M&V Protocol Thermal Power Sector
Perform-Achieve and Trade Scheme

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Prepared By:

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ABBREVIATIONS

APC	*Auxiliary power consumption*
BEE	*Bureau of Energy Efficiency*
CEA	*Central Electricity Authority*
CERC	*Central electricity regulatory commission*
CNG	*Compressed natural gas*
CPP	*Captive power plant*
CU	*Capacity utilisation*
CUM	*Cubic meter*
DC	*Designated consumer*
DESL	*Development Environergy Services Limited (Formerly Dalkia Energy Services Ltd)*
EC	*Energy conservation*
EE	*Energy efficiency*
Escert	*Energy savings certificate*
GCV	*Gross calorific value*
GtG	*Gate to gate*
KA	*Kilo amperes*
Kcal	*Kilocalorie*
KLPY	*Kilo liter per year*
LDO	*Light diesel oil*
LNG	*Liquefied natural gas*
LTPY	*Lakh tonnes per year*
MKCal	*Million kilocalorie*
MOP	*Ministry of power*
MT	*Metric Ton*
MU	*Million kWh*
M&V	*Measurement & Verification*
PAT	*Perform achieve & trade*
PLF	*Plant load factor*
SCUM	*Standard cubic meter*
SEC	*Specific energy consumption*
SHR	*Station heat rate*
TOE/MTOE	*Tonnes oil equivalent*
TPD	*Tonnes per day*

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EXECUTIVE SUMMARY

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

- Determination of the 'Gate to Gate Specific Energy Consumption' (GtG SEC) as per prescribed procedure
- Normalisation of the determined GtG SEC using the normalisation guideline recommended for each individual sector
- Data and information protocol for carrying out determination of GtG SEC exercise & normalisation
- Monitoring & verification (M&V) protocol for assessment of performance of ECM projects
- Validation process and reporting of normalised GtG SEC for the PAT cycle

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

Thermal power sector has been identified as the most important sector with potential contribution of 3.211 million MTOE/year savings representing 48% of the overall PAT target[1]. The target for individual DC has been set based on the present heat rate as per the baseline audit reports and deviation from the designed heat rate.

CEA has been monitoring performance of, practically, all the thermal power plants in the country since long and a very robust system has been developed for the same. Key parameters like CU (PLF), fuel availability and quality, specific coal and auxiliary energy consumptions, which directly impact the GtG SEC are amongst the various parameters monitored on periodic basis.

Methodology for application of correction factor on account of coal quality variation has been provided in the PAT notification document. Like in case of other sector, it has also been provided to carry out normalisation based on statistical analysis for CU & GtG SEC corelationship in case CU varies by more than 30%.

Considerable work has already been done by CEA and CERC in identification of variables and normalisation of heat rate on these accounts[2]. Following key variables have been identified that can impact the GtG SEC.

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[1] MOP notification on PAT, July, 2012

[2] Recommendations on Operation Norms for Thermal Power Stations for Tariff Period beginning 1st April, 2009-CERC, Nov 4, 2008

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- Technology & equipments
- Fuel quality
- Ambient conditions
- Grid frequency
- Plant capacity utilisation-despatch
- Plant operation & maintenance

The overall impact of all variables put together has been assessed to range from 0.4% to 0.8%[2] depending upon the plant vintage and technology. The recommendations from this document are proposed to be adopted with the following modifications for the normalisation process.

- Coal quality variation impact as per PAT notification
- Reconciliation with assessed impact of implementation of energy saving projects.

The targets for the two units for which baseline reports have been obtained have been set at 0% and 0.4% respectively. It would therefore, be necessary to exercise extreme due diligence in maintaining data and information, carrying out statistical analysis and the normalisation and validation process.

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

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

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

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

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

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

Specific energy consumptions (SEC) in any process would vary over time due to changes, which can be classified under controllable and uncontrollable variables. The controllable variables include those, which can be changed by internal intervention including through behavioral changes and investment in energy efficient technologies. The factors over which an individual DC does not have any control but that can impact the SEC are classified as uncontrollable. The design intent of the PAT process is to insulate the DC from variability due to changes in the uncontrollable factors. The baseline conditions are defined so that the impact of uncontrollable variables can be neutralised by application of suitable adjustment factors ('Normalisation' factors in the BEE document).[3]

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

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[3] PAT consultative document

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2. THERMAL POWER SECTOR-OVERVIEW

2.1 THERMAL POWER SECTOR-SITUATIONAL OVERVIEW

India is the world's 6th largest producer of power. The installed capacity as on September 30, 2012 stands at 207876 MW comprising of thermal at over 57% followed by other hydro and other sources. Including the captive capacity, which is mostly thermal, the share of thermal power increases to over 70%.
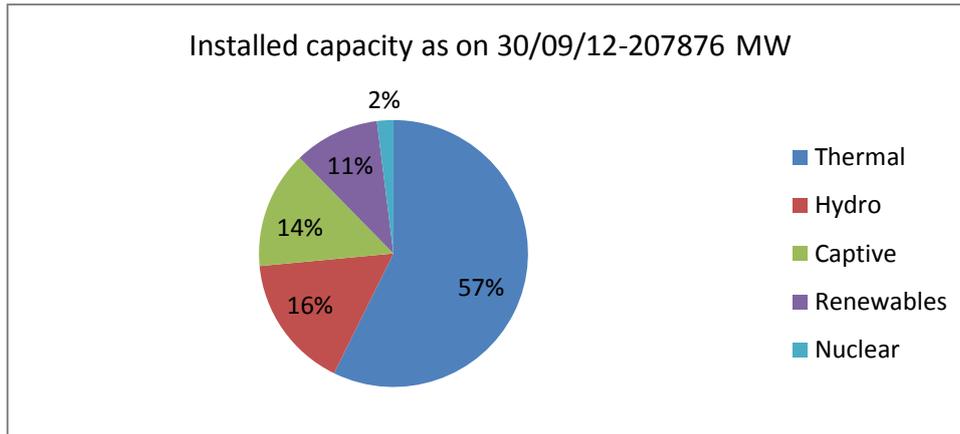
Figure 1: Share of various power capacities from different sources

The actual generation from thermal resources during the period April-August, 2012, stands at over 310 BU with close to 90% from coal and lignite.
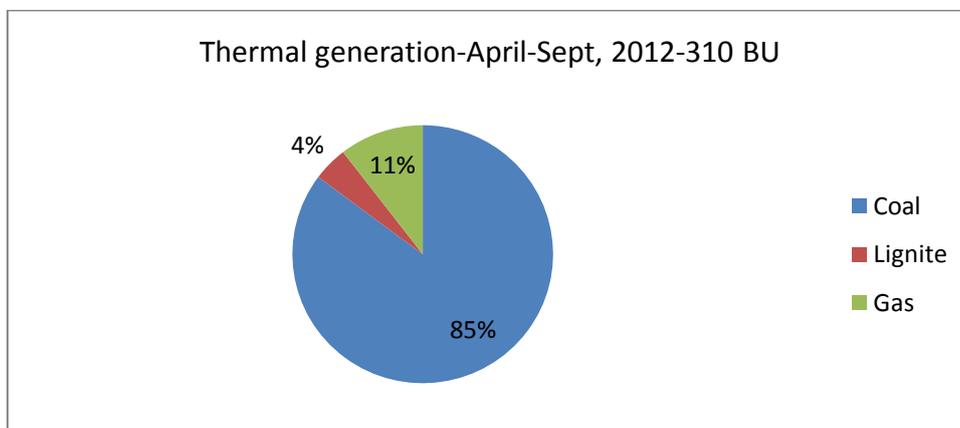
Figure 2: Share of various thermal resources

During this period, the growth of generation from coal and lignite has been over 12% & 22% respectively while that from gas has declined by close to 19%.

In the 11th plan period, the sector performance has been best ever with impressive growth in the per capital energy consumption overall.

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Per capital growth-kWh
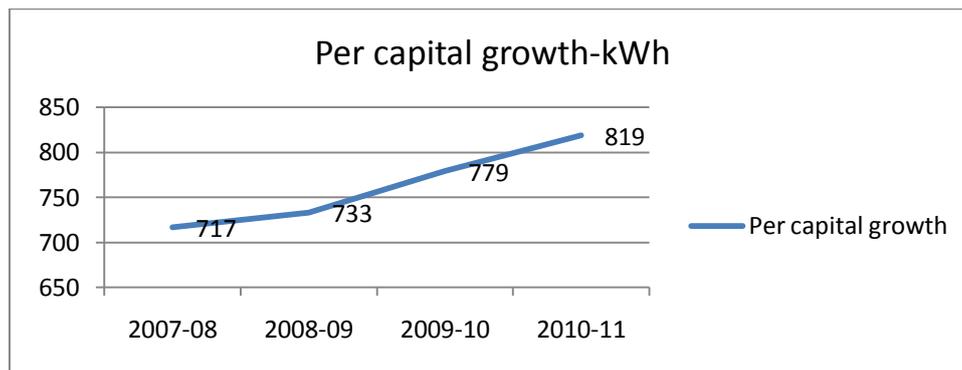
Figure 3: Growth in per capita energy consumption

During this period, there have been both peak shortage at about 9% and energy shortage at about 8.8%[4]. To overcome the shortages and meet the additional demand from the expansion of the system to meet the policy objective of universal energy access, the capacity addition would have to be significantly augmented.

Though there has been good growth in capacity addition from renewable resources, the contribution in actual generation is still less than 5%. Coal would therefore, continue to be main source for capacity addition and also generation in the foreseeable future. With a view to minimize the adverse impact on environment as a result, Government has taken many policy initiatives such as adaptation of clean coal technologies for future capacity addition and improving the efficiency of the existing plants through R&M activities. Inclusion of thermal power plants under the PAT scheme is one of the measures introduced for attracting higher level of investment in the R&M activities.

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[4] CEA website

3. DESIGNATED CONSUMERS-THERMAL POWER SECTOR

The designated consumers in thermal power sector have been grouped under:

- Coal
- Gas
- Diesel

There are 144 DCs in the thermal power sector. 107 units are based on coal/lignite whereas those on gas and DG constitute 33 and 4 respectively.

For the thermal power sector, the norms and standards have been specified based on the deviations of the average net heat rate of the three years (2007 to 2010) from the designed net heat rate as shown in the following table.

Table 1: Reduction norms for thermal power sector

Deviation in net station heat rate from the designed net heat rate	Reduction target as percentage of deviation in the net heat rate
Upto five percent	Ten percent (10%)
More than five percent and upto ten percent	Seventeen percent (17%)
More than ten percent and upto twenty percent	Twenty-one percent (21%)
More than twenty percent	Twenty-four percent (24%)

This would mean the lowest target at 0.5% reduction from the three years average and the highest at 4.8% for deviation upto 20%.

The specific reduction targets for individual units have been accordingly determined and announced as provided in the BEE notification document of July 2012. Of the 144 DCs, average annual generation data for 25 units are not available in the notification document. For some of these units, data could be obtained from the respective websites of these stations. For the rest, capacity figures could also been obtained from the websites. Generation figures for these units have been estimated based on assumed PLF for similar units. The individual targets for all the units have been computed accordingly.

Close to 98% of the savings target pertain to the coal fired stations as would be seen from the following figures.

Reduction target

- Gas — 2%
- DG — 0%
- Coal/lignite — 98%
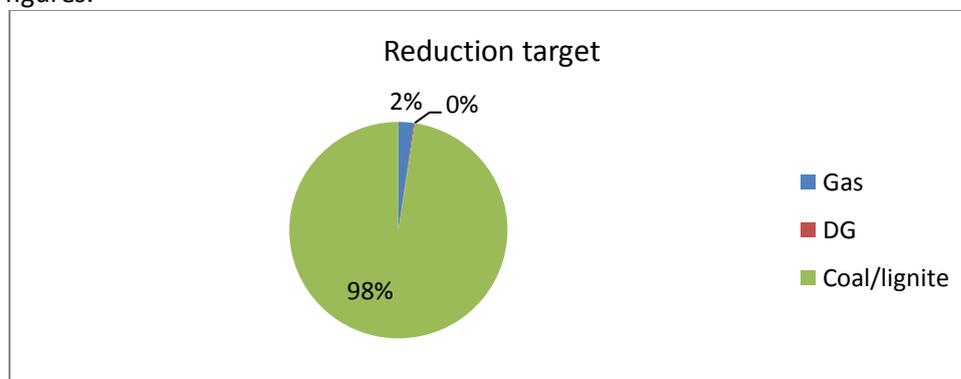
Figure 4: Reduction target

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From the PAT normalisation and M&V perspective therefore, coal/lignite fired stations would be the main considerations.

19 coal based power plants have savings target over 50000 TOE each, which accounts for aggregate target of over 1.78 MnTOE, 42% of the overall target. Panipat station leads the DCs with target of 165665 TOE, which is the highest individual target for all the DCs. Next 35 units with aggregate target of over 1 MnTOE accounts for 26% of the overall target. Thus, one third of all the DCs account for close to 90% of the overall target.
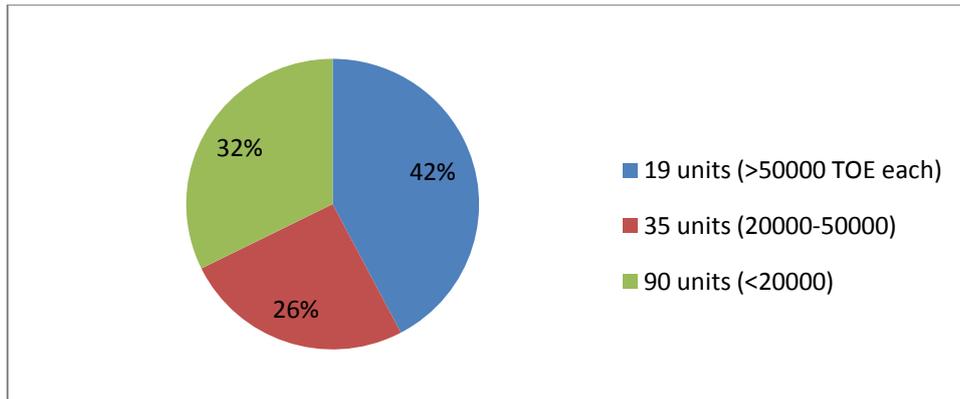
Figure 5: Distribution-savings target

Baseline assessment has therefore, been carried out based on review of two larger coal fired units, reports for which have been obtained from BEE.

4. BASELINE & NORMALISATION-OVERVIEW

4.1 BEE GUIDELINES

The PAT scheme is an operating unit-specific scheme, targeting reduction of energy intensity of the products being manufactured in the unit. The energy intensity has been defined as 'Gate to Gate' specific energy consumption (GtG SEC) determined by dividing the thermal equivalent of all energy inputs within the unit boundary by total electricity exported in the target period (Text box-1). With a view to neutralize the impact of uncontrollable variables, the concept of baseline and normalisation has been introduced (Text box-2). For the power sector, the unit for reporting GtG SEC is the net station heat rate (SHR) expressed as Kcal/kWh. The methodology for target setting is also shown in table-1.

Text Box 1: Gate to Gate SEC

The SEC of an industry would be calculated based on Gate-to-Gate concept with the following formula:

SEC = Total energy input to the plant boundary / Total electricity exported

While calculating the total energy input to the plant, all energy sources would be converted to a single unit i.e. MTOE (metric ton of oil equivalent) using standard engineering conversion formula. In this calculation, the following would be considered:

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

The principles for the normalisation process have been outlined with capacity utilisation as the key variable. However, it has also been provided that such normalisation factor would be applied if the capacity utilisation has deviated by more than 30% due to uncontrollable factors described in rule 4[5].

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

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[5] Section 1.4 © of Schedule (MOP/BEE)

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Text Box 2: Baseline & normalisation

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

a) All DCs would submit the details of power generation and export and annual fuel consumption since 2005-6 to 2009-10 through a notified form which is mandatory as per EC Act, 2001. Few additional sector specific information like process technology, process flow, raw material, product mix etc. would also be collected.

b) The SEC calculated from step (a) would be the 'Reported SEC' by the DC. As there may be various variable factors which affect the energy consumption significantly, some 'Normalization Factors' would be considered. It is proposed to consider the 'capacity utilization' as one of the most important parameter to have a normalization factor. However, the rationale for developing the 'normalization factors' is underway by suitable agencies through a scientific manner.

c) Now the reported SEC will be normalized after incorporating the normalization factor.

d) Normalized SEC = f (Reported SEC, Normalization factors)

e) The base line SEC will be estimated by taking the average normalized SEC of last 3 years i.e. 2007-8, 2008-9, and 2009-10.

f) The base year may be defined as 2009-10.

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Provision has been made for application of correction factor for the boiler efficiency (normalisation factor) for the key coal quality parameters as per the following formula:

Boiler efficiency=92.5-{50*A+630(M+9H)}/GCV

Where:

A=Ash percentage in coal

M=Moisture percentage in coal

H=Hydrogen percentage in coal

GCV=Gross calorific value in Kcal/Kg

4.2 PROPOSED METHODOLOGY

The proposed methodology has been developed considering the followings:

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

Using BEE/EESL guideline

BEE document has provided clear guidelines on production and energy consumption variables as discussed at section 4.1 above. Methodology for baseline energy audit adopted by auditing agencies as per EESL guidelines are as follows:

- Fixing up the plant boundary
- Analysis of power production trends and capacity utilization
- Detailed process flow study
- Analysis of energy scenario
- Estimation of Specific Energy Consumption (SEC)

- Analysis of various factors affecting GtG SEC
- Listing of energy efficiency projects identified by the DC and assessment of impact

BEE guideline as rightly highlighted the need for statistical analysis for establishment of the relationship coefficient of identified variables for the purpose of normalisation. In respect of capacity utilisation coefficient, the guideline has provided for consideration only if deviation is by 30% or more. This issue would have to be reviewed for every DC after carrying out the statistical analysis.

Using the baseline reports

Two baseline audit reports have been obtained with a view to analyze and assess the CU impact on GtG SEC based on outlined principles and develop M&V protocol for the PAT cycle. The baseline audit reports have provided statistical analysis for determination of CU GtG corelationship. There is strong corelationship in a particular range. However, data points are not sufficient enough to take these coefficients for normalisation. It would be necessary to carry out statistical analysis based on more number of data. Frequency of data collection has accordingly been recommended in the data protocol.

The baseline reports have also included the identified energy saving projects and analysis on impact of these projects on reduction of GtG SEC. The auditors have made strong recommendations on application of M&V protocol for assessing the impact of implementation of energy saving projects.

The reports have not included the other key variables including coal quality and analysis and observations on their impacts.

DESL analysis & recommendations-other factors

With a view to assess the impact, DESL has carried out further analysis based on the available data and information in the baseline reports as well as further research based on DESL database and information available in the public domain. The entire aspect of normalisation for variables has been most comprehensively dealt in a CERC document[2].

The identified variables are:

- Technology & equipments
- Fuel quality
- Ambient conditions
- Grid frequency
- Plant capacity utilisation-despatch
- Plant operation & maintenance

CERC document has made the following important conclusions:

- There has been continuous improvement in the heat rate of the operating thermal power plants. Weighted average deviation from the design heat rates for all the plants has reduced from 7.33% in 2002-03 to 5.46% in 2006-07
- All the plants are operating at better than normative heat rate-improvement% has improved from 1.42% in 2002-03 3.14% in 2006-07
- There has not been much degradation in the coal quality for NTPC plants
- Combined impacts of all uncontrollable variables other than coal can range from 0.4% to 0.8%
- Operation and maintenance practices have the highest impact on achievable heat rate

The recommendation provided in the CERC report can be straightaway adopted with further provisions for normalisation on fuel quality variability as per the BEE guideline provided in the PAT notification document. Normalised figure so determined can be reconciled with the assessed reduction of SEC by implementation of energy saving projects.

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

GtG SEC corelationship

Two reports obtained from BEE have been perused. Both the plants are coal based using pulverized fuel and sub-critical technology, though plant sizes and vintages are different. However, from normalisation perspective, they have common characteristics. Hence, analysis and reports are being presented together for both the units.

The broad particulars of the units are as shown in the following table.

Table 2: Particulars of the units

Parameter	Unit-1	Unit-2
Sub-sector	Coal	Coal
Capacity (MW)	62.5	500
Fuel-Primary	Coal -Indian	Coal –Indian

In case of both the units, data has been provided in different formats with graphical representation on variables like power generation, PLF, coal and auxiliary fuel consumptions. Good quality data has been presented on the opportunities for energy savings and consequent impact on GtG SEC. The relationships between CU and GtG SEC for the units are as represented by the following figures.
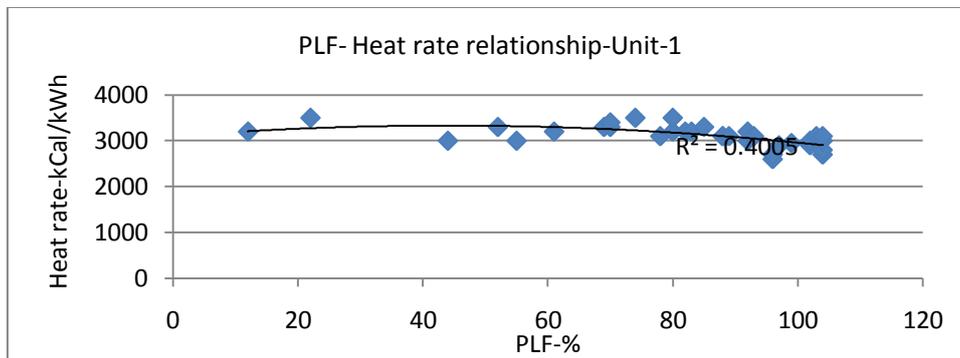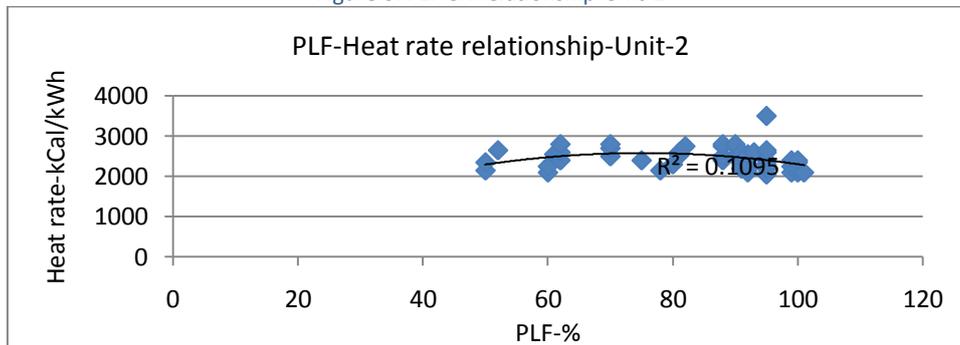

Figure 6: PLF-SHRelationship-Unit-1

Figure 7: PLF-SHR relationship-Unit-2

From the R^2 value (co- relationship), it is seen that very good corelatioship between PLF and heat rate (GtG SEC) exists over a limited range and not for the large PLF variation.

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The PLF impact on SHR also seems to be more than 0.8% upper limit mentioned in the CERC document[2]. However, data points are insufficient for proper statistical analysis required for making a definitive conclusion.

Both the plants have been consistently improving the PLF over last five years. Average PLF for the last three years has been:

- Plant-1-90.2%
- Plant-2-88.75%

The auditors have noted that since the average PLF is well over the threshold value of variation by over 30% as per BEE guidelines, normalisation is not required on this account. However, as stated above, the issue would require review based on statistical analysis covering larger sets of data points.

Impact of identified energy saving projects

The auditors have carried out detailed analysis of possible energy efficiency enhancement measures based on which maximum possible reduction in GtG SEC has been identified. Following tables show the possible impact on reduction of SEC by implementation of the energy saving projects.

Table 3 : Impact of energy saving projects-Unit-1

Sl No	Parameters	Units	Present	Post	Impact
1	Coal consumption	MT/year	3,38,710	3,23,031	-4.63%
2	HFO consumption	KL/year	98	98	0.00%
3	HSD consumption	KL/year	134	134	0.00%
4	Annual overall energy consumption	MTOE	1,29,034	1,23,071	-4.62%
5	Auxiliary power consumption	MU/year	45.4	37.43	-17.57%
		%	9.19%	7.57%	-17.57%
7	Generation	MU/year	494	494	0.00%
8	Net SHR	kCal/kWh	2,875.22	2,694.46	-6.29%

Table 4: Impact of energy saving projects-Unit-2

Sl No	Parameters	Units	Present	Post	Impact (%)
1	Coal consumption	MT/year	30,49, 821	30,31, 269	-0.61%
2	HFO consumption	KL/year	2097	2097	0.00%
3	HSD consumption	KL/year	68	68	0.00%
4	Annual overall energy consumption	MTOE	9,89,884	9,83,875	-0.61%

5	Aux. power consumption	MU/year	352.2	309.99	-11.99%
		%	9.05%	7.97%	-11.99%
7	Generation	MU/year	3891	3891	0.00%
8	Net SHR	kCal/kWh	2,805.00	2,748.00	-2.03%

Opportunity for saving in case of unit-2 is limited mainly to marginal reduction of auxiliary power consumption whereas for unit-1, both coal and auxiliary power consumption can be reduced.

Impact of other variables

There seems to have been some difference in application of the concept of gross heat rate and net heat rate while presenting the findings by the auditors. For example, the gross and net heat rates for unit no 2 have been shown at 2550 Kcal/kWh and 2805 respectively in the baseline report whereas BEE has notified the baseline net heat rate at 2565 Kcal/kWh, which is closer to the gross heat rate shown by the auditor. This could be typo error and hence ignored for further analysis.

Baseline and target set by BEE for the two units against the findings of the baseline reports are as shown in the following table.

Table 5: Baseline & target GtG

Parameters	Unit-1		Unit-2	
	Baseline audit report	BEE notification	Baseline audit report	BEE notification
Baseline GtG SEC (Kcal/kWh)	2875	2885	2550	2565
Possible benchmark/target	2694	2885	2498	2556
% Reduction	6.3	0	2	0.4

BEE would have computed the targets based on:
- % age deviation from the designed heat rate
- Coal quality variation as provided in the guidelines

These issues would require scrutiny during the validation stage. Considering the reduction target of only 0.4% for unit-2, great deal of diligence has to be exercised in carrying out statistical analysis and process of validation and verification.

6. VARIABILITY FACTORS & NORMALISATION-THERMAL POWER

In addition to the review of the baseline reports and own database, DESL has carried out survey of literature available in the public domain and interaction with sectoral experts to establish the variables, which can impact the energy consumption and therefore, need to be factored for the process of normalisation. The CERC document referred to above has included all the key variables impacting the SEC for the sector as follows[2]:

- Technology & equipments
- Fuel quality
- Ambient conditions
- Grid frequency
- Plant capacity utilisation-despatch
- Plant operation & maintenance

6.1 TECHNOLOGY & EQUIPMENTS

The station heat rate and consequently the GtG SEC are very closely related to the technology and vintage of plants. It may happen that in a single location, machines of different vintages have been installed at different points of time. In such cases, it would be necessary to determine the weighted average figures of GtG SEC for the purpose of reporting.

6.2 FUEL QUALITY

The normalisation formula has been provided in the PAT notification document. It would be desirable to validate the normalisation formula using available data on coal quality. However, in case of plants operating fully on linked coal from a particular mine; it may not be necessary to do any adjustment as per observation made in the CERC document.

6.3 AMBIENT CONDITIONS

Ambient conditions particularly temperature and humidity level can impact the cooling tower performance, which in effect would impact the turbine performance. It has been estimated that there would be degradation in heat rate by 0.07% due to higher temperature prevailing for about 10% of the operating time.

6.4 GRID FREQUENCY

It has been estimated that there would be increase in heat rate by about 3 Kcal/kWh for operation of the plant at 49 Hz.

6.5 PLANT CAPACITY UTILISATION (PLF)

The impact of reduction in loading due to despatch instruction has been estimated to range from 0.25% to 0.7% depending upon the unit vintage and operational technology (less impact for those with sliding pressure system).

6.6 PLANT OPERATION & MAINTENANCE

It has been assessed by CERC that the overall impact of all the uncontrollable variables may range from 0.4% to 0.8%. Operation and maintenance practices have been identified as major reasons for deviation from design heat rate. Considering the objective of the Pat scheme, this factor need not be considered for normalisation.

6.7 SUMMARY

The recommended normalisation process is summarised in the following table.

Table 6: Normalisation process

Parameters	Baseline report	Recommendation	Remarks
Technology & equipments	Not considered	Not required	
Fuel quality	Not considered	Needs critical considerations	Boiler design considerations to be factored
Ambient conditions	Not considered	Needs consideration	In case of very low target such as the case of unit-2, the impact can be high
Grid frequency	Not considered	Needs consideration	In case of very low target such as the case of unit-2, the impact can be high
Plant capacity utilisation-despatch	Provided	Important normalisation factor	30% limit provided in the BEE document needs to be reviewed
Plant operation & maintenance	Not considered	Not to be considered	Basic improvement objective of PAT scheme

6.8 RECONCILIATION-IMPACT OF ENERGY SAVING PROJECTS

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

- Review of larger number of representative baseline audit reports to assess the CU GtG SEC relationship, which can stand to statistical scrutiny
- The reasons for deviations particularly for units showing distinctly contra behavior need to be further analysed based on collection of larger number of data for hourly, daily, monthly

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and annual basis and impacts of other variables established. For reconciliation, impact of implementation of EE projects is to be assessed as illustrated below.
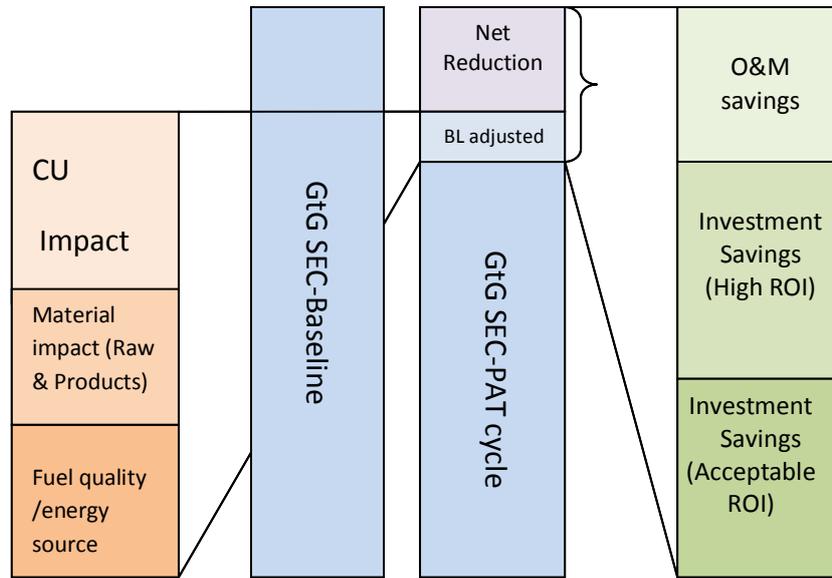
Figure 8: Normalisation & baseline adjustment

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

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

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

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

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7. M&V PROCESS AND PROTOCOL

7.1 INPUT OUTPUT M&V

The metering & measurement systems for both the plants, as detailed out in the baseline report are adequate for determination of GtG SEC and most of the parameters for the normalisation. Some additional provisions are required (may be already existing in the plants but not reported in the baseline document). The suggested overall metering and measurement plans are presented in the following flow sheet.
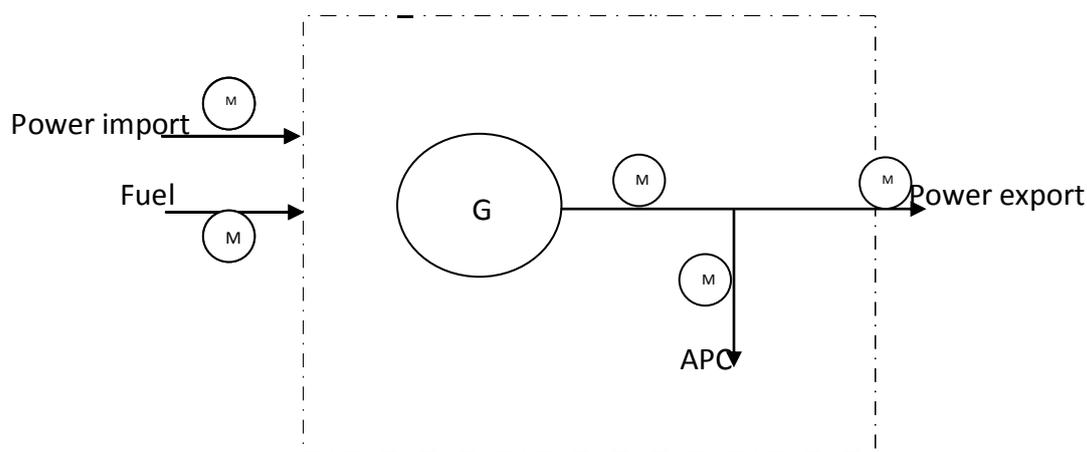
Figure 9: Metering & measurement

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

- Primary system
  - Grid power import
  - Export of power
  - Primary & secondary fuel for power
- Secondary system
  - Power generation
  - Auxiliary power consumption at different sections

The primary system would be used for determination of GtG SEC whereas the secondary system would be used only for reconciliation. For the thermal power sector, most critical challenge would be faced in monitoring the quality of coal considering the small target of reduction of SEC for many plants at less than a percent. It would be desirable for BEE/CEA to put in place a standard system to be followed by all thermal power plants for the same.

The data and information management system has been accordingly proposed as shown at the section 7.2 below.

DESL

7.2 Data & Infromation Protocol

ID	Data variable	Source of data	Data unit	Measured (M), calculated (C) or estimated (E)	Recording Frequency	How will the data be archived? (electronic, E/ paper, P)	Comment
A	*Power*						
A1	Power import	Utility bill	Million kWh (MU)	M/C	Monthly	P	
A2	Power export	Utility billing	Million kWh (MU)	M/C	Monthly	P	
A3	Power from renewable	Utility billing	Million kWh (MU)	M/C	Monthly	P	
A4	Gross generation-Unit-1	DCS/Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
A5	Gross generation-Unit-2	DCS/Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
A6	Gross generation-Unit-3	DCS/Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
A7	Auxiliary power consumption-1	Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
A8	Auxiliary power consumption-2	Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
A9	Auxiliary power consumption-3	Monthly report	Million kWh (MU)	M/C	Monthly	P/E	
B	*Fuel purchased*						
B1	Imported coal quantity	Monthly cost audit reports	LTPY	M/C	Monthly	P/E	
B 2	Imported coal GCV	Lab analysis report	Kcal/Kg	M/C/E	Per Consignment	P/E	
B 3	Domestic coal quantity	Monthly cost audit reports	LTPY	M/C	Monthly	P/E	
B 4	Domestic coal GCV	Lab analysis report	Kcal/Kg	M/C/E	Per Consignment	P/E	
B 5	Lignite/petcoke quantity	Monthly cost audit reports	LTPY	M/C	Monthly	P/E	
B 6	Lignite/petcoke quality	Lab analysis report	Kcal/Kg	M/C/E	Per Consignment	P/E	
B 7	Biomass quantity	Monthly cost audit report	LTPY	M/C	Monthly	P/E	
B 8	Biomass quality	Lab analysis report	Kcal/Kg	M/C/E	Per Consignment	P/E	
B 9	HSD quantity	Monthly cost audit report	Kilo Liter/year	M/C	Monthly	P/E	
B 10	HSD quality-	Lab analysis	Kg/Liter	M/C	Per	P/E	

					Consignment	
B 11	HSD quality-GCV	Lab analysis report	Kcal/Kg	M/C	Per Consignment	P/E
B 12	Furnace oil (FO) quantity	Monthly cost audit report	Kilo Liter/Year	M/C	Monthly	P/E
B 13	FO quality-density	Lab analysis report	Kg/Liter	M/C	Per Consignment	P/E
B 14	FO quality-GCV	Lab analysis report	Kcal/Kg	M/C	Per Consignment	P/E
B 15	PNG/LNG/NG-Quantity	Utility bill	Million SCUM/year	M	Monthly	P/E
B16	PNG/CNG/NG-Quality	Lab analysis report	Kcal/CUM	M/C	Daily	P/E
C	*Fuel inventory*					
C1	Imported coal-opening stock	Annual audit report	MT	C/E	Annual	P/E
C2	Imported coal-purchased	Annual audit report	MT	C/E	Annual	P/E
C3	Imported coal-closing stock	Annual audit report	MT	C/E	Annual	P/E
C4	Domestic coal-opening stock	Annual audit report	MT	C/E	Annual	P/E
C5	Domestic coal-purchased	Annual audit report	MT	C/E	Annual	P/E
C6	Domestic coal-closing stock	Annual audit report	MT	C/E	Annual	P/E
C7	HSD-opening stock	Annual audit report	KL	C/E	Annual	P/E
C8	HSD -purchased	Annual audit report	KL	C/E	Annual	P/E
C9	HSD – closing stock	Annual audit report	KL	C/E	Annual	P/E
C10	FO -opening stock	Annual audit report	KL	C/E	Annual	P/E
C11	FO -purchased	Annual audit report	KL	C/E	Annual	P/E
C12	FO -closing stock	Annual audit report	KL	C/E	Annual	P/E

7.3 M&V PROTOCOL-EE PROJECT

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

Option	Description	Pros	Cons	Recommendation
C-whole facility	Energy savings can be directly determined by actual measurements of inputs and outputs	Most accurate Results & impact can be transparently established Easy to vary out baseline adjustment	Difficult to implement in retrofit applications particularly where inputs and outputs cannot be specifically linked to the EE projects	Can be implemented for utility systems like pumps, compressors, lighting etc. Most of the identified projects can use this method since adequate energy meters seem to be there as has been seen from the analysis of the auxiliary consumption in the baseline reports
D-Calibrated simulation	The energy savings are determined based on pilot study and applying simulation methodology for application to the whole facility or sub-facility	Reasonably accurate system can be developed for determination of energy savings by periodic test & performance analysis	Requires higher skill for carrying out simulation. Information asymmetry can create problem of acceptability	Best suited for systems like furnace, boilers etc
A-Partial retrofit isolation	Savings are estimated based on partial measurements and assumptions for certain parameters	Very easy and low cost of M&V	Lower level of acceptability particularly when responsibility for operation control is not clear-for example streetlight system	Would be the practical system for most of the retrofit projects
B-Retrofit isolation	Same as above except full systems are to be measured & monitored	Robust and accurate	Very high cost of metering & monitoring	Only for high investment projects, where high cost of metering would be justified

8. NORMALISATION PROCESS

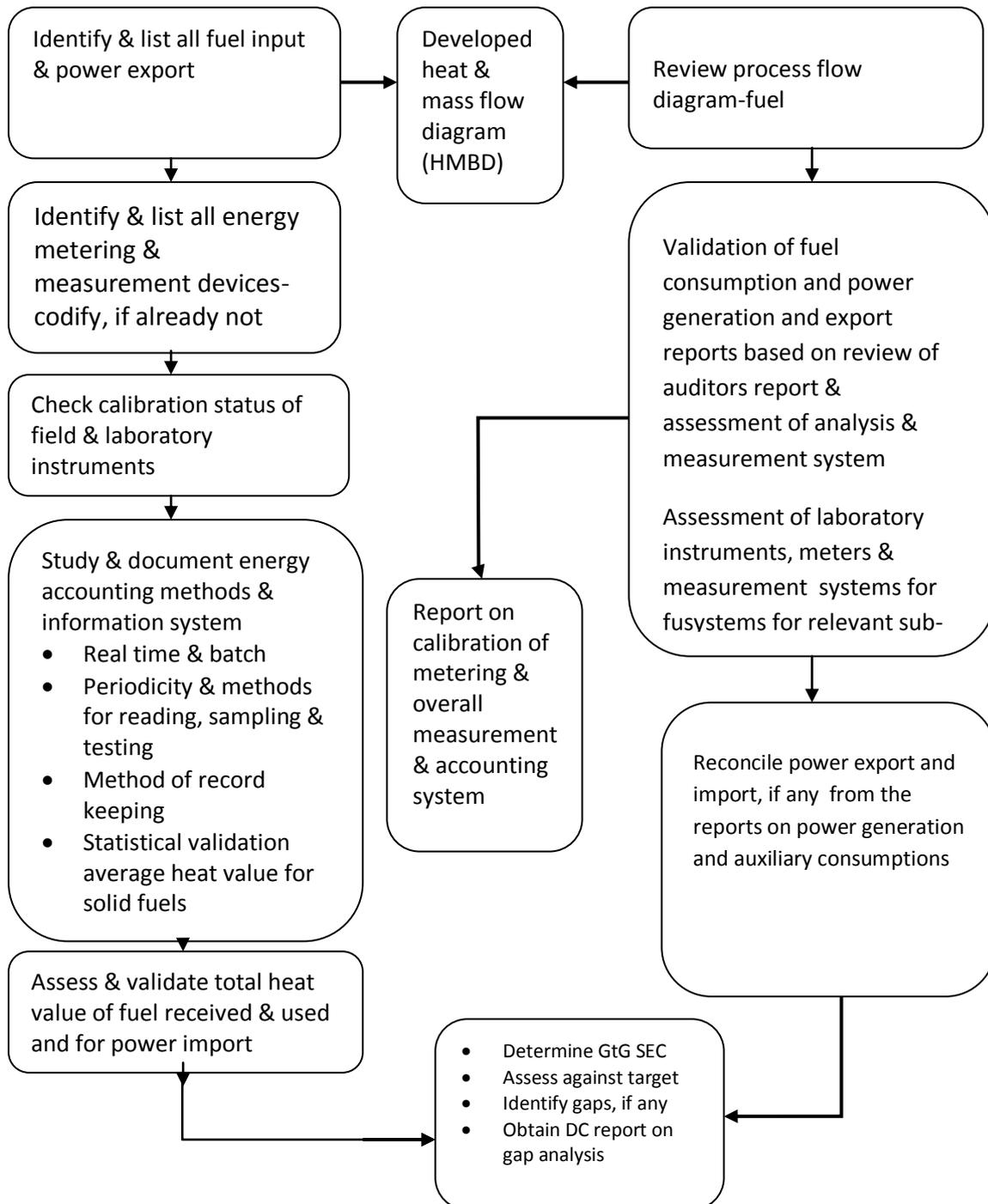The normalisation process is proposed to be carried out in three stages:
Sep-1-Determination of GtG SEC as has been done in the baseline audit report
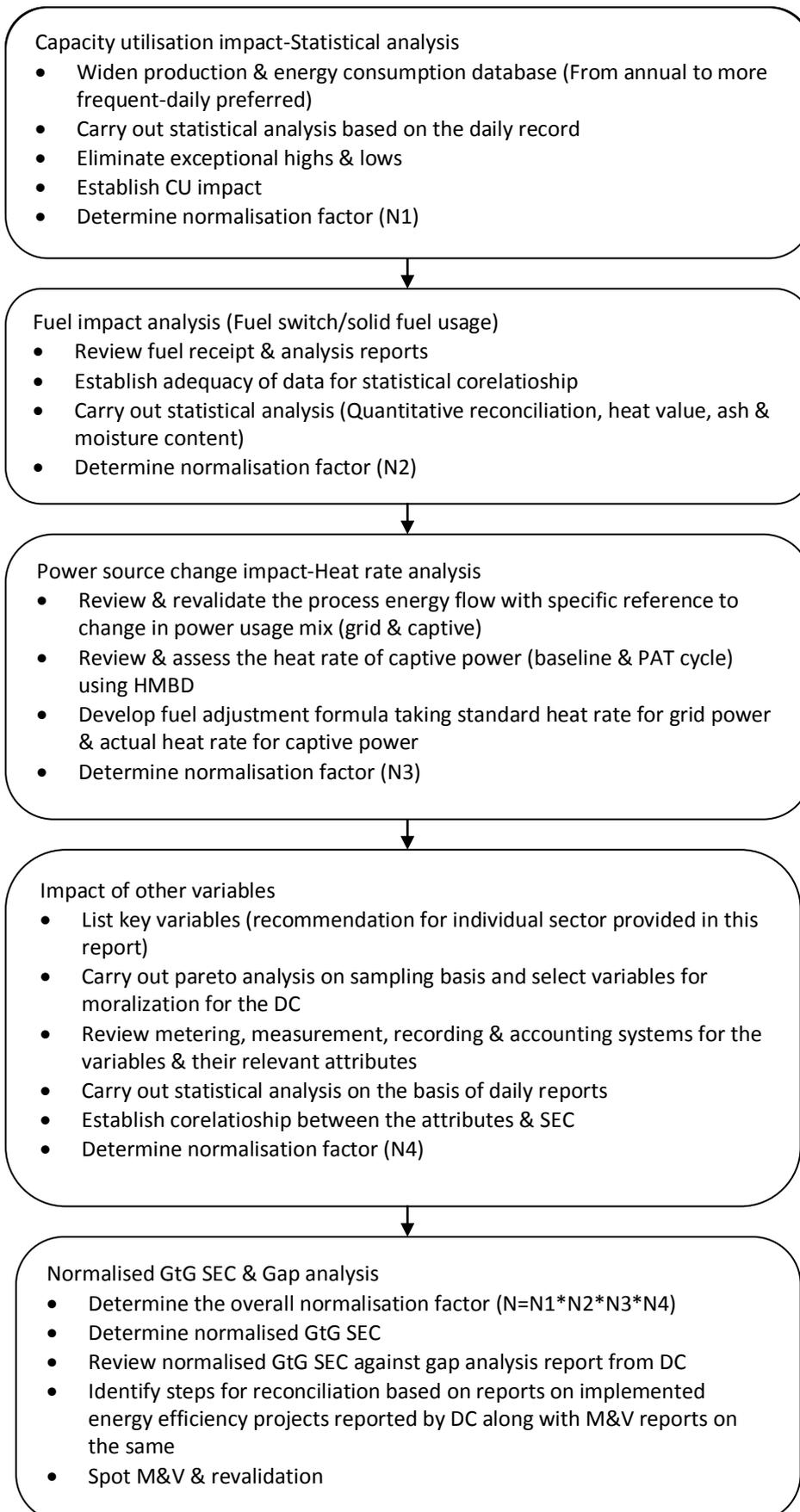Step-2-Determination of the overall normalisation factors
Step-3-Verification & validation based on evaluation of implemented EE projects
The process and illustrative examples are as follows:

Step-1-Determination of GtG SEC

An initiative supported by

Step-2: Normalisation

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

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

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

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

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

Step-3-Verification

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

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

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

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