHV of feed and actual Hydrogen production
- Energy factor for CCRU and CRU are calculated based on Σ (Temp difference across Rectors)
- NHDT energy factor taken separately for CRU and ISOM
- SWS, ATU and Merox units are excluded from NRGF calculation
- Energy factor for offsites and utilities (calculated) is introduced in the NRGF calculation
- Energy factor for ISOM is based on hardware configuration specific to each Refinery, as calculated as per CHT procedure and approved by CHT
- Calculations for energy factor for heat integrated dis-similar units and those with high severity operation are made by CHT as and when need arises.
- Energy factor for Lube units is calculated based on solvent to feed ratio

NRO estimation for units to be excluded from MBN calculation (Linear Alkyl Benzene, Poly propylene units etc.)

The NRO estimation for these units will include NRO due to Fuel, Steam & Power.

- NRO Fuel: This is calculated by considering the total fuel quantity imported to unit plus any fuel generated & multiplying it with the NHV of fuel. The overall number is then converted to SRFT by multiplying it with 10,000 kcal/kg
- NRO steam: This applies to the total steam imported from the boiler. This value is estimated by converting different steam quantities at CPP battery limit in terms of the equivalent high-pressure steam & dividing it by the steam to fuel ratio to get the value in terms of SRFT
- NRO electrical energy: This will include two components

o Due to overall electricity consumption in the unit (MWh): This value is multiplied by the net heat rate to to get MMBTU which is then divided by 10000/252 to get the value in SRFT

o Cooling water circulated through the unit in M3 should be divided by 20000 to get the SRFT which should be converted to MMBTU and then to MWh using the calculated NHR

The resulting SRFT (Fuel) to be subtracted

from the Gross SRFT. Loss SRFT of the unit also to be subtracted from the Gross SRFT

Checklist & Data source for MBN calculation

The data to be considered for MBN calculation is as below,

Data	Unit	Remarks
For process		
Steam for NRO (export)	MT	Flow integrated value shown in NRO list
Power for NRO (export)	MWH	Electrical Energy integrated shown in NRO list
Fuel & loss	MT	Material balance
Hydrocarbon loss	MT	Material balance
Power Import	MWH	Import bill
Power Export	MWH	Invoice for export
For NHR calculation		
Boiler efficiency	%	90% for Oil/gas and 85% for CFBC
BFW temperature	Deg C	IP 24/RTDB
Aux. power consumption	MWH	Energy meter if it is segregated else detailed calculation with Pump/Fan run hours

TABLE 38: DATA SOURCES FOR MBN CALCULATION

Data source include,

- **Natural gas (imported)**

o Quantity: As per the joint ticketing done with pipeline transporter Cross checking: Invoice

- **NHV: As per the invoice by Pipeline transporter**

o Cross check: Lab analysis at Refinery end. (Transporter's figure is final)

- **Note:**

o Natural gas is used as Feed to HGU, as Fuel in GTs and for make up in FG network

o Fuel NG quantity is based on RTDB/IP21 download

o NG feed to HGU is accounted as input (crude + NG) in material balance

- **PSA off gas (ex HGU):**

The waste gas from HGU which is separated in PSA unit (Predominantly CO2& balance H2, methane, N2, Moisture, CO). Flowmeter is in the supply line to Reformer burners.

o Quantity: As calculated by the Refinery (Naphtha feed- Hydrogen production)

o Cross check: Flow meter (Not reliable due to varying Molecular weight of gas)

o NHV: Taken as 3600 Kcal/kg for MBN calculation.

- **Note:**

o In some Refineries ROG-PSA (Refinery off gas PSA) has been installed to recover Hydrogen from H2 rich off gas streams from Hydro processing units.

o PSA unit in CCRU separates H2 from H2 rich off gas.

o Tail gas from PSA unit of ROG-PSA and CCRU-PSA join FG network. Hence no separate SRFT calculation for MBN is required, unlike PSA off gas from HGU.

o H2 recovered from PSA units should not be added to Hydrogen produced in HGU while calculating MBN

- **Naphtha Fuel: Used in GTs as Fuel. Also, as Fuel in HGU Reformer furnace**

o Quantity: As per RTDB/ IP21 download

o NHV: Average as per LIMS/SAP download

o Cross check: Gross Heat rate of GT / Oil accounting

- **HSD as Fuel: Used in GTs as Fuel. Also used in Boilers as start-up Fuel.**

o Quantity: As per RTDB/ IP21 download

o NHV: Average as per LIMS/SAP download

o Cross check: Gross Heat rate of GT/ Oil accounting

- **Coke burnt in FCC**

Coke formed on Catalyst under operating condition for Cracking heavier Gas oil feed is burnt partially in the Regenerator and fully in the CO Boiler. The heat released is utilised to produce steam. Hence coke quantity burnt in FCC is accounted as Fuel in MBN calculation.

o Source: Coke yield calculation done by process Engineering group of the Refinery (by Heat balance).

o NHV: Taken as 9500 kcal/kg

- **Cross checking:**

i) RTDB/ IP 21 download for each CDU

ii) Monthly operation report

iii) reconciled data to Ministry month wise (PSU)

- **Fuel & Loss, MT:**

o Except Natural Gas and Coal which are imported, entire fuel used in the Refinery is from Crude oil.

o Fuel &Loss, MT = (Crude oil processed+ Natural Gas as Feed+ Blending components from outside)-products produced-ISD build up

o ISD: Intermediate Stock differential is the difference in stock, say, on 1.4.19 vis-à-vis stock on 1.4.18 in intermediate Tanks (Tanks meant for feeding to secondary units and hence it is not accounted as finished product)

o Fuel and loss increase with increase in number of emergency shutdowns, bypassing of heat recovery equipment like CO Boiler, Operation of equipment at below the best efficiency point, poor maintenance, insulation losses and steam leaks etc.,

o Fuel & Loss reduces with implementation of energy saving schemes and better operation and maintenance practices

- **Cross checking:**

o Cross check Fuel & Loss % over previous years and correlate with schemes implemented, run days, % loading, capacity revamp etc.,

o Fuel & loss calculated by Refineries reported as "by material balance" is based on the actual material balance for the year.

o MBN calculation has an inbuilt cross check for correctness. The gross Fuel quantity in MBN worksheet plus reported hydrocarbon loss should match with the Fuel & loss by material balance.

- **Hydrocarbon Loss, MT:**

Loss includes Flare loss, despatch losses, loss due to fugitive emissions, unrecovered

hydrocarbon loss from Effluents & accounting losses

Loss is accounted in MBN with NHV of 10000 kcal/kg.

- Data source: Estimated loss by the Refinery (Planning group).
- Does not include chemical loss at present.
- Loss= Fuel & Loss by Material Balance in MT (-) Gross Fuel used in MT.

• Cross checking: Some Refineries calculate loss on daily basis. It can be used to cross check the annual figure.

Crude Mbbls Source: Published processing figure in TMT and Weighted average Density from LIMS/SAP

• **NRO steam:**

Source: RTDB/IP download/Local flow meter/ Estimation based on Steam pressure and line size

Note:

- If Power is imported from HGU under BOO, it is taken as –ve NRO consumption and the bill for steam import is taken as the document.
- Steam supplied to petrochemicals is taken as NRO consumption
- Steam qty is divided by calculated Steam/Fuel ratio to arrive at SRFT value. For this steam is converted to highest steam pressure in CPP Battery limit, before dividing

Data Required for calculating NRGF;

• **Unit Feed (TMT):**

- Source: Published report (AOR) /MOR
- Cross check: RTDB/IP21 downloads
- Density of Feed streams: Weighted average density from LIMS/SAP download

Fixed factors in MBN Calculations	UOM	Value
NHV of Coke in FCCU	kcal/kg	9500
NHV of PSA off gases	kcal/kg	3600
Heat rate if imported power > NRO	MBTU/ kWh	9

TABLE 39: FIXED FACTORS CONSIDERED

Normalization factors for the Refinery sector

Normalization refers to the rationalization of the energy & production data of a plant to take into account the impact of quantifiable external variables that are beyond the control of a designated consumer. It becomes necessary to ensure this, so that no DC's are in a position of advantage or disadvantage

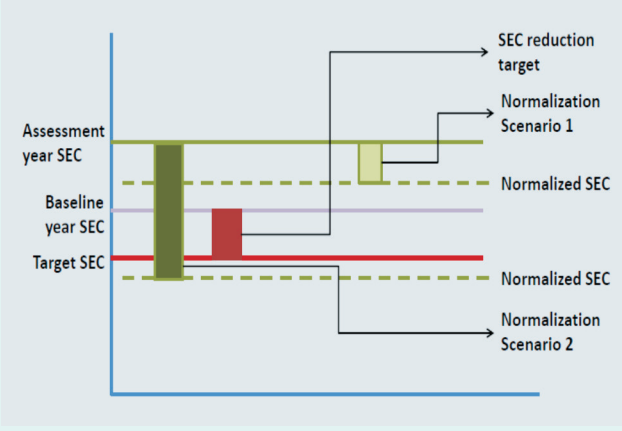


FIGURE 42: CONCEPT OF NORMALIZATION

when in comparison to the baseline scenario. The factors to be considered for normalization were decided by a technical committee involving experts from BEE & CHT through meetings & consultation workshops identifying the issues of DC's & finding of ways

to address them. Data required to support the different conditions to be normalized have to be submitted by the different DC's for validation. Since normalization are compared between baseline year & assessment year data corresponding to the same needs to be furnished.

Normalization factors basically fall into the following categories,

a) Capacity utilization: This includes,

- Availability of fuel/raw materials
- Natural calamity/Riots & other social factors
- Start/Stop plant

b) Import/Export of different products & intermediate products

c) Fuel/Power mix & APC Normalization: Power mix incudes import & export of electricity to/from grid & also captive power generation

d) Fuel Quality

e) Low PLF

f) Raw material quality

g) Environmental Concerns: Additional environmental requirements due to changes in govt. policies & environment

h) Unavailability of Alternate Fuels & Biomass

i) Construction phase & project activities

j) Commissioning of a new line/project

k) Start-up & Shutdown of plant

Selection of factors against which the MBN needs to normalized

The MBN calculated as per the formula previously needs to be corrected for different normalization conditions. The committee formed has decided to consider the following factors to be normalized,

S.no	Factors considered
1	Fuel & loss during planned shutdown & turnarounds
2	Additional fuel consumption to produce BS IV & BS VI grade fuels
3	Natural calamities & external factors
4	Power consumed during construction of a new project
5	Renewable energy
6	New/revamp project –pre-commissioning & commissioning
7	Disruption of Natural Gas supply
8	Normalization for imported power
9	Export of utility
10	Normalization for projects mechanically completed but could not be commissioned for want of shutdown for hook ups.

TABLE 40: NORMALIZATION FACTORS FOR REFINERY SECTOR

1. Fuel and Loss during planned shutdown & turnarounds

i) Need to normalize

The fuel for planned shutdown and turnarounds (excluding emergency shutdowns) due to scheduled activities (Cleaning, Inspection, repair, replacement, metallurgical upgradation, modification for enhancement of reliability, energy efficiency, safety or Capacity enhancement, Testing, hook ups with newer units, catalyst regeneration/ replacement etc) or for reasons related to facility's ability to operate like shortfall of funding or shutdowns due to environment/ regulatory requirement

(emission standards, pollution levels etc.,) shall be indicated for the base line year as well as the assessment year and the difference shall be used for normalisation. These factors may force the units to consume more fuel/electricity during the period which needs to be normalized for the MBN calculation. Additional energy consumption may be in the form of electricity for maintenance activities & gas/steam consumption for boiler start up, column refuelling etc.). Duration between Feed cut off & feed cut in for different units considered as the period of normalization .

Also, additional fuel loss due to depressurizing for hydro-processing units in between start-stops will also be considered as a part of normalization.

Note: For units that are shutdown due to non – availability of 'indigenous crude', the same will be considered under normalization due to planned shutdown provided that the unit supports this with relevant documents supporting the same in terms of crude specifications of the unit, time of shutdown etc.

ii) Supporting Documents

i. Refineries are required to provide section-wise details on account of planned shutdown, turnaround and environment/ regulatory requirement.

ii. DC's need to furnish details to support the reasons for higher fuel/electricity consumption during the normalization period – Details of fuel/electricity consumed – Fuel receipt details, electricity bills etc.

iii. Letter from authorised signatory stating the need for shutdown & time period

iv. Data to support feed cut in & cut out time.

v. Data to support the schedule considered for the planned shutdown including the number of hours considered.

vi. Data to support the environmental regulations specifying the need for the shutdown.

iii) Calculation of normalization factor

MBN Impact for baseline year

Electricity consumed during the planned shutdow	=	X1 MWh
Heat rate of CPP	=	Y1 MBTU/kWh
Therefore, electrical energy consumed (E1)	=	X1 * Y1 MMBTU
HHP steam consumed in the plant	=	q1 MT
HP steam consumed in the plant	=	q2 MT
MP steam consumed in the plant	=	q3 MT
LP steam consumed in the plant	=	q4 MT
Enthalpy of HHP team	=	H1 kcal/kg

[15]No normalization done for flare loss as it's a small quantity

Enthalpy of HP team	=	H2 kcal/kg
Enthalpy of MP team	=	H3 kcal/kg
Enthalpy of LP team	=	H4 kcal/kg
Enthalpy of feed water	=	h1 kcal/kg
Equivalent HHP steam (S)	=	(q1+q2*H2/ H1+q3*H3/ H1+q4*H4/H1)
Thermal energy consumed (T1) ratio)	=	(S*10000/252) MMBTU (S/F
Cooling water circulation	=	Q1 m3
Cooling water circulation factor	=	0.00005
Energy from cooling water circulation (C1) MMBTU	=	Q1 x 0.00005 x 10000/252

Start-up fuel consumption

F1	=	L1 MT
F2	=	L2 MT
F3	=	L3 MT
F4	=	L4 MT

Calorific Value

NCV of F1 Fuel	=	N1 kcal/kg
NCV of F2 Fuel	=	N2 kcal/kg
NCV of F3 Fuel	=	N3 kcal/kg
NCV of F4 Fuel	=	N4 kcal/kg
Energy Consumption (K1)	=	(L1 * N1 + L2 * N2 + L3* N3 + L4* N4)/252 MMBTU
Quantity of H2 / HC during depressurization	=	T1 Tonnes
Loss due to depressurization for Hydro processing units (H)	=	(T1 x 10000)/ 252
Therefore, MBN $_{\text{Baseline}}$ Impact	=	(E1+T1+C1+K1+ H)/ (NRGF $_{\text{Refinery baseline}}$ x Crude processed in barrels
MBN Impact for current year Electricity consumed during the planned shutdown	=	X2 MWh

Heat rate of CPP	=	Y1 MBTU/kWh
Therefore, electrical energy consumed (E2)	=	X2 * Y1 MMBTU
HHP steam consumed in the plant	=	q1^ MT
HP steam consumed in the plant	=	q2^ MT
MP steam consumed in the plant	=	q3^ MT
LP steam consumed in the plant	=	q4^ MT
Enthalpy of HHP team	=	H1^ kcal/kg
Enthalpy of HP team	=	H2^ kcal/kg
Enthalpy of MP team	=	H3^ kcal/kg
Enthalpy of LP team	=	H4^ kcal/kg
Enthalpy of feed water	=	h1^ kcal/kg
Equivalent HHP steam (S^)	=	(q1^+q2^*H2^/ H1^+q3^*H3^/ H1^+q4^*H4^/H1^)
Thermal energy consumed (T2)	=	(S^*10000/252) MMBTU (S/F ratio)
Cooling water circulation	=	Q2 m3
Cooling water circulation factor	=	0.00005
Energy from cooling water circulation (C2)	=	Q2 x 0.00005 x 10000/252 MMBTU
Start-up fuel consumption		
F1^	=	L1^ MT
F2^	=	L2^ MT
F3^	=	L3^ MT
F4^	=	L4^ MT
Calorific Value		
NCV of F1^ Fuel	=	N1^ kcal/kg
NCV of F2^ Fuel	=	N2^ kcal/kg
NCV of F3^ Fuel	=	N3^ kcal/kg
NCV of F4^ Fuel	=	N4^ kcal/kg
Energy Consumption (K2)	=	(L1^ * N1^ + L2^ * N2^ + L3^* N3^ +L4^* N4^) /252 MMBTU
Quantity of H2 / HC during depressurization	=	T1^ Tonnes

Loss due to depressurization for Hydro processing units (H^)	=	(T1^ x 10000)/252
Therefore, MBN Assessment Impact NRGF	=	(E2 + T2 + C2 + K2 + H^)/ Refinery Assessment x Crude processed in barrels)

Net MBN Impact = MBN Assessment Impact- MBN Baseline Impact

List of major processing units to be covered under normalisation during planned maintenance & inspection shutdown

a) CDU
b) VDU/FPU
c) FCCU/PFCC
d) MHC/OHCU/HCU
e) DHDT/VGO-HDT
f) NHDS/KHDS/DHDS
g) CRU/CCRU/ISOM
h) PRU
i) Alkylation
j) DCU
k) VBU
l) FEU/NMP
m) SDU/ Iso-dewaxing unit
n) Lube HFU
o) Wax HFU

Illustrative Example

Electricity during the planned shutdown	=	100 MWh
Heat rate of CPP	=	8.56 MBTU/kWh
Therefore, electrical energy consumed (E2)	=	856.33 MMBTU
HHP steam consumed in the plant	=	0 MT

HP steam consumed in the plant	=	1440 MT
MP steam consumed in the plant	=	2160 MT
LP steam consumed in the plant	=	3600 MT
Enthalpy of HP team	=	776 kcal/kg
Enthalpy of MP team	=	666 kcal/kg
Enthalpy of LP team	=	657 kcal/kg
Equivalent HHP steam (S^)	=	1440 + ((2160 x 666)/776) + ((3600 x 657)/776)
	=	6341.75 MT
Thermal energy consumed (T2)	=	(6341.75/856.33) x (10000/252)
	=	18641.25
Cooling water circulation	=	60,000 m3
Cooling water circulation factor	=	0.00005
Energy from cooling water circulation (C2)	=	Q2 x 0.00005 x 10000/252 MMBTU
	=	60,000 x 0.00005 x 10000/252
	=	119.05 MMBTU
Start-up fuel consumed	=	4320 MT
NCV of Fuel	=	9600 kcal/kg
Energy Consumption (K2)	=	4320 x 9600
	=	164571.43 MMBTU
NRGF	=	5.48
Crude processed	=	67740 M barrels
Energy consumed	=	18641.25 + 164571.43 + 119.05 + 856.33

	=	184188 MMBTU
MBN Impact	=	(184188/ (5.48 x 67740))
	=	0.50

2. Additional fuel consumption for producing BS-IV & BS-VI grade fuels

i) Need for normalization

Introduction of stringent norms to reduce emissions into the atmosphere have forced refineries to produce fuelswith stringent specifications like Sulphur content than what was that there in the baseline year. The BS-IV has become effective from 1.4.2017 & BS-VI grade of fuels has been mandated from 1.4.2020. The production of low sulphur fuels requires operation of Hydro-processing units at high severity (Rector bed temperature) which results in higher Fuel consumption.

The introduction of BS IV & BS VI norms has resulted in

1. Increase in the complexity of the refining processes
2. More fuel & infrastructure requirement
3. Variation in the NRGF factor for the units,

If the operating pressure of the plant is less than 50 kg/cm2 then it is considered as DHDS else DHDT

The % increase in NRGF to account for additional fuel to meet the stringent sulphur specification of BS-IV / BS-VI HSD in DHDS/DHDT is calculated and the impact of this on MBN is further calculated

ii) Calculation of normalization factor

For DHDS/DHDT Plant

Operating pressure of the separator	=	P kg/cm2
Percentage weight output (throughput) of BS III operation (Baseline Year)	=	X1 M3
Percentage weight output (throughput) of BS IV operation (Baseline Year)	=	Y1 M3
Percentage weight output (throughput) of BS VI operation (Baseline Year)	=	Z1 M3
Percentage weight output (throughput) of BS III operation (Assessment Year)	=	X2 M3
Percentage weight output (throughput) of BS IV operation (Assessment Year)	=	Y2 M3

Percentage weight output (throughput) of BS VI operation (Assessment Year)	=	Z2 M3

Based on the operating pressure of the separation unit, if P < 50 kg/cm2

Diff. in NRGF (ΔN)	=	(0.975 * ((X2 – X1) * 1 + (Y2 – Y1) * 1.09+ (Z2 – Z1) *1.33))/100 Else if, P > 50 kg/cm2
Diff. in NRGF (ΔN)	=	(0.975 * ((X2 – X1) * 1 + (Y2 – Y1) * 1.07+(Z2 – Z1) * 1.24))/100

Difference in NRGF represents the increase in complexity of operation due to change of fuel grade from BSIII to BSIV and BSVI

Crude processed in assessment year	=	'A' M barrels
Feed intake to plant for assessment year	=	F kL
In M barrels, B	=	F x 6.29/1000
NRGF for assessment year	=	N1
MBN before normalization	=	M1
Normalized NRGF, N2	=	N1 + ((B/A) x ΔN)
New MBN, M2	=	M1 x (N2/N1 – 1)
Impact of Normalisation on MBN	=	(M1-M2)

iii) Supporting Documents

i. Refineries are required to provide details in support of the additional fuel consumption due to the introduction of the new emission standards by way of unit condition adjustment to produce BS-IV /BS-VI grade fuel from the unit (Reactor bed Temperature and product rundown sulphur from LIMS/SAP).

Illustrative example

Operating pressure of the separator	=	34.50 kg/cm2
Percentage weight output (throughput) of BS III operation (Baseline Year)	=	100 %
Percentage weight output (throughput) of BS IV operation (Baseline Year)	=	0%
Percentage weight output (throughput) of BS VI operation (Baseline Year)	=	0%

Percentage weight output (throughput) of BS III operation (Assessment Year)	=	0 %
Percentage weight output (throughput) of BS IV operation (Assessment Year)	=	100 %
Percentage weight output (throughput) of BS VI operation (Assessment Year)	=	0 %
Diff. in NRGF (ΔN) = (0.975 * ((100 – 0) * 1 + (0 - 100) * 1.09+ (0 – 0) *1.33))/100	=	0.088
Crude processed in assessment year	=	67440 M barrels
Feed intake to plant for assessment year	=	48.197 M barrels
NRGF for assessment year	=	5.473
MBN before normalization	=	68.920
Normalized NRGF, N2	=	5.473 + (48.197/67440) x 0.088)
	=	5.473
Impact of Normalisation on MBN	=	68.920 – (68.920 x (5.473/5.473 – 1))
	=	-0.001

3. Natural Calamities & External factors

i) Need for normalization

Occurrence of natural calamities during the period of assessment may force the plant to shutdown thereby leading to difference in operating practices in comparison to that of the baseline year. Therefore, in such cases the additional energy to account for this has to be normalized. Calamities as specified under the NDRF (National Disaster Relief Fund) viz. cyclone, earthquake, fire, flood, tsunami, landslide, will be considered

Normalisation would be considered for abnormal energy consumption, if units are forced to shut down under the influence of natural calamities & external factors. However, normalisation would be done, only if the plants are forced to take shutdown due to these factors.

During idling of refinery, in case of natural calamity, the fuel consumed during outages of CDU, i.e., feed cut in to feed cut out shall be calculated by refinery from tank dips & other documents. Maximum of 1.5 times the value may be considered as total fuel because of natural calamity subject to satisfaction of the auditor

ii) Supporting Documents

i. Backup data regarding the unproductive energy consumption in bringing back the section back into production

ii. Letter from authorised signatory stating the time of outage

iii. Data to support feed cut off and feed cut in time.

iii) Calculation of normalization factor

MBN Impact for baseline year		
Electricity consumed during natural calamity	=	X1 MWh
Heat rate of CPP	=	Y1 MBTU/kWh
Therefore, electrical energy consumed (E1)	=	X1 * Y1 MMBTU
HHP steam consumed in the plant	=	q1 MT
HP steam consumed in the plant	=	q2 MT
MP steam consumed in the plant	=	q3 MT
LP steam consumed in the plant	=	q4 MT
Enthalpy of HHP team	=	H1 kcal/kg
Enthalpy of HP team	=	H2 kcal/kg
Enthalpy of MP team	=	H3 kcal/kg
Enthalpy of LP team	=	H4 kcal/kg
Enthalpy of feed water	=	h1 kcal/kg
Equivalent HHP steam (S) H1)	=	(q1+q2*H2/H1+q3*H3/H1+q4*H4/
Thermal energy consumed (T1)	=	(S*10000/252) MMBTU (S/F ratio)
Cooling water circulation	=	Q1 m3
Cooling water circulation factor	=	0.00005
Energy from cooling water circulation (C1)	=	Q1 x 0.00005 x 10000/252 MMBTU
Start-up fuel consumption		
F1	=	L1 MT
F2	=	L2 MT
F3	=	L3 MT
F4	=	L4 MT
Calorific Value		
NCV of F1 Fuel	=	N1 kcal/kg
NCV of F2 Fuel	=	N2 kcal/kg
NCV of F3 Fuel	=	N3 kcal/kg

NCV of F4 Fuel	=	N4 kcal/kg
Energy Consumption (K1)	=	(L1*N1+L2*N2+L3*N3+L4*N4)/252 MMBTU
Quantity of H2 / HC during depressurization	=	T1 Tonnes
Loss due to depressurization for Hydro processing units (H)	=	(T1 x 10000)/252

Therefore, MBN Baseline Impact = (E1 + T1 + C1 + K1 + H)/ (NRGF Refinery baseline x Crude processed in barrels)

MBN Impact for current year

Electricity consumed during natural calamity	=	X2 MWh
Heat rate of CPP	=	Y1 MBTU/kWh
Therefore, electrical energy consumed (E2)	=	X2 * Y1 MMBTU
HHP steam consumed in the plant	=	q1^ MT
HP steam consumed in the plant	=	q2^ MT
MP steam consumed in the plant	=	q3^ MT
LP steam consumed in the plant	=	q4^ MT
Enthalpy of HHP team	=	H1^ kcal/kg
Enthalpy of HP team	=	H2^ kcal/kg
Enthalpy of MP team	=	H3^ kcal/kg
Enthalpy of LP team	=	H4^ kcal/kg
Enthalpy of feed water	=	h1^ kcal/kg
Equivalent HHP steam (S^)	=	(q1^+q2^*H2^/H1^+q3^*H3^/H1^+q4^*H4^/H1^)
Thermal energy consumed (T2)	=	(S^*10000/252) MMBTU / (S/F ratio)
Cooling water circulation	=	Q2 m3
Cooling water circulation factor	=	0.00005
Energy from cooling water circulation (C2)	=	Q2 x 0.00005 x 10000/252 MMBTU

Start-up fuel consumption

F1^	=	L1^ MT
F2^	=	L2^ MT
F3^	=	L3^ MT
F4^	=	L4^ MT

Calorific Value		
NCV of F1^ Fuel	=	N1^ kcal/kg
NCV of F2^ Fuel	=	N2^ kcal/kg
NCV of F3^ Fuel	=	N3^ kcal/kg
NCV of F4^ Fuel	=	N4^ kcal/kg
Energy Consumption (K2)	=	(L1^ * N1^ + L2^ * N2^ + L3^* N3^ + L4^* N4^) /252 MMBTU
Quantity of H2 / HC during depressurization	=	T1^ Tonnes
Loss due to depressurization for Hydro processing units (H^)	=	(T1^ x 10000)/252

Therefore, MBN $_{Assessment}$ Impact = (E2 + T2 + C2 + K2 + H^)/ (NRGF $_{Refinery\ Assessment}$ x Crude processed in barrels)

NetMBN Impact = MBN $_{Assessment}$ Impact- MBN $_{Baseline}$ Impact

Illustrative Example

Electricity during the natural calamity	=	100 MWh
Heat rate of CPP	=	8.56 MBTU/kWh
Therefore, electrical energy consumed (E2)	=	856.33 MMBTU
HHP steam consumed in the plant	=	0 MT
HP steam consumed in the plant	=	1440 MT
MP steam consumed in the plant	=	2160 MT
LP steam consumed in the plant	=	3600 MT
Enthalpy of HP team	=	776 kcal/kg
Enthalpy of MP team	=	666 kcal/kg
Enthalpy of LP team	=	657 kcal/kg
Equivalent HHP steam (S^)	=	1440 + ((2160 x 666)/776) + ((3600 x 657)/776)
	=	6341.75 MT

Thermal energy consumed (T2)	=	(6341.75/13.5) x (10000/252), (where 13.5 is the steam to fuel ratio)
	=	18641.25
Cooling water circulation	=	60,000 m3
Cooling water circulation factor	=	0.00005
Energy from cooling water circulation (C2)	=	Q2 x 0.00005 x 10000/252 MMB-TU
	=	60,000 x 0.00005 x 10000/252
	=	119.05 MMBTU
Fuel oil consumption for light up	=	4320 MT
NCV of Fuel	=	9600 kcal/kg
Energy Consumption during Natural calamity	=	4320 x 9600
	=	164571.43 MMBTU
NRGF	=	5.48
Crude processed	=	67740 Mbarrels
Energy consumed	=	18641.25 + 164571.43 + 119.05 + 856.33
	=	184188 MMBTU
MBN Impact	=	(184188/ (5.48 x 67740))
	=	0.50

4. Power consumed during construction of a new project

i) Need for normalization

Electricity consumed during construction phase of any project activity will be additional energy load on the Refinery which is not connected with production and hence will have to be subtracted while calculating MBN. Electricity supplied to Project site from Refinery CPP is treated as Non-Refinery operation (NRO) in MBN calculation. However, normalisation will be done only if refinery provide the supporting documentary evidence for electricity consumption from the energy meters, etc.

ii) Supporting Documents

i. The list of equipment with Electrical Energy Consumption details need to be maintained

for Normalization

ii. Energy Meter Readings of each project activity with list of equipment /activities with power consumption.

iii) Calculation of normalization factor

For project 1,

Electricity consumed	=	E1 MWh
CPP heat rate	=	H1 MBTU/kWh
Therefore, units consumed, E	=	E1 x H1 MMBTU
MBN impact, (MMBTU/M Barrels/NRGF)	=	E/ (NRGF of refinery x Mbbls)

Since Power supplied to New Project site is already covered in MBN calculation as NRO Power, no further normalisation would be required

Illustrative example

For project 1,

Electricity consumed	=	8760 MWh
CPP heat rate	=	8.56 MBTU/kWh
Therefore, units consumed, E	=	8760 x 8.56
	=	75014.09 MMBTU
NRGF for refinery	=	5.48
Crude processed	=	67740 M barrels
MBN impact, MMBTU/M Barrels	=	E/ (NRGF of refinery x Mbbls)
MBN Impact	=	75014.09 / (67740 x 5.48)
	=	0.202

5. Renewable Energy Plants

i) Need for normalization

The refinery with renewable energy source inside the battery limit, connected to the grid to comply with RPO but not claiming the REC Certificate, will be able to take benefits in ESCerts. Further, for refineries with renewable energy source outside the battery limit, connected to the grid, the supplied power will be considered as import energy. RE power supplied by a facility located outside the Battery limit through dedicated power cables and not connected with the grid will not be considered as import of power for MBN calculation and ESCerts benefit can be taken.

The quantity of exported power (partially or fully) on which Renewable Energy Certificates have been earned by Designated Consumer in the assessment year under REC mechanism shall be treated as Exported power and normalization will apply. However, the normalized power export will not qualify for issue of Energy Saving Certificates under PAT Scheme.

The quantity of exported power (partially or fully) from Renewable energy which has been sold at a preferential tariff by the Designated consumer in the assessment year under REC mechanism shall be treated as Exported power. However, the normalized power export will not qualify for issue of Energy Saving Certificates under PAT Scheme.

ii) Supporting Documents

i. RE certificates

ii. Power Purchase Agreement (PPA)for the capacity related to such generation to sell electricity at preferential tariff determined by the Appropriate Commission

iii. Renewal Purchase Obligation document

iii) Calculation of normalization factor

Target saving to be achieved by the unit	=	T MMBTU/MBBLs/NRGF
Actual savings achieved without normalization	=	A MMBTU/MBBLs/NRGF
MBN shortfall w.r.t Target, R	=	(T - A) MMBTU/MBBLs/NRGF

If, T< or = R, normalization for renewable energy will be applicable,

Then, Energy eq. of MBN shortfall w.r.t target (E)	=	R x Mbbls x NRGF, MMBTU
Total RE power generated in MWh	=	R1 MWh
REC equivalent RE generated	=	R2 MWh
RE sold on preferential tariff	=	R3 MWh
Total RE (REC + preferential tariff)	=	R2 + R3 MWh
CPP heat rate	=	H kBTU /kWh
Energy equivalent of RE power generated, E'	=	(R2 + R3) x H MMBTU

Thermal Energy equivalent of RE power qualified for normalization, Q'=Lowest of E or E' (in MMBTU)

Whether Refinery has claimed REC certificate /sold RE at preferential Tariff or intends to claim REC certificate or intend to sell RE at preferential Tariff = "Y/N"

MBN to be Normalised = 0, if above answer =" Y"

Else, MBN to be Normalised=Q'/NRGF/crude Mbbls

Illustrative example

Target received for MBN in Assessment Year (T)	=	72.480 MBN
MBN achieved without Normalization (A)	=	70.000 MBN
Difference in target & achieved MBN without normalization,	=	72.48 – 70
	=	-2.48 MBN
Normalization is applicable in this case,		
NRGF for refinery	=	5.48
Crude processed	=	67740 M barrels
Energy Equivalent of MBN Excess w.r.t. target,	=	Abs (-2.48 x 67740 x 5.48)
	=	920613.70 MMBTU
MWh of RE Power Generated	=	1,000 MWh
Energy equivalent of REC accrued on RE generated	=	500 MWh
RE power sold at Preferential Tarriff	=	0 MWh
Total RE Power corresponding to REC and preferential Tariff,	=	500 + 0
	=	500 MWh
CPP Heat rate	=	8.56 kBTU/kWh
Energy Equivalent of RE Power Generated,	=	8.56 x 500
	=	4281.63 MMBTU
The least of Energy Eq. of MBN & the energy Eq. of RE generated is available for normalization,		
Therefore, MBN impact	=	4281.63/ (5.48 x 67740)
	=	0.012

6. Energy consumed for a new/ revamp project

i) Need for normalization

While commissioning any new unit, it takes some time to bring the unit to a steady operating level without any need for shutdown to take care of nagging problems, instrument faults and also to ensure smooth running of equipment etc., During this period, the unit Throughput will not be at the Design level and hence the specific energy consumption of the unit will be higher. Hence the NRGF for the Refinery will be higher and also there is additional fuel consumption during pre-commissioning stage and start-up of unit post every shutdown to attend the problems. It is therefore normalisation is required to restore the MBN for normal operation only. Stabilization of the plant means routing of all the products

ii) Supporting Documents

i. Data on Pre-commissioning: activities conducted with dates

ii. Energy usage during pre-commissioning: Record of steam, Power and cooling water used during pre-commissioning

iii. Line fill taken: quantity as capitalised or as declared to Finance department (MT)

iv. Energy usage for start-up of unit: Start up fuel till product routing to Tank.

iii) Calculation of normalization factor

For Project 1

Calculation for baseline year

Fuel equivalent involved in pre-commissioning	= X Tonnes (converted to SRFT)
Line fill quantity	= Y Tonnes (SRFT)
Fuel & loss for start-up	= Z Tonnes (SRFT)
Total fuel loss, L	= (X + Y + Z) SRFT
Total energy loss, E	= (L x 10000/252) MMBTU
Therefore, MBN Impact in baseline	= (E /Crude processed (M Barrels)/NRGF

Calculation for assessment year

Fuel & loss involved in pre-commissioning	= X1 Tonnes (converted to SRFT)
Line fill quantity	= Y1 Tonnes (SRFT)
Fuel & loss for start-up	= Z1 Tonnes (SRFT)
Total fuel loss, L1	= (X1 + Y1 + Z1) SRFT
Total energy loss, E1	= (L1 x (10000/252) MMBTU
Therefore, assessment year MBN,	= (E1 /Crude processed (M Barrels)/NRGF

Therefore, for project 1, MBN Net Impact = MBN impact in assessment year - MBN impact in baseline year

Similar calculations apply for other projects. The overall impact of MBN will be the sum of impacts of all individual projects

Illustrative example

For project ABC,

Fuel & loss involved in pre-commissioning	=	3000 SRFT
Line fill quantity	=	3000 SRFT
Fuel & loss for start-up	=	500 SRFT
Total fuel loss, L1	=	(3000+3000+500)
	=	6500 SRFT

Total energy loss, E1	=	6500 x (10000/252)
	=	257937 MMBTU
Crude processed	=	67740 Mbarrels
NRGF of refinery	=	5.480
Therefore, assessment year MBN,	=	(E1/Crude processed (M Barrels)/NRGF
	=	257937/ (67740 x 5.48)
	=	0.695

7. Extra fuel in Boilers & STGs due to disruption of NG supply

i) Need for normalization

Extra fuel in Boilers & STG's due to disruption of NG supply may be considered as an external factor and should be normalized. Additional energy gets consumed due to low quality fuel usage in boilers or STG's which will be normalized during the assessment year.

ii) Supporting Documents

i. Quantity of NG disruption/ lower availability as compared to agreement quantity
ii. Period of NG disruption /lower availability (Daily joint ticketing)
iii. Communication from RLNG supplier/ transporter regarding disruption
iv. Alternate fuel used during the above period
v. Quantity of alternate fuel used as substitution for RLNG (RTDB download/DOR/MOR)

iii) Calculation of normalization factor

a) For Boiler,

In Baseline year

Qty of NG disrupted for boiler	=	X1 tonnes
Eff of boiler with NG firing	=	B1
Eff of boiler with 'other' fuel firing	=	B'1
'Other' fuel used during the disruption, X'1	=	(X1 x B1)/B'1
Additional qty of fuel used, F1	=	X'1 – X1
NCV of 'other' Fuel	=	N1 Kcal/kg
Additional Energy consumed, E1	=	F1 x N1/252 MMBTU
MBN Impact	=	E1 /Mbbls crude/ NRGF
In Assessment year		
Qty of NG disrupted for boiler	=	X2 tonnes

Eff of boiler with NG firing	=	B2
Eff of boiler with 'other' fuel firing	=	B'2
'Other' fuel used during the disruption, X'2	=	(X2 x B2)/B'2
Additional qty of fuel used, F2	=	X'2 – X2
NCV of 'other' Fuel	=	N2 Kcal/kg
Additional Energy consumed, E2	=	F2 x N2/252 MMBTU
MBN Impact	=	E2/Mbbls crude/NRGF

MBN Net Impact= Impact in assessment year-Impact in Baseline year

b) For Gas Turbine (GT)

In Baseline year

NHR with NG firing	=	NHR1 MBTU/kWh
NHR with 'other' fuel firing	=	NHR2 MBTU/kWh
Difference in heat rates due to NG disruption	=	(NHR2-NHR1) MBTU/kWh
Net Electrical Energy generated	=	E MWh
Extra energy spent with NG disruption	=	(NHR2-NHR1) * E MMBTU
Impact on MBN	=	(NHR2-NHR1) *E/(Mbbls*NRGF)

In Assessment year

NHR with NG firing	=	NHR3 MBTU/kWh
NHR with 'other' fuel firing	=	NHR4 MBTU/kW
Difference in heat rates due to NG disruption	=	(NHR4-NHR3) MBTU/kWh
Net Electrical Energy generated	=	E' MWh
Extra energy spent with alternate Fuel	=	(NHR4-NHR3) * E' MMBTU
Impact on MBN	=	(NHR4-NHR3) *E'/(Mbbls*NRGF)

Net Impact = Impact during assessment year – Impact during Baseline year

c) For Hydrogen Generation unit (HGU)

In Baseline year

Qty of NG disrupted for HGU	=	X1 tonnes
Feed to Hydrogen ratio for NG as fuel	=	R1
Feed to Hydrogen ratio for Naphtha fuel	=	R2
Difference in Hydrogen ratio	=	R2 – R1
Hydrogen produced during NG disruption	=	H tonnes
Additional feed required, MMBTU, F	=	(R2 – R1) x H x 10000/252
Additional loss due to feed, L1, MBN	=	F/ (NRGF x Crude processed)

NG fuel to Hydrogen ratio per unit hydrogen (Design value),	=	R3
Naphtha to Hydrogen ratio per unit hydrogen (Design value),	=	R4
Increase in direct fuel per unit of Hydrogen produced,	=	R4 – R3
Therefore, extra fuel required, F1	=	((R4 - R3) x H x 10000)/252
Additional loss due to fuel, L2, MBN x NRGF)	=	F1/ (Crude processed
Total impact for MBN	=	L1 + L2

In Baseline year

Qty of NG disrupted for HGU	=	X'1 tonnes
Feed to Hydrogen ratio for NG as fuel	=	R'1
Feed to Hydrogen ratio for Naphtha fuel	=	R'2
Difference in Hydrogen ratio	=	R'2 – R'1
Hydrogen produced during NG disruption	=	H' tonnes
Additional feed required, MMBTU, F	=	(R'2 – R'1) x H' x 10000/252
Additional loss due to feed, L1', MBN processed)	=	F'/ (NRGF x Crude
NG fuel to Hydrogen ratio per unit hydrogen (Design value),	=	R'3
Naphtha to Hydrogen ratio per unit hydrogen (Design value),	=	R'4
Increase in direct fuel per unit of Hydrogen produced,	=	R'4 – R'3
Therefore, extra fuel required, F'1	=	((R'4 – R'3) x H x 10000)/252
Additional loss due to fuel, L2', MBN x NRGF)	=	F'1/ (Crude processed
Total impact for MBN	=	L1' + L2'

Net Impact = Impact during assessment year – Impact during Baseline year

Illustrative example

For Boiler

Qty of NG disrupted for boiler	=	10,000 Tonnes
Eff of boiler with NG firing	=	85%
Eff of boiler with "Other" fuel firing	=	80%

"Other" fuel used during the disruption	=	(10000 x 85)/80
	=	10,625 Tonnes
Additional quantity of fuel used,	=	625 Tonnes
NCV of "Other" fuel	=	10,000 Kcal/kg
Additional energy consumed MMBTU	=	(10000 x 625/252)
	=	24,802 MMBTU
NRGF Refinery	=	8.58
Crude Processed	=	67,400 Mbbls
MBN Impact of Boiler(s)	=	24802/ (8.58 x 67400)
	=	0.043
For GTG		
Net heat rate for turbine with Natural Gas (NHR1)	=	9 MBTU/kWh
Net heat rate for turbine with "Other Fuel" (NHR2)	=	11 MBTU/kWh
Difference in Heat rates due to NG disruption,	=	2 MBTU/kWh
Net Power Generation	=	10,000 kWh
Extra energy consumed due to NG disruption	=	(2 x 10000)/1000
	=	20 MMBTU
NRGF Refinery	=	8.58
Crude Processed	=	67,400 Mbbls
MBN impact for Gas Turbine(s)	=	20/ (67400 x 8.58)
	=	0.035
For HGU		
Qty of NG disrupted for HGU(s)	=	10,000 Tonnes
Feed to Hydrogen ratio for NG as fuel (R1)	=	0.5
Feed to Hydrogen ratio for Naptha as fuel (R2)	=	0.7
Difference in Hydrogen ratio, (R2-R1)	=	0.2
Hydrogen produced during NG Disruption	=	5,000 Tonnes
Additional feed required	=	(5000 x 0.2 x 10000)/252
	=	39,682.54 MMBTU
NRGF Refinery	=	8.58
Crude Processed	=	67,400 Mbbls
Additional loss due to feed	=	39682.54/ (8.58 x 67400)

	=	0.07
"NG fuel to Hydrogen ratio per unit hydrogen (R3)	=	0.86
"Naptha to Hydrogen ratio per unit hydrogen (R4)	=	0.9
Increase in direct fuel per unit of hydrogen produced (R4-R3)		
	=	0.04
Extra fuel required	=	(0.04 x 5000)/252
	=	7,936.51 MMBTU
Additional loss due to fuel	=	7936.51/ (8.58 x 67400)
	=	0.01
Total MBN Impact for HGU(s)	=	0.01 + 0.07
	=	0.08

8. Normalisation of Imported Power

Lower of the average heat rate of the grid and the actual heat rate shall be considered for normalisation. Refineries were advised to provide actual heat rate for 2014-15 onwards. CHT has calculated impact in MBN nos. refinery wise based on the available data on heat rate and power import for refinery operations.

Units with heat rate values lower than 9 MBTU/kWh will be given the benefit of normalization & accordingly corrections will be applied,

For Baseline year,

Net power imported for refinery operation,	=	E1 MWh
CPP heat rate	=	H1 kBTU/kWh
Normalization impact in MMBTU, N1	=	9; if plant heat rate > 9 kBTU/kWh
	=	(9 – H1) x E1 MMBTU
Therefore, MBN baseline,	=	(N1/NRGF)/ Crude Mbarrels

For Assessment year,

Net power imported for refinery operation,	=	E2 MWh
CPP heat rate	=	H2 kBTU/kWh
Normalization impact in MMBTU, N1	=	9; if plant heat rate > 9 kBTU/kWh
	=	(9 – H2) x E2 MMBTU
Therefore, MBN baseline,	=	(N2/NRGF)/ Crude Mbarrels

MBN normalized = MBN current - MBN Baseline

Illustrative example		
Net power imported for refinery operation,	=	8000 MWh (changed)
CPP heat rate	=	7 kBTU/kWh
Normalization impact in MMBTU, N1	=	9; if plant heat rate > 9 kBTU/kWh
	=	(9 – Heat rate) x Imported power
In this case heat rate < 9,		
Therefore, Normalization impact	=	(9 – 7) x 8000 MWh
	=	16000 MMBTU
NRGF of refinery	=	5.48
Crude processed	=	67740 M barrels
Therefore, MBN impact,	=	(N2 x NRGF)/ Crude processed
	=	(16000 x 5.48)/67740
	=	0.043

9. Impact arising due to export of utility

Calculation

For baseline year,

1. For export of power (E1)

Total power exported	=	P1 MWh
CPP heat rate	=	H MBTU/kWh
Total electrical energy export, E1, MMBTU	=	P1 x H

2. Steam Quantity exported (E2)

HHP steam consumed	=	q1 TPH
HP steam consumed	=	q2 TPH
MP steam consumed	=	q3 TPH
LP steam consumed	=	q4 TPH
Enthalpy of HHP team	=	H1 kcal/kg
Enthalpy of HP team	=	H2 kcal/kg

Enthalpy of MP team	=	H3 kcal/kg
Enthalpy of LP team	=	H4 kcal/kg
Total thermal energy exported in kcal, Q	=	((H1 x q1) + (H2 x q2) + (H3 x q3) + (H4 x q4)) x 1000
In MMBTU, E2	=	Q x 1000/252/10^6
Total energy exported, E total	=	E1 + E2
Net MBN baseline	=	E total/ NRGF/Crude processed

For assessment year,

1. For export of power (E1′)

Total power exported	=	P1′ MWh
CPP heat rate	=	H′ MBTU/kWh
Total electrical energy export, E1′, MMBTU	=	P1′ x H′

2. Steam Quantity exported (E2′)

HHP steam consumed	=	q1′ TPH
HP steam consumed	=	q2′ TPH
MP steam consumed	=	q3′ TPH
LP steam consumed	=	q4′ TPH
Enthalpy of HHP team	=	H1′ kcal/kg
Enthalpy of HP team	=	H2′ kcal/kg
Enthalpy of MP team	=	H3′ kcal/kg
Enthalpy of LP team	=	H4′ kcal/kg
Total thermal energy exported in kcal, Q′	=	((H1′ x q1′) + (H2′ x q2′) + (H3′ x q3′) + (H4′ x q4′)) x 1000
In MMBTU, E2′	=	Q x 1000/252/10^6
Total energy exported, E total	=	E1′ + E2′
Net MBN baseline	=	E′ total/ NRGF/Crude processed

MBN normalized = MBN current - MBN Baseline

Illustrative example

Export of Power	=	100 MWh
CPP heat rate	=	8.59 MBTU/kWh
Electrical Energy Exported	=	859 MMBTU
Steam Quantity Exported		

HP Steam	=	1440 TPH
MP Steam	=	2160 TPH
LP Steam	=	3600 TPH
Enthalpy of HP Steam	=	776 kcal/kg
Enthalpy of MP Steam	=	666 kcal/kg
Enthalpy of LP Steam	=	657 kcal/kg
Thermal Energy Exported	=	(1440 x 776 + 2160 x 666 + 3600 x 657) x 1000
	=	4,92,12,00,000
Thermal Energy Exported	=	4921200000 x 1000/252/10^6
	=	19,529 MMBTU
Total Energy Exported	=	19,529 + 859
	=	20,388 MMBTU
NRGF – Refinery	=	5.48
Crude Processed	=	64,700 M barrels
Net MBN	=	20388/ (5.48 x 64700)
	=	0.058

10. Normalization for projects mechanically completed but could not be commissioned for want of shutdown for hook ups.

In case of units, which are mechanically completed but could not be commissioned due to non-availability of plant shutdown at the end of assessment year, the notional energy savings will be used for normalization. The notional energy may be estimated based on the design or the approved investment proposal.

ii) Need for normalization

This condition arising in the plant needs to be normalized on the account of the unavailability of shutdowns, approval for projects not going through, space constraints, equipment availability etc. The refineries shall submit the list of such projects with estimated notional energy saving and date of completion to BEE for normalization in the assessment year. The notional energy may be estimated based on the design or the approved investment proposal.

iii) Supporting Documents

i. Details of energy saving projects – Investment, payback, thermal/electrical savings estimated

ii. Time required for implementation

iii. Vendor/ Supplier information

iv. Downtime for hook-up

v. Reason for not commissioning

iv) Calculation of normalization factor

MBN before addition of new unit	=	M1
Total energy & loss, MMBTU	=	E1
Total crude processed in the unit	=	L Mbbls
NRGF of refinery	=	N
NRGF of new unit	=	N'
Capacity of new unit	=	C m3/h
Number of hours delayed	=	T1 hours Then,
Eq. volume of new unit, V1 m3	=	N' x T1 x C
Eq. volume of balance units, V2 m3	=	N x L 6.29 x 1000
The total equivalent volume, V m3	=	V1 + V2
New overall NRGF of the plant	=	V/ (L x 1000 x 6.29)
Notional energy consumed, E2	=	C x T x 113610 x 1 x N' x 1000 MMBTU 252 x 10^6 x 0.85

Then, the total energy & loss after unit addition,

	E	=	E1 + E2 MMBTU
New MBN therefore,	M2	=	E / (L x N')
MBN impact		=	M1 – M2

Note: For Notional energy calculation, the energy level considered for new unit is @ 85% of the standard energy in view of energy efficient design of newer units.

Energy savings from scheme which could not be mechanically completed for the want of shutdown

Details regarding the following aspects to be collected

a) Name of the scheme

b) Date of mechanical commissioning

c) Date of actual commissioning

Actual hook-up time	=	T1 months
Analysed savings in SRFT, F'	=	(Actual savings achieved (SRFT) x T1)/ Total number of months

This saving achieved can be subtracted from the actual F&L% for normalization

Illustrative Example

MBN before addition of New unit	=	67
Energy & Loss	=	24871418 MMBTU
Crude processed,	=	67740 Mbbls

NRGF of Refinery	=	5.48
NRGF of New unit	=	0.975
New unit capacity,	=	200 M3/hr
No of Hrs delayed	=	2000 hrs
Equivalent volume of New unit,	=	200 x 2000 x 0.975
	=	390000 m3
Equivalent volume of balance units,	=	(5.48 x 67740)/ (6.29 x 1000)
	=	59016724.96 m3
Total equivalent volume	=	59016724.96 + 390000
	=	59406724.96 m3
New NRGF of the unit	=	(59406724.96 x 6.29)/ (67740 x 1000)
	=	5.52
Notional energy in New Unit,	=	200 x 2000 x 113610 x 1 x 0.975 x 1000
	=	252 x 10^6 x 0.85
	=	149451.25 MMBTU
Total Energy & Loss after unit add	=	24871418 + 149451.25
	=	25020869.25 MMBTU
MBN (New)	=	25020869.25 / (67740 x 5.52)
	=	66.96
MBN Impact (to be reduced)	=	67 – 66.96
	=	0.040

Abbreviations

1. ARU – Amine Recovery Unit
2. ASU – Air Separation Unit
3. BBL – Billion Barrels
4. BBU – Bitumen Blowing Unit
5. CCR – Continuous Catalytic Reforming
6. CDU – Crude Distillation unit
7. CFBC – Circulating Fluidized Bed combustion
8. CPP – Captive power plant
9. CRU – Catalytic Reformer Unit
10. DCS – Distributed control System
11. DHDS – Diesel Hydrodesulphurization
12. DHDT – Diesel Hydrotreating
13. DISCOM – Distribution Company
14. GCV – Gross calorific value
15. ISOM – Isomerization Unit
16. LPG – Liquified Petroleum Gas
17. MMBTU – Metric Million British Thermal Units
18. MMTPA – Million Metric Tonnes per Annum
19. MSQ – Motor Spirit Quality
20. MTBE – Methyl Tert-Butyl Ether
21. MTOE – Metric Tonnes of Oil Equivalent
22. NCV – Net calorific value
23. NHR – Net Heat rate
24. NHT – Naphtha Hydrotreater Unit
25. NRGF – Energy Factor
26. NSU – Naphtha Splitter unit
27. PDU – Propane De-asphalting Unit
28. PLC – Programmable Logic controller
29. PSA – Pressure Swing Adsorption
30. SRFT – Standard Refinery Fuel Tonnes
31. SRU – Solvent Recovery Unit
32. VBU – Vis-breaker Unit
33. VDU – Vacuum Distillation Unit
34. VGO – Vacuum Gas Oil
35. VRU – Vacuum Residue Unit

The M&V report to be submitted to BEE shall include the following details,

I. Details about the DC which includes name of the plant, registration number, details about energy manager/auditor

II. Period over which the verification was done

III. Block diagram/ single line diagram showing entire process (all units) of the plant with clear boundary conditions, fuel sampling points (if applicable), and intermediate import/ export channels for fuel, raw materials, and products. If any condition has been changed in the assessment year, the same needs to be clearly highlighted (with dotted line, other colour, etc)

IV. Block diagram/ single line diagram showing entire electrical system in the present boundary condition, with import/ export, as and where applicable.

V. Details about the scenario of the baseline & verification year – Production, energy consumption pattern, sources of energy etc.

VI. Quarterly, Yearly and End of Cycle (EoC) Data Reports by DCs (2015-2018)

VII. Measuring Equipment and Instrument Calibration

VIII. Energy scenario in the assessment year – Main plant, CPP, HRSG, GTG etc.

IX. Addition or deletion of Equipment as compared to baseline scenario

X. Changes in Process Flow, Plant & Machinery, Technology, Product Mix, addition, deletion of products etc. in current year as compared to baseline

XI. Details of raw materials prepared used in the year with quality parameters

XII. Fuel related information including usage, fuel analysis (solid, liquid & gaseous), procedure carried out for fuel analysis in lab

XIII. Fuel Analysis report (Internal and External) with frequency of fuel testing

XIV. Energy and mass balance of the entire process.

XV. Suggestions/comments on the proforma by Accredited energy auditor

XVI. List of documents verified with each parameter (both baseline & assessment year)

XVII. Details about normalization factors identified

XVIII. Gate-to-gate diagrams (Baseline & Assessment year)

XIX. Annexure required:

i. Proforma

ii. Production reports

iii. Annual power cost reports

iv. CPP/HRSG/WHR monthly reports

v. Signed copy of Form A & B

vi. Calculation of normalization factors – with supporting documents

vii. Details about Energy Manager, PCB Consent, calibration certificates, Fuel receipt details etc.

viii. Supporting document for all the parameters in the proforma.

ix. Reconciliation document, as applicable

Since, the petroleum refinery sector differs from the other sectors, eth specific documentation needed is mentioned in the table below:

S. No	Details	Unit	Frequency of data collection	Primary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor	Secondary Documents from where the information can be sourced and to be kept ready for verification by Accredited Energy Auditor
Parameters – Quantity					
1	Crude T'put	TMT	Monthly	Any tax return, e.g. GST return, Custom duty return, bill of lading etc.	-

2	Secondary unit's T'put	TMT	Monthly	Density corrected flow meters and its integration for the month	-
3	Liquid Fuel quantity	TMT	Monthly	SAP/IP-21/RTDB	Technical Department MIS Report/ Encon Report
4	Purge gas quantity	TMT	Monthly	Flow Meters/DCS and formula/ IP-21/RTDB/ Calculation for BOO	Flow Meters/DCS/ IP-21/RTDB
5	Fuel Gas quantity	TMT	Monthly	AOR/Encon report/ Design values if meter does not exist	IP-21/RTDB
6	Natural Gas receipt quantity	TMT	Monthly	AOR/Encon report/ Calculation for BOO	Record maintain by P&U/Calculation for BOO
7	Solid Fuel feed quantity calculation	TMT	Monthly	Calculated by Process	AOR/Encon Report
8	Coke Yield Calculation	TMT	Monthly	AOR/ Process report/ AOR	Plant calculation sheet/Dept. report/Encon Report
9	Imported liquid Fuel quantity	TMT	Monthly	Technical Department MIS Report	Plant calculation sheet
10	Imported gas Fuel quantity	TMT	Monthly	Technical Department MIS Report	Plant calculation sheet
11	Imported Electrical Energy-quantity	KWH	Monthly	Energy meter of various feeders, electricity bills	Integrated value based on load manager.
12	Exported Electrical Energy -quantity	KWH	Monthly	Energy meter of various feeders, gas turbine/CPP log book	Integrated value based on load manager.
13	Non-refinery steam supplied-quantity	TMT	Monthly	Technical Department MIS Report/Flow meter readings corrected for density	Automated monthly material balance calculations/software based/IP21/RTDB

14	Non-refinery power supplied-quantity	KWH	Monthly	Energy meter of various feeders, electricity bills	Integrated value based on load manager.
15	Heat rate calculation	MBTU/KWH	Monthly	Heat supplied to furnace and Power generation from Gas turbine	-
16	Hydrogen Production	MMT	Monthly	Flow meters/DCS & formula/Calculation for BOO data	MIS/Lab reports/ Technical report/ Calculation for BOO data
17	Reported Fuel & Loss - material balance	TMT & %	Monthly	Plant calculation/AOR	Technical Reports/Design details/Encon Report
18	Reported Hydrocarbon loss	TMT & %	Monthly	Technical Department MIS Report/AOR Report	Can be calculated by process/Encon Report
Unit Operating Parameters					
CDU & VDU					
19	Flash Zone Temp	deg F	Daily	Technical MIS Department Report	Log Sheets/Daily Report/IP21/ RTDB
20	Flash Zone pressure	mm Hg abs	Daily	Technical MIS Department Report	Log Sheets/Daily Report/IP21/ RTDB
21	Bottom product percentage	%	Monthly	Technical MIS Department Report	Log Sheets/Daily Report/IP21/ RTDB
HCU					
22	% conversion	%	Monthly	Plant Calculation sheet	MIS Report
23	Feed Temp	deg C	Daily	DCS Data/IP21/RTDB	Log Sheets/IP21/ RTDB
CRU/CCRU					
24	∑(ΔT) across all Reactors	deg F	Daily	Plant calculation sheet	MIS reports/IP21/ RTDB
Lab Sampling Results					
25	Crude density (weighted average)	kg/M3	Daily	Internal Lab report	

26	Secondary unit's density	kg/M3	Monthly	Internal Lab report	
27	NHV of FO/ LSHS	K Cal/ kg	Monthly	Internal Lab report	
28	NHV of Naphtha as Feed & Fuel to HGU	K Cal/ kg	Monthly	Internal Lab report	
29	NHV of Naphtha as fuel to GTs	K Cal/ kg	Monthly	Internal Lab report	
30	NHV of HSD as fuel to GTs	K Cal/ kg	Weekly/Monthly	Internal Lab report	
31	GCV of Imported coal	K Cal/ kg	Daily	Internal Lab report	External NABL accredited Lab reports
32	GCV of petroleum coke	K Cal/ kg	Daily	Internal Lab report	External NABL accredited Lab reports
33	NHV of Fuel gas	K Cal/ kg	Fortnightly	Internal Lab report	
34	NHV of imported gas from Petrochemicals	K Cal/ kg	Fortnightly	Internal Lab report	External NABL accredited Lab reports
35	NHV of imported Natural gas/ LNG	K Cal/ kg	Fortnightly/ Monthly	Internal Lab report/ Calculation based on supplier joint ticketing invoice	
36	FCCU feed CCR	K Cal/ kg	Monthly	Internal Lab report	

S. No	Details
Document related to external factor	
(i)	**Grid Failure**
	1) SLDC Reference No. for planned Stoppages from respective Substation 2) Log book record of Main Electrical Substation of Plant 3) DPR 4) MPR 5) SAP entry in PM module of Electrical department

(ii)	**Natural Disaster**
	1) Supporting Authentic document from Local district Administration 2) Major Eqp Log Sheet 3) Major Eqp operators Report book 4) DPR 5) MPR
(iii)	**Major change in government policy hampering plant's process system**
	1)Government Notification or Statutory order 2) Authentic document from plant on effect of Major Eqp production due to policy change 3) DPR 4) MPR 5) SAP Entry on production change
(iv)	**Unforeseen circumstances/Labor Strike/Lockouts/Social Unrest/Riots**
	1) Relevant document on Unforeseen Circumstances beyond the control of plant 2) Energy Meter Readings and Power Consumption during the said period of un-foreseen circumstances 3) Thermal Energy Consumption record during the said period of unforeseen circumstances from DPR/Log book/SAP Entry
B	**Note**
(i)	The hard copy/Printouts are to be signed by Authorized signatory, if SAP data is used as documents

For all practical and legal purposes in connection with M&V guidelines, the English version of the notified PAT rules 2012 and EC Act, 2001 will be considered as final.

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