Approved baseline methodology AM0018

“Baseline methodology for steam optimization systems”

Source

This methodology is based on the “Energy efficiency project by modification of CO₂ removal system of Ammonia Plant to reduce steam consumption”, India, whose baseline study, monitoring and verification plan and project design document were prepared by Indo Gulf Fertilisers Ltd. For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0037-rev: “Energy efficiency project by modification of CO₂ removal system of Ammonia Plant to reduce steam consumption” on http://cdm.unfccc.int/methodologies/approved.

Selected approach from paragraph 48 of the CDM modalities and procedures

“Existing actual or historical emissions, as applicable”

Applicability

This methodology is applicable to steam optimization projects in production processes with homogeneous and relatively constant outputs with continuous monitoring of steam output.

This baseline methodology shall be used in conjunction with the approved monitoring methodology AM0018 (“Monitoring methodology for steam optimization systems”).

Project activity

Steam optimization projects.

Additionality

To demonstrate that the proposed project activity is additional project participants shall use the latest version of the “Tool for the demonstration and assessment of additionality” agreed by the Executive Board¹.

Project boundary

The project boundary would cover the following:

- Steam generator
- Source of electricity for additional electrical loads (if any) due to project activity
- Process area where the steam consumption is expected to be reduced

¹ The latest version of the “Tool for the demonstration and assessment of additionality” is available on the UNFCCC CDM web site: <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>.\n
Baseline

The methodology addresses the improvement of energy efficiency by reducing steam consumption in industrial processes, in the case where the most likely baseline scenario is the continuation of production using current processes and efficiencies (though steam production efficiency may improve as indicated below).

Therefore, after assessing whether the project is additional, the next step is to determine which of the plausible alternatives scenarios as identified in Step 1 of the “Tool for the demonstration and assessment of additionality” is the most likely baseline scenario. Please provide a thorough explanation to justify your choice, based on the various factors (e.g. investment or other barriers) described in the additionality tool above. If the most likely baseline scenario is not the continuation of production using current processes and efficiencies, then this methodology does not apply.

Based on historical data from the existing process, a benchmark Specific Steam Consumption Ratio (SSCR, steam consumption per product output) is defined as the baseline energy efficiency. The improvement of the benchmark after project implementation is monitored and the corresponding steam savings and CO2 emission reductions from fuel combustion in the boiler are determined.

The methodology addresses also possible increases in electricity consumption as a result of the project activity (using the small-scale methodology) and captures the impact of future retrofits and their impact on steam and CO2 savings.

The baseline Specific Steam Consumption Ratio SSCR is determined in 3 steps.

**Step 1: Benchmarking baseline output**

The historical data on shift-wise or batch-wise (in case of batch process) output of the process area is to be analyzed and a representative output value (Prep) is to be calculated. The extreme values are to be excluded from the available values of output rate. This is because the specific steam consumption in a plant reduces with increased production rates. The methodology suggests fixing baseline specific energy consumption for representative production rate. A “normal” production range can be defined based on the relationship between production rates and energy consumption. Based on general
experience the energy consumption per unit of production is not significantly sensitive up to +/-5% of nameplate capacity. For the purpose of this methodology, a normal production range can be defined as the range in which production levels are 5% above or below the verifiable nameplate capacity. If production fluctuates (from shift to shift or batch to batch) beyond this normal production range, these specific values can be excluded to derive a representative production level of the day. Similarly steam consumption values corresponding to the excluded production values can be also excluded.

The production (output) values of $P_1$, $P_2$, $P_3$ given in the Equation below should be selected based on the normal range of rated plant capacity.

$$P_{rep} = \frac{(P_1 + P_2 + \ldots + P_n)}{n} \times A$$

where

$P_1$, $P_2$, $\ldots$, $P_n$ = Shift/batch-wise production values for the baseline

$P_{rep}$ = Representative production for the day

$A$ = number of shifts/day for continuous processes (shift-wise monitoring)

$A$ = number of batches/day for batch processes (batch-wise monitoring)

**Step 2: Benchmarking baseline steam consumption**

From the historical data for steam consumption, the values corresponding to the representative production or output values determined above need to be determined.

$$S_{rep} = \frac{(S_1 + S_2 + \ldots + S_n)}{n} \times A$$

where

$S_1$, $S_2$, $\ldots$, $S_n$ = Shift/batch-wise steam consumption values for baseline, corresponding to $P_1$, $\ldots$, $P_n$

$S_{rep}$ = Representative steam consumption for the day, corresponding to $P_{rep}$

$A$ = number of shifts/day for continuous processes (shift-wise monitoring)

$A$ = number of batches/day for batch processes (batch-wise monitoring)

In the following cases, batch-wise values should be used instead of daily values:

- If the batch time is more than 24 hours;
- If the number of batches in a day is not an integer number (e.g. 2.3 batches per day)

The duration of the period during which historical data on production and steam consumption are monitored to determine the SSCR should represent all seasonal demand variation factors (if any) with regard to (representative) production, energy use and equipment performance. In case there is no seasonal demand variation, one-month baseline data (daily average of production values and corresponding steam consumption values) are considered adequate.

**Step 3: Benchmarking of Process Specific Steam Consumption Ratio (SSCR)**

The SSCR is determined by the ratio of above two parameters.

$^2$ E.g. on the basis of construction or design specifications
\[
\text{SSCR} = \frac{S_{\text{rep}}}{P_{\text{rep}}}
\]  
\[\text{(3)}\]

where

- SSCR = Specific Steam Consumption Ratio in the baseline
- \(S_{\text{rep}}\) = Representative steam consumption for the day/batch
- \(P_{\text{rep}}\) = Representative production for the day/batch

**Leakage**

No leakage is envisaged for this type of projects. The additional electrical load that may result from the project activity (and could be seen as leakage) is accounted for in the determination of emission reductions.

**Emission Reductions**

Emission reductions are determined ex-post by multiplying the improvement of the baseline benchmark SSCR with the actual, monitored output of the project after implementation. This is done in the following steps:

**Step 1: Monitor actual output**

Actual output (\(P_{\text{act}}\)) needs to be monitored shift-wise or batch-wise. This can be done either by maintaining a shift-wise/batch-wise logbook or with the help of DCS (Distributed Control System).

**Step 2: Determine representative output**

The representative output rate for the day or batch (\(P_{\text{rep}}\)) is determined by selecting and averaging the representative output values (i.e. within the normal production range, as described in the baseline section above).

\[
P_{\text{rep}} = \frac{(P_1 + P_2 + \ldots + P_m)}{m} \times A
\]
\[\text{(4)}\]

where

- \(P_{\text{rep}}\) = Representative production for the day
- \(P_1, P_2, \ldots, P_m\) = Shift/batch-wise production values for project scenario
- \(A\) = number of shifts/day for continuous processes (shift-wise monitoring)
- \(A\) = number of batches/day for batch processes (batch-wise monitoring)

**Step 3: Monitor steam consumption**

Steam consumption needs to be monitored for every shift/batch. This may be done either by maintaining an hourly logbook or with the help of DCS (Distributed Control System).

**Step 4: Determine average steam consumption**

Average shift-wise/batch-wise steam consumption rate for the day (\(S_{\text{rep}}\)) is determined by selecting the steam consumption rate values corresponding to representative output rates and averaging them.

\[
S_{\text{rep}} = \frac{(S_1 + S_2 + \ldots + S_z)}{z} \times A
\]
\[\text{(5)}\]
where

\[ S_{1}, S_{2}, \ldots, S_{m} = \text{Shift/batch-wise steam consumption values for project, corresponding to } P_{1}, \ldots, P_{m} \]

\[ S_{\text{rep1}} = \text{Representative steam consumption for the day (corresponding to } P_{\text{rep1}}) \]

\[ A = \text{number of shifts/day for continuous processes (shift-wise monitoring)} \]

\[ A_{\text{b}} = \text{number of batches/day for batch processes (batch-wise monitoring)} \]

**Step 5: Determine the Specific Steam Consumption Ratio for the day**

The Specific Steam Consumption Ratio is determined by the ratio of the two parameters calculated above.

\[ \text{SSCR}_{1} = \frac{S_{\text{rep1}}}{P_{\text{rep1}}} \]  

(6)

where

\[ \text{SSCR}_{1} = \text{Specific Steam Consumption Ratio for the project activity} \]

\[ S_{\text{rep1}} = \text{Representative steam consumption for the day (corresponding to } P_{\text{rep1}}) \]

\[ P_{\text{rep1}} = \text{Representative production for the day} \]

**Step 6: Estimate the difference in SSCR of baseline and project scenarios.**

\[ \text{SSCR}_{\text{diff}} = \text{SSCR} - \text{SSCR}_{1} \]  

(7)

where

\[ \text{SSCR}_{\text{diff}} = \text{difference in SSCR of baseline and project scenarios} \]

\[ \text{SSCR} = \text{Specific Steam Consumption Ratio in the baseline} \]

\[ \text{SSCR}_{1} = \text{Specific Steam Consumption Ratio for the project activity} \]

**Step 7: Estimate net daily reduction in steam consumption**

\[ S_{\text{net}} = \text{SSCR}_{\text{diff}} \times P_{\text{act}} \]  

(8)

where

\[ S_{\text{net}} = \text{Net reduction in steam consumption per day (kg/day)} \]

\[ \text{SSCR}_{\text{diff}} = \text{difference in SSCR of baseline and project scenarios} \]

\[ P_{\text{act}} = \text{Actual value of output on the day.} \]

**Step 8: Estimate the net daily reduction in energy due to reduction in steam consumption**

\[ E_{\text{net}} = S_{\text{net}} \times E_{s} \]  

(9)

where
\[ E_{\text{net}} = \text{Net reduction in steam energy consumption per day (kCal/day)} \]
\[ S_{\text{net}} = \text{Net reduction in steam consumption per day (kg/day)} \]
\[ E_s = \text{Net enthalpy of steam being supplied in boiler (kCal/kg). (To be monitored)} \]

and

\[ E_s = E_{\text{tot}} - E_{fw} \tag{10} \]

where

\[ E_s = \text{Net enthalpy of steam being supplied in boiler (kCal/kg). (To be monitored)} \]
\[ E_{\text{tot}} = \text{Total enthalpy of steam at the boiler outlet (kCal/kg)} \]
\[ E_{fw} = \text{Heat content of feed water (kCal/kg)} \]

**Step 9: Estimate daily reduction in input energy to the boiler**

\[ E_{\text{in}} = E_{\text{net}} / \eta_b \tag{11} \]

where

\[ E_{\text{in}} = \text{Energy input in boiler} \]
\[ E_{\text{net}} = \text{Net reduction in steam energy consumption per day (kCal/day)} \]
\[ \eta_b = \text{Efficiency of boiler, to be monitored periodically by direct or indirect method.} \]

**Step 10: Estimate CO₂ emission reductions (C_{er}) in the boiler per day**

\[ C_{er} = E_{\text{in}} \times \sum (F_{\text{fuel}} \times %H_{\text{fuel}}) \tag{12} \]

where

\[ C_{er} = \text{CO₂ emission reductions in the boiler per day} \]
\[ E_{\text{in}} = \text{Energy input in boiler} \]
\[ F_{\text{fuel}} = \text{Carbon emission factor for fuel to be taken based on actual laboratory tests}^3 \]
\[ %H_{\text{fuel}} = \% \text{ of hours per day for each type of fuel. (To be monitored)}^4 \]

**Step 11: Estimate additional CO₂ emissions due to additional electrical load in project scenario**

If the steam optimisation project requires operation of additional electrical load, the following steps can be followed to estimate the additional CO₂ emissions.

- **Sub-step 1:** Monitor the shift-wise/batch-wise electrical consumption. If a monitoring facility is not available, take the maximum rating (Nameplate data) of the motor, heater or any other electricity consuming device as the consumption.
- **Sub-step 2:** Estimate the average daily electricity consumption \( (E_{\text{avg}}) \).\(^5\) The shift-wise/batch-wise electrical consumption values corresponding to representative shift-wise/batch-wise output values

---

\(^3\) In case, reliable test report unavailable, use IPCC factor or a national factor for fuel from reliable sources.

\(^4\) In case, under direct method of boiler efficiency estimation, fuel metering/measurement facility is available, the \% of fuel use is derived by actual consumption of respective fuel

\(^5\) This sub-step is only to be used in case of actual monitoring of electricity consumption. In case of Nameplate data, the rated value is the average value.
(as given above) are to be selected and averaged out. The daily consumption is to be estimated by multiplying the representative value with the number of shifts (or batches) per day.

- **Sub-step 3:** Estimate daily input energy \((E_{\text{ine}})\) to the electrical energy source (in case of captive generation):

\[
E_{\text{ine}} = \frac{E_{\text{avg}}}{\eta_g}
\]

where

- \(E_{\text{ine}}\) = Daily input energy into electrical energy source
- \(E_{\text{avg}}\) = Average daily electricity consumption
- \(\eta_g\) = Minimum efficiency of Electricity Generating System (EGS) based on historical data of EGS operation during ‘normal range’ of output (assumed constant).\(^6\)

- **Sub-step 4:** Estimate CO\(_2\) emissions (in case of captive generation).

\[
C_{\text{er1}} = E_{\text{ine}} \times F_c
\]

where

- \(C_{\text{er1}}\) = CO\(_2\) emissions in case of captive generation
- \(E_{\text{ine}}\) = Daily input energy into electrical energy source
- \(F_c\) = Carbon emission factor for fuel (IPCC)

- **Sub-step 5:** Estimate CO\(_2\) emissions (in case of External grid supply).

\[
C_{\text{er2}} = E_{\text{avg}} \times F_{\text{grid}}
\]

where

- \(C_{\text{er2}}\) = CO\(_2\) emissions in case of external grid supply
- \(E_{\text{avg}}\) = Average daily electricity consumption
- \(F_{\text{grid}}\) = Carbon emission factor of the selected grid.

The Carbon emission factor of the selected grid is determined by the combined margin method, mentioned in point no.29 of the UNFCCC document “Indicative simplified baseline and monitoring methodologies for selected small scale CDM project activity categories”. The Combined Margin is the average of the “approximate operating margin” and the build margin”, where:

(i) The “approximate operating margin” is the weighted average emissions factor (in kg CO\(_2\)-eq/kWh) of all generating sources serving the system, excluding hydro, geothermal, wind, low-cost biomass, nuclear and solar generation;

(ii) The “build margin” is the weighted average emissions (in kg CO\(_2\)-eq/kWh) of recent capacity additions to the system, which capacity additions are defined as the greater (in MWh) of the most recent 20% of existing plants or the 5 most recent plants.”

This grid emission factor can be applied for entire crediting period.

**Step 12: Estimate the net CO\(_2\) emission reductions due to project**

\(^6\) In case the efficiency of the power plant improves due to retrofitting or replacement, the general guideline is to select the lowest efficiency, which existed before retrofitting/replacement.
\[ C_{\text{er} \text{net}} = C_{\text{er}} - (C_{\text{er}1} + C_{\text{er}2}) \]  

where

- \( C_{\text{er} \text{net}} \) = net CO₂ emission reductions due to the project
- \( C_{\text{er}} \) = CO₂ emission reductions in the boiler per day
- \( C_{\text{er}1} \) = CO₂ emissions in case of captive generation
- \( C_{\text{er}2} \) = CO₂ emissions in case of external grid supply

**Effect of future retrofitting on baseline and project emissions:**

The following test should be applied while monitoring the effect of future retrofitting within the project boundary (change in output level, process change, equipment change etc. affecting specific steam consumption) on baseline and project emissions.

The following question should be asked if retrofit measures reduce the steam consumption within the project boundary.

**Question:** Does retrofitting reduce the steam consumption of the CDM project activity? (I.e. there is a reduction in estimated project emissions, though not caused by the CDM project activity itself.)

**Action:** The enhanced steam saving due to the impact of retrofit on CDM project activity needs to be estimated and deducted from claimed emission reductions.
Approved monitoring methodology AM0018

“Monitoring methodology for steam optimization systems”

Source

This methodology is based on the ‘Energy efficiency project by modification of CO\textsubscript{2} removal system of Ammonia Plant to reduce steam consumption’, India, whose baseline study, monitoring and verification plan and project design document were prepared by Indo Gulf Fertilisers Ltd. For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0037-rev: “Energy efficiency project by modification of CO\textsubscript{2} removal system of Ammonia Plant to reduce steam consumption” on http://cdm.unfccc.int/methodologies/approved.

Applicability

This methodology is applicable to steam optimization projects in production processes with homogeneous and relatively constant outputs with continuous monitoring of steam output.

This monitoring methodology shall be used in conjunction with the approved baseline methodology AM0018 (“Baseline methodology for steam optimization systems”).

Monitoring Methodology

The monitoring methodology requires monitoring of the following:

- The output rate is to be monitored shift-wise (for continuous processes) or batch-wise (for batch processes);
- The steam consumption rate for the process, where the optimisation has taken place, needs to be monitored shift-wise (for continuous processes) or batch-wise (for batch processes);
- Boiler efficiency (see below for different monitoring methodologies);
- Steam enthalpy (see below for details);
- Additional electricity consumption due to the project activity needs to be monitored shift-wise (for continuous processes) and batch-wise (for batch processes).\(^7\);
- The fuel composition analysis and calorific value.

The following methods can be used to estimate boiler efficiency. Depending upon the method, the monitoring parameters are different.

Direct Boiler Efficiency Method (Input-Output Method):

The following parameters need to be monitored.

- Input fuel to the boiler (by fuel meter, level gauge or by weighing balance - in case of solid fuels - or any other method);
- Output steam of boiler (by steam meter). This steam is different than the steam consumed in the CDM project activity.

\(^7\) In case of non-availability of monitoring facility of electrical equipment, the nameplate rating can be used as a basis for calculation of power consumption.
The boiler efficiency is to be estimated as follows:

\[ \eta_{\text{boiler}} = \frac{E_s}{E_i} \]  

(17)

where

- \( \eta_{\text{boiler}} \) = Efficiency of the boiler
- \( E_s \) = Enthalpy of steam (kCal/kg)
- \( E_i \) = Input energy of fuel (kCal/hr)

\[ E_s = E_{\text{net}} \times S \]  

(18)

where

- \( E_s \) = Enthalpy of steam (kCal/hr)
- \( E_{\text{net}} \) = Net enthalpy of steam monitored as given ahead (kCal/kg)
- \( S \) = Steam flow monitored by flow meter (kg/hr)

\[ E_i = NCV_{\text{fuel}} \times F \]  

(19)

where

- \( E_i \) = Input energy of fuel (kCal/hr)
- \( NCV_{\text{fuel}} \) = Net Calorific Value of Fuel monitored as given ahead (kCal/kg)
- \( F \) = Fuel consumption rate monitored as given ahead (kg/hr).

**Indirect Boiler Efficiency Method (Input-loss Method):**

Estimating boiler efficiency using the indirect method should be done as per British Standard BS-845. The following parameters need to be monitored. For calculations of efficiency based on following monitored (and assumed radiation losses) parameters, please refer BS-845.

- Excess air or % Oxygen in dry flue gas, % Carbon Monoxide in dry flue gas, Flue Gas temperature need to be monitored (on regular intervals or continuously through DCS);
- In case of solid fuels, heat loss due to unburnt fuel in bottom ash and fly ash loss needs to be monitored. The bottom ash weight measurements in grate and fly ash weight measurement collected in cyclone needs to be done. The calorific value of bottom ash and fly ash needs to be tested separately in an in-house or external laboratory;
- Monitoring of combustion air temperature will be done, particularly in case combustion air-preheater is provided to boiler;
- Monitoring of moisture in air needs to be conducted.

**Note:** In case of mix fuel (generally mix solid fuel), the only method possible for efficiency estimation is ‘Direct Efficiency’ method, because fuel flow needs to be monitored in such case. Indirect efficiency method cannot be applied, because flue gas analysis will be very difficult in case of mix fuel.

**Steam enthalpy**

The following parameters will be monitored to evaluate the net steam enthalpy:

- Monitoring of enthalpy of steam needs to be done by recording generation pressure and temperature. Refer to steam tables for the enthalpy of steam at given pressures and temperatures;
- Monitoring of boiler Feed Water (FW) temperature needs to be conducted (before de-aerator and economizer). The mass flow of feed water (kg/hr) can either be directly measured using flow meters or an estimated or metered quantity of blow-down can be added in the steam flow to arrive
at the feed water flow. The enthalpy of FW can be estimated by multiplying the mass flow by the specific heat (1) and temperature (Deg C) of FW;

• The net enthalpy can be estimated by subtracting the enthalpy of FW from the enthalpy of steam.
## Parameters to be monitored

<table>
<thead>
<tr>
<th>ID number</th>
<th>Data type</th>
<th>Data variable</th>
<th>Data unit</th>
<th>Measured (m), calculated (c) or estimated (e)</th>
<th>Recording Frequency</th>
<th>Proportion of data to be monitored</th>
<th>How will the data be archived? (electronic/paper)</th>
<th>For how long is archived data to be kept?</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Output Rate</td>
<td>Output of process area per shift/batch</td>
<td>Kg / shift or any other</td>
<td>m</td>
<td>Every shift in continuous process and every batch in batch process</td>
<td>100%</td>
<td>paper</td>
<td>Crediting period plus 2 years</td>
<td>Measured by automatic or manual weighing balance or by volume in the plant premises to the best accuracy and will be monitored at the end of shift/batch (either manually or through DCS)</td>
</tr>
<tr>
<td>2.2</td>
<td>Steam Flow Rate</td>
<td>Steam flow in process area per shift/batch</td>
<td>Kg/shift</td>
<td>m</td>
<td>Every shift in continuous process and every batch in batch process</td>
<td>100%</td>
<td>paper</td>
<td>Crediting period plus 2 years</td>
<td>Measured by steam meter in the plant premises to the best accuracy and will be monitored end of shift/batch (either manually or through DCS)</td>
</tr>
<tr>
<td>2.3</td>
<td>Additional Electricity Consumption (if any)</td>
<td>Electrical Consumption of additional load per hour</td>
<td>KWh/shift</td>
<td>m</td>
<td>Every shift in continuous process and every batch in batch process</td>
<td>100%</td>
<td>paper</td>
<td>Crediting period plus 2 years</td>
<td>Monitored by kWh recording meter at the end of shift/batch (either manually or through DCS). In case meter not available, nameplate motor rating to be multiplied by no. of shift/batch hours.</td>
</tr>
<tr>
<td>ID number</td>
<td>Data type</td>
<td>Data variable</td>
<td>Data unit</td>
<td>Measured (m), calculated (c) or estimated (e)</td>
<td>Recording Frequency</td>
<td>Proportion of data to be monitored</td>
<td>How will the data be archived? (electronic/paper)</td>
<td>For how long is archived data to be kept?</td>
<td>Comment</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td>---------------</td>
<td>-----------</td>
<td>------------------------------------------</td>
<td>-------------------</td>
<td>----------------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>2.4</td>
<td>Fuel hours (not needed if fuel consumption is measured in case of direct efficiency estimation)</td>
<td>Hours of each fuel in boiler</td>
<td>Hrs. m</td>
<td>Every shift in continuous process and every batch in batch process</td>
<td>100%</td>
<td>paper</td>
<td>Crediting period plus 2 years</td>
<td>Monitored based on shift logbooks, for change in fuel and time of change.</td>
<td></td>
</tr>
</tbody>
</table>

Parameters related to steam enthalpy

| 2.5 | Steam temperature | Temperatur e of steam | Deg C m | Every shift in continuous process and every batch in batch process | 100% | paper | Crediting period plus 2 years | Monitored by temperature indicator at the end of shift/batch (either using instantaneous instrument or through DCS). |
| 2.6 | Steam pressure | Pressure of steam | Kg/sqc m(g) m | Every shift in continuous process and every batch in batch process | 100% | paper | Crediting period plus 2 years | Monitored by pressure gauge at the end of shift/batch (either using instantaneous instrument or through DCS). |
| 2.7 | Feed water temperature | F.W. temperature per shift/batch | Deg C m | Every shift in continuous process and every batch in batch process | 100% | paper | Crediting period plus 2 years | Monitored by temperature indicator at the end of shift/batch. |
### Parameters related to boiler efficiency estimation by indirect method

<table>
<thead>
<tr>
<th>ID number</th>
<th>Data type</th>
<th>Data variable</th>
<th>Data unit</th>
<th>Measured (m), calculated (c) or estimated (e)</th>
<th>Recording Frequency</th>
<th>Proportion of data to be monitored</th>
<th>How will the data be archived? (electronic/paper)</th>
<th>For how long is archived data to be kept?</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.8</td>
<td>Feed water flow or blowdown water flow</td>
<td>Boiler feed water flow or blowdown water flow per shift/batch</td>
<td>kg/shift</td>
<td>Every shift in continuous process and every batch in batch process</td>
<td>100%</td>
<td>paper</td>
<td>Crediting period plus 2 years</td>
<td>Monitored by flow recording meter at the end of shift/batch. Or blowdown level indicator in case of one time blow down at the end of shift (and not continuous blow down)</td>
<td></td>
</tr>
<tr>
<td>2.9</td>
<td>% Oxygen in dry flue gas</td>
<td>% Oxygen in dry flue gas</td>
<td>% on mole basis.</td>
<td>Monthly (Refer guidelines on boiler efficiency monitoring)</td>
<td>100%</td>
<td>paper</td>
<td>Crediting period plus 2 years</td>
<td>Monitored by Electrochemical Analyzer/ Orsat Apparatus/ Zirconia Analyser at the end of month.</td>
<td></td>
</tr>
<tr>
<td>2.10</td>
<td>% CO in dry flue gas</td>
<td>% CO in dry flue gas</td>
<td>% on mole basis.</td>
<td>Monthly (Refer guidelines on boiler efficiency monitoring)</td>
<td>100%</td>
<td>paper</td>
<td>Crediting period plus 2 years</td>
<td>Monitored by Electrochemical Analyzer/ Orsat Apparatus/ Zirconia Analyser at the end of month.</td>
<td></td>
</tr>
<tr>
<td>2.11</td>
<td>Bottom ash quantity (in case of solid fuel)</td>
<td>Bottom ash quantity</td>
<td>In Kgs or tonnes</td>
<td>Monthly (Refer guidelines on boiler efficiency monitoring)</td>
<td>100%</td>
<td>paper</td>
<td>Crediting period plus 2 years</td>
<td>Monitored by weighing balance every month. (Refer guidelines on boiler efficiency monitoring)</td>
<td></td>
</tr>
<tr>
<td>2.12</td>
<td>Fly ash quantity (in case of solid fuel)</td>
<td>Fly ash quantity</td>
<td>In Kgs or tonnes</td>
<td>Monthly (Refer guidelines on boiler efficiency monitoring)</td>
<td>100%</td>
<td>paper</td>
<td>Crediting period plus 2 years</td>
<td>Monitored by weighing balance every month. (Refer guidelines on boiler efficiency monitoring)</td>
<td></td>
</tr>
<tr>
<td>ID number</td>
<td>Data type</td>
<td>Data variable</td>
<td>Data unit</td>
<td>Measured (m), calculated (c) or estimated (e)</td>
<td>Recording Frequency</td>
<td>Proportion of data to be monitored</td>
<td>How will the data be archived? (electronic/paper)</td>
<td>For how long is archived data to be kept?</td>
<td>Comment</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------</td>
<td>--------------------------------</td>
<td>-----------</td>
<td>-----------------------------------------------</td>
<td>--------------------</td>
<td>------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>2.13</td>
<td>Flue Gas temperature</td>
<td>Flue Gas temperature</td>
<td>Deg C</td>
<td>Monthly (Refer guidelines on boiler efficiency monitoring)</td>
<td>100%</td>
<td>paper</td>
<td>Crediting period plus 2 years</td>
<td>Monitored by temperature indicator at the end of month. (Refer guidelines on boiler efficiency monitoring)</td>
<td></td>
</tr>
<tr>
<td>2.14</td>
<td>Combustion air temperature</td>
<td>Combustion air temperature</td>
<td>Deg C</td>
<td>Monthly (Refer guidelines on boiler efficiency monitoring)</td>
<td>100%</td>
<td>paper</td>
<td>Crediting period plus 2 years</td>
<td>Monitored by temperature indicator at the end of month. (Refer guidelines on boiler efficiency monitoring)</td>
<td></td>
</tr>
<tr>
<td>2.15</td>
<td>Moisture in combustion air</td>
<td>Moisture in combustion air</td>
<td>Kg moisture /kg air</td>
<td>Monthly (Refer guidelines on boiler efficiency monitoring)</td>
<td>100%</td>
<td>paper</td>
<td>Crediting period plus 2 years</td>
<td>Monitored by humidity meter or hygrometer or drybulb and wetbulb temperature indicator and referring psychrometric chart at the end of month. (Refer guidelines on boiler efficiency monitoring)</td>
<td></td>
</tr>
<tr>
<td>2.16</td>
<td>Net Calorific Value of Bottom Ash (in case of solid fuel only)</td>
<td>Net Calorific value of fuel.</td>
<td>KCal/kg</td>
<td>Monthly (Refer guidelines on boiler efficiency monitoring)</td>
<td>100%</td>
<td>paper</td>
<td>Crediting period plus 2 years</td>
<td>Ash tested by in-house or external reliable laboratory. (Refer guidelines on boiler efficiency monitoring)</td>
<td></td>
</tr>
<tr>
<td>ID number</td>
<td>Data type</td>
<td>Variable</td>
<td>Data unit</td>
<td>Measured (m), calculated (c) or estimated (e)</td>
<td>Recording Frequency</td>
<td>Proportion of data to be monitored</td>
<td>How will the data be archived? (electronic/paper)</td>
<td>For how long is archived data to be kept?</td>
<td>Comment</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td>----------</td>
<td>-----------</td>
<td>---------------------------------------------</td>
<td>---------------------</td>
<td>-----------------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>2.17</td>
<td>Net Calorific Value of Fly Ash (in case of solid fuel only)</td>
<td>Net Calorific value of fuel.</td>
<td>KCal/kg</td>
<td>m</td>
<td>Monthly (Refer guidelines on boiler efficiency monitoring)</td>
<td>100% paper</td>
<td>Crediting period plus 2 years</td>
<td>Ash tested by in-house or external reliable laboratory. (Refer guidelines on boiler efficiency monitoring)</td>
<td></td>
</tr>
<tr>
<td>2.18</td>
<td>Steam Generation of Boiler</td>
<td>Steam Generation of Boiler</td>
<td>Kg/hr</td>
<td>m</td>
<td>Monthly (Refer guidelines on boiler efficiency monitoring)</td>
<td>100% paper</td>
<td>Crediting period plus 2 years</td>
<td>Measured by steam meter in the plant premises to the best accuracy (either manually or through DCS). (Refer guidelines on boiler efficiency monitoring)</td>
<td></td>
</tr>
<tr>
<td>2.19</td>
<td>Fuel consumption</td>
<td>Fuel consumption</td>
<td>Kg/hr or NM3/hr</td>
<td>m</td>
<td>Monthly (Refer guidelines on boiler efficiency monitoring)</td>
<td>100% paper</td>
<td>Crediting period plus 2 years</td>
<td>Measured by fuel meter/level gauge/weighing balance or any other method in the plant premises to the best accuracy (either manually or through DCS) (Refer guidelines on boiler efficiency monitoring)</td>
<td></td>
</tr>
<tr>
<td>ID number</td>
<td>Data type</td>
<td>Data variable</td>
<td>Data unit</td>
<td>Measured (m), calculated (c) or estimated (e)</td>
<td>Recording Frequency</td>
<td>Proportion of data to be monitored</td>
<td>How will the data be archived? (electronic/paper)</td>
<td>For how long is archived data to be kept?</td>
<td>Comment</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------------</td>
<td>----------------------------------------------------</td>
<td>---------------</td>
<td>-----------------------------------------------</td>
<td>---------------------</td>
<td>-----------------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------------</td>
<td>-----------------------------------------------------------------------</td>
</tr>
<tr>
<td>2.20</td>
<td>Fuel Related Parameters</td>
<td>Net Calorific Value of Fuel</td>
<td>Gross and Net Calorific value of fuel.</td>
<td>KCal/kg m</td>
<td>With every delivery of fuel. (Refer guidelines on boiler efficiency monitoring)</td>
<td>100% paper</td>
<td>Crediting period plus 2 years</td>
<td>Fuel tested for each delivery by in-house or external reliable laboratory. (Refer guidelines on boiler efficiency monitoring)</td>
<td></td>
</tr>
<tr>
<td>2.21</td>
<td></td>
<td>Ultimate Analysis of fuel</td>
<td>Elemental percentage on weight basis</td>
<td>Kg or kg-mole m</td>
<td>With every delivery of fuel. (Refer guidelines on boiler efficiency monitoring)</td>
<td>100% paper</td>
<td>Crediting period plus 2 years</td>
<td>Fuel tested for each delivery by in-house or external reliable laboratory. (Refer guidelines on boiler efficiency monitoring)</td>
<td></td>
</tr>
<tr>
<td>2.22</td>
<td>Other Parameters</td>
<td>Boiler efficiency</td>
<td>Boiler efficiency</td>
<td>% e</td>
<td>Monthly (Refer guidelines on boiler efficiency monitoring)</td>
<td>100% paper</td>
<td>Crediting period plus 2 years</td>
<td>Either by direct method or based on BS-845 standard boiler flue gas losses and bottom and fly ash losses (for solid fuels only) to be estimated and efficiency to be determined. Radiation losses assumed constant. (Refer guidelines on boiler efficiency monitoring)</td>
<td></td>
</tr>
<tr>
<td>2.23</td>
<td></td>
<td>Retrofit Event</td>
<td>Event</td>
<td>- m</td>
<td>As and when occurs.</td>
<td>100% paper</td>
<td>Crediting period plus 2 years</td>
<td>Follow Retrofit Monitoring Test as given in this methodology.</td>
<td></td>
</tr>
</tbody>
</table>
### Quality Control (QC) and Quality Assurance (QA) Procedures

<table>
<thead>
<tr>
<th>Data</th>
<th>Uncertainty level of data (High/Medium/Low)</th>
<th>Are QA/QC procedures planned for these data?</th>
<th>Outline explanation why QA/QC procedures * are or are not being planned</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Low</td>
<td>Yes</td>
<td>The QA procedure needs to be planned because the monitoring and selection of representative data from total data is important for accurate emission reduction calculations.</td>
</tr>
<tr>
<td>2.2</td>
<td>Low</td>
<td>Yes</td>
<td>The QA procedure needs to be planned because the monitoring and selection of data corresponding to representative output is important for accurate emission reduction calculations.</td>
</tr>
<tr>
<td>2.3</td>
<td>Low</td>
<td>Yes</td>
<td>The QA procedure needs to be planned because the monitoring and selection of reliable data corresponding to emission factor due to electricity consumption is important for accurate emission reduction calculations.</td>
</tr>
<tr>
<td>2.4</td>
<td>Low</td>
<td>No</td>
<td>There is no procedure required for the measurement of hours of fuel use.</td>
</tr>
<tr>
<td>2.5</td>
<td>Low</td>
<td>No</td>
<td>There is no procedure required for the measurement of temperature of steam.</td>
</tr>
<tr>
<td>2.6</td>
<td>Low</td>
<td>No</td>
<td>There is no procedure required for the measurement of pressure of steam.</td>
</tr>
<tr>
<td>2.7</td>
<td>Low</td>
<td>No</td>
<td>There is no procedure required for the measurement of temperature of feed water.</td>
</tr>
<tr>
<td>2.8</td>
<td>Low</td>
<td>No</td>
<td>There is no procedure required for the measurement of flow of feed water or blow down.</td>
</tr>
<tr>
<td>2.9</td>
<td>Low</td>
<td>Yes</td>
<td>The measurement of %Oxygen in dry flue gas requires proper understanding of instrument and method of drawing flue gas sample. A procedure should be defined based on type of instrument used.</td>
</tr>
<tr>
<td>Data</td>
<td>Uncertainty level of data (High/Medium/Low)</td>
<td>Are QA/QC procedures planned for these data?</td>
<td>Outline explanation why QA/QC procedures * are or are not being planned</td>
</tr>
<tr>
<td>------</td>
<td>------------------------------------------</td>
<td>------------------------------------------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>2.10</td>
<td>Low</td>
<td>Yes</td>
<td>The measurement of %CO in dry flue gas requires proper understanding of instrument and method of drawing flue gas sample. A procedure should be defined based on type of instrument used.</td>
</tr>
<tr>
<td>2.11</td>
<td>Low</td>
<td>Yes</td>
<td>The weighing of bottom ash is a skillful process, since errors in ash collection may lead to inaccuracies. Procedure is needed for this activity</td>
</tr>
<tr>
<td>2.12</td>
<td>Low</td>
<td>Yes</td>
<td>The collection of fly ash from cyclone and its weighing is a skillful process, since errors in ash collection may lead to inaccuracies. Procedure is needed for this activity</td>
</tr>
<tr>
<td>2.13</td>
<td>Low</td>
<td>No</td>
<td>There is no procedure required for the measurement of temperature of flue gas.</td>
</tr>
<tr>
<td>2.14</td>
<td>Low</td>
<td>No</td>
<td>There is no procedure required for the measurement of temperature of combustion air.</td>
</tr>
<tr>
<td>2.15</td>
<td>Low</td>
<td>Yes</td>
<td>The value of dry bulb temperature and wet bulb temperature of air monitored by psychrometer. Based on these values the psychrometric charts should be referred to find out air moisture. Therefore a procedure is required for measurements and estimations.</td>
</tr>
<tr>
<td>2.16</td>
<td>Low</td>
<td>Yes</td>
<td>If in-house laboratory is used, the testing methodology should be defined.</td>
</tr>
<tr>
<td>2.17</td>
<td>Low</td>
<td>Yes</td>
<td>If in-house laboratory is used, the testing methodology should be defined.</td>
</tr>
<tr>
<td>2.18</td>
<td>Low</td>
<td>No</td>
<td>There is no procedure required for the measurement of flow of steam.</td>
</tr>
<tr>
<td>2.19</td>
<td>Low</td>
<td>No</td>
<td>There is no procedure required for the measurement of consumption of fuel.</td>
</tr>
<tr>
<td>2.20</td>
<td>Low</td>
<td>Yes</td>
<td>If in-house laboratory is used, the testing methodology should be defined.</td>
</tr>
<tr>
<td>Data</td>
<td>Uncertainty level of data (High/Medium/Low)</td>
<td>Are QA/QC procedures planned for these data?</td>
<td>Outline explanation why QA/QC procedures * are or are not being planned</td>
</tr>
<tr>
<td>------</td>
<td>------------------------------------------</td>
<td>---------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td>2.21</td>
<td>Low</td>
<td>Yes</td>
<td>If in-house laboratory is used, the testing methodology should be defined.</td>
</tr>
<tr>
<td>2.22</td>
<td>Low</td>
<td>Yes</td>
<td>The estimation of boiler efficiency based on measured parameters is very critical parameter for estimation of emission reduction. The methodology should be derived from British Standard BS-845.</td>
</tr>
<tr>
<td>2.23</td>
<td>Low</td>
<td>Yes</td>
<td>For retrofit monitoring retrofit test should be followed as given in methodology. The responsibility for monitoring of retrofit should be defined clearly.</td>
</tr>
</tbody>
</table>