Eskom	Eskom Air Quality Offset Implementation Plans for Lethabo Power Station	Sustainability Division: Environmental Management

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CONTENTS

Page

EXECUTIVE SUMMARY

Eskom is pursuing a multi-pronged approach to improving ambient air quality, including reducing emissions at the existing coal-fired fleet, investing in power generation from renewables and nuclear, and implementing air quality offsets. Retrofitting abatement technology and diversifying the energy fleet are extremely costly (hundreds of billions of rands) and take a long time to implement. Air quality offsets address emission sources directly within vulnerable communities, targeting greater improvement in community experienced air quality than is achievable from other approaches. In addition, such offsets are more cost effective and result in meaningful improvement of air quality within a shorter time frame.

This Air Quality Implementation Plan for Lethabo Power Station covers the period from April 2019 to March 2025, and aims to improve ambient air quality in several communities around Lethabo.

This high-level plan has been compiled in order to:

- obtain approval from the authorities on the proposed offsets methodology, the types of offsets to be implemented, and the areas for implementation
- fulfil the requirement in Lethabo Power Station's Atmospheric Emission Licence to submit an offsets implementation plan

This plan has been developed based on rigorous scientific methods and testing, and in consultation with key stakeholders. Consultation conducted for the development of this high-level plan is merely the start of the public participation process that will be undertaken for the air quality offsets programme. In-depth community consultation will be undertaken prior to the implementation of the interventions. This community consultation will inform the offsets project design for each area, and ensure support for and correct implementation of the offsets in each community.

This Air Quality Offsets Implementation Plan is an update of the plan submitted in March 2018, and it will be updated further at regular intervals, as experience is gained and more detailed information becomes available. Main updates from the March 2018 version of the plan include:

- The implementation of offsets initiatives in the selected communities will now be executed in three phases (refer to figure 1 below). The lead implementation which entail rollout of a waste solution in Sharpeville as part of phase 1. Phase 2 will entail rollout of waste related solution in BoiTshepiVille (Boipatong, Tshepiso and Sharpeville) and Refengkotso. Phase 3 will entail a household solution in Refengkotso. Figure 1 provide summary of the plan.
- Phase 1, the lead implementation in Sharpeville, was initially planned to start in January 2019, but has been delayed due to challenges with the internal approval processes and delays with procurement of the required services to execute the project. It is now intended to start physical implementation from October 2019
- The criteria for selection of illegible households have been changed to include only solid fuel using household living in formal houses. The installation of the ceiling will be limited to 60 m^2 per household. The community of Refengkotso will be engaged prior to implementation and will be invited to register their interest to participant in the programme and sign an enabling contract.
- A contract has been put in place with the Medical Research Council (MRC) to determine the health impacts of the air quality offsets in KwaZamokuhle and Emzimnoni. Lessons from the study will be applied to household solution in Refengkotso.

The baseline assessment in Sharpeville has been concluded, and confirms waste burning as an important local source of emissions. This was further confirmed by the source apportionment study recently conducted for the Vaal Triangle Priority Area by North West University.

The Air Quality Offset Implementation Plan for the Lethabo Power Station proposes the following:

1. A phased approach

Air quality offsets is a nascent field, and interventions of the type and scale contemplated in this document have not been implemented before. Accordingly, a phased approach is adopted to increase probability of success and to ensure that learnings from early phases are incorporated into an accelerated large scale roll-out:

Phase 0: Pilot project. An intervention is tested on a small scale to discover practically what works.

Phase 1: Lead implementation. The intervention is tested on an entire community to see how best to scale up an initiative. The lead implementation is designed to benefit the specific local community, minimize implementation risk, increase practical and scientific knowledge, and develop and refine monitoring, reporting and verification processes.

Phase 2: Full implementation in Boipatong, Tshepiso and Sharpeville. Once the intervention has been refined and the learnings of the lead implementation incorporated, the intervention will be rolled out at a bigger scale across BoiTshepiVille (Boipatong, Tshepiso and Sharpeville).

Phase 3: Full implementation in smaller settlements. In this phase, the interventions will be rolled out at the remaining settlement i.e. Refengkotso. More information needs to be gathered in Refengkotso to understand the nature and extend pollution sources so that appropriate intervention could be designed.

A typical offset implementation in a community will have three stages:

i) *Baseline establishment*: The baseline will provide a basis for comparison to determine the improvement in air quality due to the offset, and information gathered from the community will inform the project design for the offset roll-out.

ii) *Implementation*: The speed of implementation depends on the number of work teams set up in the community. Teams need to be mainly recruited from the local community as far as possible.

iii) *Maintenance, monitoring and verification*: A structure will be set up to ensure that the interventions can be maintained by local entities, and the effectiveness of the interventions will be monitored.

2. Selection of offset interventions

Scientific studies have repeatedly shown that, in areas where households burn coal or wood for cooking and heating, it is emissions from this domestic burning that makes the greatest contribution to ambient levels of particulate matter (FRIDGE, 2004; MRC, 2008; Lim et al. (2012)). However, there has been a steady move away from domestic coal burning in the Vaal over the last decade or so, and it is estimated that between 35% of households in lower income areas use coal for cooking and heating (compared to 50-70% of households in lower income areas in Mpumalanga). It is clear then that a focus on reducing domestic burning alone will not be adequate for the Vaal, and so Eskom is exploring alternative ways to improve local air quality. Waste burning has been identified as another significant source of local emissions in many settlements.

Lethabo's offsets programme will have two main thrusts: addressing waste burning and domestic fuel burning for heating and cooking. This Air Quality Offsets Implementation Plan is based on a **Programme of Activities** comprising of:

i) *Waste burning interventions*: Reasons for waste burning practices will be identified in the baseline phase of the project through engagements with the community and air quality monitoring, and then an intervention will be developed. This intervention will be tested and refined in a pilot study before it is scaled up.

ii) *Household interventions*: Emissions from the domestic burning of coal/wood will be reduced through one or more of the following:
- Assist households to move to a cleaner source of energy (like electricity and/or LPG)
- Providing households with cleaner burning heating and/or cooking devices
- Reducing the need for heating by better insulating houses, where possible

iii) *Education and awareness raising*: Continual interaction with the community is needed to ensure that the interventions are used and maintained properly (for example, that waste should be recycled or disposed of in dumpsters, and not burnt on open land), and to encourage behavioural change to reduce exposure and smoke generation.

iv) *Projects in development*: Since this Air Quality Offsets Implementation Plan spans 7 years, the interventions cannot remain static but need to change as new technologies become available and as circumstances of communities change.

3. Selection of areas for offsets

Areas are selected based on the following criteria:

i) Areas are prioritised based on the impact of emissions from the power station (in order to achieve the objective of 'counterbalancing the adverse and residual environmental impact of atmospheric emissions').
ii) Only areas where there is (probably) non-compliance with ambient air quality standards are considered.

iii) Only areas where opportunities for improving ambient air quality through offsetting exist, are considered (i.e. areas where there are local sources of emissions which significantly impact ambient air quality and can be addressed through offsets).

The areas proposed for Lethabo's offsets roll-out are:

Table 1: Areas selected for Lethabo Power Station's air quality offsets roll-out

Settlement	Intervention type
Sharpeville	Waste offset (Phase 1 & 2)
Refengkotso	Waste offsets and household(Phase 2 & 3)
Tshepiso	Waste offset (Phase 2)
Boipatong	Waste offset (Phase 2)

The plan for the Lethabo offsets roll-out is as follows:

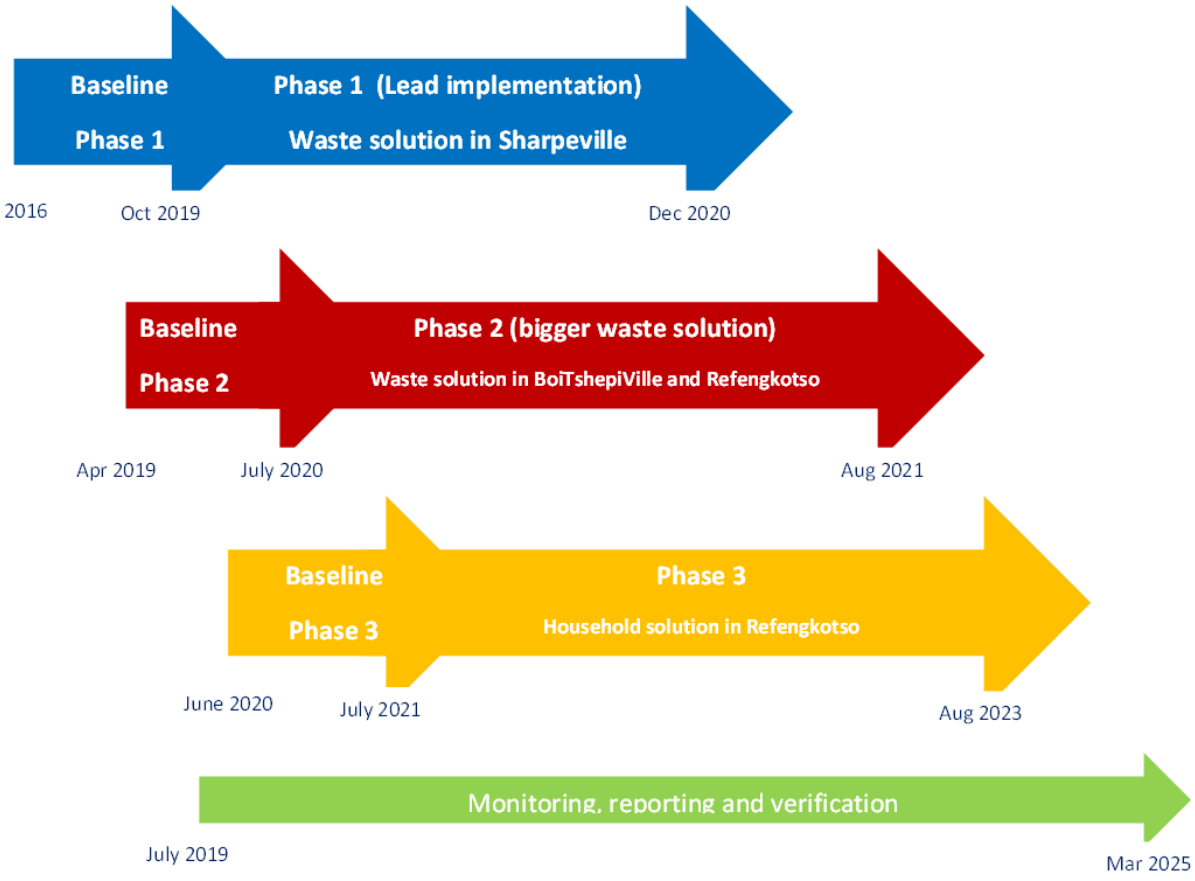


Figure 1: Preliminary schedule for the roll-out of the air quality offsets for Lethabo. This schedule will be refined after community engagements and the scope of interventions for each community decided on.

The implementation timeline is dependent on procurement approvals and on funding being allocated by Eskom. In the previous revisions of this plan Eskom indicated that the implementation time line was dependant on the NERSA tarrif approval. In March 2018 NERSA approved a tariff level below that requested by Eskom. As such Eskom will be undertaking a funding re-prioritisation exercise which may unfortunately impact on the implementation of this plan. The authorities will be notified of any significant changes in the plan necessitated by funding reviews.

We propose that this Air Quality Offsets Implementation Plan for Lethabo Power Station be updated annually, as experience is gained and more information becomes available. In addition, we propose that Eskom's implementation of air quality offsets in the vicinity of Lethabo Power Station be documented in an annual progress report.

The offset plan described in this document illustrates that improvement of community environmental parameters are achievable within the context of limited national resources and competing national imperatives.

The air quality offset implementation plan submitted in April 2016 was approved by the National Air Quality Officer, after consultation with the Atmospheric Emission Licencing Authority, in a letter to Eskom dated 16 September 2016. We consider that this approval extends to this revised version of the implementation plan, as the changes to the original plan are not substantial and the additional conditions of the approval will still be complied with.

ABBREVIATIONS

Abbreviation	Description
AEL	Atmospheric Emission Licence
AQA	National Environmental Management: Air Quality Act (Act No 39 of 2004)
CPA-DD	Component project activity design document
DEA	Department of Environmental Affairs
DoE	Department of Energy
ESP	Electrostatic precipitator
FFP	Fabric filter plant
LPG	Liquid petroleum gas
LSRG	Local Stakeholder Reference Group
MYPD	Multi-Year Price Determination (for Eskom's electricity tariff)
NERSA	National Electricity Regulator
NOx	Oxides of nitrogen
PDD	Project design document
PM	Particulate matter
PoA	Programme of activities
PoA-DD	Programme of activities design document
RDP	Reconstruction and Development Programme
SO_2	Sulphur dioxide
NWU	North West University

1. INTRODUCTION

Eskom is pursuing a multi-pronged approach to improving ambient air quality, including investing in power generation from renewables and nuclear, reducing emissions at the existing coal-fired fleet (Figure 2), and air quality offsets. Air quality offsets are designed to reduce human exposure to harmful levels of air pollution by reducing emissions from local sources, like domestic coal burning and waste burning. Examples of air quality offsets are switching households from coal to cleaner energy sources, and improving waste collection and recycling. Air quality offsets can counterbalance the effect of emissions from power stations on the air quality in the vicinity of power stations. This document deals with the offset initiative, while the emission reduction plans are embedded in Eskom's capital expenditure budgets.

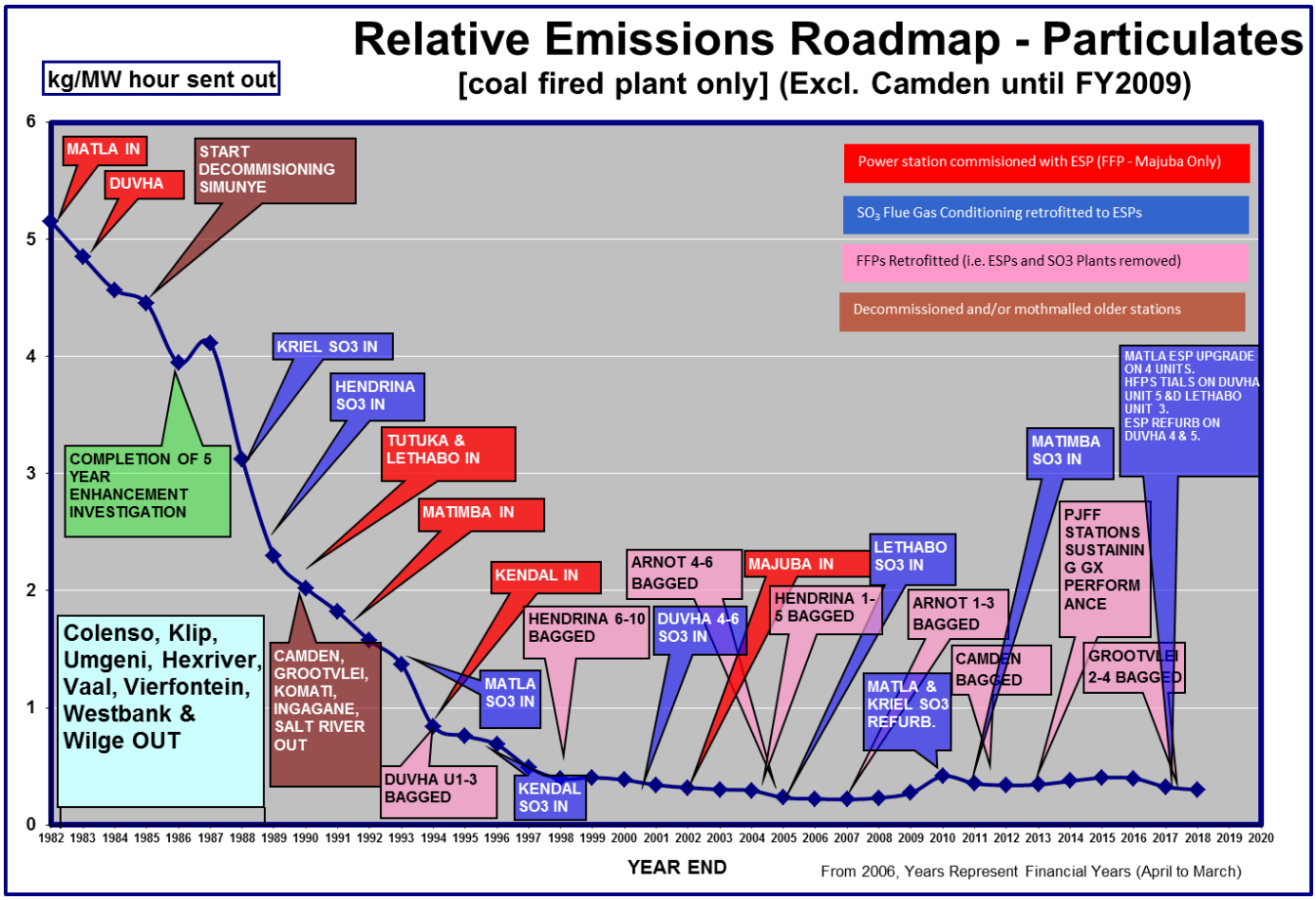


Figure 2: Change in relative emissions of particulates (ash) from Eskom's power stations from the early 1980s to present.

Lethabo Power Station wishes to implement air quality offsets in order to:

- Improve the air quality of communities affected by emissions from Lethabo
- Comply to the requirements of Lethabo's Atmospheric Emission Licence

- Achieve a solution to air quality issues that is beneficial to affected communities and the South African economy, while also meeting the requirement of the relevant authorities

This Air Quality Offsets Implementation Plan is for Lethabo Power Station (Figure 3). It covers the period from April 2019 to March 2025. This document has been developed for submission to the National Air Quality Officer and the Licencing Authority (the Fezile Dabi Municipality), and also to elicit input from key stakeholders into the development of the power stations' air quality offsets programme.

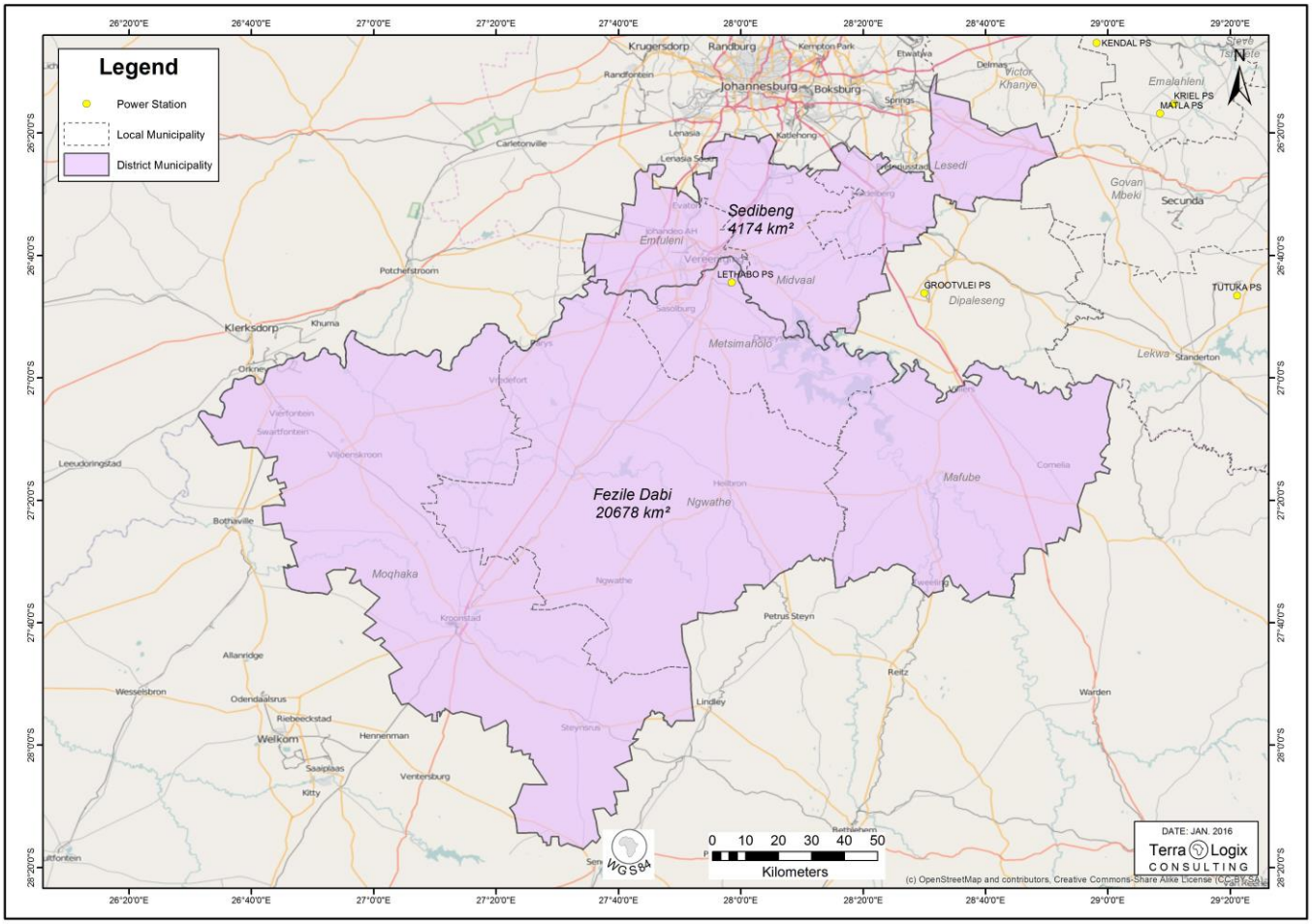


Figure 3: Location of Lethabo Power Station in the Fezile Dabi District Municipality

This is a high-level plan, based on the information available at the time of compilation. It is an update of the updated plan published in March 2018 (the plan was first published in April 2016). The plan details, to the extent possible, the proposed offset interventions per selected settlement. It details the approach followed in selecting settlements; selecting, designing and implementing interventions; and assessing the effectiveness of the interventions. Detailed plans per community can only be developed based on extensive consultation with each community and baseline monitoring conducted in each community. However, the extensive community consultation and monitoring can only take place once there has been high level approval of the principles used to compile the offset plans, the areas where offsets are to be implemented, and the timeline for implementation which form the basis of the extensive community

consultation and monitoring. This plan will be updated and refined annually as more information becomes available.

In the previous revisions of this plan Eskom indicated that the implementation time line was dependant on the NERSA tarrif approval. In March 2018 NERSA approved a tariff level below that requested by Eskom. As such Eskom will be undertaking a funding re-prioritisation exercise which may unfortunately impact on the implementation of this plan. The authorities will be notified of any significant changes in the plan necessitated by funding reviews.

2. APPLICABLE LEGISLATION AND REGULATORY REQUIREMENTS

2.1 ATMOSPHERIC EMISSION LICENCE

Section 4.4 of Lethabo Power Station's Atmospheric Emission Licence (AEL) number FDDM-MET-2011-08-P1 states that:
'A definite offsets implementation plan to reduce PM pollution in the ambient/receiving environment is to be presented to the NAQO and the Licensing Authority by 31 March 2016 and followed by an appropriate public participation process.'

2.2 DECISION ON POSTPONEMENT OF COMPLIANCE TIMEFRAMES WITH MINIMUM EMISSION STANDARDS

The AEL requirement is similar to a condition in the National Air Quality Officer's decision (February 2015) on Lethabo Power Station's application for postponement of the compliance timeframes with the National Environmental Management: Air Quality Act (Act No 39 of 2004) section 21 Minimum Emission Standards, which states that Lethabo is '*to implement an offset programme to reduce PM in the ambient/receiving environment. A definite offset implementation plan is expected from Eskom by 31 March 2016.*'

2.3 AIR QUALITY OFFSETS GUIDELINE

This Air Quality Offsets Implementation Plan has been drafted according to the Air Quality Offsets Guideline (Notice 333 of 2016) published on 18 March 2016.

Eskom adopts the definition of an air quality offsets given in this document as '*an intervention, or interventions, specifically implemented to counterbalance the adverse and residual environmental impact of atmospheric emissions in order to deliver a net ambient air quality benefit within, but not limited to, the affected airshed where ambient air quality standards are being or have the potential to be exceeded and whereby opportunities and need for offsetting exist*.'

The Air Quality Offsets Guideline lays out the legislative context for air quality offsets, and states that '*offsets can provide an option for achieving improvements in ambient air quality, thereby improving human health while promoting justifiable economic development*.'

The Air Quality Offsets Guideline lists the following air quality offsetting principles:

a) Outcome based: The primary aim of air quality offsets is '*improvements in ambient air quality within the airshed.*'

b) No "like for like": Offsets should '*address pollutant(s) whose ambient concentration is/are of concern in a particular area, and not necessarily the pollutant(s) whose emission from a specific facility is/are of concern.*'

c) Transparency and acceptability: '*Air Quality offsets should be based on open, fair and accountable administrations by both the applicants and the authorities. A public consultation process should be undertaken to ensure public buy-in of offsets'*.

d) Complementarity: '*The facility must make all reasonable efforts to avoid and reduce/mitigate emissions before offsets can be considered*'

e) Sustainability: '*Offset projects should be based on long-term air quality improvement without impeding on other socio-economic and environmental objectives*.'

f) Measurable and scientifically robust: '*Any approved offset must have measureable air quality outcomes … In order to quantify emission reduction of an offset, [a] realistic baseline representing forecasted emission levels in the absence and presence of the offset project should be established*.'

3. ESKOM'S AIR QUALITY OFFSETTING PRINCIPLES

Eskom has strived to align its understanding of air quality offsetting with others as far as possible by basing this plan on the Air Quality Offset Guideline (published on 18 March 2016), and through consultation with key stakeholders in the development of this plan.

The following principles underpin Eskom's offsetting philosophy:

i) Do no harm:
- All households and communities should be better off after an offsets roll-out
- Offset interventions must have a *positive impact on both the livelihoods and the quality of life* of the community where they are implemented.
- Households will not be required to pay more for fuel after the offsets implementation than before.

ii) Complementary measure to power station abatement efforts:
- Air quality offsets are to be implemented *in conjunction with emission reductions at power stations* through upgrades and emission abatement retrofits. Eskom has updated it Emission Reduction Plan as part of its 2019 MES postponement application. Key elements of the plan include:
- Eskom proposes to continue adopting a phased and prioritised approach to achieve compliance in terms of the MES. Reduction of Particulate Matter (PM) emissions has been prioritised, as PM is considered to be the ambient pollutant of greatest concern in South Africa.

- Eskom proposes to reduce NO_x emissions at the three highest emitting stations. Kusile Power Station will be commissioned with abatement technology to achieve the new plant standards for PM, NO_x and SO_2.
- Medupi is commissioned with abatement technology which can meet PM and NO_x new plant standards and will be retrofitted with flue-gas desulphurisation (FGD) so that the new plant SO_2 limit will also be achieved over time.
- There are six power stations which will be decommissioned before 2030 (totalling in excess of 10 000MW), and an additional two by 2035 (totalling in excess of 7 000MW) and the remaining existing plants by 2044 (excluding Majuba, Medupi and Kusile).
- Lethabo Power Station will be reducing participate emissions by installing high frequency transformers, refurbishing the electrostatic precipitator and dust handling plants, and upgrading the SO_3 plants.

iii) Cost effective:

- Offsetting is a *cost effective* way of improving poor air quality and reducing exposure to harmful levels of pollution, at least cost to the South African economy. If an emission reduction retrofit can achieve a greater improvement in air quality at less cost than an offset, then the retrofit will be conducted rather than the offset.

iv) Focus on communities and reducing human exposure:

- The main objective of air quality offsetting is to *improve ambient air quality*. Only projects which have the potential to improve ambient air quality will be included in the offsets programme.
- Offsets specifically target ambient air quality as experienced by impacted *communities* (thus not all air is of equal importance)

v) A transitional solution:

- Offsetting is seen as an *interim measure* to address poor air quality, while the South African electricity generation mix transitions to cleaner technologies, and while communities move up the energy ladder and have access to improved services. Nevertheless, offsets which are implemented need to be sustainable.
- Offset interventions that decrease structural (long term) energy requirements are preferred over interventions that merely move pollution to other areas or temporarily avoid pollution

vi) Transparent and acceptable:

- Participation in the offsets interventions is *voluntary*. People will not be coerced to participate in the project.

4. PROCESS FOLLOWED TO DEVELOP THE AIR QUALITY OFFSETS IMPLEMENTATION PLAN

This Air Quality Offsets Implementation Plan has been based on a scientific process of feasibility studies, testing and demonstration, and on consultation with key stakeholders. . It is also influenced by the role

that Eskom is required to play in the South African economy. Cognisance was taken of the synthesis in *Air Pollution in Dense, Low-income Settlements in South Africa* (Pauw et al., 2008).

4.1 SCIENTIFIC DEVELOPMENT PROCESS

Between 2011 and 2013, Eskom conducted a *desktop pre-feasibility study* to identify the most feasible household emission offsets. Based on studies like those conducted by Scorgie et al. (2004a), Friedl et al. (2008) and Norman et al. (2007a and 2007b), which show that the domestic burning of fuels like coal and wood have the greatest negative impact on human health of all sources of air pollution in South Africa, the focus of this study was on reducing household emissions. An exhaustive list of interventions was evaluated against a number of weighted criteria, the most important of which was community acceptance. The weighted criteria and the results of this study are summarised in Appendix B.

In 2015, the most feasible options identified in the pre-feasibility study were tested in a *pilot project* on 120 formal houses in KwaZamokuhle (a community 17 km from Hendrina Power Station and 3 km from Hendrina town in Mpumalanga). Each participating household was given either a ceiling or a full insulation retrofit (ceiling and insulation on three exterior walls), AND either a low emission coal-burning stove, or a liquid petroleum gas (LPG) stove and heater, or an electricity subsidy. Forty-eight (48) members of the local community were employed to conduct the surveys and installations.

In 2017, an additional pilot study on 30 formal houses in KwaZamokuhle was conducted to test the feasibility of switching households from coal to electricity. Each of the 30 participating households were given a full insulation retrofit (insulation on three exterior walls) and an electrical heater.

The following findings of the two pilot studies informed the household offset component of this Implementation Plan:

- Domestic coal burning in KwaZamokuhle does emit a large proportion of the ambient particulate matter, and presents the greatest opportunity for improving local air quality and improving health
- Residents were very willing to participate in the project (>80%), and preferred the new stoves/heaters that they were given during the offsets roll-out to their old ones
- The electricity subsidy without a stove swop did not eliminate coal burning, but an LPG stove and heater swopped for the coal stove did
- A stove swop and housing insulation (to raise the indoor temperature, especially on winter nights) are needed to eliminate domestic coal burning
- It is feasible to switch households from coal to electricity. However, there were several risks that were raised, which would limit the success of the strategy in the event that the intervention was solely limited to electricity starter packs only. To address the abovementioned risks with the electricity based solution, it is recommended that the electricity solution include LPG as a backup

Based on the findings of the pilot studies, the following interventions are proposed for each participating household;

- Provision of basic plus retrofit which consists mainly of:
  - An Spray Polyurethane Foam (SPF) ceiling system;
  - Draft proofing, and
  - Rewiring and issuance of electrical Certificate of Competence

- Stove swap which entails:
  - Provision of electricity based energy source with LPG backup. This will include a hybrid electric gas stove, LPG heater plus 2x9 kg LPG cylinders and CFL lighting, and
  - The removal and disposal of coal stoves.

More information on Eskom's air quality offsets pilot project is in Appendix C.

Interventions other than those that address household fuel burning need to follow a similar process of a pre-feasibility study followed by a pilot study.

4.2 STAKEHOLDER CONSULTATION

In parallel in the latter half of 2015, input was obtained from key stakeholders, particularly from government, into the implementation of air quality offsets.

Public input into the original version of this Implementation Plan was solicited during a 30-day public comment period from 22 February to 23 March 2016. An independent consultant, EkoInfo CC, was employed to facilitate an objective public participation process. The public participation process and outcome are detailed in EkoInfo's *Public Participation Report*.

Information about the Air Quality Implementation Plan for the Lethabo Power Station was distributed through the following means:

i) An email was sent to Interested and Affected Parties
ii) Newspaper notices were published in a number of local and national newspapers
iii) A draft of this Implementation Plan was made available for downloading on EkoInfo's website
iv) Copies of the Draft Implementation Plan were made available for viewing at several public libraries
v) Notices were posted at the power stations
vi) Public meetings was held to present and discuss the implementation plan in Vanderbijlpark on 14 March 2016 and at the Lethabo Power Station Visitors' Centre on 19 April 2016. The second meeting held on 19 April 2016 was facilitated by Eskom, and the attendance register and minutes of this meeting are included as Appendix D of this document.

The issues raised formally during the public participation process and Eskom's responses to these comments are summarised in the Comments and Responses Report (Appendix D of the *Public Participation Report*).

The stakeholder consultation thus far has focussed on the offset strategy and high-level plan. Prior to the implementation of offsets, in-depth engagement with each community will be conducted to provide local perspective, understand the baseline and inform the project design.

Since development of the original plan there have been limited stakeholder engagements in the Sharpeville. Eskom aims to address these with the rollout of the pilot from October 2019.

5. METHODOLOGY

The approach to be followed to develop and implement air quality offsets for Lethabo Power Station is described in this section.

5.1 DUAL FOCUS ON REDUCING DOMESTIC BURNING AND WASTE BURNING EMISSIONS

Scientific studies have repeatedly shown that, in areas where households burn coal or wood for cooking and heating, the emissions from the domestic burning make the greatest contribution to ambient levels of particulate matter (FRIDGE, 2004; MRC, 2008; Lim et al. (2012)). The proximity of people to domestic burning also plays a crucial role in exposure since people are very close to the source. Additionally, the fact that the source is often indoors further exacerbates the impact on human health.

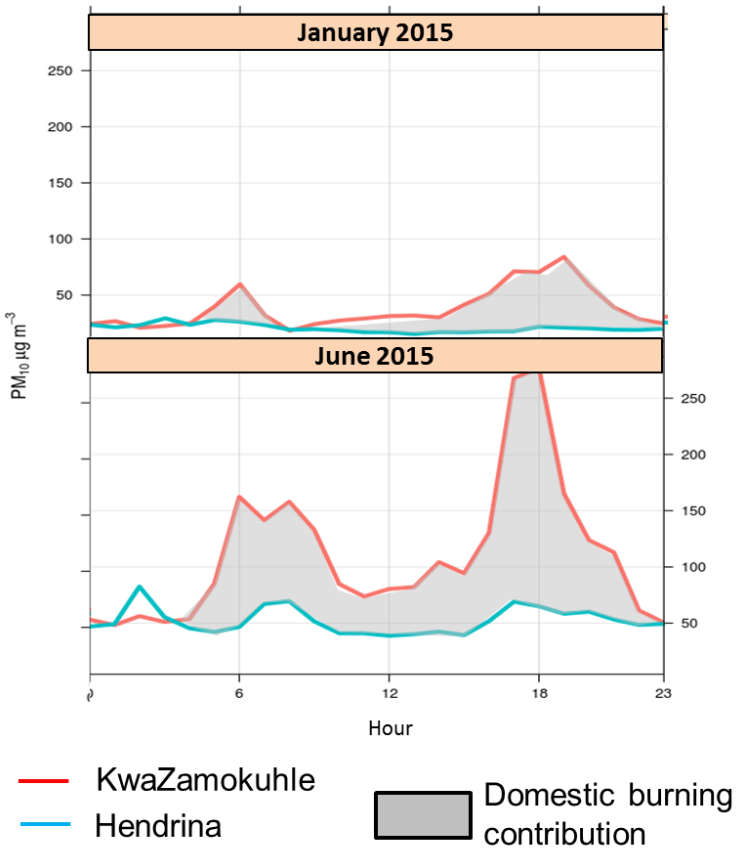


Figure 4: Average diurnal ambient PM10 concentrations (µg/m^3) measured in KwaZamokuhle and neighbouring Hendrina in summer (January 2015) and winter (June 2015). The difference in concentration between the two areas, shaded in grey, is mainly due to domestic burning in KwaZamokuhle.

Ambient air quality measurements collected in 2015 in Hendrina (where there is influence of regional air pollution sources but no significant local source) and in KwaZamokhule (3 km away, affected by the same regional sources and domestic coal burning) showed that domestic coal burning is responsible for a significant proportion of PM10 in the winter (June 2015), and also raises ambient PM10 levels in the summer (January 2015 – upper graph; Figure 4). In fact, between April and November 2015, ambient

PM10 and PM2.5 levels in KwaZamokhule were more than double levels in Hendrina. Moreover, from January to November 2015, SO_2 levels in KwaZamokhlue were on average 67% higher than SO_2 levels in Hendrina.

The large contribution to particulate matter concentrations from domestic burning has been confirmed by the source apportionment conducted in KwaZamokuhle in winter 2015. More than 50% of the fine particulate matter (PM2.5) is from domestic coal burning (Figure 5).

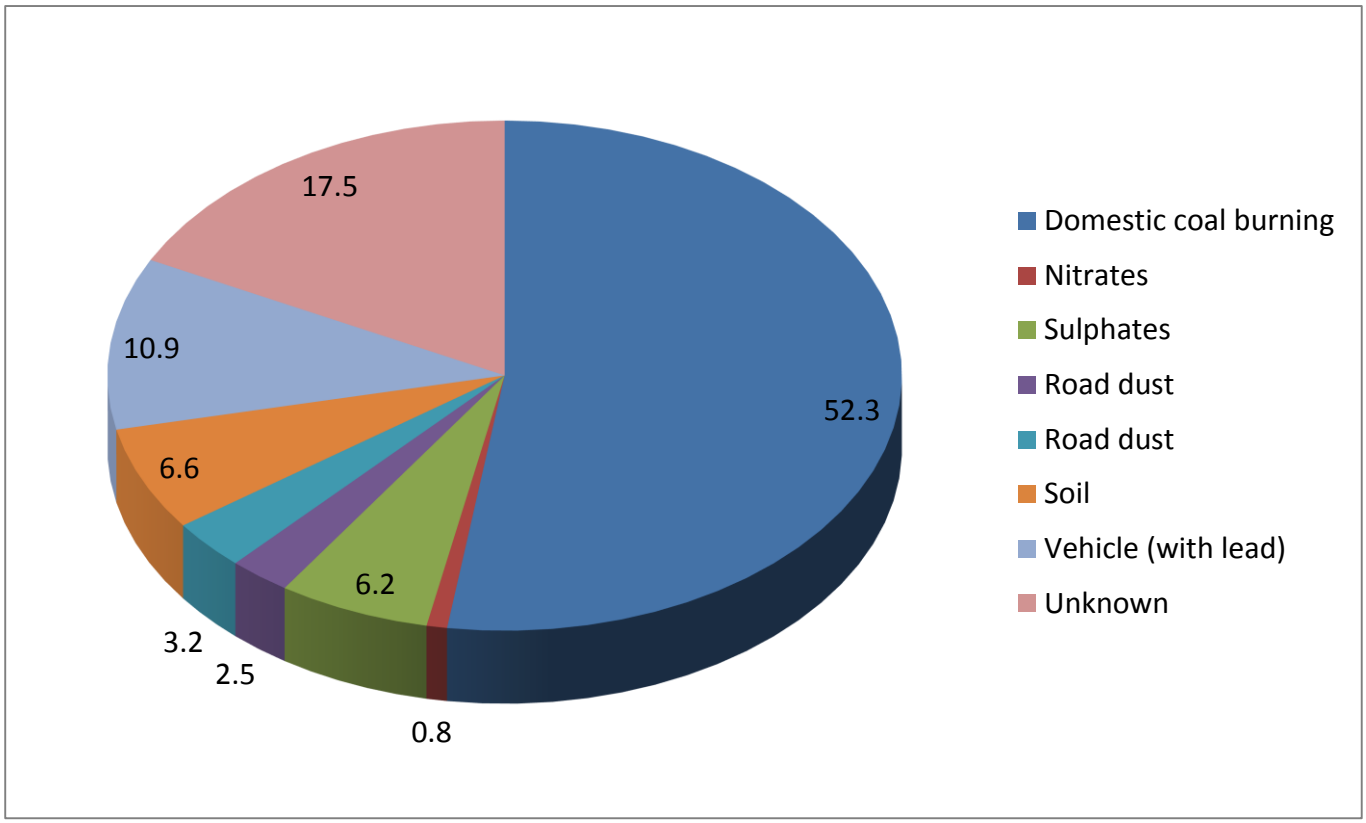


Figure 5: Source apportionment of the fine particulate matter (PM2.5) in KwaZamokuhle in winter 2015

Modelling conducted for the FRIDGE Report for the year 2002 (Scorgie et al., 2004b) showed that in the Vaal Triangle, highest ambient PM10 levels from domestic burning are more than 10 times higher than those from power generation (Table 2). Due to the high exposure to domestic burning emissions, it was calculated that in 2002 domestic burning accounted for 77% of hospitalisations for respiratory illnesses (Scorgie et al., 2004b).

However, the domestic burning figures that were used an input for the FRIDGE model are no longer an accurate reflection of the present situation in the Vaal. There has been a steady move away from domestic coal burning in the Vaal over the last decade or so, and it is estimated that 35% of households in lower income areas use coal for cooking and heating (compared to 50%-70% of households in lower income areas in Mpumalanga). The proportion of households in the Vaal using coal continues to decline.

It is clear then that a focus on reducing domestic burning alone will not be adequate for the Vaal, and so Eskom is exploring alternative ways to improve local air quality.

Table 2: Predicted air pollution concentrations due to domestic burning and power generation in the Vaal Triangle for 2002 (concentrations are highest hourly, highest daily and annual average ground-level concentrations in μg/m^3) (Scorgie et al., 2004b)

		Domestic coal burning	Power generation – 2002 emissions	Power generation – 2011 predicted emissions
PM10	Hourly	1879	137	169
	Daily	288	17	21
	Annual	49	2	3

Waste burning has been identified as another significant source of local emissions. Waste is burnt in areas where the waste collection services are unreliable or non-existent, and also in areas where there is an adequate waste collection service. The burning of old tyres to extract the steel reinforcing inside has been identified anecdotally as a significant source of emissions.

Initial observations in Sharpeville indicate that many residents dispose of their household waste in open spaces close to people's houses, for example in the veld on the edge of the township, the road servitude, the power line servitude between Sharpeville and Tshepiso, a traffic circle or an open stand, and even an open stand right across from the memorial. There is evidence that this waste is then regularly burnt. From informal interviews with residents we infer that there is a regular municipal waste removal service. However, households do not have waste bins. There is therefore a problem of keeping household waste for a week until the next removal. This makes dumping / burning an attractive solution. There are also waste recyclers walking around with carts collecting metal, paper and plastic and sometimes glass for recycling. Apparently there is a place in Sharpeville that takes the paper and plastic. We also found people recovering wood from the waste dumps - likely for firewood. A quick visit to Boipatong and Tshepiso showed that the same pattern is also present there.

In an explorative paper by Fischer and Sanchez (2013), it was estimated that PM10 emissions from waste burning in the Sedibeng District Municipality was around 130 tons per annum in 2001 (Figure 6). Some of the highest emission rates were calculated to be found in the Sedibeng District Municipality. More work is needed to refine these estimates, and to understand where, when and why waste is burnt.
The importance of waste burning and dust as pollution sources in the area was further confirmed by the source apportionment study recently conducted for the Vaal Triangle Priority Area by North West University.

Figure 6: Waste burning in Sebokeng on 30 August 2012 (photo credit: Theo Fischer)

Figure 7: Waste next to a road in Sharpeville, containing burnt and unburnt material (photo credit: Nova Institute, 2017)

Figure 8: Waste disposed of in servitude in Sharpeville (photo credit: Nova Institute, 2017)

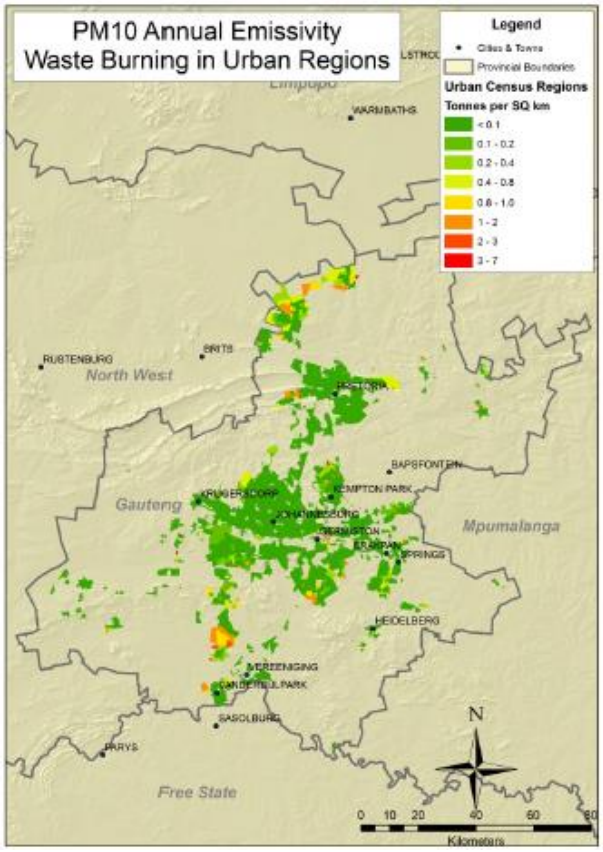


Figure 6: PM10 emissions (tons per square kilometre per annum) from waste burning in urban areas in Gauteng (Fischer and Sanchez, 2013)

5.2 OFFSETS IMPLEMENTATION STRATEGY FOR LETHABO POWER STATION: A PHASED APPROACH

The need for rapid implementation of offsets needs to be balanced with the need to reduce the risk of undertaking initiatives which have not been previously undertaken in South Africa. Given the state of air quality on the Vaal Triangle, initiatives which promise to improve air quality and reduce exposure to harmful levels of air pollution need to be rolled out as quickly as possible. On the other hand, rolling out an untested intervention on a large scale may lead to failed interventions, and the negative sentiment may then lead to offsets being abandoned completely and forfeiting the potentially massive benefits that air quality offsets may have if successful.

Eskom has been proactive in exploring and supporting the science relating to atmospheric emissions and dispersion, offset selection, and the practicalities of implementing interventions in the community and households, as well as creating procedures and methods for offset accounting thereby increasing the available knowledge and the probability of success of air quality offsets. However, Eskom is required to plan and implement air quality offset interventions despite medium term uncertainty and constraints, particularly:

- Lack of quantified scientific understanding of how an offset will affect ambient air quality (in the context of many other factors that affect air quality, like meteorology and change in source strengths over time)

- Offset measurement methodology is in an early stage of development and has not been agreed upon
- Understanding practical aspects of specific interventions and community dynamics requires further development
- Financial constraints on Eskom specifically, and South Africa generally
- The regulatory framework relating to offsets is still developing

The bulk of Eskom's work so far has focused on the situation in the Mpumalanga Highveld, where domestic coal use is still prevalent and household emission offsets offer the greatest potential for improving local air quality. Addressing local waste burning is a new area of work for Eskom's offsets efforts, and thus levels of uncertainty are higher than for addressing domestic burning emissions.

It is proposed that the risks of rolling out untested interventions be reduced by following a phased approach to air quality offset implementation. For each type of offset intervention, the following phases need to be followed as the interventions are successively scaled up, and the learnings from each phase incorporated to deal with implementation problems that arise:

Phase 0: Pilot project. An intervention is tested on a small scale to discover practically what works.

Phase 1: Lead implementation. The intervention is tested on an entire community to see how best to scale up an initiative. The lead implementation is designed to benefit the specific local communities, minimize implementation risk, increase practical and scientific knowledge, and develop and refine monitoring, reporting and verifications processes.

Phase 2: Full implementation in Boipatong, Tshepiso and Sharpeville. Once the intervention has been refined and the learnings of the lead implementation incorporated, the intervention will be rolled out at a bigger scale across BoiTshepiVille (Boipatong, Tshepiso and Sharpeville).

Phase 3: Full implementation in smaller settlements. In this phase, the interventions will be rolled out at the remaining settlement i.e. Refengkotso. More information needs to be gathered in Refengkotso to understand the nature and extend pollution sources so that appropriate intervention could be designed.
Eskom will develop offsets to address waste burning in the Vaal, and will have to follow phases 0-3 as part of Lethabo's offsets implementation. Household offsets are being developed in other district municipalities, so it is proposed to incorporate the learnings of the lead implementations for household offsets in the Gert Sibande District Municipality (at Ezamokhuhle) and Nkangala District Municipality (at KwaZamokuhe) into phase 3 implementation (Refengkosto household solution) offsets for Lethabo Power Station.

5.3 OFFSETS IMPLEMENTATION PROCESS PER COMMUNITY

A typical offset implementation in a community will have three stages:

i) *Baseline establishment*: This is conducted for roughly a year (depending on the size of the community) prior to the implementation of the offset and informs the project design. See section 5.6 for more information on how the baseline will be established.

ii) *Implementation*: The speed of implementation depends on the number of work teams set up in the community and the specific offset being implemented.

iii) *Sustainability, monitoring and verification*: Once the implementation is underway and after it has been completed, infrastructure will be set up to ensure that the implementation can be maintained. The effectiveness of the intervention will also be monitored. See section 5.9 for information on monitoring and verification.

Table 3: Activities to be conducted during each phase of the offsets roll-out in a community

Baseline	Implementation	Maintenance and monitoring
• Community consultation • Ambient air quality monitoring (and source apportionment) • Community focus groups (optional) • Education and awareness • Planning for implementation **For household offsets:** • Socio-economic surveys of households • Inventory of number of households and energy usage patterns • Placement of bulk supply contracts **For waste offsets:** • Investigate waste collection and recycling services	• Roll-out of intervention(s) • Ambient monitoring continues • Recruitment and training of local community members for implementation of interventions • Monitoring of success of interventions through follow-up surveys and monitoring • Education and awareness • Auditing of implementation **For household offsets:** • Implementation of interventions in houses • Set up fuel distribution network (if required) • Develop locally owned SMME(s) to satisfy household maintenance requirements	• Ensure required supply chain remains in place, including supporting SMMEs • Ambient monitoring continues • Reporting and awareness • Independent verification **For household offsets:** • Measures to ensure that new fuel introduced is dependably available and affordable

5.4 SELECTION OF AREAS FOR OFFSETTING

The methodology used to select the areas for offsetting for each power station is based on the definition of an air quality offset in the Department of Environmental Affairs's Air Quality Offsets Guideline published on 18 March 2016:

> *'an offset is an intervention, or interventions, specifically implemented to counterbalance the adverse and residual environmental impact of atmospheric emissions in order to deliver a net ambient air quality benefit within, but not limited to, the affected airshed where ambient air quality standards are being or have the potential to be exceeded and whereby opportunities and need for offsetting exist'.*

In accordance with this, the following **area selection criteria** have been used to select the areas where offsets will be implemented for power stations that are required to implement offsets:

i) Areas are prioritised based on the impact of emissions from the power station (in order to achieve the objective of 'counterbalancing the adverse and residual environmental impacts of atmospheric emissions').
ii) Only areas where there is (probably) non-compliance with ambient air quality standards are considered.
iii) Only areas where opportunities and need for improving ambient air quality through offsetting exist, are considered (i.e. areas where there are local sources of emissions which significantly impact ambient air quality and can be addressed through offsets).

Points ii) and iii) can be considered to be 'pre-qualifying' criteria.

Other considerations used in the selection of areas are as follows:

i) An offset should preferably not be rolled out to a section of a community only. The large-scale roll-out of the offset needs to include the entire community or at least large discrete sections where emissions influence air quality. (Only activities causing air pollution can be addressed, however.)
ii) Eskom will not implement offsets in communities where other industries are already embarking on offset projects
iii) While each power station needs to have their own offset project, there needs to be cognisance of the bigger picture when planning the offsets. In some cases, power stations in close proximity to each other impact on an overlapping area. In these cases, areas for offsets need to be selected to ensure that all priority settlements area allocated to a power station, although it may not be the power station in closest proximity to them.

Standard RDP houses inhabited by legal occupants in urban areas are obvious candidates for household emission offsets since the houses are of fairly uniform design, and these households often use solid fuels. However, many South Africans live in other types of dwellings and settlements, and household offsets also need to be implemented there as far as is feasible.

Informal dwellings pose perhaps the greatest challenge for offset implementation, and the approach to be adopted towards informal dwellings was much debated with stakeholders in the development of this plan. On the one hand, shacks are often illegally located, and their temporary nature means that any intervention may not have a lasting impact (shacks could well be moved, for example). On the other hand, shack dwellers are subjected to some of the worst air quality and are a highly vulnerable group, and as such are most in need of an intervention. Many urban areas have both formal and informal houses. If emissions from informal dwellings are not reduced, an offsets project may fail to significantly improve ambient air quality.

As such, Eskom will be adopting a nuanced approach towards informal dwellings. Dwellings which are semi-permanent and have been somehow 'officially' established will be considered candidates for an offsets roll-out. Appropriate interventions still need to be evaluated through a pilot study, planned to be conducted in KwaZamokuhle. A stove swap is a promising intervention for an informal dwelling, but insulation will be trickier, and needs to be properly tested before it is suggested for implementation.

5.5 SELECTION OF OFFSET INTERVENTIONS

Lethabo's offsets programme will have two main thrusts: addressing domestic burning and waste burning. It is proposed that this Air Quality Offsets Implementation Plan is based on a **Programme of Activities**, comprising of:

i) *Waste burning interventions*: Reasons for waste burning practices will be identified in the baseline phase of the roll-out through engagements with the community and air quality monitoring, and then an intervention will be developed. This intervention will be tested and refined in a pilot study before it is scaled up.

ii) *Household interventions*: Emissions from the domestic burning of coal/wood will be reduced through one or more of the following:

- Assist households to move to a cleaner source of energy (like electricity, or LPG for unelectrified houses)
- Providing households with cleaner burning heating and/or cooking devices (such as a low emission coal/wood stove)
- Reducing the need for heating by better insulating houses, where possible

Space heating is a key structural cause for coal use in urban areas. Coal use is seen as economic and practical when there is a requirement for space heating (in which case users also get "free" cooking and water heating). When there is no need for space heating (i.e. in summer) people tend to cook and heat water on non-coal stoves rather. Effective interventions thus need to both reduce the need for space heating through improving housing insulation, and moving households to a cleaner burning fuel or stove/heater.

The interventions need to be tailored to each community based on the dwelling type and energy use. They will also be informed by the lead implementations in KwaZamokhule and Ezamokuhle, where all qualifying and willing households residing in formal dwellings will receive an insulation retrofit and an electricity starter pack. A suitable intervention for informal dwellings still needs to be developed..

iii) *Education and awareness raising*: Continual interaction with the community is needed to ensure that the intervention is used and maintained properly (for example, that waste should be recycled or disposed of in dumpsters, and not burnt on open land), and to encourage behavioural change to reduce exposure and smoke generation. Schools will be one of the main targets for education initiatives. These initiatives will need to be done in partnership with local environmental health practitioners.

iv) *Projects in development*: Since this Air Quality Offsets Implementation Plan spans 7 years, the interventions cannot remain static but need to change as new technologies become available and as circumstances of communities change. Renewable energy technologies, in particular, are developing rapidly, and may be a viable offset option in future, especially in more remote areas which are not connected to the electricity grid. Initially, the projects in development will focus on:

- Non-household intervention pilot: This will be conducted in the Vaal, also from October 2019, and will test ways of reducing emissions from local waste burning through improving waste collection and/or recycling.
- Informal housing pilot: This will be conducted in KwaZamokhule from 2020, during the lead implementation there. Some of the most feasible options for reducing emissions from informal dwellings will be tested, taking into account the interventions and supply networks that are being set up for the roll-out targeting formal households.
- Farm dwelling/rural pilot: Farm and rural dwellings are often not uniform, and use wood rather than coal. Solutions for these types of communities will be tested at Sheepmoor (in the vicinity of Camden Power Station).

The intervention designed for each community will need to be tailored to take into account:

- The main source(s) of local emissions in the community
- The energy sources used by the community
- The size of the community (which may determine the available energy sources or level of municipal services provided, for example)
- The housing structures and permanence thereof (insulation may not be a viable option for all housing structures, for example)
- Service provision in a community

5.6 BASELINE ESTABLISHMENT

A baseline needs to be established for each community prior to implementation of the offset intervention in order to:

- Provide a basis for comparison to determine the improvement in air quality due to the offset
- Inform the scope of the offset intervention and the project design

For example, the number of households eligible to participate in the offsets intervention will be established based on the number of solid fuel-using households in the area immediately prior to the start of the implementation. Additional households established during the implementation (which may be stimulated by the revenue and benefits brought by the intervention) can unfortunately not be considered in this phase of the offsets roll-out.

Furthermore, the success of the intervention will be evaluated relative to the baseline as it changes over time. An offset cannot be considered to fail if the number of households in an area doubles (and thus local emissions double) during the offset roll-out. Similarly, an offset intervention cannot be considered to be successful if it is not additional to changes that would have happened in the absence of the roll-out (for example, the trend of decreasing coal use). As such any foreseen changes in the community must be determined during the baseline assessment before a roll-out can be planned.

The baseline will be established in each community through two main activities:

i) Air quality monitoring, to establish baseline levels of PM and SO_2

ii) Surveys focussing on quality of life (comprising objective living standard and subjective well-being), energy use and waste disposal practices of a sample of willing households in the community

Additional tools may be employed from time to time to aid in the understanding of the offset on the community and the air quality, for example air quality and/or dispersion modelling and source apportionment measurements.

5.6.1 Air quality monitoring

Since the overarching objective of Eskom's air quality offsets is to improve ambient air quality, specifically ambient PM levels, ambient air quality measurements need to be performed before the implementation of the offsets to establish baseline conditions (for a year); during the implementation; and after the implementation for at least a year to monitor retention.

A 'standard' monitoring station will be sited in all larger areas where offsets are implemented. The following parameters will be continuously monitored at the standard monitoring stations:

- PM10 and PM2.5
- SO_2
- NOx
- Meteorology: temperature, wind direction, wind speed, pressure, humidity, rainfall

Where possible, an additional 'standard' monitoring station will also be sited upwind of the area where the offsets are implemented. It is hypothesised that regional and large pollution sources (like power stations and biomass burning in August/September) will have a similar impact on both monitoring stations, but that the influence of local emissions in the offset area will not greatly influence measurements at the upwind monitoring station. The difference between the measurements collected at the two monitoring stations will provide a good indication of the influence of local emissions on air quality in the area selected for the offset and how they decrease over time, and will hopefully allow for the variability introduced by meteorological conditions and changing strengths of regional sources to be accounted for. It may not be possible to establish upwind monitoring stations in Emfuleni, since the communities identified for offsets border other communities or activities. In this case, other methods will need to be used to quantify the influence of the offset intervention on ambient air quality.

In addition to the standard permanent monitoring stations, standard mobile monitoring stations (equipped to measure the same set of parameters as the standard permanent monitoring stations) will be deployed for shorter periods of time, in order to ascertain the effectiveness of the offsets roll-out in smaller settlements.

Lastly, a mobile monitoring station equipped with a much more extensive set of instruments will be moved between communities to ensure that we obtain a good scientific understanding of the impact of the offset interventions on ambient air quality. Parameters monitoring by this 'scientific' mobile monitoring station may include:

- Black carbon
- Carbon monoxide

- Ozone

Department of Environmental Affairs has a monitoring site in Sharpeville. This will be used as part of the offset programme to establish an ambient air quality baseline in Sharpeville. If required, monitoring will be extended to Boipatong, Tshepiso and Refengkotso.

5.7 COMMUNITY CONSULTATION

Community support is vital to the success of offsets. Communities have not been consulted in the development of this high-level plan, as approval of the proposed methodology and areas selected is needed before the expectation of an intervention can be created with communities. It is also preferable to engage with communities shortly before an intervention roll-out, not several years before.

Nevertheless, very comprehensive community consultation needs to be undertaken before the implementation of offsets in a community. This consultation will inform the development of a project plan for each community. Through the community consultation, we will:

i) Ascertain what the significant local emission sources are, and how they can best be addressed.
ii) Establish a baseline for a community (how many households are there? What are their energy usage patterns? What type of housing structures do they have?). This baseline will be used to scope the intervention, and evaluate success of the intervention.
iii) Understand levels of service provision (how frequently is refuse removed? Is there a waste recycling programme?)
iv) Identify troublesome sources of emissions
v) Create awareness as to how air pollution affects health and what can be done to stay healthy
vi) Educate the community members on how to best employ and maintain the offset
vii) Get buy-in from the community

In each community where offsets will be implemented, a Local Stakeholder Reference Group (LSRG) will be set up. The LSRG is a forum through which Eskom and the local community communicate with each other.

The LSRG will be established before project implementation and continue throughout it, with at least three LSRG meetings per year. Community understanding and support of the intervention is fundamental to the implementation of air quality offsets. The communities are much more likely to accept an offsets intervention if there is transparent and active communication between all parties. The aim of the LSRG is to achieve such communal support.

Key stakeholders for the LSRG and associated engagements include all households in the engaged community, qualifying intervention households in particular, political leaders (such as councillors and ward committees), social leaders (such as religious leaders, traditional leaders and educators), local government, the South African Police Service, Eskom and Eskom contractors.

Communication with the community may proceed in four stages if necessary:

Stage 1: Engage licensing authorities, local government and formally elected leaders. These introductory engagements will also align Eskom's LSRG strategy with local protocol. Issues to be discussed include the project history and objectives, the choice of the particular community, the choice of interventions, qualifying criteria for participating households, technical information, funding, expectations from all sides and risks.

Stage 2: Establish a LSRG. A comprehensive selection of representatives will be invited personally and/or publicly (through advertisements and public notices) to participate in the LSRG, including partners from Stage 1. The LSRG meetings will have a clear and fixed procedure with a strong focus on the Offset Programme, thereby preventing secondary issues impeding on available time. The LSRG meetings will take place on an ongoing basis and be scheduled at prominent periods of implementation. The LSRG will address all the elements of stage 1, as well as having a focus on the community perspectives and the promotion of better energy use choices and practices.

Stage 3: Conduct public communication meeting(s) if needed. There might be a need for one or more public communication meetings, depending on the outcomes of stages 1 and 2. A public meeting might coincide with existing meetings conducted by the political leadership. These public meetings will discuss all the issues mentioned in stage 1 and stage 2, with a strong focus on the community perspectives.

Stage 4 for household offsets: Communicate with qualifying households. Following the successful completion of stages 1 to 3, communication with qualifying households must take place. This part of the communication will continue over a longer period than stages 1 to 3, and parallel to the start of implementation. The aim of this communication will be to inform households about the planned interventions so that they can make a decision whether to participate in the project or not. Stage 4 will have as content all the elements of stage 1, as well as the household selection process, technical information, household responsibilities including maintenance, contractual considerations, contract and construction scheduling.

Stage 4 for waste offsets: Communicate with participating individuals and/or companies. Communication with those participating in the waste pilot will continue in parallel to the implementation, in order to inform, monitor and continually improve implementation.

The following administrative requirements will be adhered to during community engagements:

- Strict and comprehensive documentation will be kept
- Where possible, audio recordings of proceedings will be taken
- Full meeting scripts will be circulated to all invitees whether they attended or not
- The local project office will be accessible to the public for enquiries
- Translation services at meetings and documents in multiple languages will be provided

Since development of the original plan there have been limited stakeholder engagements in the Sharpeville. Eskom aims to address these with the rollout of the pilot from October 2019.

5.8 LOCAL EMPLOYMENT CREATION

The air quality offsets programme offers potential for creating local employment (albeit on a temporary basis), which needs to be taken advantage of. Teams which conduct the socio-economic surveys and implement the interventions need to be mainly recruited from the local community.

5.9 MONITORING, VERIFICATION AND REPORTING

The effectiveness of the offsets roll-out will be tracked through monitoring, independently verified, and reported on annually to the Fezile Dabi District Municipality and National Air Quality Officer.

A project design document (PDD) will be compiled for every area where offsets are to be implemented, after the baseline measurements and consultation with the community but before implementation starts. This PDD includes a monitoring plan that describes the parameters that will be monitored as well as the frequency and method of monitoring.

We foresee that following an initial design phase, monitoring and reporting will take place annually. Each project design will be aligned to a calculation methodology relevant to its intervention type.

Some monitoring activities will take place during the design phase (i.e. before the project is implemented) and will include the initial state of the parameters that will be monitored annually but also includes parameters that will only be monitored once during the project lifetime. Parameters monitored only once during the project lifetime include emission factors for specific fuel-device type combinations as well as certain modelling parameters.

It is proposed that three indicator domains be monitored before and during the offsets implementation, namely *the state of ambient air, emissions* and *quality of life*. Over every monitoring period the project scenario (as it actually took place) will be compared to a credible baseline scenario (i.e. the situation that would have been the case if the project was not implemented). It is just as important to monitor parameters that allows one to describe the project scenario as it is to monitor parameters that allows one to construct the baseline scenario. The terms *describe* and *construct* are significant: after the project starts, the project scenario is the state of affairs that exists in reality and must therefore be described while the baseline scenario does not exist (because the baseline is what would have existed without the offset intervention) and must therefore be theoretically constructed.

Examples of the parameters monitored include:

i) Ambient air quality
   a. Hourly, daily and annual PM and SO_2 concentrations within the implementation area
   b. Hourly, daily and annual PM and SO_2 concentrations at a reference site outside the implementation area

ii) Household emissions (for household offsets)
   a. Number of solid fuel using households within the project boundary per fuel type
   b. Average solid fuel use per household per season per fuel type
   c. Number of households at which the offset has been successfully implemented

iii) Waste emissions (for waste offsets)

a. Additional waste collected and/or recycled

iv) Quality of life

a. Demographic factors such as age and sex distribution which is important to monitor the level of vulnerability due to exposure to air pollution in a community
b. Health and well-being such as poverty lines and employment, as well as perceptions regarding air quality and the desirability of the air quality offset project
c. Services and infrastructure such as water, waste removal and sanitation, as well as housing with particular emphasis on measuring temperature inside homes, in order to determine the appropriate indoor thermal range which influence domestic energy usage patterns
d. Education, safety and security aspects as far as it relates and could be impacted by the offset project

The relationship between the emissions from households/waste and the state of ambient air must be established through some form of modelling (dispersion modelling, receptor modelling or both). Model validation forms an important part of the design phase of the project.

The offset project impact is the difference between the baseline scenario and the project scenario. The principle indicator for the success of the intervention will be related to a change in exposure to air pollution. This can be expressed as a reduction in the ambient concentration of particulate matter, or as a reduction in standards weighted pollution intake, or a reduction in inhalation related health risk or a reduction in the expected burden of disease from air pollution. The particular method and indicators for success will further be described in the project design document (PDD) of the lead implementations and in the programme of activities design document (PoA-DD) and the component project activity design document (CPA-PDD).

Relevant reporting will take place at each stage of the project. Before the project starts, a baseline study and detailed project design are undertaken. The results will give shape to a project design document in the case of the lead implementations or a PoA-DD later in the programme. This document will contain details of the exact project location and boundary, the project schedule over the whole lifecycle, the specific intervention design and the monitoring plan. This PDD will be validated by the regulator or by an independent third party.

Details of the project implementation will be monitored continuously and stored in a project database that will contain details of every installation.

Annual monitoring of relevant indicator domains will be conducted in accordance with the monitoring plan. An annual monitoring report will be produced in accordance with the PDD and methodology and verified by an independent third party.

We envision that after some refinements during the lead implementation, the air quality offset initiative will be structured as programme of activities (PoA). The monitoring and reporting requirements are essentially the same as described above except the third party validation and verification takes place at the scale of the programme and not at the scale of each project (referred to as a component project activity (CPA) in PoA terminology).

The Vaal area has been subject to various monitoring exercises as part of the review of the Vaal Triangle Priority Area undertaken in 2018/19. Attempts will be made to make use of this data where possible to limit the need for further monitoring and research.

5.10 HEALTH IMPACTS ASSESSMENT

Exposure to air pollution is strongly associated with respiratory health impacts, especially in vulnerable groups, such as young children. Acute respiratory health impact, especially pneumonia, continues to count among the top five causes of death in South African children under the age of five years. A contract has been put in place with the Medical Research Council (MRC) to determine the health impacts of the air quality offsets roll-out in one area in KwaZamokuhle and Emzimnoni.) Lessons from the health study will be applied to Refengkotso household intervention.

The aim of the study will be to determine the personal health effects of chosen offset interventions in one settlement compared to a control site. To fully comprehend the personal health effects related to air pollution exposure, a two-pronged approach is necessary. First, a household survey to establish symptoms and pre-existing diseases in relation to risk factor and exposure pathways provides a snapshot view of the health status of a community. Second, vulnerable sub-population groups within a community are most likely to experience the subtle effects of increased or decreased air pollution levels in their places of work, play and residence. In this respect, it is important to assess physiological responses i.e. lung function, to air pollution exposure. Children under the age of 10 years are an important target group for assessment since they are usually not actively smoking and their physiology is susceptible to small increment pollution changes. By focussing on a susceptible group, the likelihood of detecting change is higher.

6. AIR QUALITY OFFSET IMPLEMENTATION PLAN SPECIFICS

The communities which have been proposed for offsets and the timeline for implementation are described in this section. 10 shows the area of impact of the emissions from Lethabo (annual average concentrations), and was extracted from the Atmospheric Impact Reports submitted in support of Lethabo's application for postponement of the Minimum Emission Standards compliance timeframes (uMoya-NILU 2014).

6.1 LETHABO POWER STATION

Lethabo Power Station is a six-pack coal-fired power station with an installed capacity of 3708 MW, commissioned between 1985 and 1990. Lethabo is situated in the Free State, between Sasolburg and Vereeniging. Electrostatic precipitators (ESPs) are installed at the station to remove the ash from the flue gas before it exits to the atmosphere. A flue gas conditioning plant increases ESP efficiency.

In terms of the MES postponement application submitted in March 2019 Eskom is committing to implement upgrades to the particulate emission reduction equipment efficiency (High Frequency Transformers and ESP upgrades and or flue gas conditioning) at Lethabo. No commitment to install technology to reduce NO_x or SO_2 given that Eskom does not contribute to significance non-compliance in

the area and the cost implications of these technologies (see the Eskom MES application for further details).

6.2 TARGET AREAS AND INTERVENTIONS

Large numbers of people live in the vicinity of Lethabo Power Station (within 50 km of Lethabo), but the area most highly impacted by emissions from Lethabo (to the east and south-east of the power station) is relatively sparsely populated.

The proposal on areas for offsets implementation is based on considering, in accordance with the area selection criteria in section 5.4:

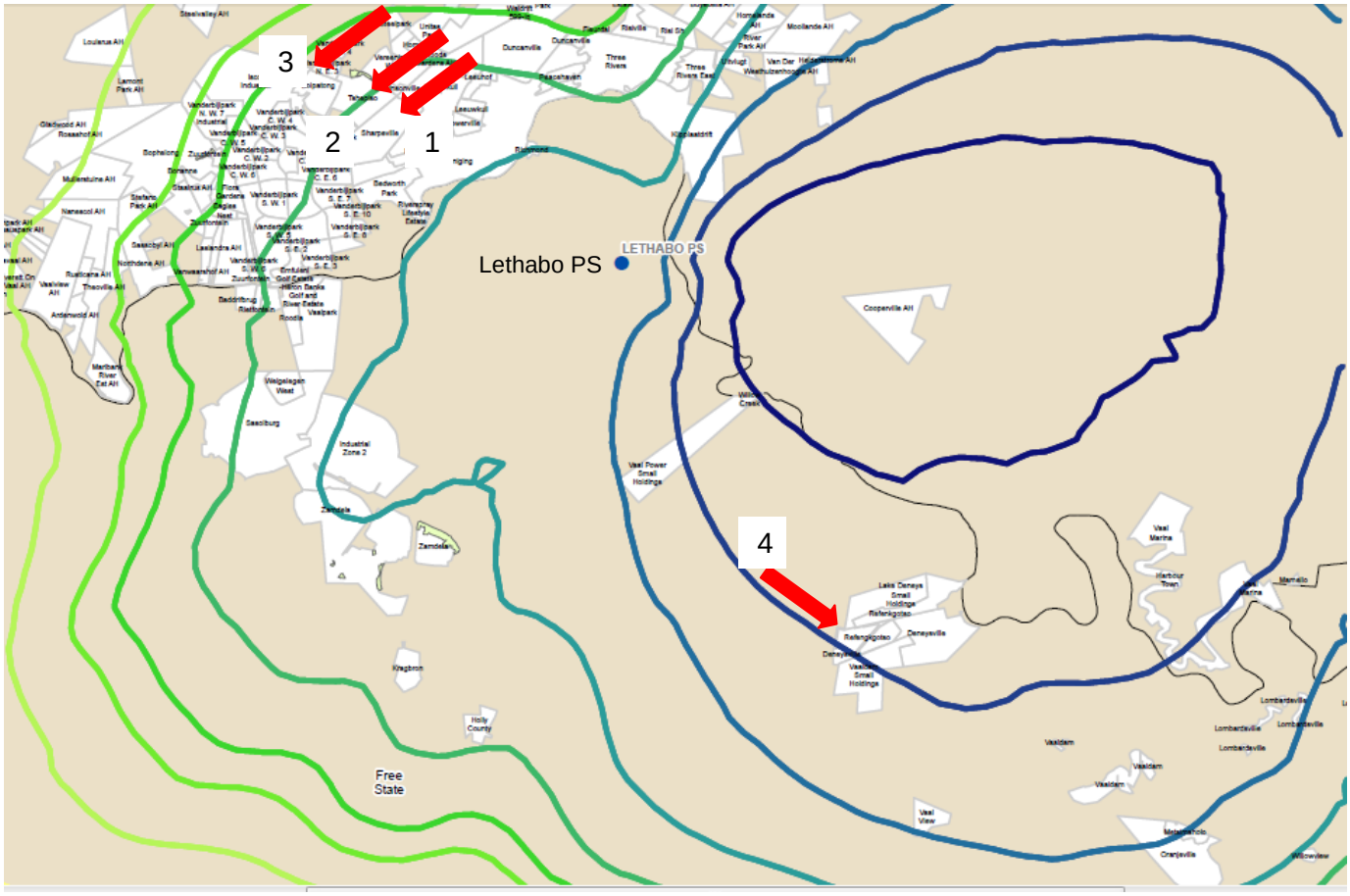
- Which areas are impacted the most by Lethabo's emissions?
- Where is ambient air quality the worst?
- Where can offsets make the greatest improvement to ambient air quality?

The following settlements have been selected for Lethabo's air quality offsets implementation since they are the largest areas affected by Lethabo's emissions (Figure 7), where there is the potential to significantly improve ambient air quality through offsets:

- Refengkotso
- Sharpville
- Tshepiso
- Boipatong

Lethabo is aware that residents of Three Rivers are at times affected by fugitive emissions from Lethabo's ash dump. Unfortunately, there are no significant sources of emissions in Three Rivers which can be addressed through offsets, and so it is not possible for Lethabo to implement offsets at Three Rivers.

Zamdela is also influenced by Lethabo's emissions, but since Sasol is implementing offsets in Zamdela, Eskom will not.



Lethabo SO2	Lethabo NOXs1	Lethabo PMs1
Concentration Contours	Concentration Contours	Concentration Contours
0.556539633	0.229866087	0.025289989
0.771808068	0.318777546	0.035072091
0.897296981	0.370607729	0.040774485
0.97044968	0.400821695	0.044098647
1.09593859	0.452651878	0.049801041
1.31120703	0.541563337	0.059583143
1.68048666	0.694085424	0.076363732
2.31396294	0.955727592	0.10514979
3.40065215	1.40455848	0.154530485

Figure 7: Area of impact of Lethabo Power Station's emissions (annual average concentrations in μg/m^3 from uMoya-NILU, 2014), and locations of intervention target areas (indicated with red arrows). Areas for offsets are: 1: Sharpeville; 2: Tshepiso; 3. Boipatong; 4. Refengkotso

Table 4: Total population, number of households and energy usage patterns in the target areas for Lethabo's offsets programme

Settlement	Refengkotso	Sharpeville	Tshepiso	Boipatong
Population	17 646	37 599	29 271	22 167
Number of households	4 883	12 170	8 998	7 059
Number of households using coal according to Census 2011	390	214	114	66
Number of households using wood according to Census 2011	510	159	680	108
Number of households using coal according to NOVA's Carbon Monitoring Report (2013-2014)	n/a	2772*	n/a	1 369
Type of intervention proposed	Waste and household	Waste	Waste	Waste

*The number of coal users in Sharpeville was 2772 in 2012 according to NOVA's Carbon Monitoring Report. The number of coal users is falling rapidly, and is currently estimated to be around 1000.

It is proposed that the starting point for Lethabo's offsets roll-out be a waste solutionproject in Sharpeville (phase 1). Interventions under consideration are detailed in table 5 below. Offset interventions to reduce waste burning emissions will then successively be rolled out in Sharpeville, Refengkotso, Tshepiso and Boipatong (phase 2). In addition, household emission offsets will be conducted in Refengkotso (phase 3). Although Lethabo Power Station is situated in Fezile Dabi District Municipality and it has the greatest impact on ambient air quality in Fezile Dabi District Municipality, most of the people affected by Lethabo's emissions live in Sedibeng District Municipality. This is why Lethabo's offset efforts will start in Sedibeng, and why more people in Sedibeng will be eventually affected by the offsets roll-out. However, in acknowledgement of the fact that people in Fezile Dabi living downwind of Lethabo are subjected to the highest impact of Lethabo's emissions, both waste and household offsets will be rolled out in Refengkotso. This should result a greater improvement in ambient air quality than a waste roll-out alone.

The baseline assessments that will be conducted in all four areas and the results of the interventions in other district municipalities will be used to compile Project Design Documents for each area, which will identify the extent to which the household and/or waste offsets can be implemented.

The household emission offset in Refenkotso will be informed by the lead implementations in KwaZamokhule and Ezamokuhle, but will likely be the installation of housing insulation and swopping of coal stoves for cleaner energy.

6.3 TIMELINE FOR IMPLEMENTATION

This offset plan covers the period from April 2019 to March 2025 (

Figure 8). The proposed schedule allows for phased implementation, so that the learnings of each roll-out can influence the design and improve the next roll-out.

This schedule depends on budget being made available. Should there be delays in the allocation of funding to this project, it will translate directly into a delay in this schedule. This schedule also depends on approval from the relevant authorities. Work can only commence once approval from the authorities has been received. Should approval be delayed, or should significant changes be required to this plan, the roll-out of offsets will be delayed.

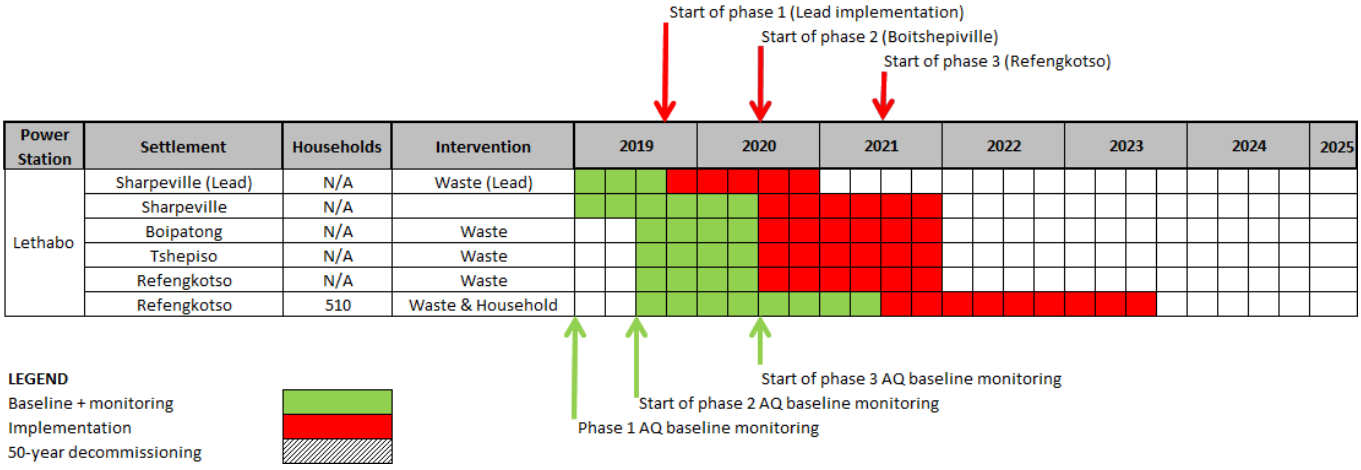


Figure 8: Preliminary schedule for the roll-out of the air quality offsets for Lethabo. This schedule will be refined as more information about the settlements become available. The timelines are dependent on procurement processes, authority approvals and budget allocation.

6.4 PROPOSED LEAD IMPLEMENTATION WASTE SOLUTIONS

The baseline assessment in Sharpeville has been concluded, and confirms waste burning as an important local source of emissions. This was further confirmed by the source apportionment study recently conducted for the Vaal Triangle Priority Area by North West University.

To help address the waste burning problem, the following possible initiatives are being considered for the lead implementation phase in Sharpeville:

Table 5: Waste related initiatives under consideration

Cleanup illegal dumps	Conduct site cleanups where dumping takes place and convert areas into parks or recreation areas
Placement of skips in strategic locations	Place skips at strategic sites where dumping occurs and establish weekly collection system.
Clean waste under powerlines	Remove waste from areas under the powerlines (powerline servitude) in Sharpeville.
Vegetable garden under powerlines	Work hand in hand with local NGOs to establish vegetable gardens under the powerlines

The outcome of the lead implementation (phase 1) will inform the plan for the wider implementation of the waste offset in phase 2.

7. RISK MITIGATION

Risks and unintended consequences of air quality offsets, and the way in which Eskom proposes to mitigate these risks, are as follows:

Table 6: Risks of air quality offsets and proposed mitigation

Risk	Rating	Mitigation already in place	Planned mitigation
Funding constraints: Funds have been allocated for offsets implementation but they may be cut	Medium	Funding requirements were included in MYPD tariff application but with tariff reduction this provides limited mitigation now	Compliance aspects of offsets will be presented during capital reprioritisation and with specific offset funding requests.
Objections from communities which are not included in the offsets implementation	Medium	An objective process has been used to select communities. Also, offsets will not be implemented in a section of a community only. In-depth community consultation will only occur after authority approval of the plan and allocation of budget.	Most communities in the vicinity of power stations will eventually receive an offset implementation
Unreliable supply of electricity will leave communities without an energy source at times.	Medium		The proposed intervention includes provision of an LPG backup.
Safety: Electric wiring in many houses is unsafe. Injuries may be caused by electric heaters or stoves.	Low	-	The project team will ensure the wiring is safe after installation of the gas electric stove and ceiling. An electrical CoC will be issued by a competent electrician. Members of the local community will be trained in safe operations prior to the installations. Health and safety requirements of Eskom's procurement process will be adhered to.
Inability of local authority to support/facilitate waste and household solutions impacting on ability to create	High	Continued engagement with authorities	Continued engagement with authorities Consider projects which require less authority involvement

Risk	Rating	Mitigation already in place	Planned mitigation
sustainable solutions			

8. WAY FORWARD

There needs to be regular engagement between Eskom and the authorities so that the offsets implementation proceeds according to everyone's satisfaction, and that learnings are incorporated into the more refined plans. We propose that this takes the following form:

- Annual updates of this Air Quality Offsets Implementation Plan for Lethabo Power Station. This document is the second such update
- Annual progress reports. See the annual progress report also submitted in March 2019.
- Bi-annual (twice a year) meetings between Eskom and the authorities.

9. CONCLUSION

The air quality offsets regime being developed by DEA provides a practical and realistic way of improving air quality in communities. Despite the economic constraints faced by South Africa in general and Eskom in particular, the offset plan described in this document illustrates that improvement of community environmental parameters are achievable within the context of limited national resources and competing national imperatives.

Although the offset plan is ambitious in scope and reach, the phased approach ensures a higher probability of achieving the desired outcomes, which include

- acting responsibly with and towards affected communities
- demonstrably improving community experienced air quality in a cost-effective manner
- meeting air quality license conditions

The planned solution adapts to local conditions and immediate context through community consultation and ongoing development. However, the ultimate goal is national and long term in nature: the aim is to focus the available national resources to achieve a sustained improvement in quality of life for current and future citizens of South Africa.

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11. APPENDIX A: SATELLITE IMAGES OF AREAS SELECTED FOR OFFSET INTERVENTIONS

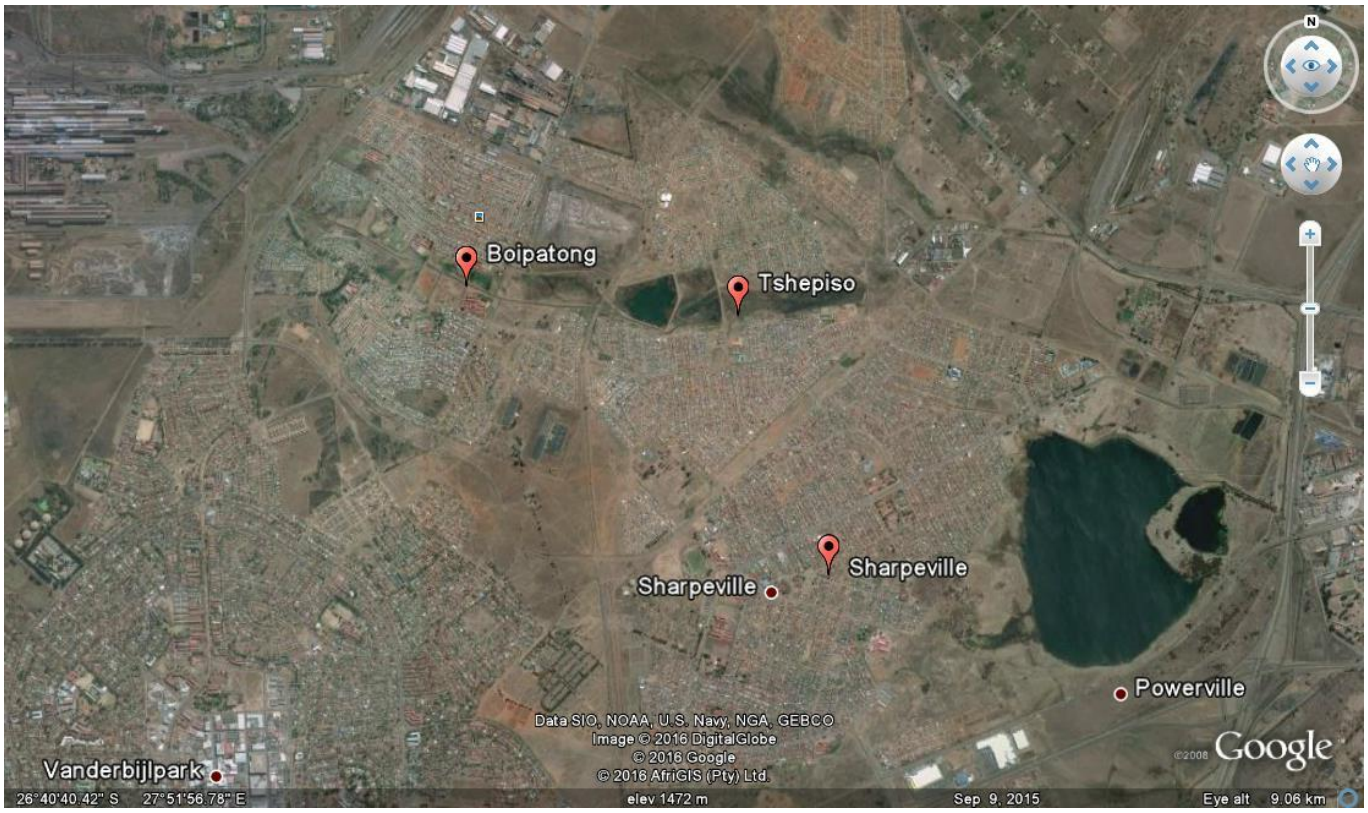

Figure 9: Sharpeville, Tshepiso and Boipatong

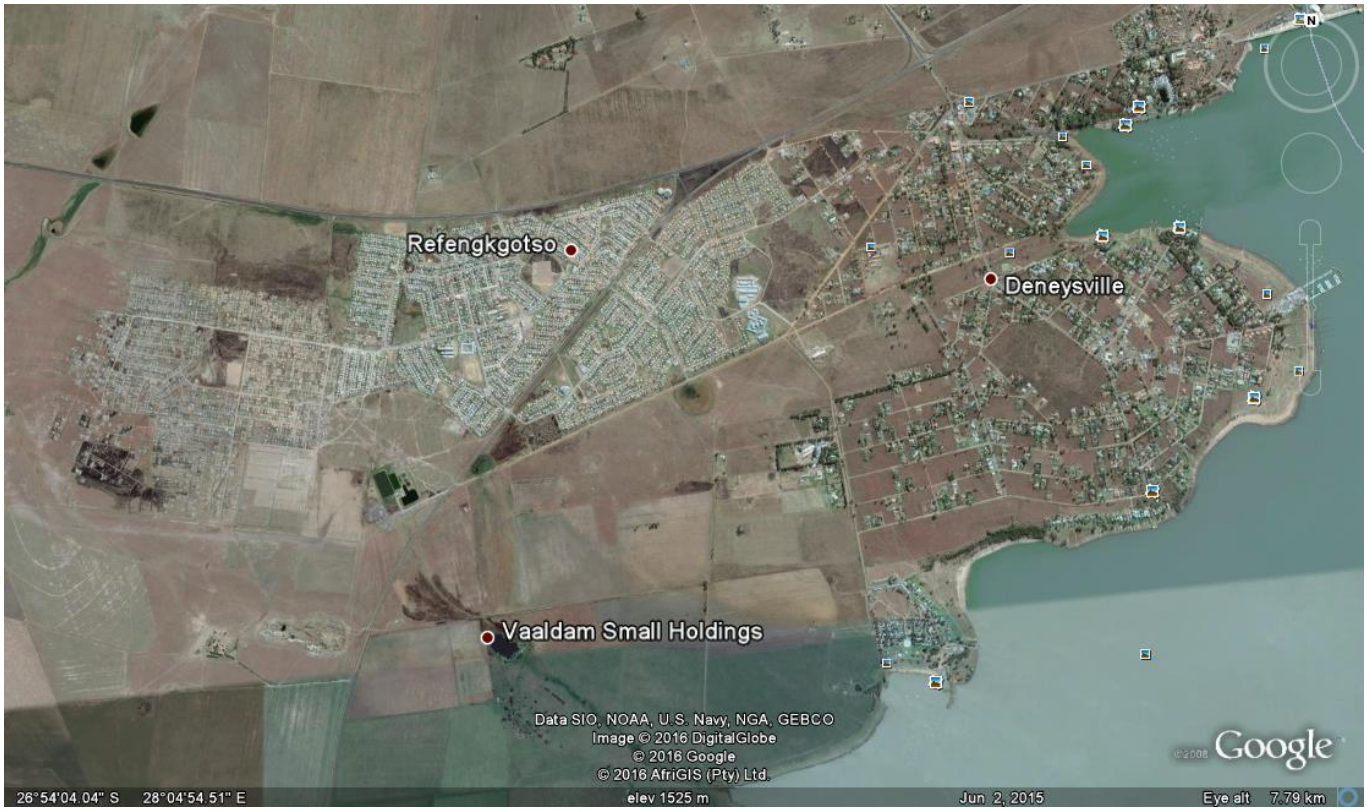

Figure 10: Refengkotso (and neighbouring Deneysville, on the Vaal Dam)

12. APPENDIX B: SUMMARY OF THE HOUSEHOLD EMISSION OFFSET PRE-FEASIBILITY STUDY

Eskom's exploration of air quality offsets started with a pre-feasibility study conducted by EScience Associates and the Nova Institute in 2013. The objective of this study was to determine the most feasible interventions to offset tall stack emissions from Eskom's power stations by reducing household emissions. Household interventions were selected based on the numerous scientific studies that show that in South Africa the main cause of harmful health effects due to poor air quality is the domestic burning of solid fuels.

An exhaustive list of household interventions was brainstormed, and kick-out criteria were then applied to reduce the list for detailed evaluation. The shortened list of interventions was then evaluated according to the following weighted criteria (Figure 11):

- Reduced human exposure to ambient PM10
- Reduced human exposure to ambient SO_2
- Implementation cost attractiveness of intervention
- Success probability of intervention
- Government and Eskom Board acceptance of intervention
- Sustainability of intervention
- Household acceptance of intervention
- Indirect impact of implementation (long and short term)

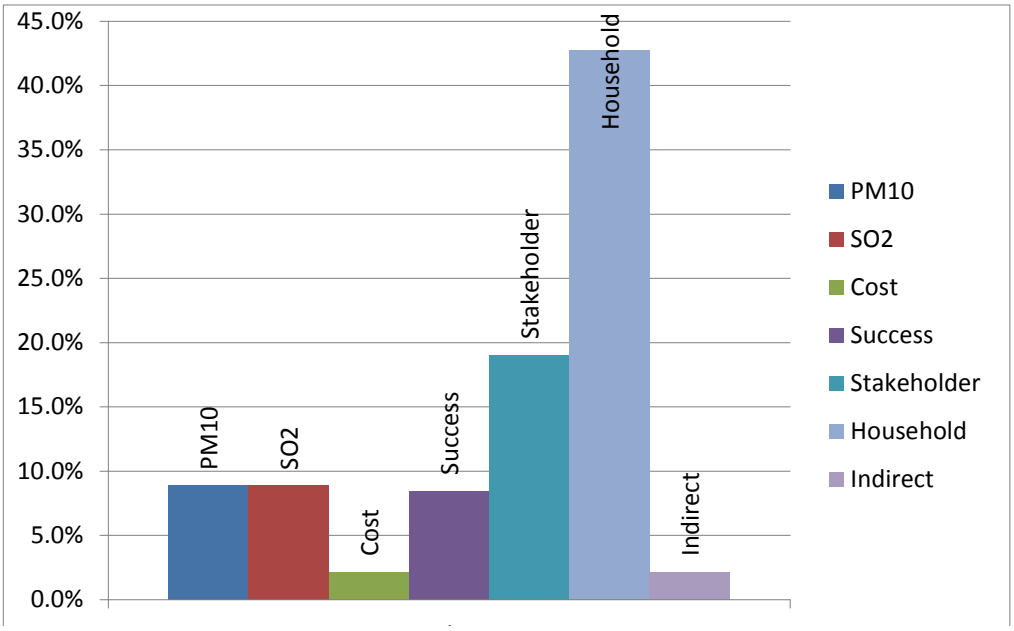

Figure 11: Weighting of the criteria used to evaluate the proposed offset interventions

Households are considered to be the most important stakeholder, and their acceptance was identified as the most important criterion that would determine the success of the offset projects, followed by acceptance by licencing authorities and the Eskom Board.

The interventions recommended for further study, based on applying the weighted criteria (results in Figure 12) are:

- Retrofit full suite of thermal shell insulation (ceilings and three walls), draft proofing and Trombe wall on all existing subsidy houses [Full retrofit]
- Install ceilings in all formal houses [Ceilings]
- Optimise house size, shell insulation, ventilation, orientation and solar heat absorption for new subsidy houses and social housing [EE RDP]
- Replace coal / wood stove with multi-purpose, high quality, low emission stove [New stove]
- Electricity subsidy
- Gas subsidy with equipment [LPG subsidy & heater]

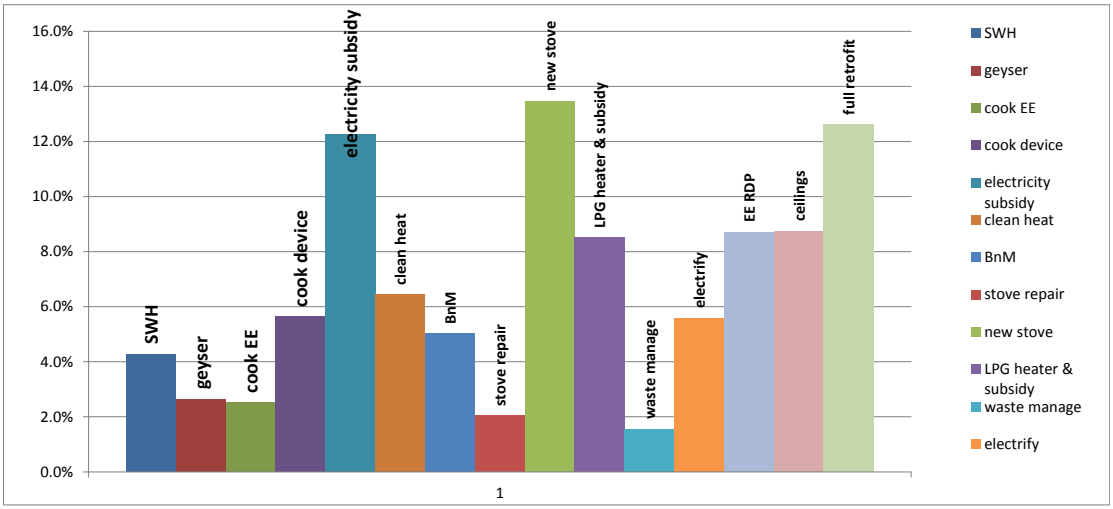

Figure 12: Result of applying the evaluation criteria (relative weighting on the y-axis)

13. APPENDIX C: SUMMARY OF THE AIR QUALITY OFFSETS PILOT STUDY IN KWAZAMOKUHLE

Following on from the pre-feasibility study, the next step in Eskom's air quality offsets journey was an air quality offsets pilot project, which was conducted in KwaZamokuhle (3 km from Hendrina town, Mpumalanga) from mid-2014 to end 2015. The project team was comprised of experts from the North-West University, the Nova Institute, the Council for Scientific and Industrial Research, EScience Associates and Prime Africa Consulting.

The most promising interventions identified in the pre-feasibility study were implemented at 120 formal houses: ceilings were installed at 60 of the houses, and the remaining 60 houses were fitted with a ceiling, insulation on three walls, and the north-facing wall was painted black and a Trombe wall was constructed to trap and store additional energy from the sun. Each of these houses was then either given an electricity subsidy for the winter months, or their coal stoves were swopped for a low emission stove, or their coal stoves were swopped for an LPG heater, stove and gas cylinder.

Prior to the roll-out of the interventions, a baseline assessment was conducted, including detailed surveys of most households in KwaZamokhule and ambient air quality monitoring. In-depth community consultation was conducted both to inform the design of the interventions (we learnt that the community required the low emission stoves to be big enough to hold at least three pots, and the stove needs to be sturdy because there are often small children around, for example), and to educate the participating households on how to light low emission fires in the new stoves, how to cook with LPG, and how to use LPG safely, for example. Forty eight members of the local community were recruited and trained to conduct the surveys and implement the interventions.

Much was learnt about the energy use patterns, health and economic status of the community, and there were many practical learnings as to how the interventions can be improved (for example, moisture in the roofs stained the ceilings, so the ceilings need to be water resistant). Some of the most significant findings of the pilot study, which have informed Eskom's large-scale offsets implementation plan, are:

- 65% of households in KwaZamokhule use coal. KwaZamokhule and other similar communities in Mpumalanga thus have great potential for offsetting.

- Domestic coal burning is a significant source of pollution for KwaZamokuhle. A comparison between the ambient air quality in KwaZamokuhle and Hendrina, which is 3 km away and influenced by the same regional sources but does not have domestic burning, showed that PM10 and PM2.5 levels in KwaZamokuhle are between 2 and 5 times higher than in Hendrina during the early morning and evening (when households light fires). Average PM concentrations are twice as high in KwaZamokuhle than in Hendrina. A reduction in domestic coal burning thus should result in a noticeable improvement in ambient air quality.

- Participation rates in the pilot project were high. Of the qualifying households who were approached to participate in the roll-out, 66% agreed to accept a ceiling and low emission stove, 88% agreed to accept a full insulation retrofit and low emission stove, 83% agreed to accept a ceiling and LPG appliances, and 87% accepted a full insulation retrofit and LPG appliances.

- Ceilings were the intervention received most positively by the residents. Not only do they improve the appearance of the houses, they also raise the minimum indoor temperature in winter by 4°C on average and keep houses warmer for 2-3 hours longer at night.

- Permanent uptake of the interventions was high. 100% of the ceiling and LPG households, 98% of the full retrofit and LPG households, 98% of the ceiling and low emission stove households, and 95% of the full retrofit and low emission stove households chose to keep their new stoves, rather than getting back their original stoves.

- The electricity subsidy did not bring about a shift from coal to electricity.

- Approximately 30% of dwellings in KwaZamokhule are informal, and of these 90% use solid fuel for heating and cooking. An intervention which shifts inhabitants of informal houses away from solid fuel use will need to be found.

- Around 25% of households burn their waste, further contributing to the poor air quality, in spite of municipal waste removal services in parts of KwaZamokuhle.

- The participatory approach, which involves communication and consultation with the community and also recruitment and training of project staff from the local community, was very successful.

More information on the pilot project can be found in the paper presented by Langerman *et al.* at the National Association of Clean Air Conference in 2015.

Results of the 30 house pilot

At the conclusion of the 120-House pilot, the project team was requested by Eskom management to pilot test the feasibility providing household with electrical devices - stove and heater (rather than previous approach which involve provision of an LPG stove and heater). The pilot study was conducted on 30 households during 2017. The main objective of the pilot study was understand willingness of coal-using households to swap their coal stove for an electric stove, electric heater, energy efficient lighting and a full retrofit (wall and ceiling insulation plus draft proofing).

The results of the pilot study indicated that it was feasible to switch households from coal to electricity, however there were several risks raised, which would limit the success of an electricity-based intervention. To address the risks identified with the electricity based solution, recommended mitigation measures are detailed in the table below:

Table C1: Risks and mitigation measures for the electricity based intervention

Risk	Possible mitigation measures
Electricity interruptions due to faults or outages	This risk will be mitigated by the fact that an LPG backup will be provided. The project team will work with Eskom Distribution and the affected Local Municipality to strengthen supply in the area and limit interruptions.
Social unrest resulting from Eskom debt collection through municipality electricity cut-offs	Eskom customer services stakeholder engagement is assumed to address this issue. LPG back up also mitigates this risk.
Electricity price increases	Insulation of the houses will result in a lower or equal energy cost relative to the post-intervention situation. Electricity and Gas prices are likely to increase the extent of which is dependent on many factors e.g. health the economy and demand for the commodity.

Based on the results of the studies conducted to date it was concluded that ambient air quality in the affected communities could be improved by replacing household's coal stoves with electricity stoves and a heater plus an LPG backup together with retrofitting the ceiling to insulate the houses.

The recommended Air Quality Offset intervention for the lead implementation entails the following (Figure 10);

- Provision of a basic plus retrofit which consists of;
    - Insulation entailing installation of a ceiling system and draft proofing
    - Rewiring and issuance of Certificate of Competence (CoC).
- Stove swap which entails
    - Provision of electricity based energy source with LPG backup. This will include a hybrid electric gas stove, LPG heater plus 2x9 kg LPG cylinders and CFL lighting.
    - Removal and disposal of the coal stove

Electricity is the cleanest source of domestic energy. Rather than providing an LPG stove, heater and cylinder in exchange for the household's coal stove, Eskom is now proposing to provide an electric stove and heater. The proposed changes have impacted the planned schedule for the roll-out of the interventions especially in Nkangala and Gert Sibande.

Figure C1: Household Intervention for Lead Implementation Sites (KwaZamokuhle and Ezamokuhle)