



**PROGRAMME DESIGN DOCUMENT FORM FOR
SMALL-SCALE CDM PROGRAMMES OF ACTIVITIES (F-CDM-SSC-PoA-DD)
Version 02.0**

PROGRAMME OF ACTIVITIES DESIGN DOCUMENT (PoA-DD)

PART I. Programme of activities (PoA)

SECTION A. General description of PoA

A.1. Title of the PoA

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Title: Residential Hot Water Efficiency Programme in South Africa

Version Number: 01

Date: 23 May 2012

A.2. Purpose and general description of the PoA

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Policy/measure or stated goal of the PoA

The small-scale Programme of Activities (henceforth referred to as PoA) is a programme for the installation of solar water heaters and heat pumps at residential facilities throughout South Africa. The objective of the PoA is to reduce greenhouse gas emissions through the roll out of energy efficient water heating technologies in South Africa which displace the consumption of fossil fuels or electricity. The technologies included in this PoA are solar water heating systems and heat pumps.

Solar water heating and heat pumps have not gained significant traction in South Africa.

South Africa has average daily solar radiation of between 4.5 and 6.5 kWh per square meter. This resource is relatively predictable and well distributed throughout the country (with some regional variations)¹. This makes South Africa a good place for the development of a robust solar water heating market. Despite the high daily solar radiation, the South African solar water heater market was dormant until 2007 when Eskom introduced a rebate program and load-shedding became a reality in South Africa. Between 2007 and 2012 there was significant market volatility and quality issues. During these years, there were numerous teething problems which caused stunted uptake of solar water heaters. The lack of uptake can be attributed to consumer confusion, low rebate, accreditation issues, installation issues, operational problems and loss of interest by potential end-user. To date, the growth in the solar water heating market is still relatively stunted².

The market for heat pumps is also immature in South Africa. The market has only started to grow with the introduction of the heat pump rebate from Eskom in 2011. The market will most likely follow the development of the solar water heating market.

The aim of the PoA is to promote the uptake of solar water heaters and heat pumps for water heating.

¹ Energy Research Centre. University of Cape Town. South Africa. October 2006. Renewable Energy Technologies for Poverty Alleviation. Available online from <http://www.erc.uct.ac.za/Research/publications/06Visagie-Prasad%20RET.pdf>. [Accessed 26 March 2012]

² Frost and Sullivan. 28 July 2011. *The South African Solar Water Heater Industry*. Available online from <http://www.reafrika.co.za/Images/Presentations%20Day%202/Dominic%20Goncalves.pdf>. [Accessed 26 March 2012]

General operating and implementing framework of PoA

The PoA involves the implementation of solar water heaters or heat pumps in existing residential units:

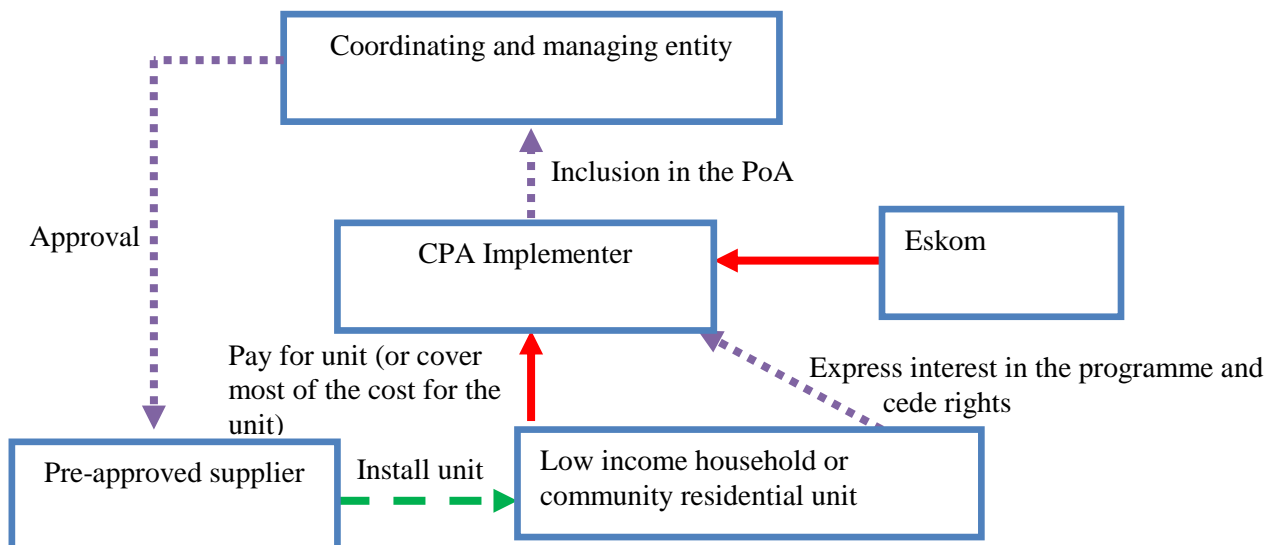
- Low income households: Low pressure solar water heaters are installed in low income households;
- Community residential units: Low or high pressure solar water heaters or heat pumps are installed in community residential units; and
- Middle and high income households: High pressure solar water heaters or heat pumps are installed in middle and high income households.

The PoA involves two project models:

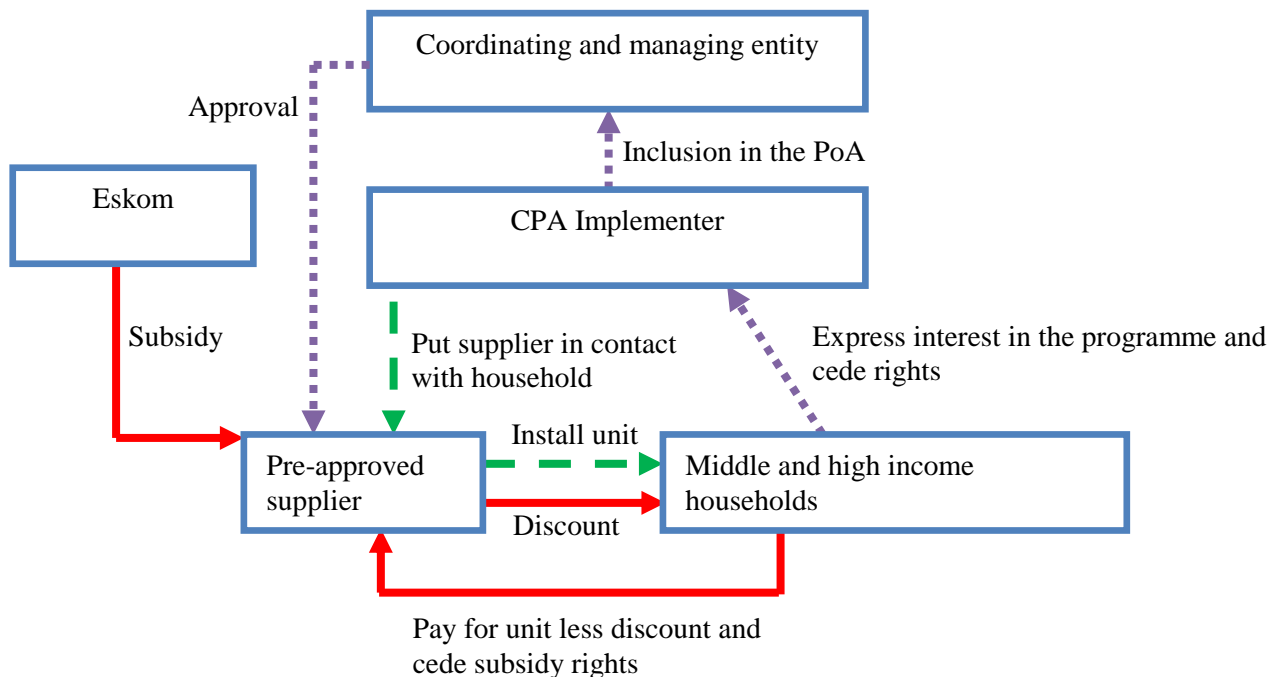
1. The CPA implementer will provide solar water heaters or heat pumps to community residential units free of charge or at a nominal amount and solar water heaters to low income households free of charge or at a nominal amount. These units are provided on the condition that the resident cedes all rights to subsidies and Certified Emission Reductions (CERs) to the managing entity.
2. The CPA implementer will provide solar water heaters and heat pumps to middle and high income households at a discount. The CPA implementer will facilitate and coordinate the installation with the condition that the resident cedes all the rights to the CERs to the managing entity.

The PoA only applies to the installation of solar water heaters and heat pumps in existing residential facilities. The two models are depicted below:

Low income households and community residential units:



Middle and upper income households:



Confirmation that the proposed PoA is a voluntary action by the CME

The PoA is a voluntary action undertaken by the eThekweni Municipality who is the CME for the PoA. There are no laws or regulations that mandate the installation of solar water heaters or heat pumps in existing residential facilities in South Africa.

The South African Designated National Authority (DNA) has defined sustainable development in terms of three core categories: economic, social and environmental. The project contributes to each of the three categories in the following manner:

Economic

- Solar water heaters make use of renewable energy to generate warm water. The use of renewable energy (solar radiation) to generate hot water results in a saving in electricity or fossil fuel consumption. Heat pumps use electricity more efficiently and hence also reduce the costs associated with heating water. Therefore this PoA will reduce household expenditure on electricity and will protect end users from the rising electricity and fossil fuel prices.
- The PoA will result in a reduction in power demand which will help avoid power shortages in the future. Reliable power supply and access to power is an important requirement for economic development.
- Eskom foresees future power shortages which is a significant hindrance to the fast growing economy of the country. The proposed PoA will reduce electricity demand for water heating and correct the energy mix, with a greater focus on renewable energy. This will assist in the diversification of the sources of hot water supply, which is important for meeting growing energy demands and facilitating the move away from fossil fuels.

- The PoA will strengthen the solar water heating and heat pump industries in South Africa by providing state-of-the art technology, creating job opportunities in the supply, installation, operation and maintenance fields as well as stimulating the interest of new investors in the solar energy sector and energy efficiency.
- The Municipality is showing foresight in innovation by taking this route to supplying hot water to its residents.

Social

- The PoA will provide households and community residential units with a clean, practical and convenient way to meet their daily hot water demand. It will increase energy security for warm water supply in households and community residential units. It will assist in reducing the household's and South Africa's dependence on fossil fuels.
- The PoA will contribute to social development by income and employment generation. The PoA will create job opportunities in solar water heating and heat pump manufacturing, supply, distribution, installation and maintenance. In addition, the solar water heaters provide access to a renewable source of energy, which will reduce household expenditure on electricity and both technologies will reduce their users' exposure to increases in electricity prices.

Environmental

- The PoA will result in a reduction of greenhouse gas emissions by increasing the efficiency of domestic water heating. The installed solar water heaters will displace coal-fired grid electricity and fossil fuels with heat being generated using renewable resources. The heat pumps will heat water more efficiently than conventional electric geysers, reducing electricity consumption. The reduction in the consumption of electricity and fossil fuels for water heating results in a reduction in greenhouse gas emissions. This reduction in greenhouse gas emissions will play a role in assisting South Africa to achieve its emission reduction target of 34% below business-as-usual by 2020.
- Apart from reducing greenhouse gas emissions, the PoA will displace the negative impacts of coal- mining and beneficiation as well as the adverse environmental impacts of combusting coal (particulate and sulphur emissions and water consumption and contamination). The success of this PoA will increase the uptake of solar water heaters and heat pumps in South Africa

A.3. CMEs and participants of PoA

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The CME of the proposed PoA is the eThekwini Municipality. The eThekwini Municipality is also the project participant to the PoA.

A.4. Party(ies)

| Name of Party involved (host) indicates a host Party | Private and/or public entity(ies) project participants (as applicable) | Indicate if the Party involved wishes to be considered as project participant (Yes/No) |
|---|---|---|
| South Africa (host) | eThekwini Municipality (public entity) | No |

A.5. Physical/ Geographical boundary of the PoA

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The boundary of a PoA is defined as the geographical area within which all the small-scale CDM programme activities (SSC-CPAs) included under the PoA will be implemented. All the CPAs included under this PoA will be implemented within the geographical boundary of the Republic of South Africa. Therefore the boundary of the PoA is defined as the geographical boundaries of the Republic of South Africa.

The PoA is located within the geographical boundaries of the Republic of South Africa:



Figure 1: Provincial Map of South Africa from One World nations Online³

A.6. Technologies/measures

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The PoA involves the installation of solar water heaters and heat pumps. These technologies reduce the amount of grid electricity or fossil fuel required for water heating. The PoA applies only to existing residential facilities in South Africa.

The PoA covers low, middle and high income households and community residential units. The following technologies are installed in each household type:

- Low pressure solar water heaters will be installed in low income households and may also be installed in community residential units.

Solar water heaters convert solar radiation into thermal energy for the heating of water. Solar energy is classified as renewable energy and, as such, does not result in greenhouse gas emissions.

³ One World Nations Online. 2010. Map of South Africa Provinces. Available online from http://www.nationsonline.org/oneworld/map/za_provinces_map.htm. Accessed 11 August 2011.



Low pressure units are particularly applicable to low income households where there may not be grid electricity available for water heating because these units rely on gravity to feed water to the taps as opposed to pumps. They operate at zero pressure and consist of a tank and the solar collector. The system does not generally have an electrical back-up element and does not use electricity from the grid when sunlight is unavailable.

- High pressure solar water heaters will be installed in middle and high income households and in community residential units

In high pressure systems, the solar collector is mounted on the roof and the heated water is circulated to an internal water cylinder that stores the heated water. These systems make use of a circulation pump which circulates the water from the water cylinder or geyser to the collector where it is heated by the sun.

High pressure systems have an electrical back-up element so that the water can be heated in the absence of sunlight. Hence, the electricity used to heat the water when there is no sunlight will need to be accounted for under the calculation of the emission reductions should high pressure solar water heaters be installed.

In addition, it may also be possible to convert the existing electric geyser into a high pressure system. Should this be done, it will not qualify under this programme. The programme does not allow for the retrofitting of an existing electric geyser, but only the installation of a new solar water heater into existing homes.

- Heat pumps will be installed in middle and high income households and in community residential units

Heat pumps work in a similar manner to air conditioning units. However, instead of the vapour compression cycle being used to cool the air with heat as a by-product, a heat pump uses the heat recovered and generated in the cycle to heat water.

A heat pump uses a small amount of energy to move heat from one medium to another, using mechanical work to move heat from a low temperature source to a high temperature sink. There are two types of heat pump systems (integrated and split systems). The integrated system consists of a storage tank and a heat pump and the system is contained in one unit. In a split system, the tank is separated from the heat pump.

The main components in such a heat pump system are the compressor, the expansion valve and two heat exchangers referred to as evaporator and condenser and a refrigerant gas. The compressor is driven by an electric motor.

The heat pump uses electricity more efficiently to heat water than a conventional electric geyser. In other words, a heat pump uses approximately one unit of electrical energy to produce three units of thermal energy whereas a conventional electric geyser uses three units of electrical energy to produce three units of thermal energy. The Coefficient of Performance is a measure of the energy efficiency of a heat pump.

A.7. Public funding of PoA

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The proposed PoA will not receive any public funds in the operation resulting from official development assistance from Parties included in Annex I to the Convention.



SECTION B. Demonstration of additionality and development of eligibility criteria

B.1. Demonstration of additionality for PoA

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The proposed PoA is a voluntary coordinated action

The PoA is a voluntary programme implemented and coordinated by the eThekweni Municipality. The objective of the PoA is to reduce greenhouse gas emissions through the roll out of energy efficiency water heating technologies in South Africa which displace the consumption of grid electricity or fossil fuels. The technologies included in this PoA are solar water heating systems and heat pumps.

If the PoA is implementing a voluntary coordinated action, it would not be implemented in the absence of the PoA

The ‘Standard for the demonstration of additionality, development of eligibility criteria and application of multiple methodologies for programme of activities (Version 01.1, EB 65, Annex 3)’ was used to determine additionality for the PoA.

The demonstration that the programme would not be implemented in the absence of the PoA follows paragraph 28 of the ‘Simplified Modalities and Procedures for Small-Scale Clean Development Mechanism Project Activities.’ The Simplified Modalities and Procedures require project proponents to demonstrate that the project activity would otherwise not be implemented due to the existence of one or more of the barriers listed in Attachment A to Appendix B of the Simplified Modalities and Procedures.

There are a number of barriers to the installation of solar water heaters and heat pumps. According to Frost and Sullivan, between 2007 and 2012 there was a significant market volatility and quality issue in the solar water heating industry. During these years, there were numerous teething problems which caused stunted uptake of solar water heaters. The lack of uptake can be attributed to consumer confusion, low price of the rebate, accreditation issues, installation issues, operational problems and loss of interest by potential end-user. To date, the growth in the solar water heating market is still relatively stunted⁴.

This is demonstrated by a report on the South African solar water heating industry which indicates that less than 100 000 solar water heaters had been installed even though there are close to 13 million households in South Africa.

For low income households and community residential units, the major barrier to the installation of solar water heating systems is cost⁵. The cost of installing a solar water heater is R16 187 which is approximately twice as expensive as an electric geyser. This includes the Eskom rebate so the cost of a solar water heater is actually more than double the cost of an electric geyser⁶. Low income households and community residential units cannot afford this cost. The low income household earning band is below R6 000 per month⁷. The objective of the PoA is to alleviate this barrier through paying for the installation of the solar water heater in low income households and community residential units.

⁴ Frost and Sullivan. 28 July 2011. *The South African Solar Water Heater Industry*. Available online from <http://www.reafira.co.za/Images/Presentations%20Day%20/Dominic%20Goncalves.pdf>. [Accessed 26 March 2012]

⁵ Energy Research Centre. University of Cape Town. October 2006. *Renewable Energy Technologies for Poverty Alleviation*. Available online from <http://www.erc.uct.ac.za/Research/publications/06Visagie-Prasad%20RET.pdf>. [Accessed 28 March 2012]

⁶ Kayema Renewable Energy Solutions. 2010. *Domestic Solar Water Heater Financial Analysis*. Available online from <http://kayema.co.za/sitefiles/wp-content/uploads/2010/01/domestic-system-financial-analysis-2010-200L.pdf>. [Accessed 28 March 2012]

⁷ National solar water heating strategy

Heat pumps are faced with the same cost challenge for community residential units. The cost to install a heat pump is around R15 000⁸. This is too expensive for community residential units. The PoA will alleviate this barrier by paying for the installation of the heat pump for community residential units.

The major barrier for middle and high income households is customer confusion, installation or operational issues and a lack of understanding of the technology. The PoA aims to alleviate this barrier by putting the household in touch with credible suppliers, offering a discount and ensuring that the unit is inspected after installation to ensure it is operating and that it is maintained in accordance with customer specifications.

Prevailing practice is also a major barrier for middle and high income households. These households use electric geysers and are familiar with this technology. There is very little reason for them to move to solar water heaters unless the hassle of selecting a supplier and getting the technology working is taken out of their hands.

Another significant barrier is long term maintenance of water heating systems in low income residential facilities. There is currently no budget for long term maintenance of such water heating systems and the beneficiaries cannot afford this. The revenue from the CDM will be used to ensure that systems are operational for the entire project period and to ensure that there is a long term maintenance plan.

Without the PoA, the barriers of cost, technology and prevailing practice would not be alleviated.

If the PoA is implementing a mandatory policy/regulation, this would/is not enforced;

The PoA is not a mandatory policy or regulation and, as such, this is not applicable.

If mandatory a policy/regulation are enforced, the PoA will lead to a greater level of enforcement of the existing mandatory policy/regulation.

The PoA is not a mandatory policy or regulation and, as such, this is not applicable.

B.2. Eligibility criteria for inclusion of a CPA in the PoA

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The ‘Standard for the demonstration of additionality, development of eligibility criteria and application of multiple methodologies for programme of activities (Version 01.1, EB 65, Annex 3)’ was used to define the eligibility criteria for this PoA.

All installations of solar water heating systems and heat pumps must comply with the following:

| No. | Requirement as per standard | Eligibility criteria |
|-----|---|--|
| 1 | The geographical boundary of the CPA including any time-induced boundary consistent with the geographical boundary set in the PoA | All installations shall take place in residential buildings within the geographical boundaries of South Africa |
| 2 | Conditions that avoid double counting of emission reductions like unique identifications | All solar water heaters and heat pumps installed under the PoA must be uniquely identified by a serial or barcode number that is recorded on installation of the unit. |

⁸ Eskom. *Integrated Demand Management: Heat Pumps*. Available online from http://www.eskomidm.co.za/docs/2011_12_09_Residential_heat_pump_rebate_programme_brochure_FINAL.PDF. [Accessed 28 March 2012]



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| | of product and end-user locations (e.g. programme logo); | The address and date of each solar water heating and heat pump installation must be recorded on installation of the unit. This information must be captured on the Eskom rebate form. All the relevant details from the form must be recorded in the CME's electronic database. |
| 3 | The specifications of technology/measure including the level and type of service, performance specifications including compliance with testing/certifications; | <p>All solar water heating systems and heat pumps installed under this PoA must be SABS tested and approved.</p> <p>All units installed under this PoA must be done by a supplier that has been pre-approved for the PoA by the CME.</p> <p>All solar water heaters and heat pumps installed under the PoA must be new equipment.</p> <p>All technical specifications of the unit must be available in manufacturer's specifications and the type of unit installed must be recorded upon installation of the unit. This information must be captured on the Eskom rebate form by the supplier. All relevant details from the form must be recorded in the CME's electronic database.</p> <p>All relevant technical specifications of the existing water heating device must be recorded such as type of fuel used, type of unit used and size of geyser. . This information (particularly the size of the geyser) will be used to inform the sizing calculations of the unit. These sizing calculations must be recorded by the supplier/installer and submitted to the CME to be recorded in the electronic database.</p> |
| 4 | Conditions to check the start date of the CPA through documentary evidence | The start date of the CPA is the date on which the first unit is installed under the CPA. This is captured by the supplier and recorded in the CME's electronic database. |
| 5 | Conditions that ensure compliance with applicability and other requirements of single or multiple methodologies applied by CPAs | Each CPA must meet the applicability criteria of the applicable methodologies. The applicable methodology for solar water heaters is Approved methodology small-scale (AMS) I.J 'Solar water heating systems (SWH)' Version 01, EB 60. The applicable methodology for heat pumps is Approved methodology small-scale (AMS) II.C 'Demand-side energy efficiency activities for specific technologies' Version 13, EB 48. |
| 6 | The conditions that ensure that CPAs meet the requirements pertaining to the demonstration of additionality as specified in Section A above | Each CPA must demonstrate additionality in accordance with the procedure as set out under this PoA. The additionality demonstration is checked by the CME and the selected DOE. |
| 7 | The PoA-specific requirements stipulated by the CME including any conditions related to undertaking local stakeholder consultations and environmental | Local stakeholder consultation must be completed before the start date of the CPA. A local consultation report must be submitted to the CME before the first unit is installed under the CPA. |



| | | |
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| | impact analysis | Environmental impact analysis is done at PoA level. The CPA implementer is not required to do an environmental impact assessment. |
| 8 | Conditions to provide an affirmation that funding from Annex I parties, if any, does not result in a diversion of official development assistance | The CPA implementer must provide the CME with a description of the financing arrangement for the units to be installed. The CME will check with the CPA implementer on an annual basis to ensure that no funding from Annex 1 parties that result in the diversion of official development assistance is used. |
| 9 | Where applicable, target group (e.g. domestic/commercial/industrial, rural/urban, grid-connected/off-grid) and distribution mechanisms (e.g. direct installation) | The target group is domestic water heating. This is confirmed by the supplier upon the installation. |
| 10 | Where applicable, the conditions related to sampling requirements for a PoA in accordance with the approved guidelines/standard from the Board pertaining to sampling and surveys | Each CPA implementer must apply the monitoring plan and the sampling requirements as set out in this PoA. The CPA implementer must produce monthly monitoring reports for the CME which will be checked by the CME. |
| 11 | Where applicable, the conditions that ensure that every CPA in aggregate meets the small-scale or microscale threshold criteria and remains within those thresholds throughout the crediting period of the CPA; | The energy savings from the solar water heaters and heat pumps installed under a single CPA must not exceed the small-scale thresholds of the relevant methodologies. |
| 12 | Where applicable, the requirements for the debundling check, in case CPAs belong to small-scale (SSC) or microscale project categories. | Each unit included in the CPA must not be larger than 1% of the small-scale thresholds defined by the methodology applied. This means that: <ol style="list-style-type: none"> 1. Each solar water heater must have an installed capacity of less than 450 kW(th). According to Appendix B of the Simplified modalities and procedures for small-scale clean development mechanism project activities, '<i>For thermal applications of solar energy projects, 'maximum output' shall be calculated using a conversion factor of 700 Wth/m² of aperture area of glazed flat plate or evacuated tubular collector i.e. eligibility limit in terms of aperture area is 64 000 m² of the collector.</i>' Hence, each CPA will not exceed 64 000 m² threshold. 2. Each heat pump must result in an energy saving of less than 600 MWh per year. |
| 13 | Rights to the carbon credits | The owner of the solar water heater or heat pump must cede their rights to the carbon credits. This is done through ensuring that the agreement between the CME and the resident |

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| | | of the household is signed prior to installation of the unit. |
| 14 | For low income households, the model-based approach is used. The model must be calibrated as per the requirements in the monitoring plan of the PoA. | The measurements and calibration results are recorded in the database maintained by the CME. |

In addition, in order to participate in this programme, it is not possible to install both a solar water heater and a heat pump at the same household. Each household is only allowed one type of installation (either a solar water heater or a heat pump).

Each CPA must ensure that leakage, additionality, the establishment of the baseline scenario, baseline emissions, eligibility and double counting are unambiguously defined.

Each SSC-CPA must be approved by the CME and DOE prior to its incorporation into the PoA.

B.3. Application of methodologies

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The following methodologies are used for this PoA:

- Solar water heating: Approved methodology small-scale (AMS) I.J ‘*Solar water heating systems (SWH)*’ Version 01, EB 60
- Heat pumps: Approved methodology small-scale (AMS) II.C ‘*Demand-side energy efficiency activities for specific technologies*’ Version 13, EB 48

Since two methodologies are applied in the same PoA, the ‘*Standard for the demonstration of additionality, development of eligibility criteria and application of multiple methodologies for programme of activities (Version 01.1, EB 65, Annex 3)*’ was applied. The standard is applicable to CMEs seeking to apply multiple technologies or approved methodologies. A combination of methodologies can be applied if the following can be demonstrated:

1. There is no cross effect between technologies installed; and
2. The policy or goal of the PoA can only be reached through the use of multiple methodologies.

In terms of this PoA, each residential building or household can only have one of the technologies implemented. No household or community residential unit can have both a solar water heater and a heat pump installed. Only one technology may be installed per household or residential unit. This is an eligibility criterion for the inclusion of a CPA in the PoA. This eliminates any potential for cross effects or over-estimation of emission reductions.

The objective of this PoA is to improve energy efficiency in domestic water heating. This can only be achieved through the installation of heat pumps and solar water heaters in existing residential buildings. To exclude one of the two technologies would mean that the PoA would not achieve this objective. The selection of technology for the household is dependent on the suitability of the technology for the household.

Each CPA implementer can choose to use either one of the methodologies or both methodologies together – depending on the technology installed. If the CPA implementer is only installing solar water heaters then only AMS I.J ‘*Solar water heating systems (SWH)*’ should be used. If the CPA implementer

is only installing heat pumps then only AMS I.I.C ‘Demand-side energy efficiency activities for specific technologies’ should be used. Both methodologies can be used together if the CPA implementer is installing both solar water heaters and heat pumps.

The sampling plan is described in detail in the monitoring section. Please see this section for a description of how sampling will be conducted. Sampling will be conducted for each CPA.

SECTION C. Management system

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The operational and management arrangements established by the CME for the implementation of the PoA include the following components:

A record keeping system for each CPA under the PoA

A central electronic database has been set up by the CME which includes the following information for each solar water heater and each heat pump installed:

| No. | Parameter Description | Heat pumps | Solar water heaters | |
|-----|--|---|---|---|
| | | Middle and high income households and community residential units | Middle and high income households and community residential units | Low income households |
| 1 | Name of owner (title, first name, surname) | Eskom rebate form | Eskom rebate form | Eskom rebate form |
| 2 | Contact details (email address, cell phone number, landline) | Eskom rebate form | Eskom rebate form | Eskom rebate form |
| 3 | Type of home | Eskom rebate form | Eskom rebate form | Eskom rebate form |
| 4 | Location of installation (street number, street name, suburb, complex, unit number or GPS co-ordinates) | Eskom rebate form | Eskom rebate form | Eskom rebate form |
| 5 | Date of installation | Eskom rebate form | Eskom rebate form | Eskom rebate form |
| 6 | Details on household if applicable (number of bathrooms, number of people per geyser etc.) | Database – provided by suppliers | Database – provided by suppliers | Not required |
| 7 | Technical details about the existing water heating method | Database – provided by suppliers | Database – provided by suppliers | Database – provided by selected supplier |
| 8 | Sizing calculation (middle and high income households and community residential units only) | Not required | Database – provided by the selected supplier | Not required |
| 9 | Technical details in the unit to be installed For solar water heaters: <ul style="list-style-type: none"> • Type of solar water heater (supplier and model) • Collector area • Tank size | Eskom rebate form and manufacturer’s specifications | Eskom rebate form and manufacturer’s specifications | Eskom rebate form and manufacturer’s specifications |



| | | | | |
|----|---|--|--|--|
| | <ul style="list-style-type: none"> Serial or barcode number SABS test document Confirmation that the unit is new and not transferred from another installation. Tilt and orientation of the solar water heater upon installation. Confirmation that there is no shading of the solar water heater upon installation. <p>For heat pumps:</p> <ul style="list-style-type: none"> Type of heat pump (supplier and model) The rated water temperature Heating capacity Coefficient of Performance of the heat pump Refrigerant type Refrigerant charge Rated power input Serial or barcode number Geyser integral, split , retrofit Confirmation that the unit is new and not transferred from another installation. | | | |
| 10 | Name of supplier and supplier details | Eskom rebate form | Eskom rebate form | Eskom rebate form |
| 11 | Serial or barcode number of unit(s) installed and unique CPA number | Database – serial or barcode number is provided by the supplier and CPA number is allocated by the CME | Database – serial or barcode number is provided by the supplier and CPA number is allocated by the CME | Database – serial or barcode number is provided by the supplier and CPA number is allocated by the CME |
| 12 | Confirmation whether the solar water heater or heat pump is in a residential application | Eskom rebate form – address of household | Eskom rebate form – address of household | Eskom rebate form – address of household |
| 13 | Confirmation that the unit is installed in the primary residence of the household which has hot water consumption year-round. | Not required | Database – provided by the selected supplier | Not required |
| 14 | Installation inspection form (indicating the results of the inspection that has taken place within three months of the installation) | Installation inspection form | Installation inspection form | Installation inspection form |
| 15 | Monitoring information recorded in the monitoring form | Monitoring information will be recorded in | Monitoring information will be recorded in | Monitoring information will be recorded in the |



| | | | | |
|----|-------------|---|---|--|
| | | the monitoring form. Monitoring consists of checking that the selected sample of units is operational. | the monitoring form. Monitoring consists of checking that the selected sample of units is operational. | monitoring form. Monitoring consists of checking that the selected sample of units is operational. |
| 15 | Measurement | A sample of units will be selected for measurement. The measurements are recorded in the database. | Not required | A sample of sites is selected for measurement. The measurements are used to calibrate the model. The measurements and calibration is included in the database. |

All of this information is captured by the suppliers and submitted to the CPA implementer. The CPA implementer compiles the documentation and gives them to the CME to be recorded in the electronic database. The following documents are required for each installation:

1. Eskom rebate forms
2. Manufacturer's specifications of the unit
3. Installation inspection form
4. Monitoring form

The CME or a representative of the CME will physically inspect each installation within three months of installation to ensure quality of installation and will only include units that have been correctly installed under the CPA. See monitoring plan for more information.

The CPA implementer will physically inspect a sample of units each year to check that the units are operational.

Please also note that the household will be provided with a manual for the unit upon installation. This manual will provide information on the technology and contact details of the supplier and the CPA implementer in case of problems with the unit.

A system/procedure to avoid double accounting e.g. to avoid the case of including a new CPA that has been already registered either as a CDM project activity or as a CPA of another PoA.

In order to avoid double accounting:

- The serial or barcode number of the unit installed is logged in the electronic database. This is a unique number which identifies each unit installed.
- The details of the location of the installation are recorded to ensure that no double accounting takes place.



- Each installation will be provided with a unique CPA identification number. This information must be captured on a form by the supplier. The form must be signed by the representative of the household. All details from the form must be recorded in the CME's electronic database.
- The CME will physically inspect a sample of installations to ensure that the serial or barcode number on the unit matches what has been recorded in the electronic database.

The SSC-CPA included in the PoA is not a de-bundled component of another CDM programme activity (CPA) or CDM project activity.

The 'Guidelines on Assessment of Debundling for SCC Project Activities' (Version 3, EB 54) is used to demonstrate that the SSC-CPA included in the PoA is not a de-bundled component of another CDM Programme Activity (CPA) or CDM project activity.

According to the guidelines, if each of the independent subsystems/measures included in the CPA of a PoA is no larger than 1% of the small-scale thresholds defined by the methodology applied then that CPA of PoA is exempted from performing a de-bundling check.

The small scale threshold for the methodology applied by the solar water heaters is 45 MW thermal. Each solar water heater installed is then required to be less than 1% of 45 MW thermal which is 0.45 MW thermal. For solar energy projects, the small scale threshold is 64 000 m². This means that the maximum collector area for each of the solar water heaters installed must not exceed 640 m². None of the installations will have a collector area of larger than 640 m². In fact, the largest collector area is likely to be no more than 4.4m² (based on a 300 litre geyser) which is less than 0.007 % of the small scale threshold.

The small scale threshold for the methodology applied for heat pumps is 60 GWh per year. This means that the saving from one heat pump may not exceed 600 MWh per year. None of the heat pumps installed will save more than 600 MWh per year. A typical low density house with a hot water consumption of 283.34 litres per day will require 5.42 MWh thermal per year for water heating. If we assume that a heat pump has a Coefficient of Performance of 3 then the total electrical energy required to generate this thermal energy is 1.8 MWh electrical per year. If this same amount of thermal energy were generated by an electric geyser and assuming an efficiency of 100% then the total electrical energy required is 5.42 MWh electrical per year. Hence, a single heat pump will result in approximately a saving of 3.62 MWh per year which is below 600 MWh per year.

The provisions to ensure that those operating the CPA are aware of and have agreed that their activity is being subscribed to the PoA:

A contract will be signed by the representative of the household where the unit is installed. This agreement ensures that they are aware that they are participating in the PoA. By signing the contract it is accepted that their solar water heater or heat pump is included in a CPA and that the CME is the legal owner of the CERs from the installed solar water heater or heat pump.

The CME will also be responsible for pre-approving suppliers for the PoA. In other words, only installations done by approved suppliers/installers will be allowed under the PoA. Only the CME can pre-approve suppliers. This ensures that the units installed are SABS approved and credible suppliers are used to conduct the installations.

SECTION D. Duration of PoA

D.1. Start date of PoA

>>



1 January 2013, but not prior to the start of registration of the PoA

The start date of the PoA will be the start date of the first CPA. The start date of the first CPA is the earliest date at which either the implementation or construction or real action of a programme activity begins, and cannot be prior to the commencement of validation of the PoA. The start date will be the date on which the first unit is installed under the CPA and monitored as per the requirements specified in this document.

D.2. Length of the PoA

>>

28 years

SECTION E. Environmental impacts

E.1. Level at which environmental analysis is undertaken

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Environmental analysis as per the requirements of the CDM modalities and procedures is undertaken at PoA level as the impacts of all CPAs will be similar. The PoA does not require any environmental approvals. In addition, the PoA is anticipated to have positive environmental impacts. We do not anticipate these impacts to vary for each CPA.

E.2. Analysis of the environmental impacts

>>

The objective of the PoA is to improve the efficiency of water heating in existing residential units. This involves the installation of either a solar water heater or heat pump in low, middle and upper income households and community residential units. There are no significant anticipated negative impacts on the environment or people from this programme.

The PoA displaces coal-based grid electricity and fossil fuels by using renewable energy sources and using energy more efficiently. This results in a reduction in greenhouse gas emissions.

There are no anticipated transboundary impacts as a result of this PoA.

SECTION F. Local stakeholder comments

F.1. Solicitation of comments from local stakeholders

>>

The stakeholder consultation is done at CPA level as each CPA may cover installations in a different area. Conducting stakeholder consultation at CPA level will ensure that the public is adequately informed about the CPA. The programme covers the whole of South Africa. Hence, it is considered more effective to conduct stakeholder consultation at CPA level so that the public is properly informed.

Local stakeholder consultation must be done at SSC-CPA level. Each CPA must have done the following to invite comments from stakeholders:

1. The project participant must draft an article on the CPA and publish in English in the local newspaper or publication. The article must describe the project and invite comments on the project. This article can also be sent to any identified interested and affected parties.
2. The project participant can also choose to hold a public stakeholder consultation meeting. Should this be the case, then the article drafted above should mention the date, location and time of the meeting.



Should the project participant choose to hold a meeting, this meeting must include a representative from the eThekweni Municipality. In the meeting, the project participants must describe the project and explain how the project will work. The project participants must allow stakeholders to ask questions. All questions must be recorded and responses to these questions must be provided.

F.2. Summary of comments received

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This is not applicable as stakeholder consultation is done at CPA level. However, each CPA must document fully the comments received from stakeholders.

F.3. Report on consideration of comments received

>>

This is not applicable as stakeholder consultation is done at CPA level. However, each CPA must take into account all of the comments received, address the comments and provide feedback via email or post on the comments.

SECTION G. Approval and authorization

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The letter of approval from the South African Designated National Authority (DNA) will be made available once received. The DNA requires the submission of a draft validation findings report before they will issue a letter of approval.

PART II. Generic component project activity (CPA)

SECTION A. General description of a generic CPA

A.1. Purpose and general description of generic CPAs

>>

Each CPA will involve the installation of solar water heaters or heat pumps in residential units. A single CPA may consist of both solar water heaters and heat pumps. However, each residential unit can only have a single technology installed (either solar water heaters or heat pumps).

The CPA implementer will apply to the CME to have the CPA included into the PoA. The CPA must meet all the eligibility criteria as set out in the PoA in order to be included into the PoA.

The purpose of the CPAs is to improve the energy efficiency of domestic water heating and reduce greenhouse gas emissions.

SECTION B. Application of a baseline and monitoring methodology

B.1. Reference of the approved baseline and monitoring methodology(ies) selected

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The following methodologies are used for this PoA:

- Solar water heating: Approved methodology small-scale (AMS) I.J ‘*Solar water heating systems (SWH)*’ Version 01, EB 60
- Heat pumps: Approved methodology small-scale (AMS) II.C ‘*Demand-side energy efficiency activities for specific technologies*’ Version 13, EB 48

The following tool was used as part of the PoA:

- ‘*Tool to calculate the emission factor for an electricity system*’ Version 02.2.1, EB 63

**B.2. Application of methodology(ies)**

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The applicability criteria of the methodologies are outlined below. Each CPA must meet the applicability criteria of the methodology:

Approved methodology small-scale (AMS) I.J 'Solar water heating systems (SWH)' Version 01, EB 60

| No | Applicability Criteria | PoA eligibility | Comply? |
|-----------|--|--|----------------|
| 1 | <i>This category comprises the installation of residential solar water heating (SWH) systems and commercial SWH systems for hot water production. The SWH systems displace electricity or fossil fuel that would otherwise have been used to produce hot water.</i> | The CPA involves the installation of residential solar water heating systems. The solar water heating systems displace electricity or fossil fuel. | Yes |
| 2 | <p><i>There are two types of projects included in this category: retrofits and new construction. For the purposes of defining baselines and other requirements the following definitions apply:</i></p> <p><i>(a) Retrofit projects are SWH project(s) that replace existing electric or fossil fuel based water heating system(s) in existing facility(ies);</i></p> <p><i>(b) New construction projects are: (i) SWH project(s) installed in new facility(ies); (ii) SWH project(s) installed in existing facility(ies) that, prior to the project implementation, do not have installed water heating systems; (iii) SWH project(s) installed in existing facility(ies) which require water heating capacity expansions; or (iv) Replacement of failed solar water heating system(s). This methodology is applicable if it is shown (as per paragraph 8) that for new construction projects, conventional electric or fossil fuel based water heating system(s) would have been installed in the absence of the project activity.</i></p> | The CPA only involves retrofits. | Yes |
| 3 | <i>Commercial SWH systems shall include operational indicators that may be easily interpreted by the intended users of the systems and that indicate that water is being heated by solar energy. The minimum requirement for such an indicator is a visible temperature display (thermometer) on the solar preheat storage tank. The thermometer does not require calibration.</i> | The CPA does not include commercial solar water heating systems. | Yes |



| | | | |
|---|---|--|-----|
| 4 | <i>To qualify as a small-scale project, the definitions in paragraph 4(d) in the ‘General Guidelines to SSC CDM methodologies’ (version 15), or the related paragraphs in the latest version of the guidelines are applicable.</i> | The small-scale threshold for SWH projects in terms of aperture area is 64000 m ² . Only CPAs that do not exceed the threshold are eligible for inclusion in the PoA. | Yes |
| 5 | <i>For residential and commercial SWH projects the hot water consumption rate and temperature at which the hot water is supplied to the load (for example, 40 litres per day at 40°C), that occur during the crediting period are used to determine emissions savings. The consumption rate (and temperature) is the rate (and temperature) of water actually utilized (for example for personal washing or for an industrial process) and is not the rate (and temperature) at which hot water is produced, which may be greater than the rate (and temperature) of consumption.</i> | The hot water consumption rate and the temperature at which the hot water is supplied to the load will be used to determine the emissions savings. | Yes |

Approved methodology small-scale (AMS) II.C ‘Demand-side energy efficiency activities for specific technologies’ Version 13, EB 48

| No | Applicability Criteria | Project Eligibility | Comply? |
|----|---|--|---------|
| 1 | <p><i>This methodology comprises activities that encourage the adoption of energy-efficient equipment/appliance (e.g., lamps, ballasts, refrigerators, motors, fans, air conditioners, pumping systems) at many sites.</i></p> <p><i>These technologies may replace existing equipment or be installed at new sites. In the case of new facilities, the determination of baseline scenario shall be as per the procedures described in the general guidance to SSC methodologies under the section ‘Type II and III Greenfield projects (new facilities)’.</i></p> <p><i>The aggregate energy savings by a single project may not exceed the equivalent of 60 GWh per year for electrical end use energy efficiency technologies. For fossil fuel end use energy efficient technologies, the limit is 180 GWh thermal per year in fuel input.</i></p> | <p>The CPA involves the installation of heat pumps, an energy efficient piece of equipment for heating of water in existing households and community residential units.</p> <p>The total savings from a SSC-CPA will not exceed the equivalent of 60 GWh (electric) per year for the heat pumps installed.</p> | Yes |
| 2 | <i>For each replaced appliance/equipment/</i> | The rated capacity for each replaced | Yes |

| | | | |
|---|---|---|-----|
| | <i>system the rated capacity or output or level of service (e.g., light output, water output, room temperature and comfort, the rated output capacity of air-conditioners etc.) is not significantly smaller (maximum - 10%) than the baseline or significantly larger (maximum + 50%) than the baseline.</i> | equipment will not be significantly smaller (max -10%) or significantly larger (max +50%) than the baseline. | |
| 3 | <i>If the energy efficient equipment contains refrigerants, then the refrigerant used in the project case shall be CFC free. Project emissions from the baseline refrigerant and/or project refrigerants shall be considered in accordance with the guidance of the Board (EB 34, paragraph 17). This methodology credits emission reductions only due to the reduction in electricity consumption from use of more efficient equipment/appliances.</i> | Refrigerant is used in the heat pumps. The refrigerants used are predominantly R407C, R410 and R417A (or as stipulated by Eskom, the national electricity provider for South Africa). These refrigerants are CFC free and the project emissions from the refrigerants shall be dealt with in accordance with EB 34, paragraph 17. The refrigerant used in the heat pump unit will be recorded. Should the refrigerant have a global warming potential then this should be accounted for in project emissions. Please see calculation of emission reductions. | Yes |

B.3. Sources and GHGs

>>

The greenhouse gas reduced through the CPAs under this PoA is CO₂. The reduction takes place through the avoidance of electricity or fossil fuels used to heat water, in the absence of the CPAs. The table below summarises the emission sources and greenhouse gases included in the SSC-CPA boundary:

Solar water heaters:

| Source | | GHGs | Included? | Justification/Explanation |
|-------------------|--|------------------|-----------|---|
| Baseline scenario | South African grid electricity production | CO ₂ | Yes | Only CO ₂ emissions from electricity generation should be accounted for in the emission reduction calculation. |
| | | CH ₄ | No | There are no emissions |
| | | N ₂ O | No | There are no emissions |
| Project scenario | Solar Water Heater Thermal Energy Production | CO ₂ | Yes | The installed solar water heaters may have an electric backup. If the solar water heaters have an electric element then there may be emissions from the consumption of electricity. |
| | | CH ₄ | No | There are no emissions |
| | | N ₂ O | No | There are no emissions |

For solar water heating installations, the following must be monitoring:

1. The grid emission factor in order to determine the baseline; and

2. The operation of the solar water heater.

Heat pumps:

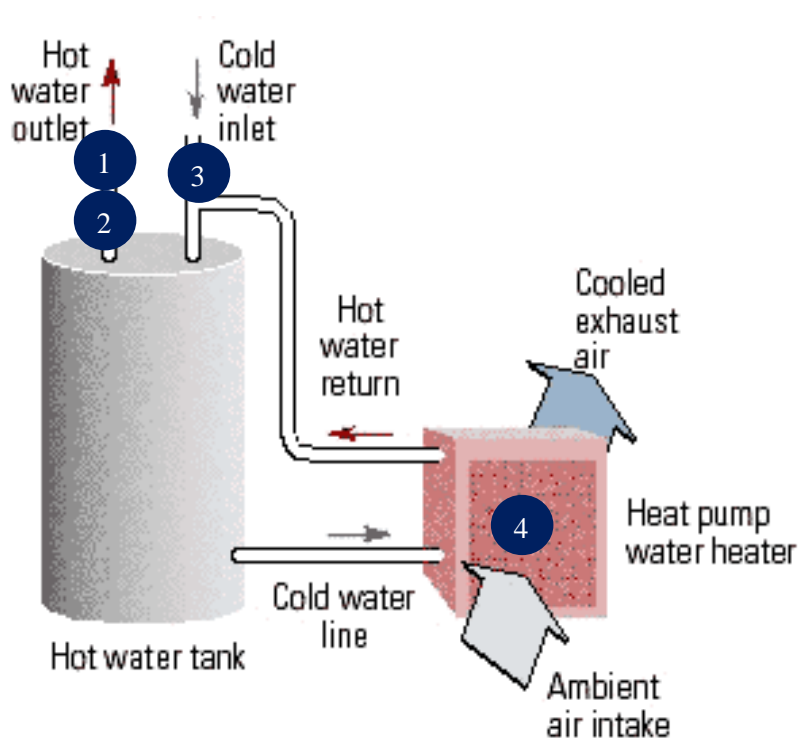
| | Source | GHGs | Included? | Justification/Explanation |
|-------------------|---|------------------|------------------------|--|
| Baseline scenario | South African grid electricity production | CO ₂ | Yes | The baseline emission for heat pump installations is the use of electricity to heat water. |
| | | CH ₄ | No | There are no emissions |
| | | N ₂ O | No | There are no emissions |
| Project scenario | Heat Pump Thermal Energy Production | CO ₂ | Yes | Emissions from electricity consumption by the heat pumps. |
| | | CH ₄ | No | There are no emissions |
| | | N ₂ O | No | There are no emissions |
| | Refrigerant consumption | CO ₂ | Yes | Emissions from refrigerant consumption in the project activity. |
| | | CH ₄ | No | There are no emissions |
| | N ₂ O | No | There are no emissions | |

For heat pumps, the following must be monitored:

1. The grid emission factor to determine the baseline and project emissions;
2. The amount of thermal energy produced;
3. The refrigerant consumption; and
4. The electricity consumption of the heat pump.

A diagram of what must be monitored for heat pumps is provided below⁹:

⁹ Reliant Energy Retail Holdings, LLC. 2012. Energy Savings Centre. Available online from http://www.reliant.com/en_US/Page/Generic/Public/esc_purchasing_advisor_electric_powered_tank_water_heaters_bus_gen.jsp. [Accessed 28 March 2012].



1. The outlet water temperature (temperature of the hot water)
2. The mass flowrate of the hot water
3. The inlet water temperature (temperature of the cold water)
4. The electricity consumption of the heat pump and the amount of refrigerant gas refilled

These parameters are monitoring for a sample of systems. The ex-ante calculations are based on manufacturer’s specifications and publically available information.

B.4. Description of baseline scenario

>>

The baseline for this PoA depends on what was used for water heating in the household before the installation of the solar water heater or heat pump. The existing heating device is recorded at the initial site visit by the supplier.

- Low income households typically use kettles and stoves to heat water. The kettles and stoves either use electricity or paraffin. Most low income households do not have an electric geyser. The penetration of electric geyser in low income households is estimated to be as low as 26%. In this income group, there are over five million households that have an electricity connection, but cannot afford a geyser.
- Middle and high income households typically use electricity to generate hot water in conventional electric geysers. According to the South African Department of Energy, most middle and high income households have electric geysers:

| Group | Income band | Total households | With an electric geyser | Geyser penetration |
|---------------|---------------|------------------|-------------------------|--------------------|
| Middle Income | <R16000/month | 2811402 | 2088883 | 76% |
| High Income | >R16000/month | 1213212 | 1187860 | 98% |

Although the existing water heating device will be recorded, we can assume the for middle and high income households, the baseline will be the use of a conventional electric geyser.

- In community residential units, water is currently heated using either an electric geyser or an electric ‘2-plate’ stove. In the eThekweni Municipality, for example, there are slightly less than 14 000 rooms or units contained in ten community residential units. Of these rooms, less than 25% are fitted with electric geysers and the remaining use stoves for heating water. Hence, the existing water heating devices may either be a conventional electric geyser or, more likely, a stove.

The PoA will install:

- High pressure solar water heaters or heat pumps in middle and high income households;
- Low and high pressure solar water heaters or heat pumps in community residential units; and
- Low pressure solar water heaters in low income households which do not have a proper water heating system.

The baseline for middle and high income households would be the use of electricity in conventional electric geyser for heating water. This represents the current situation in terms of water heating in these households.

For community residential units and low income households, the current situation may not be the use of electric geysers. Community residential units heat water using electric stoves as they cannot afford to purchase electric geysers. Low income households heat water using stoves or kettles operated using electricity or paraffin. The choice of water heating technology was limited as a result of income constraints or lack of access to funds. If community residential units and low income households could afford a proper water heating system then the most likely choice would electric geysers. **Hence, the baseline is assumed to be the use of electric geysers.**

This approach is considered conservative since it only takes into account technologies chosen by typical homes that have access to modern and efficient water heaters, and it leads to fewer emissions than the approach that includes traditional water heating means.

B.5. Demonstration of eligibility for a generic CPA

>>

Each CPA must meet the eligibility criteria in order to be included in the PoA. Each CPA must complete the following table:

| No. | Requirement as per standard | Eligibility criteria | Description of how the CPA meets the eligibility criteria | Check by the CME |
|-----|--|--|---|------------------|
| 1 | The geographical boundary of the CPA including any time-induced boundary ³ consistent with the geographical boundary set in the PoA | All installations shall take place in residential buildings within the geographical boundaries of South Africa | | |
| 2 | Conditions that avoid double | All solar water heaters and | | |



| | | | | |
|---|---|---|--|--|
| | <p>counting of emission reductions like unique identifications of product and end-user locations (e.g. programme logo);</p> | <p>heat pumps installed under the PoA must be uniquely identified by a serial or barcode number that is recorded on installation of the unit.</p> <p>The address and date of each solar water heating and heat pump installation must be recorded on installation of the unit. This information must be captured on the Eskom rebate form. All the relevant details from the form must be recorded in the CME's electronic database.</p> | | |
| 3 | <p>The specifications of technology/measure including the level and type of service, performance specifications including compliance with testing/certifications;</p> | <p>All solar water heating systems and heat pumps installed under this PoA must be SABS tested and approved.</p> <p>All units installed under this PoA must be done by a supplier that has been pre-approved for the PoA by the CME.</p> <p>All solar water heaters and heat pumps installed under the PoA must be new equipment.</p> <p>All technical specifications of the unit must be available in manufacturer's specifications and the type of unit installed must be recorded upon installation of the unit. This information must be captured on the Eskom rebate form by the supplier. All relevant details from the form must be recorded in the CME's electronic database.</p> <p>All relevant technical</p> | | |



| | | | | |
|---|---|---|--|--|
| | | <p>specifications of the existing water heating device must be recorded such as type of fuel used, type of unit used and size of geyser. . This information (particularly the size of the geyser) will be used to inform the sizing calculations of the unit. These sizing calculations must be recorded by the supplier/installer and submitted to the CME to be recorded in the electronic database.</p> | | |
| 4 | Conditions to check the start date of the CPA through documentary evidence | The start date of the CPA is the date on which the first unit is installed under the CPA. This is captured by the supplier and recorded in the CME's electronic database. | | |
| 5 | Conditions that ensure compliance with applicability and other requirements of single or multiple methodologies applied by CPAs | Each CPA must meet the applicability criteria of the applicable methodologies. The applicable methodology for solar water heaters is Approved methodology small-scale (AMS) I.J 'Solar water heating systems (SWH)' Version 01, EB 60. The applicable methodology for heat pumps is Approved methodology small-scale (AMS) II.C 'Demand-side energy efficiency activities for specific technologies' Version 13, EB 48. | | |
| 6 | The conditions that ensure that CPAs meet the requirements pertaining to the demonstration of additionality as specified in Section A above | Each CPA must demonstrate additionality in accordance with the procedure as set out under this PoA. The additionality demonstration is checked by the CME and the selected DOE. | | |
| 7 | The PoA-specific requirements stipulated by | Local stakeholder consultation must be | | |



| | | | | |
|----|---|--|--|--|
| | the CME including any conditions related to undertaking local stakeholder consultations and environmental impact analysis | completed before the start date of the CPA. A local consultation report must be submitted to the CME before the first unit is installed under the CPA. Environmental impact analysis is done at PoA level. The CPA implementer is not required to do an environmental impact assessment. | | |
| 8 | Conditions to provide an affirmation that funding from Annex I parties, if any, does not result in a diversion of official development assistance | The CPA implementer must provide the CME with a description of the financing arrangement for the units to be installed. The CME will check with the CPA implementer on an annual basis to ensure that no funding from Annex 1 parties that result in the diversion of official development assistance is used. | | |
| 9 | Where applicable, target group (e.g. domestic/commercial/industrial, rural/urban, grid-connected/off-grid) and distribution mechanisms (e.g. direct installation) | The target group is domestic water heating. This is confirmed by the supplier upon the installation. | | |
| 10 | Where applicable, the conditions related to sampling requirements for a PoA in accordance with the approved guidelines/standard from the Board pertaining to sampling and surveys | Each CPA implementer must apply the monitoring plan and the sampling requirements as set out in this PoA. The CPA implementer must produce monthly monitoring reports for the CME which will be checked by the CME. | | |
| 11 | Where applicable, the conditions that ensure that every CPA in aggregate meets the small-scale or microscale threshold criteria and remains within those thresholds throughout the crediting period of the CPA; | The energy savings from the solar water heaters and heat pumps installed under a single CPA must not exceed the small-scale thresholds of the relevant methodologies. | | |
| 12 | Where applicable, the | Each unit included in the | | |



| | | | | |
|----|--|--|--|--|
| | <p>requirements for the debundling check, in case CPAs belong to small-scale (SSC) or microscale project categories.</p> | <p>CPA must not be larger than 1% of the small-scale thresholds defined by the methodology applied. This means that:</p> <ol style="list-style-type: none"> 3. Each solar water heater must have an installed capacity of less than 450 kW(th). According to Appendix B of the Simplified modalities and procedures for small-scale clean development mechanism project activities, '<i>For thermal applications of solar energy projects, 'maximum output' shall be calculated using a conversion factor of 700 Wth/m² of aperture area of glazed flat plate or evacuated tubular collector i.e. eligibility limit in terms of aperture area is 64 000 m² of the collector.</i>' Hence, each CPA will not exceed 64 000 m² threshold. 1. Each heat pump must result in an energy saving of less than 600 MWh per year. | | |
| 13 | Rights to the carbon credits | <p>The owner of the solar water heater or heat pump must cede their rights to the carbon credits. This is done through ensuring that the agreement between the CME and the resident of</p> | | |



| | | | | |
|----|--|--|--|--|
| | | the household is signed prior to installation of the unit. | | |
| 14 | For low income households, the model-based approach is used. The model must be calibrated as per the requirements in the monitoring plan of the PoA. | The measurements and calibration results are recorded in the database maintained by the CME. | | |

B.6. Estimation of emission reductions of a generic CPA

B.6.1. Explanation of methodological choices

>>

Solar water heating systems

There are two types of solar water heating systems – high and low pressure. Low pressure systems are installed in low income households and may be installed in community residential units. High pressure systems are installed in middle and high income households and community residential units.

According to the methodology, emission reductions are calculated as the energy savings that result from the project implementation multiplied by an emission factor for the electricity or fossil fuel displaced.

The energy savings may be determined by using one of the following approaches:

- Model based method - an approved, computerized simulation model is used to determine the annual performance of the baseline system and the project system in order to calculate baseline energy use and project energy use.
- System metering method – involves metering a sample of units. The energy content of the hot water must be measured and integrated, at least one every minute by a thermal meter and recorded on a daily basis.
- Stipulated energy saving method – this method is only applicable to residential solar water heating systems that displace electricity for water heating.

Stipulated energy saving method

The baseline for the middle and high income households is a conventional electric geyser. The baseline for the community residential units is also a conventional electric geyser as per Section B.4. Hence, the stipulated energy saving method is used for these households.

The stipulated energy saving method will be used to determine the emission reductions for high pressure geysers being installed in middle and high income households and community residential units. For this method the SWH system will displace electricity for heating water using a conventional electric geyser.

The stipulated energy method is only applicable when all the following conditions are satisfied:

- Individual solar collector are a per system is less than or equal to eight square meters per residential unit (e.g. eight square meters for a single family residence or 32 square meters for a four unit apartment building);

- The tilt and orientation of the solar collectors shall be +/- 45 of due equator and a tilt +15 to -25 degrees of latitude;
- Thermal storage volume (preheat tank volume) is either: (a) At least 50 litres per square meter of collector area; or (b) Adequate to bridge time gap between solar supply and load demand during an average winter day for a typical installation, as demonstrated by calculation or model;
- The sizing calculations of the SHW systems are documented to be such that the average annual, daily amount of water heated by the SWH systems is less than or equal to the average annual, daily hot water demand for a typical installation;
- There must be no shading of the solar collectors between 10 am to 2 pm on the shortest day of the year at the time of installation; and
- The quality and performance of the solar collectors and SHW systems shall meet national standards (in this case, solar water heaters must meet SABS standards).

For applications that can reasonably demonstrate to have substantial hot water consumption demand year round, the stipulated energy saving method allows for the use of 450 kWh/ year per square meter of collector area.

Using this method, the emission reductions are calculated as follows:

$$ER_y = \sum_{i=1}^n \frac{0.450 \times A_i \times EF_{CO_2,grid,y}}{(1 - TDL_y)} \quad (1)$$

Where:

| | |
|--------------------|---|
| 0.450 | Stipulated energy saving value as per the methodology (MWh/year per square meter) |
| A_i | Collector area (square meter) of solar water heater unit i |
| $EF_{CO_2,grid,y}$ | The grid emission factor (tCO ₂ /MWh) |
| TDL_y | Transmission and distribution losses |

For applications that cannot reasonably demonstrate to have substantial hot water consumption demand year round, the stipulated energy saving method allows for the use of 300 kWh/ year per square meter of collector area.

In this case the emission reductions would be calculated as follows:

$$ER_y = \sum_{i=1}^n \frac{0.300 \times A_i \times EF_{CO_2,grid,y}}{(1 - TDL_y)} \quad (2)$$

Where:

| | |
|--------------------|---|
| 0.300 | Stipulated energy saving value as per the methodology (MWh/year per square meter) |
| A_i | Collector area (square meter) of solar water heater unit i |
| $EF_{CO_2,grid,y}$ | The grid emission factor (tCO ₂ /MWh) |
| TDL_y | Transmission and distribution losses |

The emission factor of the grid is calculated according to the procedure prescribed in the latest version of the ‘*Tool to calculate the emission factor for an electricity system.*’ The application of this tool is presented in Appendix 4. The CME is responsible for ensuring that the tool is up-to-date and for the

calculation of the grid emission factor for South Africa. Each CPA must apply the grid emission factor allocated to them by the CME.

Model based method

The model based method will be used to determine the emission reductions for solar water heaters installed low income households. The following procedures shall be followed for this method:

The pre-approved model simulation program RETScreen will be used to determine the annual performance of the baseline systems and the project systems in order to calculate baseline and project energy use.

The input parameters to the model will include:

| No | Parameter | Source |
|----|---|---|
| 1 | Characteristics of the baseline system: <ul style="list-style-type: none">• Fuel used for water heating• Water heating method | Eskom rebate form |
| 2 | Temperature of water entering the heating system (inlet temperature) | RETScreen model |
| 3 | Average end-use hot water temperature (outlet temperature) | Thermostat setpoint |
| 4 | Consumption of water | We have used a set value for the water consumption in low income households. This is in accordance with the methodology that states that <i>‘regional or national per occupant or per residence values may be used from reliable sources, not to exceed a value of 40 litres per day of hot water consumption per full time resident occupant.’</i> |
| 5 | Characteristics of project system : <ul style="list-style-type: none">• Solar collector size• Technical and thermal performance ratings• Collector orientation• Storage tank size and insulation | Manufacturer’s specifications and Eskom rebate form |
| 6 | Solar radiation data | |

The model is used to calculate the baseline and project electricity consumption, and consequently the emission reductions, on an annual basis.

Heat pumps

According to the methodology, if the energy displaced is electricity then the baseline emissions are calculated as follows:

$$BE_y = E_{BL,y} \times EF_{CO2,ELEC,y} + Q_{ref,BL} \times GWP_{ref,BL} \quad (3)$$

Where:

BE_y Baseline emissions in year y (tCO₂e)
 $E_{BL,y}$ Energy consumption in the baseline in year y (MWh)

| | |
|--------------------|--|
| $EF_{CO_2,ELEC,y}$ | Emission factor in year y (tCO ₂ /MWh) |
| $Q_{ref,BL}$ | Annual quantity of refrigerant used in the baseline to replace the refrigerant that has leaked (tonnes per year) |
| $GWP_{ref,BL}$ | Global warming potential of the baseline refrigerant (tCO ₂ e/t refrigerant) |

Since the baseline equipment does not make use of refrigerants, this equation can be simplified as follows:

$$BE_y = E_{BL,y} \times EF_{CO_2,ELEC,y} \quad (4)$$

Where:

| | |
|--------------------|--|
| BE_y | Baseline emissions in year y (tCO ₂ e) |
| $E_{BL,y}$ | Energy consumption in the baseline in year y (MWh) |
| $EF_{CO_2,ELEC,y}$ | Emission factor in year y (tCO ₂ /MWh) |

The energy consumption in the baseline is calculated using the equation below:

$$E_{BL,y} = EER \times Q_y / (1 - l_y) \quad (5)$$

Where:

| | |
|------------|--|
| $E_{BL,y}$ | Energy consumption in the baseline in year y (kWh) |
| EER | Specific energy consumption in the baseline (kWh/unit) |
| Q_y | Total quantity of supply in project year y (unit) |
| l_y | Average annual technical grid losses during year y |

The specific energy consumption in the baseline is calculated as follows, as the efficiency (converting electrical energy to thermal energy) is assumed to be 100% (this is a conservative assumption):

$$EER = EG_{thermal,k,y} \quad (6)$$

Where:

| | |
|--------------------|---|
| $EG_{thermal,k,y}$ | The net quantity of heat supplied by unit k during the year y (MWh) |
|--------------------|---|

$$EG_{thermal,k,y} = \frac{m_{k,y} \times C_{Pw} \times \Delta T}{3600} \quad (7)$$

Where:

| | |
|--------------------|--|
| $EG_{thermal,k,y}$ | The net quantity of heat supplied by unit k during the year y (MWh) |
| $m_{k,y}$ | Mass flowrate of water in unit k in year y (tonnes/year) |
| C_{Pw} | Specific heat capacity of water (MJ/tonnes ° C) (4.2 MJ/t ° C) |
| ΔT_k | Differential temperature of inlet and outlet heated water for unit k (° C) |

The mass flowrate of water is calculated as follows:

$$m_{k,y} = m_{person} \times N_{people} \quad (8)$$

Where:

| | |
|-----------|---|
| $m_{k,y}$ | Mass flowrate of water heated in unit k in year y (tonnes/year) |
|-----------|---|

| | |
|---------------------|--|
| m_{person} | The average mass flowrate of hot water consumed per person in South Africa (tonnes/year) |
| N_{people} | The number of people living in the residence |

The differential temperature is calculated as follows:

$$\Delta T = T_2 - T_1 \quad (9)$$

Where:

| | |
|-------|---|
| T_1 | Average water inlet temperature for South Africa ($^{\circ}$ C) |
| T_2 | Average thermostat setting for electric geysers in South Africa ($^{\circ}$ C) |

The project emissions consist of the electricity consumption used in the project equipment, determined as follows:

$$PE_y = E_{PJ,y} \times EF_{CO_2,y} + PE_{ref,y} \quad (10)$$

Where:

| | |
|---------------|--|
| PE_y | Project emissions in year y (tCO ₂ e) |
| $E_{PJ,y}$ | Energy consumption in the project activity in year y based on monitored values |
| $EF_{CO_2,y}$ | Emission factor for electricity from the national grid |

The emission factor of the grid is calculated according to the procedure prescribed in the latest version of the ‘*Tool to calculate the emission factor for an electricity system.*’ The application of this tool is presented in Appendix 4. The CME is responsible for ensuring that the tool is up-to-date and for the calculation of the grid emission factor for South Africa. Each CPA must apply the grid emission factor allocated to them by the CME.

The energy consumption in the project activity is determined as follows:

$$E_{PJ,y} = EER_y \times Q_y / (1 - l_y) \quad (11)$$

Where:

| | |
|------------|---|
| $E_{PJ,y}$ | Energy consumption in the project in year y (kWh) |
| EER_y | Specific energy consumption in the project (kWh/unit) |
| Q_y | Total quantity of supply in project year y (unit) |
| l_y | Average annual technical grid losses during year y |

Should a refrigerant which has a GWP be used in the heat pump, the emissions from the refrigerant must be accounted for under project emissions as follows:

$$PE_{ref,y} = (Q_{ref,PJ,y}) \times GWP_{ref,PJ} \quad (12)$$

Where:

| | |
|----------------|---|
| $PE_{ref,y}$ | Project emissions from physical leakage of refrigerant from project equipment in year y (tCO ₂ e/y) |
| $Q_{ref,PJ,y}$ | Average annual quantity of refrigerant used in year y to replace refrigerant that has leaked in year y (tonnes/year). Default values from the IPCC 2006 Guidelines may be used. |
| $GWP_{ref,PJ}$ | Global Warming Potential of the refrigerant used (tCO ₂ e/t refrigerant) |

The emission reductions are calculated as follows:

$$ER_y = BE_y - LE_y - PE_y \quad (13)$$

Where:

| | |
|-----------------|--|
| ER _y | The emission reductions in year y (tCO ₂ e) |
| BE _y | The baseline emissions in year y (tCO ₂ e) |
| LE _y | The leakage emissions in year y (tCO ₂ e) |
| PE _y | The project emissions in year y (tCO ₂ e) |

The calculation of the emission reductions from heat pumps and solar water heaters must take into account the failure rate of the heat pumps and solar water heaters. This failure rate is determined as part of the monitoring process. Please see the monitoring plan for more detail.

B.6.2. Data and parameters that are to be reported ex-ante

Solar water heating systems:

Stipulated energy savings approach:

| | |
|---|--|
| Data / Parameter | A_i |
| Unit | m ² |
| Description | Collector area (square meter) of solar water heater unit |
| Source of data | Manufacturer's specifications |
| Value(s) applied | The value applied is dependent on the type of unit installed. |
| Choice of data or Measurement methods and procedures | Manufacturer's specifications for the unit installed will be used. A sample of systems will be checked during the project crediting period in order to verify that the correct collector area has been used in the calculation of the emission reductions. |
| Purpose of data | The collector area is used to calculate the emission reductions for solar water heating installations. |
| Additional comment | |

| | |
|---|--|
| Data / Parameter | TDL_y |
| Unit | % |
| Description | Transmission and distribution losses |
| Source of data | Default value specified in the methodology AMS-I.J |
| Value(s) applied | 10% |
| Choice of data or Measurement methods and procedures | Default value specified in methodology. No applicable specific transmission and distribution losses available for the region. |
| Purpose of data | The transmission and distribution losses are included in the calculation of the energy savings from the solar water heating systems. |
| Additional comment | |

Model-based approach:

| | |
|---|--|
| Data / Parameter | Hot water consumption |
| Unit | Litres per person per day |
| Description | Consumption of hot water by low income households |
| Source of data | Gleick, P. H. <i>Basic Water Requirements for Human Activities: Meeting Basic Needs</i> . Available online from http://www.pacinst.org/reports/basic_water_needs/basic_water_needs.pdf . [Accessed 28 March 2012]. |
| Value(s) applied | 25 |
| Choice of data or Measurement methods and procedures | <p>According to the methodology: <i>‘regional or national per occupant or per residence values may be used from reliable sources, not to exceed a value of 40 litres per day of hot water consumption per full time resident occupant.’</i></p> <p>In line with this, we have used a value below 40 litres per person per day. We have based this value on the basic water need per person. This is the amount of water that each person should be allowed as a basic human right or basic need.</p> |
| Purpose of data | To calculate the emission reductions from the installation of solar water heating systems in low income households. |
| Additional comment | |

| | |
|---|--|
| Data / Parameter | Characteristics of project system |
| Unit | N/A |
| Description | Solar collector size, technical and thermal performance ratings and storage tank size and insulation |
| Source of data | Manufacturer’s specifications |
| Value(s) applied | Dependent on unit installed |
| Choice of data or Measurement methods and procedures | This information is available for each unit from the manufacturer of the unit. |
| Purpose of data | Input into the RETScreen model |
| Additional comment | |



| | |
|---|--|
| Data / Parameter | Solar radiation data |
| Unit | |
| Description | The RETScreen model provides for this data from NASA |
| Source of data | RETScreen model – climatic data from NASA |
| Value(s) applied | As per the NASA climatic data |
| Choice of data or Measurement methods and procedures | |
| Purpose of data | |
| Additional comment | |

| | |
|---|---|
| Data / Parameter | Characteristics of the baseline system |
| Unit | N/A |
| Description | Fuel used for heating and heating method |
| Source of data | Recorded in the site visit forms |
| Value(s) applied | Dependent on household |
| Choice of data or Measurement methods and procedures | The fuel and heating method are recorded as per the methodology. However, the baseline used for the model is an electric geyser. Please see baseline section for a description of the baseline for low income households. |
| Purpose of data | |
| Additional comment | |

| | |
|---|---------------------------------|
| Data / Parameter | Installation parameters |
| Unit | N/A |
| Description | Collector orientation and angle |
| Source of data | Eskom rebate form |
| Value(s) applied | Dependent on unit installed |
| Choice of data or Measurement methods and procedures | |
| Purpose of data | |
| Additional comment | |



| | |
|---|--|
| Data / Parameter | Inlet water temperature |
| Unit | Degrees centigrade |
| Description | The RETScreen model provides for this data from NASA |
| Source of data | RETScreen model – climatic data from NASA |
| Value(s) applied | As per the NASA climatic data |
| Choice of data or Measurement methods and procedures | |
| Purpose of data | |
| Additional comment | |

| | |
|---|---------------------------------|
| Data / Parameter | Outlet water temperature |
| Unit | Degrees centigrade |
| Description | Temperature of the heated water |
| Source of data | Thermostat setpoint |
| Value(s) applied | Dependent on the unit installed |
| Choice of data or Measurement methods and procedures | |
| Purpose of data | |
| Additional comment | |

Heat pumps:

| | |
|---|---|
| Data / Parameter | C_{Pw} |
| Unit | MJ/tonnes ° C |
| Description | Specific heat capacity of water |
| Source of data | Approved methodology (AMS III.K.) |
| Value(s) applied | 4.2 |
| Choice of data or Measurement methods and procedures | Standard value as specified in approved methodologies. |
| Purpose of data | The specific heat capacity of water is used to calculate the thermal energy produced by the heat pumps. |
| Additional comment | |

| | |
|---|--|
| Data / Parameter | $GWP_{ref,PJ}$ |
| Unit | |
| Description | Global warming potential of refrigerant used in the heat pump |
| Source of data | The type of refrigerant is given in manufacturer's specifications. The global warming potential of the refrigerant is sourced from Intergovernmental Panel on Climate Change (IPCC). |
| Value(s) applied | Dependent on refrigerant type |
| Choice of data or Measurement methods and procedures | |
| Purpose of data | The global warming potential of the refrigerant gas is used to determine the emissions that result from refrigerant loss. |
| Additional comment | |

| | |
|---|--|
| Data / Parameter | I_y |
| Unit | % |
| Description | Transmission and distribution losses |
| Source of data | Default value specified in the methodology AMS-II.C |
| Value(s) applied | 10% |
| Choice of data or Measurement methods and procedures | Default value specified in methodology. No applicable specific transmission and distribution losses available for the region. |
| Purpose of data | The transmission and distribution losses are included in the calculation of the energy savings from the solar water heating systems. |
| Additional comment | |

There are a number of parameters that are determined ex-ante, but monitored in a sample of systems ex-post. These parameters are included in the monitoring section.

B.6.3. Ex-ante calculations of emission reductions

>>

Solar water heating systems:

Stipulated Energy Method

Equation 1

$$ER_y = \sum_{i=1}^n \frac{0.450 \times A_i \times EF_{CO2,grid,y}}{(1 - TDL_y)}$$

| Year | ER _y | 0.450 | A _i | EF _{CO2,grid,y} | TDL _y |
|------|-----------------|-------|----------------|--------------------------|------------------|
| 20XX | | 0.450 | | 1.0 | 0.1 |
| 20XX | | 0.450 | | 1.0 | 0.1 |
| 20XX | | 0.450 | | 1.0 | 0.1 |
| 20XX | | 0.450 | | 1.0 | 0.1 |
| 20XX | | 0.450 | | 1.0 | 0.1 |
| 20XX | | 0.450 | | 1.0 | 0.1 |
| 20XX | | 0.450 | | 1.0 | 0.1 |
| 20XX | | 0.450 | | 1.0 | 0.1 |
| 20XX | | 0.450 | | 1.0 | 0.1 |
| 20XX | | 0.450 | | 1.0 | 0.1 |

Equation 2

$$ER_y = \sum_{i=1}^n \frac{0.300 \times A_i \times EF_{CO2,grid,y}}{(1 - TDL_y)}$$

| Year | ER _y | 0.300 | A _i | EF _{CO2,grid,y} | TDL _y |
|------|-----------------|-------|----------------|--------------------------|------------------|
| 20XX | | 0.300 | | 1.0 | 0.1 |
| 20XX | | 0.300 | | 1.0 | 0.1 |
| 20XX | | 0.300 | | 1.0 | 0.1 |
| 20XX | | 0.300 | | 1.0 | 0.1 |
| 20XX | | 0.300 | | 1.0 | 0.1 |
| 20XX | | 0.300 | | 1.0 | 0.1 |
| 20XX | | 0.300 | | 1.0 | 0.1 |
| 20XX | | 0.300 | | 1.0 | 0.1 |
| 20XX | | 0.300 | | 1.0 | 0.1 |
| 20XX | | 0.300 | | 1.0 | 0.1 |

Model Based Method

The pre-approved model simulation program RETScreen will be used to determine the annual performance of the baseline systems and the project systems in order to calculate baseline and project energy use.

The input parameters to the model shall include:

- Characteristics of the baseline system including the fossil fuel or electricity input and output capacity, water heating system efficiency, and storage tank size and insulation;
- Temperature of water entering the water heating system (e.g., ground water temperature) and average end-use hot water temperature (°C) and consumption, (litres per day);
- Characteristics of the project system including solar collector size and technical and thermal performance ratings, collector orientation, back-up system characteristics, pumping system characteristics, and storage tank size and insulation, and
- Solar radiation data, i.e. daily or monthly average daily solar insolation data (kwh/m²/day) and ambient temperature data, i.e. daily or monthly average daily values (°C).

| Year | ER _y |
|------|-----------------|
| 20XX | |
| 20XX | |
| 20XX | |
| 20XX | |
| 20XX | |
| 20XX | |
| 20XX | |
| 20XX | |
| 20XX | |
| 20XX | |

Heat pumps:

Equation 4

$$BE_y = E_{BL,y} \times EF_{CO2,ELEC,y}$$

| Year | BE _y | E _{BL,y} | EF _{CO2,ELEC,y} |
|------|-----------------|-------------------|--------------------------|
| 20XX | | | 1.0 |
| 20XX | | | 1.0 |
| 20XX | | | 1.0 |
| 20XX | | | 1.0 |
| 20XX | | | 1.0 |
| 20XX | | | 1.0 |
| 20XX | | | 1.0 |
| 20XX | | | 1.0 |
| 20XX | | | 1.0 |
| 20XX | | | 1.0 |

Equation 5

$$E_{BL,y} = EER \times Q_y / (1 - l_y)$$

| Year | E _{BL,y} | EER | Q _y | 1 | l _y |
|------|-------------------|-----|----------------|-----|----------------|
| 20XX | | | | 1.0 | 0.1 |



| | | | | | |
|------|--|--|--|-----|-----|
| 20XX | | | | 1.0 | 0.1 |
| 20XX | | | | 1.0 | 0.1 |
| 20XX | | | | 1.0 | 0.1 |
| 20XX | | | | 1.0 | 0.1 |
| 20XX | | | | 1.0 | 0.1 |
| 20XX | | | | 1.0 | 0.1 |
| 20XX | | | | 1.0 | 0.1 |
| 20XX | | | | 1.0 | 0.1 |
| 20XX | | | | 1.0 | 0.1 |
| 20XX | | | | 1.0 | 0.1 |

Equation 6

$$EER = EG_{thermal,k,y}$$

| Year | EER | EG _{thermal,k,y} |
|------|-----|---------------------------|
| 20XX | | |
| 20XX | | |
| 20XX | | |
| 20XX | | |
| 20XX | | |
| 20XX | | |
| 20XX | | |
| 20XX | | |
| 20XX | | |
| 20XX | | |

Equation 7

$$EG_{thermal,k,y} = \frac{m_{k,y} \times C_{Pw} \times \Delta T}{3600}$$

| Year | EG _{thermal,k,y} | m _{k,y} | C _{Pw} | ΔT | 3600 |
|------|---------------------------|------------------|-----------------|----|------|
| 20XX | | | 4.2 | | 3600 |
| 20XX | | | 4.2 | | 3600 |
| 20XX | | | 4.2 | | 3600 |
| 20XX | | | 4.2 | | 3600 |
| 20XX | | | 4.2 | | 3600 |
| 20XX | | | 4.2 | | 3600 |
| 20XX | | | 4.2 | | 3600 |
| 20XX | | | 4.2 | | 3600 |
| 20XX | | | 4.2 | | 3600 |
| 20XX | | | 4.2 | | 3600 |

Equation 8

$$m_{k,y} = m_{person} \times N_{people}$$

Middle income households:



| Year | $m_{k,y}$ | m_{person} | N_{people} |
|------|-----------|---------------------|---------------------|
| 20XX | | 50 | |
| 20XX | | 50 | |
| 20XX | | 50 | |
| 20XX | | 50 | |
| 20XX | | 50 | |
| 20XX | | 50 | |
| 20XX | | 50 | |
| 20XX | | 50 | |
| 20XX | | 50 | |
| 20XX | | 50 | |

Community residential units

| Year | $m_{k,y}$ | m_{person} | N_{people} |
|------|-----------|---------------------|---------------------|
| 20XX | | 21.6 | |
| 20XX | | 21.6 | |
| 20XX | | 21.6 | |
| 20XX | | 21.6 | |
| 20XX | | 21.6 | |
| 20XX | | 21.6 | |
| 20XX | | 21.6 | |
| 20XX | | 21.6 | |
| 20XX | | 21.6 | |
| 20XX | | 21.6 | |

Equation 9

$$\Delta T = T_2 - T_1$$

| Year | ΔT | T_2 | T_1 |
|------|------------|-------|-------|
| 20XX | | 65 | |
| 20XX | | 65 | |
| 20XX | | 65 | |
| 20XX | | 65 | |
| 20XX | | 65 | |
| 20XX | | 65 | |
| 20XX | | 65 | |
| 20XX | | 65 | |
| 20XX | | 65 | |
| 20XX | | 65 | |

Equation 10

$$PE_y = E_{PJ,y} \times EF_{CO_2,y} + PE_{ref,y}$$

| Year | PE_y | $E_{PJ,y}$ | $EF_{CO_2,y}$ |
|------|--------|------------|---------------|
| 20XX | | | 1.0 |
| 20XX | | | 1.0 |
| 20XX | | | 1.0 |



| | | | | |
|------|--|--|--|--|
| 20XX | | | | |
| 20XX | | | | |
| 20XX | | | | |

B.7. Application of the monitoring methodology and description of the monitoring plan

B.7.1. Data and parameters to be monitored by each generic CPA

Solar water heating systems:

Stipulated energy savings approach:

| | |
|---|---|
| Data / Parameter | EF_{CO₂,grid,y} |
| Unit | tCO ₂ /MWh |
| Description | Electricity grid emission factor for the South African national electricity grid |
| Source of data | The grid emission factor is calculated in accordance with the latest version of the 'Tool to calculate the emission factor for an electricity system.' The grid emission factor is calculated by the CME and the calculation is updated annually. The CPA implementer must use the grid emission factor as calculated by the CME. |
| Value(s) applied | 1.00 |
| Measurement methods and procedures | Calculated in accordance with the latest version of the 'Tool to calculate the emission factor for an electricity system.' The grid emission factor calculated is checked annually and updated if required by the CME. |
| Monitoring frequency | Annually |
| QA/QC procedures | The calculation will be checked annually by the DOE as a QA/QC measure. |
| Purpose of data | The electricity grid emission factor is used to determine the emission reductions resulting from the installation and use of solar water heating systems. |
| Additional comments | |

Model-based approach:

The model needs to be calibrated. Please see monitoring plan for a description of how this calibration is conducted.

Heat pumps:



| | |
|---|--|
| Data / Parameter | EF_{CO₂,y} and EF_{CO₂,ELEC,y} |
| Unit | tCO ₂ /MWh |
| Description | Electricity grid emission factor for the South African national electricity grid |
| Source of data | The grid emission factor is calculated in accordance with the latest version of the ' <i>Tool to calculate the emission factor for an electricity system.</i> ' The grid emission factor is calculated by the CME and the calculation is updated annually. The CPA implementer must use the grid emission factor as calculated by the CME. |
| Value(s) applied | 1.00 |
| Measurement methods and procedures | Calculated in accordance with the latest version of the ' <i>Tool to calculate the emission factor for an electricity system.</i> ' The grid emission factor calculated is checked annually and updated if required by the CME. |
| Monitoring frequency | Annually |
| QA/QC procedures | The calculation will be checked annually by the DOE as a QA/QC measure. |
| Purpose of data | The electricity grid emission factor is used to determine the emission reductions resulting from the installation and use of solar water heating systems. |
| Additional comments | |

| | |
|---|---|
| Data / Parameter | N_{people} |
| Unit | Number |
| Description | The number of people in the household |
| Source of data | Documented by supplier on initial site visit |
| Value(s) applied | Dependent on the number of people residing in the residential unit |
| Measurement methods and procedures | The supplier should document the number of people living in the residential unit at the initial site visit. In addition, the number of people will be recorded for all units that are monitored during the project activity. |
| Monitoring frequency | Please see sampling plan for more details. |
| QA/QC procedures | |
| Purpose of data | |
| Additional comments | |



| | |
|---|---|
| Data / Parameter | m_{person} |
| Unit | Tonnes per person per year |
| Description | Flowrate of hot water consumed per person per year |
| Source of data | <p>The source of the ex-ante data: Review conducted by Meyer¹⁰ and the initial site visit conducted by the supplier.</p> <p>The source of the ex-post data: Monitoring conducted in a sample of households during the project activity.</p> |
| Value(s) applied | <p>Heat pumps may be installed in middle and high income households and in community residential units.</p> <p>According to a review conducted by Meyer, the hot water consumption for developed communities is 50 litres per person per day. This value will be used for all middle and high income households.</p> <p>For community residential units, the hot water consumption can be assumed to be similar to high density apartments, which is 21.6 litres per person per day according to Meyer. This will be used as the hot water consumption per person per day for the ex-ante calculations.</p> <p>These values will be checked by the supplier on the initial site visit. The supplier will review the existing water heating technology and water consumption parameters in each household. If the water consumption is likely to be lower than the values quoted above then the lower values must be used. If the hot water consumption is likely to be higher than the quoted values then the lower of the two values must be used.</p> |
| Measurement methods and procedures | <p>The hot water flowrate for an appropriate sample of the installation type will be monitored.</p> <p>Dividing the hot water flowrate by the number of residents will provide the flowrate of hot water consumed per person per year for that type of installation.</p> |
| Monitoring frequency | Please see sampling plan for more details. |
| QA/QC procedures | The hot water consumption is checked by the supplier on the initial site visit and is used to do the sizing calculations and to check the values that are being used for the hot water consumption. In addition, monitoring is conducted on a sample of installations to check the hot water consumption of the household. |
| Purpose of data | |
| Additional comments | |

¹⁰ Meyer, J.P. 2000. *A review of domestic hot water consumption in South Africa*. Available online from http://www.saimeche.org.za/resource/collection/7915CD6C-4630-4CC2-B1A9-D88F283AA600/Meyer-2000_02_600_dpi_-_2000_16_3_55-61.pdf. [Accessed 13 November 2011].

| | |
|---|---|
| Data / Parameter | T₁ |
| Unit | ° C |
| Description | Water inlet temperature |
| Source of data | The water inlet temperature is based on measurements. |
| Value(s) applied | Dependent on the area of installation |
| Measurement methods and procedures | The water inlet temperature is monitored for a sample of installations. |
| Monitoring frequency | Please see sampling plan for more details. |
| QA/QC procedures | Check with average ambient temperature for the region. |
| Purpose of data | |
| Additional comments | |

| | |
|---|--|
| Data / Parameter | T₂ |
| Unit | ° C |
| Description | Water outlet temperature |
| Source of data | The source of the ex-ante data: Manufacturer's setting for electric geysers in South Africa The source of the ex-post data: Monitoring conducted in a sample of households during the project activity. |
| Value(s) applied | 65 (Review conducted by Meyer ¹¹) |
| Measurement methods and procedures | The setpoint of the geyser is recorded at installation. The outlet temperature for selected units is measured using a thermocouple. |
| Monitoring frequency | Please see sampling plan for more details. |
| QA/QC procedures | The monitored values will be compared with the values recorded at installation of the unit. If there is a difference between the two values then the lowest one will be selected. |
| Purpose of data | The outlet water temperature is used to calculate the thermal energy produced by the unit. |
| Additional comments | |

¹¹ Meyer, J.P. 2000. *A review of domestic hot water consumption in South Africa*. Available online from http://www.saimeche.org.za/resource/collection/7915CD6C-4630-4CC2-B1A9-D88F283AA600/Meyer-2000_02_600_dpi_-_2000_16_3_55-61.pdf. [Accessed 13 November 2011].



| | |
|---|--|
| Data / Parameter | $Q_{ref,PJ,y}$ |
| Unit | Tonnes/year |
| Description | Average annual quantity of refrigerant used in year y to replace refrigerant that has leaked in year y |
| Source of data | <p>The source of the ex-ante data: Default values for refrigerant charge from manufacturer's specifications.</p> <p>The source of the ex-post data: The household is provided with a manual that contains the contact details of the supplier and CPA implementer. If the household contacts the supplier or the CPA implementer and requires a refrigerant refill then the amount refilled must be recorded. During annual inspection of the operation of the heat pump, the refrigerant levels must be checked. If the refrigerant is refilled then this must be recorded.</p> |
| Value(s) applied | As per manufacturer's specifications for the unit installed. |
| Measurement methods and procedures | <p>The refrigerant consumption is monitored as follows:</p> <ol style="list-style-type: none">1. If the household contacts the supplier or CPA implementer and the refrigerant is refilled then the amount refilled must be recorded.2. During annual inspection of the operation of the heat pump, the refrigerant levels must be checked. If the refrigerant is refilled then this must be recorded. |
| Monitoring frequency | Annually |
| QA/QC procedures | The amount refilled will be compared with manufacturer's specifications. If the difference is greater than 10% then the CPA implementer is required to justify the difference or the higher of the two values must be applied to the emission reduction calculations. |
| Purpose of data | This is used to calculate the emissions resulting from the consumption of refrigerant. This is only required if the refrigerant used has a global warming potential. |
| Additional comments | |

| | |
|---|---|
| Data / Parameter | EER _y |
| Unit | kWh per unit |
| Description | Specific energy consumption in the project |
| Source of data | The source of the ex-ante data: The amount of thermal energy generated as calculated by the baseline emissions divided by the Coefficient of Performance for heat pumps from manufacturer's specifications The source of the ex-post data: Monitoring conducted in a sample of households during the project activity. |
| Value(s) applied | The Coefficient of Performance for the heat pump The thermal energy is calculated in the baseline emissions |
| Measurement methods and procedures | The Coefficient of Performance is taken from manufacturer's specifications. The energy consumption for selected units is measured in the project activity. |
| Monitoring frequency | Please see sampling plan for more details. |
| QA/QC procedures | The monitored values will be compared with the values recorded at installation of the unit. If there is a difference between the two values then the lowest one will be selected. |
| Purpose of data | The electricity consumption is used to determine the project emissions from the heat pump |
| Additional comments | Not applicable |

B.7.2. Description of the monitoring plan for a generic CPA

>>

The monitoring will be the responsibility of the CME. The CME can choose to involve third-parties in the monitoring of the PoA. The CME will be responsible for producing annual monitoring reports with all the required information.

All data is stored for two years after the end of the crediting period.

Solar water heating systems

Stipulated energy savings approach:

Solar water heating installations in middle and high income households and community residential units will be monitored as follows:

- The supplier must document the sizing calculations of the solar water heating system. The sizing calculations must be done so that the average annual, daily amount of water heated by the system is less than or equal to the average annual, daily hot water demand for a typical installation.

The sizing calculations must be done by the supplier and based on the daily hot water demand of the household. This can be obtained by interviewing the residents and, in middle and high income households, by evaluating the size of the existing electric geyser.

- Upon installation of the solar water heating system, the supplier is required to record the solar collector area, tilt and orientation of the solar collectors and preheat tank volume. The supplier must also check that there is no shading of the solar collectors between 10am to 2pm on the shortest day of the year at the time of installation.

These parameters will be checked at the same time as the sample of systems is checked to ensure operation and compliance with manufacturer-required maintenance procedures.

- The installation date of each solar water heating system will be recorded by the supplier.
- Within three months of the installation, each system will be inspected and undergo acceptance testing (commissioning) for proper operation in compliance with manufacturer specifications. Acceptance testing will be documented and confirm system operation, per design specifications, and change-of-operating modes over a range of typical operating conditions.
- Emission reductions can only be claimed for systems that are operational and in compliance with manufacturer-required maintenance procedures. A sample of systems will be checked annually to ensure that they are operating and are in compliance with manufacturer-required maintenance procedures. The sample size will be selected to meet a 90% confidence interval and 10% margin of error. Please see the sampling plan for more information on how the sample size will be determined.
- Upon installation of the unit, the household representative is presented with a manual for the operation of the solar water heater. The manual contains the contact details of the supplier and the CPA implementer. If there is a problem with the unit then the household can contact either the supplier or the CPA implementer. The problem and solution must be recorded and form part of the monitoring forms that the CPA implementer prepares and submits to the CME.

Model-based approach:

Solar water heating installations in low income households will be monitored as follows:

- Upon the initial site visit or installation of the solar water heater, the supplier must record the characteristics of the baseline water heating system (fuel type and water heating method) and the characteristics of the project system (solar collector area, tilt and orientation of the solar collectors and tank volume).
- Within three months of the installation, each system will be inspected and undergo acceptance testing (commissioning) for proper operation in compliance with manufacturer specifications. Acceptance testing will be documented and confirm system operation, per design specifications, and change-of-operating modes over a range of typical operating conditions.
- Emission reductions can only be claimed for systems that are operational and in compliance with manufacturer-required maintenance procedures. A sample of systems will be checked annually to ensure that they are operating and are in compliance with manufacturer-required maintenance procedures. The sample size will be selected to meet a 90% confidence interval and 10% margin of error. Please see the sampling plan for more information on how the sample size will be determined.
- Upon installation of the unit, the household representative is presented with a manual for the operation of the solar water heater. The manual contains the contact details of the supplier and

the CPA implementer. If there is a problem with the unit then the household can contact either the supplier or the CPA implementer. The problem and solution must be recorded and form part of the monitoring forms that the CPA implementer prepares and submits to the CME.

- The model must be calibrated. The following parameters must be measured: weather data and inlet and outlet water temperatures. This will be done for two periods of 30 days (one in winter and one in summer). These values will be used to check the values used in the model. The water flowrate is a default value and does not need to be calibrated. The baseline and project system characteristics are all recorded for each installation and used in the model. The parameters measured are linked to the climatic conditions in the area. The results from the measurement site will be used for all installations within a 50 km radius of the installation as weather patterns are similar within this area.

Heat pumps

The methodology applied to heat pump installations requires the following to be monitored:

- The supplier is required to record technical information regarding the existing water heating system in the household at the initial site visit. In addition, the sizing calculations and the selection of the heat pump technology must be documented at either the initial site visit or installation.
- Upon installation of the unit, the household representative is presented with a manual for the operation of the solar water heater. The manual contains the contact details of the supplier and the CPA implementer. If there is a problem with the unit then the household can contact either the supplier or the CPA implementer. The problem and solution must be recorded and form part of the monitoring forms that the CPA implementer prepares and submits to the CME.
- Within three months of the installation, each system will be inspected and undergo acceptance testing (commissioning) for proper operation in compliance with manufacturer specifications.
- Emission reductions can only be claimed for systems that are operational and in compliance with manufacturer-required maintenance procedures. A sample of systems will be checked annually to ensure that they are operating and are in compliance with manufacturer-required maintenance procedures. The sample size will be selected to meet a 90% confidence interval and 10% margin of error. Please see the sampling plan for more information on how the sample size will be determined.
- Monitoring should also include metering the ‘energy use’ of an appropriate sample of devices installed. A sample of units installed will be monitored on an annual basis. The following will be monitored in the sample of units:
 - The inlet water temperature is monitored using a thermocouple;
 - The outlet water temperature is monitored using a thermocouple;
 - The flowrate of hot water is monitored using a flowmeter;
 - The electricity used by the unit; and
 - The number of people in the household.

Please see sampling plan for more information on the sample size and sampling methodology.

- The total number of heat pumps installed will be monitored and recorded in the electronic database. This will be based on their unique serial or barcode number and the forms completed at installation and monitoring.
- The annual quantity of refrigerant used will be monitored. If there is a problem with the unit then the household can contact the supplier or CPA implementer. If this problem is the refrigerant and a refill is required then the amount refilled and the type of refrigerant must be recorded. At the annual inspection of the operation of the unit, the amount of refrigerant will be checked. If a refill is required then the amount refilled and the type of refrigerant must be recorded. This must form part of the monitoring report. The refrigerant only needs to be monitored if it has a global warming potential in accordance with the Intergovernmental Panel on Climate Change (IPCC).

Sampling Plan

Each CPA will be divided into solar water heater and heat pump installations as monitoring is separate for these categories.

Solar water heaters:

A sample of systems will be checked annually to ensure that they are operating and are in compliance with manufacturer-required maintenance procedures. The sample size will be selected to meet a 90% confidence interval and 10% margin of error.

Since we are only checking for operation, the simple random sampling approach is appropriate. Simple random sample is a subset of a population chosen randomly, such that each element (or unit) of the population has the same probability of being selected. The sample-based estimate (mean or proportion) is an unbiased estimate of the population parameter. The electronic database will be programmed to randomly select a sample of the solar water heaters installed in each CPA for inspection.

The inspection will involve visiting the household and interviewing the residents on the operation of the system. The inspection will also involve checking the unit to ensure that it is operating and checking that it has been maintained in accordance with manufacturer's specifications.

One installation out of every 100 units installed is checked for operation.

Heat pumps:

- A sample of systems will be checked annually to ensure that they are operating and are in compliance with manufacturer-required maintenance procedures. The sample size will be selected to meet a 90% confidence interval and 10% margin of error.

Since we are only checking for operation, the simple random sampling approach is appropriate. Simple random sample is a subset of a population chosen randomly, such that each element (or unit) of the population has the same probability of being selected. The sample-based estimate (mean or proportion) is an unbiased estimate of the population parameter. The electronic database will be programmed to randomly select a sample of the solar water heaters installed in each CPA for inspection.

The inspection will involve visiting the household and interviewing the residents on the operation of the system. The inspection will also involve checking the unit to ensure that it is

operating and checking that it has been maintained in accordance with manufacturer's specifications.

The inspection includes checking if the refrigerant needs to be refilled and then recording the type and amount of refrigerant used to refill the unit.

One installation out of every 100 units installed is checked for operation.

- A sample of systems will be selected in order to monitor the energy produced and the energy consumption of the units. The population will be divided into the following two categories:
 - Middle and high income households; and
 - Community residential units.

Owing to the obvious groupings of the population, we have selected stratified random sampling. The strata have been defined above. Within each stratum, the electronic database will be programmed to randomly select a sample of the solar water heaters installed in each CPA for inspection.

Monitoring equipment will be installed on each unit selected for two periods of one month each. One of the months must be a summer month and the other must be a winter month. The measurement will take place over these two months. The CPA implementer or the representative of the CPA implementer must install the equipment before the first day of the month and must monitor the flowrate, electricity consumption and inlet and outlet water temperatures. The equipment must be fitted with the capability to record the readings and the readings must be downloaded from the instrument or equipment on a daily or weekly basis.

According to the 'General guidelines for sampling and surveys for SSC project activities,' the sample size shall be determined with minimum 90% confidence interval and 10% maximum error margin. Hence, for each CPA, the sample size must be calculated using the formula below:

$$n = \frac{\left(\frac{0.5[1-0.5]}{\frac{0.1^2}{1.6449} + \frac{0.5[1-0.5]}{N}} \right)}{R}$$

Where:

| | |
|---|-------------------------|
| n | sample size required |
| N | population size |
| R | estimated response rate |

We recommend that a response rate of 70% is used unless the CPA implementer can demonstrate why this is not applicable. This response rate can be updated based on the preceding monitoring period.

Using a response rate of 70%, the maximum sample size is 59 units.



**Appendix 1: Contact information on entity/individual responsible for the PoA**

| | |
|------------------------|-------------------------------------|
| Organization | eThekwini Municipality |
| Street/P.O. Box | PO Box 1014 Durban 4000 |
| Building | City Hall |
| City | Pixley KaSeme Street |
| State/Region | Durban |
| Postcode | 4001 |
| Country | South Africa |
| Telephone | |
| Fax | |
| E-mail | morgand@durban.gov.za |
| Website | |
| Contact person | |
| Title | Head of the eThekwini Energy Office |
| Salutation | Mr |
| Last name | Morgan |
| Middle name | |
| First name | Derek |
| Department | eThekwini Energy Office |
| Mobile | |
| Direct fax | +27 31 311 1089 |
| Direct tel. | +27 31 311 1139 |
| Personal e-mail | |



Appendix 2: Affirmation regarding public funding

Not applicable as no public funding is used in this PoA.



Appendix 3: Application of methodology(ies)

Appendix 4: Further background information on ex ante calculation of emission reductions

Application of the “Tool to calculate the emission factor for an electricity system” Version 02.2.1

The methodological tool to calculate the emission factor for an electricity system determines the CO₂ emission factor for the displacement of electricity generated by power plants in an electricity system, by calculating the “operating margin” (OM) and “build margin” (BM) as well as the “combined margin” (CM). The operating margin refers to existing power plants whose electricity generation would be affected by the proposed CDM project activity. The build margin reflects the power units whose construction would be affected by the proposed CDM project activity. The tool follows six steps in order to calculate the operating margin, build margin and the combined margin:

Step 1: Identify the relevant electricity systems.

Step 2: Choose whether to include off-grid power plants in the project electricity system (optional).

Step 3: Select a method to determine the operating margin (OM).

Step 4: Calculate the operating margin emission factor according to the selected method.

Step 5: Calculate the build margin (BM) emission factor.

Step 6: Calculate the combined margin (CM) emission factor.

Step 1: Identify the relevant electricity system

The national electricity grid consists of 95.0% of Eskom-generated electricity¹². The 5.0% remainder was private or municipal power generation. Excluding the 5% is, apart from simplicity, a conservative approach, as lower efficiencies and higher GHG emissions are assumed in these smaller and older power generation plants.

Eskom generates, transmits and distributes electricity to industrial, mining, commercial, agricultural and residential customers as well as to redistributors. Some assumptions have to be made to calculate the conservative electricity baseline.

The regional generation and consumption of Eskom transmission grids are interlinked and no distinction can be made between provincial or sectoral generation and consumption. For example: Cape Town, although located close to a nuclear power station, receives electricity via the transmission line from coal-fired power stations in Mpumalanga. The whole SA transmission system is taken as a homogenous mix of electricity supply by all generators.

Step 2: Choose whether to include off-grid power plants in the project electricity system (optional)

Option 1 was selected for the purposes of the calculation of the emission factor for this project. Hence, only grid power plants are included in the calculation. This is reflective of the project baseline where electricity was sourced from the national grid.

Step 3: Select a method to determine the operating margin (OM)

In accordance with the tool, the calculation of the operating margin emission factor ($EF_{grid,OM,y}$) must be based on one of the following methods:

- (a) Simple OM; or
- (b) Simple adjusted OM; or

¹² Eskom. Partnering for a Sustainable Future. Integrated Report for 2011.

- (c) Dispatch data analysis OM; or
- (d) Average OM.

Of these four methods anyone can be used, however the simple OM method can only be used if low-cost/must-run resources constitute less than 50.0% of total grid generation. The Tool states that:

“Low-cost/must-run resources are defined as power plants with low marginal generation costs or power plants that are dispatched independently of the daily or seasonal load of the grid. They typically include hydro, geothermal, wind, low-cost biomass, nuclear and solar generation. If coal is obviously used as must-run, it should also be included in this list, i.e. excluded from the set of plants.”

Nuclear and hydro power supplies about 6% of South Africa’s total electricity requirements¹³. Both Hydro and Nuclear are classified as low-cost and must-run power plants. Since Hydro and Nuclear power constituted 6% of the national grid in 2011 the Simple OM method can therefore be applied. The Simple OM method was selected for the calculation of the grid emission factor.

For the Simple OM the emission factor can be calculated using either of the two following data vintages:

- Ex ante option: A 3-year generation-weighted average, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation, without requirement to monitor and recalculate the emissions factor during the crediting period, or
- Ex post option: The year in which the project activity displaces grid electricity, required emissions factor to be updated annually during monitoring. If the data required calculating the emission factor for year y is usually only available later than six months after the end of year y, alternatively the emission factor of the previous year (y-1) may be used. If the data is usually only available 18 months after the end of year y, the emission factor of the year preceding the previous year (y-2) may be used. The same data vintage (y, y-1, or y-2) should be used throughout all crediting periods.

The latest data available from the Eskom website (February 2012) was the electricity generation and fuel consumption for 2008/2009, 2009/2010 and 2010/2011. This data is available from the CDM calculations webpage found on the Eskom website¹⁴.

For the purposes of this project, the ex-ante option was selected for the calculation of the operating margin. Hence, the conservative electricity baseline was calculated using the method below based on the ex ante option. A 3-year average was used, based on the most recent data available at the time of submission which was the data available for 2008/2009, 2009/2010 and 2010/2011.

Step 4: Calculate the operating margin emission factor according to the selected method

(a) Simple OM

The simple OM emission factor is calculated as the generation-weighted average CO₂ emissions per unit net electricity generation (tCO₂/MWh) of all generating power plants serving the system, **not including low-cost/must-run power plants/units**.

¹³ Eskom. Partnering for a Sustainable Future. Integrated Report for 2011.

¹⁴ <http://www.eskom.co.za/c/article/236/cdm-calculations/> (2 February 2012)

$$EF_{grid,OMsimple,y} = \frac{\sum_{i,m} FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO_2,i,y}}{\sum_m EG_{m,y}} \quad (1 \text{ and } 2)$$

Where:

- $EF_{grid,OMsimple,y}$ = Simple operating margin CO₂ emission factor in year y (tCO₂/MWh)
 $FC_{i,m,y}$ = Amount of fossil fuel type *i* consumed by power plant/unit *m* in year *y* (mass or volume unit)
 $NCV_{i,y}$ = Net calorific value (energy content) fossil fuel type *i* in year *y* (GJ/mass or volume)
 $EF_{CO_2,i,y}$ = CO₂ emission factor of fossil fuel type *i* in year *y* (tCO₂/GJ)
 $EG_{m,y}$ = Net electricity generated and delivered to the grid by power plant/unit *m* in year *y* (MWh)
m = All power plants/units serving the grid in year *y* except low-cost/must-run power plants/units
i = All fossil fuel types combusted in power plant/unit *m* in year *y*
y = Three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation.

Table 1: Summary of calculation of simple operating margin emission factor

| | | | |
|-----------|--|------------------------|-------------|
| 2008/2009 | $EF_{grid,OMsimple,y} = \sum_{i,m} FC_{i,m,y} * NCV_{i,y} * EF_{CO_2,i,y} / \sum_m EG_{m,y}$ | t CO ₂ /MWh | 1.02 |
| | $FC_{coal,m,y}$ | tonne | 122 422 536 |
| | $NCV_{coal,y}$ | GJ/tonne | 19.9 |
| | $EF_{CO_2,coal,y}$ | t CO ₂ /GJ | 0.0895 |
| | $EG_{m,y}$ | MWh | 211 690 925 |
| 2009/2010 | $EF_{grid,OMsimple,y} = \sum_{i,m} FC_{i,m,y} * NCV_{i,y} * EF_{CO_2,i,y} / \sum_m EG_{m,y}$ | t CO ₂ /MWh | 1.01 |
| | $FC_{coal,m,y}$ | tonne | 122 960 688 |
| | $NCV_{coal,y}$ | GJ/tonne | 19.9 |
| | $EF_{CO_2,coal,y}$ | t CO ₂ /GJ | 0.08950 |
| | $EG_{m,y}$ | MWh | 215 939 904 |
| 2010/2011 | $EF_{grid,OMsimple,y} = \sum_{i,m} FC_{i,m,y} * NCV_{i,y} * EF_{CO_2,i,y} / \sum_m EG_{m,y}$ | t CO ₂ /MWh | 1.009 |
| | $FC_{coal,m,y}$ | tonne | 125 505 780 |
| | $NCV_{coal,y}$ | GJ/tonne | 19.9 |
| | $EF_{CO_2,coal,y}$ | t CO ₂ /GJ | 0.08950 |
| | $EG_{m,y}$ | MWh | 220 226 102 |

The simple operating margin was calculated based on the ex ante option. The information was available from the Eskom website¹⁵ for 2008/2009, 2009/2010, 2010/2011 and the lower calorific values and emission factors were taken from the IPCC 2006 Guidelines. The power plants not included were low-cost/must-run which were identified as nuclear, hydro, low-cost biomass and solar generation.

Therefore, the power plants evaluated to be included were coal-fired and liquid fuel OCGT power stations. The net energy generation and fuel consumption data were taken from the Eskom website³.

Table 2: Breakdown of calculation of emission factor for the simple operating margin: 2008/2009

¹⁵ http://www.eskom.co.za/live/content.php?Item_ID=4226 (5 November 2010)



| Power Station | MWh | FC (tons) | Weight Ave | EFi | EF _{OMSimple,v} |
|---------------|--------------------|--------------------|------------|------|--------------------------|
| Arnot | 11 987 281 | 6 395 805 | 5.7% | 0.95 | 0.05 |
| Duvha | 21 769 489 | 11 393 553 | 10.3% | 0.93 | 0.10 |
| Hendrina | 12 296 687 | 7 122 918 | 5.8% | 1.03 | 0.06 |
| Kendal | 23 841 401 | 15 356 595 | 11.3% | 1.15 | 0.13 |
| Kriel | 18 156 686 | 9 420 764 | 8.6% | 0.92 | 0.08 |
| Lethabo | 23 580 232 | 16 715 323 | 11.1% | 1.26 | 0.14 |
| Matimba | 26 256 068 | 13 991 453 | 12.4% | 0.95 | 0.12 |
| Majuba | 22 676 924 | 12 554 406 | 10.7% | 0.99 | 0.11 |
| Matla | 21 863 400 | 12 689 387 | 10.3% | 1.03 | 0.11 |
| Tutuka | 21 504 122 | 11 231 583 | 10.2% | 0.93 | 0.09 |
| Camden | 6 509 079 | 3 876 211 | 3.1% | 1.06 | 0.03 |
| Grootvlei | 1 249 556 | 674 538 | 0.6% | 0.96 | 0.01 |
| Komati | 0 | 0 | 0% | 0 | 0 |
| Total | 215 952 310 | 121 422 536 | | | 1.02 |

Table 3: Breakdown of calculation of emission factor for the simple operating margin: 2009/2010

| Power Station | MWh | FC (tons) | Weight Ave | EFi | EF _{OMSimple,v} |
|---------------|--------------------|--------------------|------------|------|--------------------------|
| Arnot | 13 227 864 | 6 794 134 | 6.1% | 0.91 | 0.06 |
| Duvha | 22 581 228 | 11 744 606 | 10.5% | 0.93 | 0.10 |
| Hendrina | 12 143 292 | 6 905 917 | 5.6% | 1.01 | 0.06 |
| Kendal | 23 307 031 | 13 866 514 | 10.8% | 1.06 | 0.11 |
| Kriel | 15 906 816 | 8 504 715 | 7.4% | 0.95 | 0.07 |
| Lethabo | 25 522 698 | 18 170 227 | 11.8% | 1.27 | 0.15 |
| Matimba | 27 964 141 | 14 637 481 | 12.9% | 0.93 | 0.12 |
| Majuba | 22 340 081 | 12 261 833 | 10.3% | 0.98 | 0.10 |
| Matla | 21 954 536 | 12 438 391 | 10.2% | 1.01 | 0.10 |
| Tutuka | 19 847 894 | 10 602 839 | 9.2% | 0.95 | 0.09 |
| Camden | 7 472 070 | 4 732 163 | 3.5% | 1.13 | 0.04 |
| Grootvlei | 2 656 230 | 1 637 371 | 1.2% | 1.10 | 0.01 |
| Komati | 1 016 023 | 664 497 | 0.5% | 1.16 | 0.01 |
| Total | 215 952 310 | 122 960 688 | | | 1.01 |

Table 4: Breakdown of calculation of emission factor for the simple operating margin: 2010/2011

| Power Station | MWh | FC (tons) | Weight Ave | EFi | EF _{OMSimple,v} |
|---------------|--------------------|--------------------|------------|------|--------------------------|
| Arnot | 12 194 878 | 6 525 670 | 5.5% | 0.95 | 0.05 |
| Duvha | 20 267 508 | 10 639 393 | 9.2% | 0.93 | 0.09 |
| Hendrina | 11 938 206 | 7 139 198 | 5.4% | 1.07 | 0.06 |
| Kendal | 25 648 258 | 15 174 501 | 11.6% | 1.05 | 0.12 |
| Kriel | 18 204 910 | 9 527 185 | 8.3% | 0.93 | 0.08 |
| Lethabo | 25 500 366 | 17 774 699 | 11.6% | 1.24 | 0.14 |
| Matimba | 28 163 040 | 14 596 842 | 12.8% | 0.92 | 0.12 |
| Majuba | 24 632 585 | 13 020 512 | 11.2% | 0.94 | 0.11 |
| Matla | 21 504 422 | 12 155 421 | 9.8% | 1.01 | 0.10 |
| Tutuka | 19 067 501 | 10 191 709 | 8.7% | 0.95 | 0.08 |
| Acacia | 992 | 444 957 | 0.0005% | 1.02 | 0.000005 |
| Port Rex | 5 507 | 281 941 | 0.003% | 0.12 | 0.000003 |
| Camden | 7 490 836 | 4 629 763 | 3.4% | 1.10 | 0.04 |
| Grootvlei | 3 546 952 | 2 132 979 | 1.6% | 1.07 | 0.02 |
| Komati | 2 060 141 | 1 271 010 | 0.9% | 1.10 | 0.01 |
| Total | 215 952 310 | 125 505 780 | | | 1.01 |

Step 5: Calculate the build margin (BM) emission factor

In terms of vintage of data, we have selected option 1 which means that the build margin emission factor is calculated ex-ante for the first crediting period based on the most recent information available on the units already built for sample group m at the time of the CDM-PDD submission to the DOE for validation. For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period.

The following power plants are connected to the electricity grid:

| Power Station | Date of Commissioning | Generation for 2010/2011 (MWh) |
|----------------|-----------------------|--------------------------------|
| Arnot | 21/09/1971 | 12 194 878 |
| Duvha | 18/01/1980 | 20 267 508 |
| Hendrina | 12/05/1970 | 11 938 206 |
| Kendal | 01/10/1988 | 25 648 258 |
| Kriel | 06/05/1976 | 18 204 910 |
| Lethabo | 22/12/1985 | 25 500 366 |
| Matimba | 04/12/1987 | 28 163 040 |
| Majuba | 01/04/1996 | 24 632 585 |
| Matla | 29/09/1979 | 21 504 422 |
| Tutuka | 01/06/1985 | 19 067 501 |
| Koeberg | 21/07/1984 | 0 |
| Acacia | 13/05/1976 | 992 |
| Port Rex | 30/09/1976 | 5 507 |
| Camden | 21/12/1966 | 7 490 836 |
| Grootvlei | 30/06/1969 | 3 546 952 |
| Komati | 06/11/1961 | 2 060 141 |
| Colley Wobbles | 01/01/1985 | 0 |
| First Falls | 01/02/1979 | 0 |
| Gariiep | 08/09/1971 | 0 |
| Ncora | 01/03/1983 | 0 |
| Second Falls | 01/04/1979 | 0 |
| Van Der Kloof | 01/01/1977 | 0 |
| Drakensberg | 17/06/1981 | 0 |
| Palmiet | 18/04/1988 | 0 |
| Total | | 215 952 310 |

The sample group of power units m to be used to calculate the build margin is identified using the procedure as set out below:

- a) Identify the set of five power units , excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently (SET_{5-units}) and determine their annual electricity generation (AEG_{SET-5-units}, in MWh);

| Power Station | Date of Commissioning | Generation for 2010/2011 (MWh) |
|----------------|-----------------------|--------------------------------|
| Majuba | 01/04/1996 | 24 632 585 |
| Palmiet | 18/04/1988 | 0 |
| Kendal | 01/10/1988 | 25 648 258 |
| Matimba | 04/12/1987 | 28 163 040 |
| Colley Wobbles | 01/01/1985 | 0 |
| Total | | 78 443 883 |

- b) Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total} , in MWh).

| Power Station | MWh |
|---------------|--------------------|
| Arnot | 12 194 878 |
| Duvha | 20 267 508 |
| Hendrina | 11 938 206 |
| Kendal | 25 648 258 |
| Kriel | 18 204 910 |
| Lethabo | 25 500 366 |
| Matimba | 28 163 040 |
| Majuba | 24 632 585 |
| Matla | 21 504 422 |
| Tutuka | 19 067 501 |
| Acacia | 992 |
| Port Rex | 5 507 |
| Camden | 7 490 836 |
| Grootvlei | 3 546 952 |
| Komati | 2 060 141 |
| Total | 215 952 310 |

- c) Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) ($SET_{\geq 20\%}$) and determine their annual electricity generation ($AEG_{SET_{\geq 20\%}}$, in MWh);

| Power Station | Date of Commissioning | Generation for 2010/2011 (MWh) |
|---------------|-----------------------|--------------------------------|
| Majuba | 01/04/1996 | 24 632 585 |
| Palmiet | 18/04/1988 | 0 |
| Kendal | 01/10/1988 | 25 648 258 |
| Total | | 50 280 843 |

- d) From $SET_{5\text{-units}}$ and $SET_{\geq 20\%}$ select the set of power units that comprises the larger annual electricity generation (SET_{sample});

| Power Station | Date of Commissioning | Generation for 2010/2011 (MWh) |
|----------------|-----------------------|--------------------------------|
| Majuba | 01/04/1996 | 24 632 585 |
| Palmiet | 18/04/1988 | 0 |
| Kendal | 01/10/1988 | 25 648 258 |
| Matimba | 04/12/1987 | 28 163 040 |
| Colley Wobbles | 01/01/1985 | 0 |
| Total | | 78 443 883 |

- e) Identify the date when the power units in SET_{sample} started to supply electricity to the grid. If none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago, then use SET_{sample} to calculate the build margin. In this case ignore steps (d), (e) and (f).

Otherwise:

- a) Exclude from SET_{sample} the power units which started to supply electricity to the grid more than 10 years ago. Include in that set the power units registered as CDM project activities, starting with power units that started to supply electricity to the grid most recently, until the electricity generation of the new set comprises 20% of the annual electricity generation of the project

electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) to the extent is possible. Determine for the resulting set ($SET_{\text{sample-CDM}}$) the annual electricity generation ($AEG_{\text{SET-sample-CDM}}$, in MWh);

If the annual electricity generation of that set is comprises at least 20% of the annual electricity generation of the project electricity system (i.e. $AEG_{\text{SET-sample-CDM}} \geq 0.2 \times AEG_{\text{total}}$), then use the sample group $SET_{\text{sample-CDM}}$ to calculate the build margin. Ignore steps (e) and (f).

There are no power units in this sample group.

Otherwise:

- b) Include in the sample group $SET_{\text{sample-CDM}}$ the power units that started to supply electricity to the grid more than 10 years ago until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation);

| Power Station | Date of Commissioning | Generation for 2010/2011 (MWh) |
|---------------|-----------------------|--------------------------------|
| Majuba | 01/04/1996 | 24 632 585 |
| Palmiet | 18/04/1988 | 0 |
| Kendal | 01/10/1988 | 25 648 258 |
| Total | | 50 280 843 |

- c) The sample group of power units m used to calculate the build margin is the resulting set ($SET_{\text{sample-CDM->10yrs}}$).

| Power Station | Date of Commissioning | Generation for 2010/2011 (MWh) |
|---------------|-----------------------|--------------------------------|
| Majuba | 01/04/1996 | 24 632 585 |
| Palmiet | 18/04/1988 | 0 |
| Kendal | 01/10/1988 | 25 648 258 |
| Total | | 50 280 843 |

The build margin emissions factor is the generation-weighted average emission factor (tCO_2/MWh) of all power units m during the most recent year y for which power generation data is available, calculated as follows:

$$EF_{\text{grid,BM},y} = \frac{\sum_m EG_{m,y} \cdot EF_{EL,m,y}}{\sum_m EG_{m,y}} \tag{13}$$

- $EF_{\text{grid,BM},y}$ = Build margin CO_2 emission factor in year y (tCO_2/MWh)
- $EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
- $EF_{EL,m,y}$ = CO_2 emission factor of power unit m in year y (tCO_2/GJ)
- m = Power units included in the build margin
- y = Most recent historical year for which power generation is available

The CO_2 emission factor of each power unit m ($EL_{EL,m,y}$) should be determined as per the guidance in step 3(a) for the simple OM, using options B1, B2, B3, using for y the most recent historical year for which power generation data is available and using for m the power units included in the build margin.

If for a power unit m data on fuel consumption and electricity generation is available the emission factor ($EF_{EL,m,y}$) should be determined as follows:

$$EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{\sum_m EG_{m,y}} \quad (2)$$

- $EF_{EL,m,y}$ = CO₂ emission factor of power unit m in year y (tCO₂/MWh)
- $FC_{i,m,y}$ = Amount of fossil fuel type i consumed by power unit m in year y (mass or volume unit)
- $NCV_{i,y}$ = Net calorific value (energy content) fossil fuel type i in year y (GJ/mass or volume)
- $EF_{CO2,i,y}$ = CO₂ emission factor of fossil fuel type i in year y (tCO₂/GJ)
- $EG_{m,y}$ = Net electricity generated and delivered to the grid by power unit m in year y (MWh)
- m = All power plants/units serving the grid in year y except low-cost/must-run power plants/units
- i = All fossil fuel types combusted in power plant/unit m in year y
- y = either three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex ante option) or the applicable year during monitoring (ex post option), following the guidance on data vintage in step 2.

Table 3: Breakdown of calculation of emission factor of build margin

| Power Station | MWh | FC (tons) | $EF_{EL,m,y}$ | EF_{BM} |
|---------------|-------------------|------------|---------------|-------------|
| Majuba | 24 632 585 | 13 020 512 | 0.94 | 0.46 |
| Palmiet | 0 | 0 | 0 | 0 |
| Kendal | 25 648 258 | 15 174 501 | 1.05 | 0.54 |
| Total | 50 280 843 | | | 1.00 |

Step 6: Calculate the combined margin emission factor

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM} \quad (14)$$

- $EF_{grid,BM,y}$ = Build Margin CO₂ emission factor in year y (tCO₂/MWh)
- $EF_{grid,OM,y}$ = Operating margin CO₂ emission factor in year y (tCO₂/MWh)
- w_{OM} = Weighting of operating margin emissions factor (%)
- w_{BM} = Weighting of build margin emissions factor (%)

The following default values should be used for w_{OM} and w_{BM} :

- Wind and solar power generation project activities: $w_{OM} = 0.75$ and $w_{BM} = 0.25$ (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods.
- All other projects: $w_{OM} = 0.5$ and $w_{BM} = 0.5$ for the first crediting period, and $w_{OM} = 0.25$ and $w_{BM} = 0.75$ for the second and third crediting period, unless otherwise specified in the approved methodology which refers to this tool.



Alternative weights can be proposed, as long as $w_{OM} + w_{BM} = 1$, for consideration by the Executive Board, taking into account the guidance as described below. The values for $w_{OM} + w_{BM}$ applied by project participants should be fixed for a crediting period and may be revised at the renewal of the crediting period.

Table 4: Calculation of the combined margin for non-intermittent generation in the first crediting period

| | | |
|--|------------------------|-------------|
| $EF_{grid,CM,y} = EF_{grid,OM,y} * w_{OM} + EF_{grid,BM,y} * w_{BM}$ | t CO ₂ /MWh | 1.00 |
| $EF_{grid,OM,y}$ | t CO ₂ /MWh | 0.99 |
| w_{OM} | (%) | 0.5 |
| $EF_{grid,BM,y}$ | t CO ₂ /MWh | 1.0 |
| w_{BM} | (%) | 0.5 |

In conclusion, the emission factor for the South African grid for 2008/2009 – 2010/2011 was calculated to be 1.00 t CO₂/MWh.

**Appendix 5: Further background information on the monitoring plan**

History of the document

| Version | Date | Nature of revision(s) |
|---|-------------------------------|---|
| 02.0 | EB 66 13 March 2012 | Revision required to ensure consistency with the "Guidelines for completing the programme design document form for small-scale CDM programmes of activities" (EB 66, Annex 13). |
| 01 | EB33, Annex43 27 July 2007 | Initial adoption. |
| Decision Class: Regulatory Document Type: Form Business Function: Registration | | |