Approved baseline methodology AM0017

"Steam system efficiency improvements by replacing steam traps and returning condensate"

Source

This methodology is based on the project design document "Steam system efficiency improvements in refineries in Fushun, China" whose baseline study, monitoring and verification plan and project design document were prepared by Quality Tonnes and Beijing Tuofeng Armstrong Steam System Energy Conservation Technologies Co., Ltd. For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0017-rev: "Steam System Efficiency Improvements in Refineries in Fushun, China" 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 efficiency improvement project activities with the following conditions:

- Steam efficiency is improved by replacement and/or repair of steam traps and the return (collection and reutilization) of condensate;
- Steam is generated in a boiler fired with fossil fuels;
- The regular maintenance of steam traps or the return of condensate is not common practice or required under regulations in the respective country;
- Data on the condition of steam traps and the return of condensate is accessible in at least five similar other plants.

This baseline methodology shall be used in conjunction with the approved monitoring methodology AM0017 ("Steam system efficiency improvements by replacing steam traps and returning condensate").

Project Activity

The project activity addresses energy efficiency improvements by reducing losses in steam traps and by increasing the return of condensate. Efficiency improvements are achieved through the installation of additional equipment, the repair and/or replacement of steam traps and the application of O&M practices.

Additionality

The additionality of the project activity is addressed in four steps, which are (i) demonstrating that it is not common industry practice; (ii) there are no legal or regulatory requirements; (iii) there exist barriers to the implementation of the project activities; and (iv) the registration of the project as CDM allow it to overcome barriers.

Step 1: Comparison with other similar facilities
Project participants should conduct a survey in the project plant and in at least five similar other plants (control group). The plants selected for this control group should:

- Belong to the same or a similar sector;
- Have a similar steam generation capacity (choose the five plants with the nearest matching to the project plant);
- Be located in the same region or a region with similar conditions; and
- Be of similar age or built more recently than the project plant (in case the project plant is the most recent plant, the plants built just before this plant should be selected).

Project participants should justify their selection of plants and explain any deviations. The DOE should verify the selection of plants based on these criteria.

Prior to implementation of the project activity, the following information should be collected from the project plant and the plants of the control group:

- The steam trap failure rate, determined from a survey of steam traps, following the guidance in step 1 of the calculation of emission reductions, by dividing the number of failed steam traps by the number of total steam traps in operation and tested;
- Plant managers are inquired whether the plant has any kind of steam trap maintenance program, whether steam traps are being replaced and, if so, in what cases they are usually replaced;
- The relative steam savings due to return of condensate in that plant are calculated with equation 5 (see page 7);

In conducting these surveys, the guidance in the section "Emission reductions" for steam trap surveys should be followed. Based on the information from these surveys, the steam trap failure rate and condensate return rate (defined as the ratio of the quantity of condensate returned and the quantity of steam produced) in the control group plants and the project activity plant are determined. The project activity is not deemed additional, if:

- The average steam trap failure rate in the selected plants is more than 5% points lower than the failure rate in the project plant prior to implementation of the project activity; or
- The average relative condensate return in selected plants is more than 5% points higher than the relative condensate return in the project plant prior to implementation of the project activity; or
- In the project plant, a regular steam trap maintenance program is in place or planned and failed steam traps are regularly replaced.

Step 2: Assessment of legal requirements and sectoral circumstances
Project participants should evaluate national and/or sectoral policies and circumstances with respect to any requirements for or the promotion of steam trap maintenance programs or programs requiring or encouraging the return of condensate. This assessment will be verified by the DOE. The project activity is not deemed additional, if it is likely that national and/or sectoral programs require the project activities.

Step 3: Barrier analysis
The project developer will establish that prohibitive barriers within the relevant sector or project site exist to prevent proposed projects from being carried out and coming to completion, assuming the projects were not registered as a CDM activity. The Project developer will provide transparent information, including documented evidence, and offer conservative interpretations of this documented evidence as to how it demonstrates the existence and significance of the identified barriers. Anecdotal evidence can be included, but alone is not sufficient proof of barriers. Such barriers may include, but not be limited to:

- Investment barriers, other than the economic/financial barriers, e.g.:
  - Real and/or perceived risks associated with the unfamiliar technology or process are too high to attract investment;
  - Funding is not available for innovative projects.

- Technological barriers, e.g.:
  - Skilled and/or properly trained labour to operate and maintain the technology is not available, leading to equipment disrepair and malfunctioning.

- Barriers due to prevailing practice, e.g.:
  - Developers lack familiarity with state-of-the-art technologies and are reluctant to use them;
  - The project is the "first of a kind".

- Other barriers, e.g.:
  - Management lacks experience using state-of-the-art technologies, so that the project receives low priority by management.

More specifically, the barriers could include the following:

- Inadequate information, such as large industrial companies lacking information about energy-saving investments, especially on financial aspects and the implementation experiences of others; too little information is available for the real decision-makers (enterprise managers) concerning how specific energy conservation projects can be implemented.

- Technology transfer barriers, such as lack of modern, high quality steam traps and condensate-return equipment on local markets.

- Perceived technical and financial risks to enterprises in adopting innovative energy saving technologies (fears that a new technology may not work, could interrupt production, take time to perfect, or will not actually result in financial savings, which inhibit enterprise management from adopting new energy-saving technologies).

- Real and perceived insignificance of many energy efficiency investments – for example, if energy efficiency projects are relatively small and the value of the savings achieved typically is only a small percentage of enterprise operating costs; perception that small projects require planning, design, financing, monitoring, etc. which carry too-high transaction costs for the relative size of the projects.

- Difficulties in arranging financing because local financial institutions prefer not to lend for projects that solely reduce operating costs; financial institutions generally not familiar or adept at analyzing the financial aspects of these investments.

The identified barriers are sufficient grounds for additionality only if they would prevent potential project proponents from carrying out the proposed project activity were it not registered as a CDM activity.

Step 4: Explain how CDM overcomes identified project barriers
(Explain how only the approval and registration of the proposed project as a CDM activity would enable the project to overcome the identified barriers and thus be undertaken.)

This step helps to prove that the barriers identified in Step 3 are indeed prohibitive barriers. If the proposed project were able to overcome the identified barriers without registration as a CDM project, then the barriers would be surmountable, and they would not be sufficient proof of additionality. Explain how the approval and registration of the project as a CDM activity, and the attendant benefits and incentives derived there from; sufficiently alleviate the identified barriers to enable the project to be undertaken. The benefits and incentives can be of various types, such as:

- the financial benefit of the revenue obtained by selling the CO_2 emissions reductions;
- the institutional benefits of collaborating with partners in the emissions reductions *transaction;*
- the technical and capacity building benefits provided by partners in the emissions reductions transaction.

Emission Reductions

Emission reductions occur as a result of steam savings by improving the functioning of steam traps and collection and reutilization of condensate (in the following referred to as condensate return). The steam savings decrease the combustion of fossil fuels in the boiler, thereby reducing GHG emissions. To a smaller extent, GHG emissions are also reduced as a result of energy saved for pumping makeup water to the boiler. However, additional energy is required for pumping, treatment and purification of condensate return. In this methodology, only CO_2 emissions are accounted, while CH_4 and N_2O emission reductions are neglected. In the following, the calculation of CO_2 emission reductions is outlined in several steps.

Step 1: Steam trap survey
A steam trap survey is conducted, following the guidance outlined above under "Additionality", in the project plant and in five selected similar plants (control group) prior to the implementation of the project (Index 0) and at regular intervals (at a minimum once a year) (Index y) in the project plant. Prior to project implementation, in the project plant, the following information should be collected for each steam trap:

- Physical location (tag number, location, elevation, etc);
- Information on the type of steam trap (manufacturer, model, orifice size, etc);
- Pressure (steam pressure at the inlet P_{in}, steam pressure at the outlet P_{out});
- Information on the application (drip, tracer, coil, process, air vents, liquid drainers), the equipment (unit heater, radiator, humidifier, etc.) and the piping (direction, valve in, strainer, valve out);
- The operating condition, which is tested by ultrasonic listening, visual inspection where possible and automated steam trap monitoring systems;
- The annual hours of operation;
- Any further comments, including on specific problems such as water hammer, poor or improper insulation, steam leaks in piping or valves, improper installation of traps, and other steam related problems.

In the control group plants, prior to implementation of the project activity, the following information should be collected:

- The number of steam traps in operation and tested; and
- For each steam trap in operation, its operating condition, which is tested by ultrasonic listening, visual inspection where possible and automated steam trap monitoring systems.

All personnel testing the steam traps should be trained technicians with relevant experience in this field. The results of the steam trap survey should be documented in a transparent manner and should not be more than 12 months older than the start date. In assessing the operation condition, the definitions in table 1 should be used to identify failure of steam traps. Steam traps that failed due to blow-thru, leaking or rapid cycling causing steam losses are accounted for under this methodology.

Table 1: Definitions in identifying failed steam traps

TERMS	DESCRIPTION	DEFINITION
OK	Good trap	Trap in normal operating mode.
BT	Blow thru	Trap has failed in an open mode with maximum steam loss. Trap should be repaired or replaced.
LK	Leaking	Trap has failed in a partially open mode with a steam loss of approximately 25% of maximum. Trap should be repaired or replaced.
RC	Rapid cycling	Disc trap going into failure mode.
PL	Plugged	Trap has failed in a closed position and is backing up condensate. Trap should be repaired or replaced.
FL	Flooded	Trap is assumed to be undersized and unable to handle the condensate load. Trap should be replaced by one of proper size.
OS	Out of service	The steam supply line is off and the trap is not in service.
NT	Not tested	Trap in service but not tested due to inaccessibility, unable to reach, too high, etc.

Step 2: Steam savings due to repair and/or replacement of steam traps

Steam losses due to failed steam traps are calculated for each steam trap individually, based on the results of the steam trap survey. The loss of a steam trap is calculated with the following formula, which is derived from the Masoneilan approach, but has been adjusted to estimate steam losses in a more conservative manner:

$$L_{t,y} = \frac{1\,kg}{2.2046\,lbs} \cdot FT_{t,y} \cdot FS_{t,y} \cdot CV_{t,y} \cdot h_{t,y} \cdot \sqrt{\left(P_{in,t} - P_{out,t}\right) \cdot \left(P_{in,t} + P_{out,t}\right)} \qquad \textbf{(1)}$$

where

$L_{t,y}$	Is the loss of steam due to the steam trap t during the period y in kg of steam.
$FT_{t,y}$	Is the failure type factor of steam trap t during the period y.
$FS_{t,y}$	Is the service factor of steam trap t during the period y.
$CV_{t,y}$	Is the flow coefficient of steam trap t during the period y.
$h_{t,y}$	Are the hours steam trap t is operating during the period y in hours.
$P_{in,t}$	Is the pressure of the steam at the inlet of steam trap t in psia.
$P_{out,t}$	Is the pressure of the condensate at the outlet of steam trap t in psia.

Equation 1 above can be applied to those steam traps that have been identified as failed in open mode or partially open mode (blow-thru, leaking, rapid cycling) during the regular steam survey outlined in step 1. The equation is only valid for outlet pressures $P_{out,t}$ equal or larger than $P_{in,t}/2$. Hence, if in a steam trap the outlet pressure $P_{out,t}$ is less than inlet pressure divided by 2, $P_{in,t}/2$ should be used as value for the outlet pressure $P_{out,t}$ in equation 1 above.

The failure type factor is an empirical value estimated by the company *Armstrong*, reflecting that losses in case of leaking and rapid cycling are considerably lower than losses in case of blow-thru. Leaking steam traps are expected to lose 25% of the amount of steam traps that have a blow-thru failure, while rapid cycling steam traps are expected to lose 20% of the amount of steam lost by a blow-thru trap. Table 2 illustrates the values of the failure type factor FT for these three types of steam trap failure.

Table 2: Failure Type Factor FT

Type of failure	FT
Blow-thru (BT)	1
Leaking (LK)	0.25
Rapid cycling (RC)	0.2

Next to the type of failure, the service factor FS is introduced to reflect the different applications of steam traps. The service factor FS takes into account that the actual steam losses depend on the trap size (orifice) in relation to the actual load (capacity safety factor S), which differs between steam trap applications. If a steam trap fails widely open, both the normal quantity of condensate and live steam will share the orifice. Therefore, the actual steam loss in relation to the theoretical steam loss in a pure steam flow is reduced, depending on the size in relation to the actual load. In deriving the suggested service factors FS for different applications in table 3, it is assumed that the ratio of actual steam flow to the theoretical steam flow is (S-1)/S:[1]

$$FS = 2.1 \cdot \frac{S-1}{S} \tag{2}$$

where

FS Is the service factor.
S Is the capacity safety factor, expressing the ratio between the trap capacity (orifice) and the actual condensate load in an application.

Table 3: Service Factor FS

Application	Capacity safety factor S	Service Factor FS
Process steam traps	1.75	0.9
Drip and tracer steam traps	3.0	1.4
Steam flow (no condensate)	Very large	2.1

Finally, steam losses depend on the actual size of the orifice. The flow coefficient CV is a function of the orifice size:

$$CV = 22.1 \cdot D^2 \tag{3}$$

where

CV Is the flow coefficient.
D Is the diameter of the orifice of the steam trap in inches.

With table 2, table 3 and equations 1 and 3 the loss of a each failing steam trap can be calculated. The total steam savings due to the repair and/or replacement of steam traps are calculated as the difference

[1] The value of 2.1 has been included from the Masoneilan formula in the service factor FS.

between losses in the absence of the project (baseline) and losses identified in the plant during monitoring.

$$\Delta L_{steam\ traps,y} = \left[\sum_{\substack{blow-thru \\ steam\ traps}} L_{t,0} + \sum_{\substack{leaking \\ steam\ traps}} L_{t,0} + \sum_{\substack{rapid\ cycling \\ steam\ traps}} L_{t,0} - \left[\sum_{t} L_{t,y} \right] \right] \cdot \frac{1}{1000} \tag{4}$$

where

$\Delta L_{steam\ traps,y}$	Is the steam saving due to the repair and/or maintenance of steam traps during the period y in tons of steam.
$L_{t,0}$	Is the loss of steam due to the steam trap t in the project plant in the absence of the project activity in kg of steam due to blow-thru, leaking or rapid recycling.
$L_{t,y}$	Is the loss of steam due to the steam trap t during the period y in kg of steam due to blow-thru, leaking or rapid recycling.

In calculating the loss of a steam trap in the absence of the project activity $L_{t,0}$ with equation 1 above, the actual operation time $h_{t,y}$ during the monitored period y should be used, if it is lower than the operation time prior to project implementation $h_{t,0}$. Otherwise, the operation time of the steam trap prior to project implementation $h_{t,0}$ should be used as a conservative approach.

Step 3: Steam savings due to return of condensate

A survey on the quantity of condensate return is conducted in the project plant and in five selected similar plants (control group) prior to the implementation of the project (Index 0) and during implementation in the project plant (Index y), following the guidance outlined above under "Additionality". In the project activity plant and the control group plants,

- The quantity of condensate returned $m_{condensate,}$;
- The quantity of steam generation m_{steam} is determined. In the project plant;
- The enthalpy of the condensate $h_{Condensate}$ as a function of temperature, pressure and vapor fraction;
- The quantity of makeup water $m_{makeupwater}$ (cold makeup water);
- The enthalpy of the makeup water $h_{makeupwater}$ as a function of temperature;
- The quantity of steam generation m_{steam};
- The enthalpy of the steam h_{steam} as a function of temperature and pressure should be determined.

Prior to the implementation of the project activity, average values for the last two years should be calculated. Average values during the monitored period should be calculated for all variables in equation 5 for the project plant. With this data, the relative steam saving due to condensate return $l_{condensate}$ expresses the percentage of steam saved per steam generated and can be calculated during a certain period as follows:

$$l_{condensate} = \frac{\left(h_{condensate} - h_{makeupwater}\right) \cdot m_{condensate}}{h_{Steam} \cdot m_{Steam}} \tag{5}$$

where

$l_{condensate}$	Is the average relative steam saving due to return of condensate in a plant (tonnes of steam saved per tons of steam produced).
$h_{condensate}$	Is the average enthalpy of the return condensate at the boiler in kJ/kg as a function of temperature.
$h_{makeupwater}$	Is the average enthalpy of the makeup water from the deaerator at the boiler in kJ/kg as a

function of temperature.

$m_{condensate}$ Is the quantity of condensate returned to the boiler in kg.

h_{steam} Is the average enthalpy of the steam leaving the boiler kJ/kg as a function of pressure and temperature.

m_{steam} Is the quantity of steam produced in the boiler in kg (corresponds to the quantity of makeupwater, plus condensate minus boiler blowdown).

The relative increase in steam savings is the difference in relative steam savings prior to and after implementation of the project activity.

$$\Delta l_{condensate,y} = (l_{P,condensate,y} - l_{P,condensate,0}) \quad \textbf{(6)}$$

where

$\Delta l_{condensate,y}$ Is the average relative steam saving due to the increase of return of condensate in the project activity, adjusted for increases in the control group during the period y.

$l_{P,condensate,y}$ Is the average relative steam saving due to return of condensate in the project plant during the period y.

$l_{P,condensate,0}$ Is the average relative steam saving due to return of condensate in the project plant prior to implementation of the project activity.

The savings of steam in absolute terms (tons) can then be calculated as follows:

$$\Delta L_{condensate,y} = \Delta l_{condensate,y} \cdot m_{P,steam,y} \quad \textbf{(7)}$$

where

$\Delta L_{condensate,y}$ Is the steam saving due to the increase of return of condensate in the project activity, during the period y in tons of steam.

$\Delta l_{condensate,y}$ Is the average relative steam saving due to the increase of return of condensate in the project activity.

$m_{P,steam,y}$ Is the quantity of steam generation in the boiler of the project plant during the period y in tons.

The project proponent has to ensure that the steam savings due to condensate recovery using the above formulae are not greater than the absolute difference between the project activity and the baseline. The formula may result in higher steam savings in cases where the operation during the project activity is lower than in the baseline, and in cases where there is a partial or lower capacity utilization of the facilities. In the latter case, the Project Proponent shall use the lowest value for the steam savings unless it can demonstrate that the value given by the formulae above is still the most appropriate in its particular situation.

Step 4: CO_2 emissions reductions due to steam savings

CO_2 emission reductions due to steam savings are calculated assuming that steam is generated in a boiler fired with fossil fuels at the plant site.

$$ER_{steam,y} = NCV_{Fuel} \cdot EF_{CO2,Fuel} \cdot \frac{\left(\Delta L_{steam\ traps,y} + \Delta L_{condensate,y}\right) \cdot h_{steam,y}}{\varepsilon_{boiler}} \cdot \frac{1}{1000} \quad \textbf{(8)}$$

where

$ER_{steam,y}$	Are the CO_2 emission reductions due to steam savings during the period y in tons of CO_2.
NCV_{Fuel}	Is the net calorific value of the fuel type fired in the boiler in kJ/kg.
$EF_{CO2,Fuel}$	Is the CO_2 emission factor of the fuel type fired in the boiler in kg CO_2/kJ.
$\Delta L_{steam\ traps,y}$	Is the steam saving due to the repair and/or maintenance of steam traps during the period y in tons of steam.
$\Delta L_{condensate,y}$	Is the steam saving due to the increase of return of condensate in the project activity, during the period y in tons of steam.
$h_{steam,y}$	Is the average enthalpy of the steam leaving the boiler in the project plant during the period y as a function of pressure and temperature in kJ/kg.
ε_{boiler}	Is the energy efficiency of the boiler.

To estimate boiler efficiency, the highest value among the following three values should be used as a conservative approach:
1. Measured efficiency prior to project implementation.
2. Measured efficiency during monitoring.
3. Manufacturer's information on the boiler efficiency.

In determining the net calorific value (NCV) of fuels, reliable local or national data should be used, if available. Where such data is not available, IPCC default emission factors (country-specific, if available) should be chosen in a conservative manner.

Step 5: Changes in electricity consumption due to return of condensate
Project participants should determine any changes in electricity consumption as a result of the operation of the condensate return system. Additional electricity may be required for pumping and treatment (purification) of the condensate return. On the other hand, power required to pump makeup water to the plant may be reduced with the return of condensate being increased.

Power required to provide makeup water $EL_{makeupwater}$ and condensate return $EL_{condensate}$ should be determined for the specific context of the project activity. The power required for makeup water may be inquired from the local water utility or be measured, where water supply is provided locally. Power required for condensate return should be measured on-site.

Changes in electricity consumption ΔEL are calculated as difference in condensate return between the project case and the baseline case, multiplied by the difference in power required for condensate and makeup water:

$$\Delta EL_y = \left(m_{P,condensate,y} - m_{BL,condensate,y}\right)\cdot\left(EL_{condensate} - EL_{makeupwater}\right) \quad \textbf{(9)}$$

The condensate return in the absence of the project is adjusted for changes in the activity level (steam production). In addition, as a conservative approach, the condensate return is compared between the project plant prior to implementation of the project activity and the plants of the control group prior to project activity implementation. The relatively higher value should be considered as the baseline level of condensate return:

$$m_{BL,condensate,y} = m_{p,condensate,o}\cdot\frac{m_{p,steam,y}}{m_{p,steam,0}} \quad \textbf{(10)}$$

where

ΔEL_y	Is the net change in electricity consumption during the period y in kWh (a positive value indicating an increase in electricity consumption).
$m_{P,condensate,y}$	Is the quantity of condensate returned to the boiler in the project plant during the period y in tons.
$m_{BL,condensate,y}$	Is the quantity of condensate that would in the absence of the project activity have been returned to the boiler in the project plant during the period y in tons.
$EL_{condensate}$	Is the quantity of electricity required for treatment and pumping one ton of return condensate in the project plant in kWh/ton.
$EL_{feedwater}$	Is the quantity of electricity required for the provision of one ton of feedwater to the project plant in kWh/ton.
$m_{P,condensate,0}$	Is the quantity of condensate returned to the boiler in the project plant prior to implementation of the project activity in tons.
$m_{P,steam,y}$	Is the quantity of steam generation in the boiler of the project plant during the period y in tons.
$m_{P,steam,0}$	Is the quantity of steam generation in the boiler of the project plant prior to implementation of the project activity in tons.

Step 6: CO_2 emission changes due to changes in electricity consumption

CO_2 emissions due to changes in electricity consumption ΔEL are calculated using:

- The average CO_2 emission intensity of the respective electricity grid or the power plants of the electricity supply company, where electricity is purchased from the grid; or
- A project specific emission factor, where electricity is generated on-site.

Where the electricity supply company can provide an average CO_2 emission factor for electricity generation and can demonstrate that the factor is calculated in a consistent, transparent and accurate manner, this factor may be used by project participants. Where such a factor is not available, project participants should determine an average CO_2 emission factor of the electricity grid, defined as the generation-weighted average emissions per unit of electricity generation in all generating sources serving the system, based on the latest statistical data available.

$$EF_{Electicity,y} = \frac{\sum_i F_{i,y} \cdot NCV_i \cdot EF_{CO2,i}}{\sum_i GEN_{i,y} .(1 - TD_{loss})} \quad \textbf{(11)}$$

where

$EF_{Electricity,y}$	Is the CO_2 emission factor for changes in electricity changes due to the project activity during the period y in kg CO_2/kWh.
$F_{i,y}$	Is the fuel consumption of the fuel fired in power plant i during the period y in tons.
NCV_i	Is the net calorific value of the fuel type fired in power plant i in kJ/kg.
$EF_{CO2,i}$	Is the CO_2 emission factor of the fuel type fired in power plant i in kg CO_2/kJ.
$GEN_{i,y}$	Is the quantity of electricity generation in power plant i during the period y in kWh.
TD_{loss}	Are the transmission and distribution losses in the electricity system for the voltage level at which electricity is supplied to the project plant, in percentage.

For on-site electricity generation, the emission factor can be calculated in a similar manner, based on the most recent data on fuel consumption and electricity generation and system losses.

Finally, CO_2 emission changes due to changes in electricity consumption correspond to:

$$ER_{electricity,y} = -\Delta EL_y \cdot EF_{Electricity,y} \cdot \frac{1}{1000} \quad \textbf{(12)}$$

where

$ER_{electricity,y}$	Is the net change in CO_2 emissions due to changes in electricity consumption during the period y in tons of CO_2 (a positive value indicating a reduction of emissions).
ΔEL_y	Is the net change in electricity consumption during the period y in kWh (a positive value indicating an increase in electricity consumption).
$EF_{Electricity,y}$	Is the CO_2 emission factor for changes in electricity changes due to the project activity during the period y in kg CO_2/kWh.

Step 7: Net CO_2 emission reductions

Finally, net CO_2 emission reductions are determined with the CO_2 emission reductions due to steam savings and the net CO_2 emission changes due to changes in electricity consumption:

$$ER_y = ER_{steam,y} + ER_{electricity,y} \quad \textbf{(13)}$$

where

ER_y	Are the net change CO_2 emission reductions of the project activity during the period y in tons of CO_2.
$ER_{steam,y}$	Are the CO_2 emission reductions due to steam savings during the period y in tons of CO_2.
$ER_{electricity,y}$	Is the net change in CO_2 emissions due to changes in electricity consumption during the period y in tons of CO_2.

Leakage

Leakage effects are not accounted for under this methodology. Most potential sources of leakage are taken into account in the calculation of baseline emissions.

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Applicability

This methodology is applicable to steam efficiency improvement project activities with the following conditions:

- Steam efficiency is improved by replacement and/or repair of steam traps and the return (collection and re-use) of condensate;
- Steam is generated in a boiler fired with fossil fuels;
- The regular maintenance of steam traps or the return of condensate is not common practice or required under regulations in the respective country; and
- Data on the condition of steam traps and the return of condensate in at least five similar plants is accessible.

This monitoring methodology shall be used in conjunction with the approved baseline methodology AM0017 ("Steam system efficiency improvements by replacing steam traps and returning condensate").

Monitoring Methodology

The monitoring methodology involves data collection from different sources. A steam trap survey should be conducted at least annually in the project plant and the following specific data needs to be collected for each steam trap:

- Physical location (tag number, location, elevation, etc);
- Information on the type of steam trap (manufacturer, model, orifice size, etc);
- Pressure (steam pressure at the inlet P_{in}, steam pressure at the outlet P_{out});
- Information on the application (drip, tracer, coil, process, air vents, liquid drainers), the equipment (unit heater, radiator, humidifier, etc.) and the piping (direction, valve in, strainer, valve out);
- The operating condition, which is tested by ultrasonic listening, visual inspection where possible and automated steam trap monitoring systems;
- The annual hours of operation;
- Any further comments, including on specific problems such as water hammer, poor or improper insulation, steam leaks in piping or valves, improper installation of traps, and other steam related problems.

All personnel testing the steam traps should be trained technicians with relevant experience in this field. The results of the steam trap survey should be documented in a transparent manner. In assessing the operation condition, the definitions in table 1 in the baseline methodology should be used to identify

failure of steam traps. If a steam trap has been identified as failed during a survey, it is assumed that the stream trap has been failed since the last survey.

To calculate steam savings from condensate return in the project plant, the following information has to be collected:

- The quantity of steam generation, condensate return and makeup water;
- Information on steam generation in the boiler (efficiency, fuel type, NCV, CO_2 emission factor);
- In order to calculate the enthalpy of the different streams: Temperature and pressure of the steam, temperature of the makeup water, temperature, pressure and fraction of vapour in the condensate return;
- Information on electricity generation, if present (electricity generation, fuel consumption, fuel type, NCV);
- Information on electricity requirements for purification and treatment of condensate return.

Finally, data has to be collected also from other institutions:

- The CO_2 emission factor of the grid (from an electricity supply company or data on electricity generation, fuel consumption and fuel type of each power plant in the system, as well as data on net calorific values and emission factors of the fuels);
- The electricity required to pump makeup water if it is provided by a local utility.

Data to be collected or used to monitor emission reductions

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
1.	Mass	Steam generation	tonnes	m	monthly	100%	electronic	2 years until after CERs are issued	To be monitored continuously and reported in project plant
2.	Temperature	Steam temperature	Celsius degree (C°)	m	monthly	100%	electronic	2 years until after CERs are issued	To be monitored continuously and reported in project plant To calculate steam enthalpy
3.	Pressure	Steam pressure	Pa	m	monthly	100%	electronic	2 years until after CERs are issued	To be monitored continuously and reported in project plant. To calculate steam enthalpy
4.	Mass	Condensate recovered	tonnes	m	monthly	100%	electronic	2 years until after CERs are issued	To be monitored continuously and reported in project plant
5.	Temperature	Condensate temperature	Celsius degree (C°)	m	monthly	100%	electronic	2 years until after CERs are issued	To be monitored continuously and reported in project plant To calculate condensate enthalpy
6.	Mass	Makeup water	tonnes	m	monthly	100%	electronic	2 years until after CERs are issued	To be monitored continuously and reported in project plant
7.	Temperature	Makeup water temperature	Celsius degree	m	monthly	100%	electronic	2 years until after CERs	To be monitored in project plant

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
			(C°)					are issued	
8.	Quantity	Steam traps in operation and tested	units	m	quarterly/ annually	25% / 100%	electronic	2 years until after CERs are issued	To be monitored in project plant
9.	Time	Operating time of each steam trap in the project plant	h	m	continuous / annually	25% / 100%	electronic	2 years until after CERs are issued	
10.	Text	Operating condition of each steam trap in the project plant	-	m	quarterly/ annually	25% / 100%	electronic	2 years until after CERs are issued	Evaluation of each steam trap according to table 1 in the baseline methodology
11.	Pressure	Inlet pressure of each steam trap in the project plant	Psia	m	quarterly/ annually	25% / 100%	electronic	2 years until after CERs are issued	
12.	Pressure	Outlet pressure of each steam trap in the project plant	Psia	m	quarterly/ annually	25% / 100%	electronic	2 years until after CERs are issued	
13.	Efficiency	Boiler efficiency	%	m and c	monthly	100%	electronic	2 years until after CERs are issued	According to internationally recognized standards such as BS 845, ASME PTC, etc.

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
14.	Intensity	Net calorific value (NCV) of fuel fired in the boiler	kJ/kg	m or c	annually	100%	electronic	2 years until after CERs are issued	Local, national or IPCC data
15.	Emission Factor	CO_2 emission factor of the fuel fired in the boiler	Kg CO_2/kJ	m or c	annually	100%	electronic	2 years until after CERs are issued	Local, national or IPCC data. The designated operational entity has to verify the reliability of carbon content of the fuel, if estimated at the local level, or the application of relevant IPCC value.
16.	Efficiency	Electricity required for pumping makeup water	kWh/t	m or c	annually	100%	electronic	2 years until after CERs are issued	Provided by local water utility or plant
17.	Efficiency	Electricity required to operate condensate recovery equipment	kWh/t	m and c	annually	100%	electronic	2 years until after CERs are issued	

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
18.	Emission Factor	Average CO_2 emission intensity of electricity supply	CO_2 / kWh	m or c	annually	100%	electronic	2 years until after CERs are issued	Either provided by electricity supply utility, if reliable, or calculated with statistical data, or calculated for on-site generation

Quality Control (QC) and Quality Assurance (QA) Procedures

Data	Uncertainty level of Data (High/Medium/Low)	Are QA/QC procedures planned for these data?	Outline explanation how QA/QC procedures are planned
1.	Low	Yes	Meters on steam lines need to be properly calibrated and checked periodically for accuracy. Further explanation see below.
2.	Low	Yes	Temperature will be measured according to industry practices.
3.	Low	Yes	Pressure will be monitored using standard meters according to industry practices.
4.	Low	Yes	Meters on condensate lines need to be properly calibrated and checked periodically for accuracy. Further explanation see below.
5.	Low	Yes	Temperature transmitters on condensate lines need to be properly calibrated and checked periodically for accuracy. Further explanation see below.
6.	Medium	Yes	Standard flow meters will be in place and calibrated according to manufacturer specifications.
7.	Low	Yes	Temperature transmitters on makeup water lines need to be properly calibrated and checked periodically for accuracy. Further explanation see below.
8.	Low	Yes	Consistency checks with data among the control group plants and with previous surveys.
9.	Medium	Yes	Consistency checks with data from previous surveys.
10.	Medium	Yes	Determination of operating condition is conducted with different analysis methods.
11.	Low	Yes	Pressure will be monitored using standard meters according to industry practices.
12.	Low	Yes	Pressure will be monitored using standard meters according to industry practices.
13.	Medium	Yes	Regular application of different measurement methods (e.g. direct and indirect) to verify measurement results.
14.	Medium	Yes	If accurate data from fuel suppliers is not available, the most conservative IPCC default values will be used.
15.	Medium	Yes	If accurate data from fuel suppliers is not available, the most conservative

Data	Uncertainty level of Data (High/Medium/Low)	Are QA/QC procedures planned for these data?	Outline explanation how QA/QC procedures are planned
			IPCC default values will be used.
16.	Low	Yes	QA/QC for this factor is outside of the scope of the project, if the water will be provided by the water utility; however, the consistency of the data will be checked, if the plant supplies its own ground or surface water, standard flow meters and energy meters will be in place and calibrated according to manufacturer specifications.
17.	Low	Yes	Standard electricity meters will be in place and calibrated according to manufacturer specifications.
18.	Medium	Yes	The reliability of data from an electricity supply company is checked against other national sources (e.g. statistics). If accurate and reliable data from the electricity supply company is not available, an average emission factor is calculated with statistical, publicly accessible information and, where necessary IPCC default values for emission factors.

Data on CO_2 emissions from electricity supply

If a reliable and accurate CO_2 emission factor is not available from the electricity supply company, the generation-weighted average CO_2 emission factor for electricity generation, including all generating sources, is calculated with national statistics. Where possible, also national net calorific values and emission factors should be used. Where these are not available, IPCC default emission factors may be used in a conservative manner.

For default emission factors, IPCC 1996 Guidelines on GHG Inventory (The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC) and Good Practice Guidance Report (Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC) are to be referred not only for their default values, but also for their monitoring methodology as well as uncertainty management to ensure data credibility. These documents are downloadable from http://www.ipcc-nggip.iges.or.jp/. The latter document is a new supplementary document of the former.

1996 Guidelines:
  Vol. 2, Module 1 (Energy) for methodology,
  Vol. 3, Module 1 (Energy) for application (including default values)

2000 Good Practice Guidance on GHG Inventory and Uncertainty Management
  Chapter 2: Energy
  Chapter 6: Uncertainty

IEA (Yearly Statistics)
  CO_2 Emissions from Fuel Combustion
  Energy Statistics of Non-OECD Countries