Eskom	**Air Quality Offsets Implementation Plan for Nkangala District Municipality**	**Eskom**

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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 the Nkangala District Municipality covers the period from April 2017 to March 2025, and aims to improve ambient air quality in several communities around Eskom's coal-fired power stations in the district: Hendrina, Arnot, Komati, Kriel, Matla, Kendal and Duvha Power Stations.

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

- solicit information from key stakeholders into the design of the offsets programme
- obtain approval from the authorities on the proposed offsets methodology, the types of offsets to be implemented, and the areas for implementation
- form the basis of Eskom's request for offset funding in its Multi-Year Price Determination 4 (MYPD4) application to the National Electricity Regulator (NERSA)
- fulfil the requirement in the power stations' Atmospheric Emission Licences 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 once this high level plan has been approved (in particular, once the areas for offsetting have been agreed on), and 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 April 2016, and it will be updated further at regular intervals, as experience is gained and more detailed information becomes available. Main updates from the April 2016 version of the plan include:

- Coal-using households residing in formal dwellings will be switched to electricity wherever possible, and not liquid petroleum gas (LPG). Electricity is the cleanest form of energy for domestic use and the promotion of electricity is aligned with Eskom's mandate.
- Households which do not use coal will be offered a ceiling
- The start of the roll-out has been delayed by Eskom's protracted authorisation and procurement process, and the change from LPG to electricity which required new planning.

The Air Quality Offset Implementation Plan for the Nkangala District Municipality 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. Starting in 2014, Eskom developed and piloted potential offset interventions in KwaZamokuhle. The pilot provided valuable information for planning the large scale Eskom offset programme.

Phase 1: Lead implementation (one Eskom-impacted community per district municipality). 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 verification processes.

Phase 2: Full implementation (balance of qualifying households). Once the intervention has been refined and the learnings of the lead implementation incorporated, the intervention will be rolled out simultaneously at several communities across the Nkangala District Municipality

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

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*: Once the implementation is underway and after it has been completed, a structure will be set up to ensure that the installations can be maintained by the households. The effectiveness of the intervention will also be monitored.

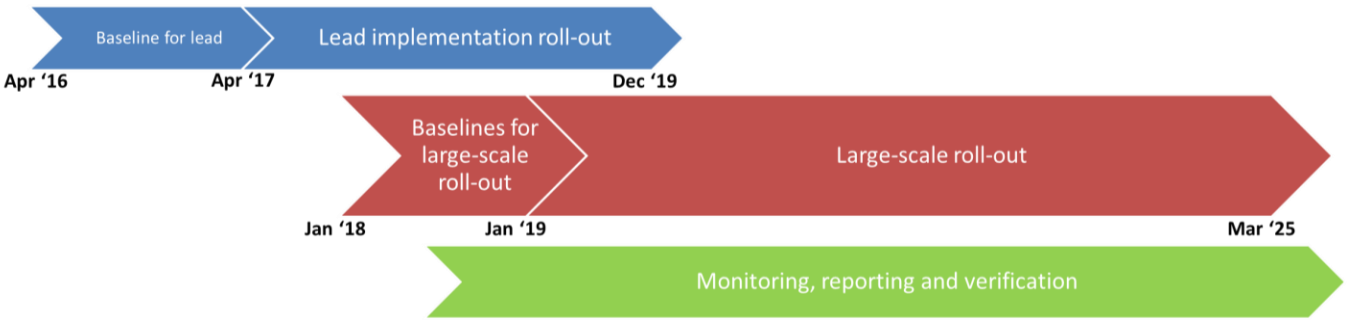


Figure 1: Concept schedule for the implementation of air quality offsets in the Nkangala District Municipality

2. Selection of offset interventions

The main thrust of Eskom's offsets programme in the Nkangala District Municipality will be reducing emissions from domestic solid fuel burning, based on scientific evidence that shows that of all sources of air pollution in South Africa, domestic burning has by far the greatest impact on human health (FRIDGE, 2004; MRC, 2008; Lim et al. (2012)). Nevertheless, other sources of pollution may also need to be addressed.

This Air Quality Offsets Implementation Plan is based on a **Programme of Activities**, comprising of:

i) *Household interventions*: Emissions from the domestic burning of coal/wood will be reduced through one or more of the following:
- Assisting households to move to a cleaner source of energy (like electricity)
- 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

ii) *Community emission interventions*: Significant local non-household sources of emissions which affect the air quality in the area, for example waste burning or smouldering landfills, will be identified in the baseline phase of the roll-out through engagements with the community.

iii) *Education and awareness*: Continual interaction with the community will ensure that the intervention is used and maintained properly, and encourage behavioural change to reduce exposure and smoke generation.

iv) *Projects in development*: Since this Air Quality Offsets Implementation Plan spans 9 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

Offsets need to be implemented on at least one settlement of reasonable size for each power station. 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 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 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).

Eskom proposes to implement offsets at qualifying households in the following settlements:

Table 1: Areas selected for the air quality offsets roll-out in the Nkangala District Municipality

Power station	Areas for offsets	Type of offset
Hendrina	KwaZamokuhle Neighbouring farms	Household – lead implementation Household
Arnot	Silobela Neighbouring farms	Household Household
Komati	Big House informal settlement Emahlathini informal settlement Goedehoop informal settlement Kamfefe (Driffontein) Vandykdrif Rethabile Neighbouring farms	Household Household Household Household Household Household Household
Kriel	Thubelihle Rietspruit Neighbouring farms	Household Household Household
Matla	Emzinoni and extensions, Chris Hani, Milan Park Extensions, Kananna Ext 6, Thambo (4300 households only) Neighbouring farms	Household Household
Kendal	Phola Eskom Triangle Khayalethu community Olympic community Makhosi community Arbor Neighbouring farms	Household Household Household Household Household Household Household
Duvha	Masakhane Neighbouring farms	Household Household

KwaZamokuhle has been proposed for the lead implementation in the Nkangala District Municipality due to its appropriate size (not too big that the full roll-out will take too long, but big enough to allow testing of key aspects of the roll-out at scale), the prevalence of domestic coal burning, and the fact that a baseline assessment has already been done and a local office established for the pilot project. The household offset will comprise of improved housing insulation (probably a ceiling), and swopping of existing coal stoves for electric stoves and heaters.

The implementation timeline is dependent on procurement approvals and on funding being allocated by Eskom and approved by NERSA in Eskom's MYPD4 application.

We propose that this Air Quality Offsets Implementation Plan for the Nkangala District Municipality 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 Nkangala 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
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 of South Africa
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

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.

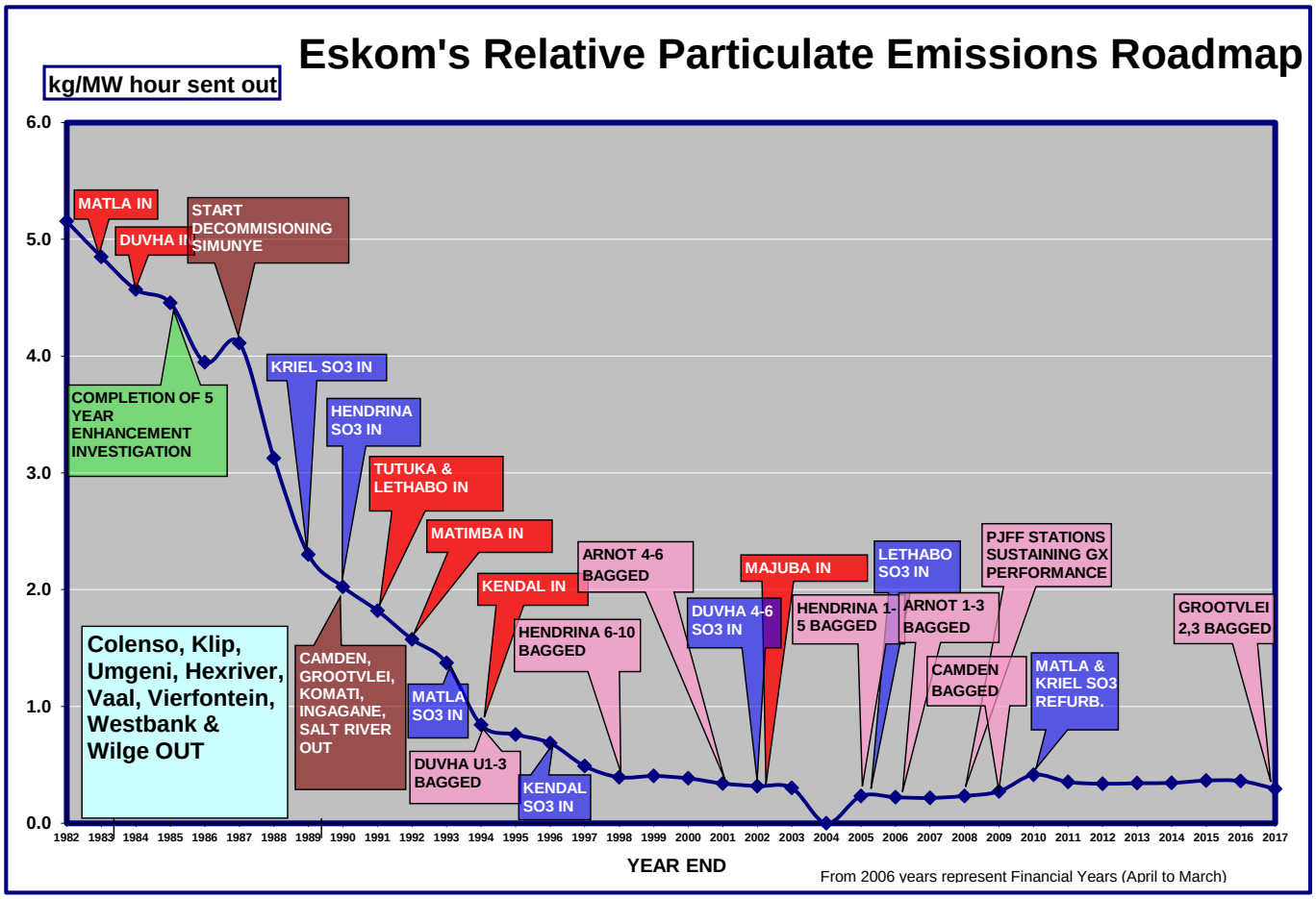


Figure 2: Change in relative emissions of particulates (ash) from Eskom's power stations from the early 1980s to present. Upgrades on power stations to reduce emissions are indicated ('bagged' refers to fabric filter plant retrofits; 'SO_3' refers to the installation of SO_3 plants which improve the efficiency of the electrostatic precipitators). Newer power stations have more efficient abatement technology

Eskom wishes to implement air quality offsets in order to:

- Improve the air quality of communities affected by emissions from power stations
- Comply to the requirements of the Atmospheric Emission Licences of each power station
- 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 Eskom's seven power stations in the Nkangala District Municipality: Hendrina, Arnot, Komati, Kriel, Matla, Kendal and Duvha Power Stations (Figure 3). It covers the period from April 2017 to March 2025. This document has been developed for submission to the National Air Quality Officer and the Licencing Authority (the Nkangala District Municipality), and also to elicit input from key stakeholders into the development of the power stations' air quality offsets programme.

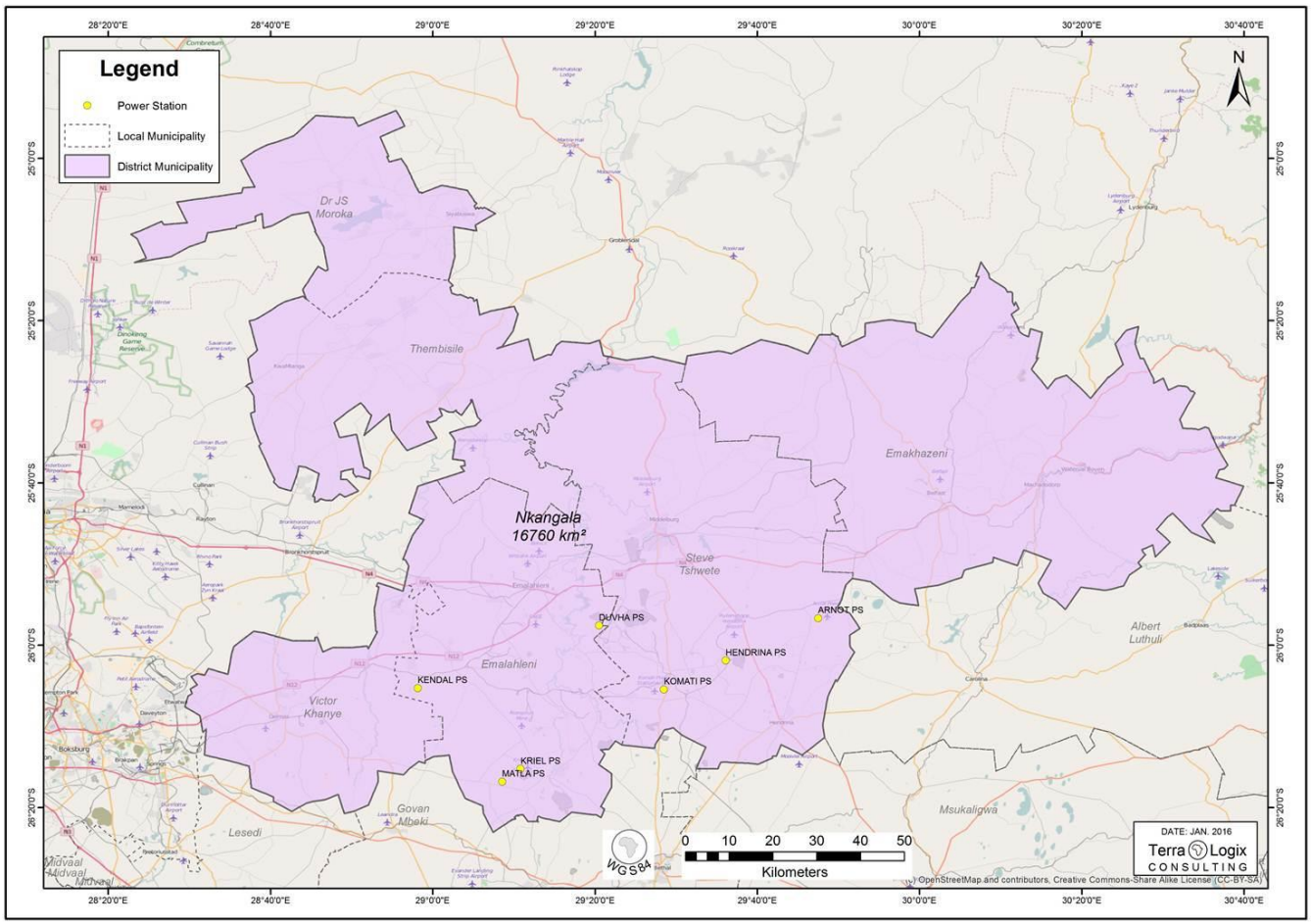


Figure 3: Power stations in the Nkangala District Municipality

This is a high level plan, based on the information available at the time of compilation. It is an update of the first plan, published in April 2016. The plan details, to the extent possible, the proposed offset interventions per selected settlement associated with each of the power stations in the Nkangala District Municipality. It details the approach to be 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. The Project Design Document for the formal dwellings in KwaZamokuhle Air Quality Offset Project is the first such detailed plan. This implementation plan lays out 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 monitoringThis plan will be updated and refined annually as more information becomes available.

The implementation of this plan is subject to approval of the funding required by the National Electricity Regulator (NERSA) in the Multi-Year Price Determination 4 (MYPD4) application.

2. APPLICABLE LEGISLATION AND REGULATORY REQUIREMENTS

2.1 ATMOSPHERIC EMISSION LICENCE

Section 4.4 of Hendrina, Arnot, Komati, Kriel, Matla, Kendal and Duvha's Atmospheric Emission Licences (AELs) requires that each of the power stations is to '*submit an Emission Offset Programme to reduce PM Pollution in the ambient/receiving environment by the 31th March 2016*'.

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 Hendrina, Arnot, Komati, Kriel, Matla, Kendal and Duvha'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 each power station 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 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's current plans include reducing PM emissions from Kriel, Matla, Kendal and Duvha (Units 4-6) Power Stations, and reducing NOx emissions from Matla Power Station, by 2025.

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.

The following findings of the pilot study informed 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

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

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* which accompanies this report.

Information about the Air Quality Implementation Plan for the Nkangala District Municipality 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) A public meeting was held to present and discuss the implementation plan in eMalahleni on 16 March 2016

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, except for in KwaZamokuhle where project-specific details are discussed with the community at the Local Stakeholder Reference Group on 23 March 2017 and at previous meetings. Prior to the implementation of offsets in each community, in-depth engagements will be held to provide local perspective, understand the baseline and inform the project design.

5. METHODOLOGY

5.1 OFFSETS IMPLEMENTATION STRATEGY: 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 Highveld, 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 (tens of thousands of households) 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 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

It is proposed that the risks of rolling out untested interventions be reduced by following a phased approach to air quality offset implementation:

Phase 0: Pilot project. From 2014 to March 2017, Eskom developed and piloted potential offset interventions in KwaZamokuhle. The pilot provided valuable information for planning the large scale Eskom offset programme.

Phase 1: Lead implementation (one Eskom-impacted community per district municipality). The selected intervention is implemented at all willing, solid fuel-using households in a community. 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. For each housing type (formal/informal/mixed formal and informal), a small-scale demonstration will be conducted to test proof of concept before rolling out to the entire community. For more information on the lead implementation, see section 6.9.

Phase 2: Full implementation (balance of qualifying households). Once the intervention has been refined and the learnings of the lead implementation incorporated, the intervention will be rolled out simultaneously at several communities across the Nkangala District Municipality (Figure 4 and Figure 5).

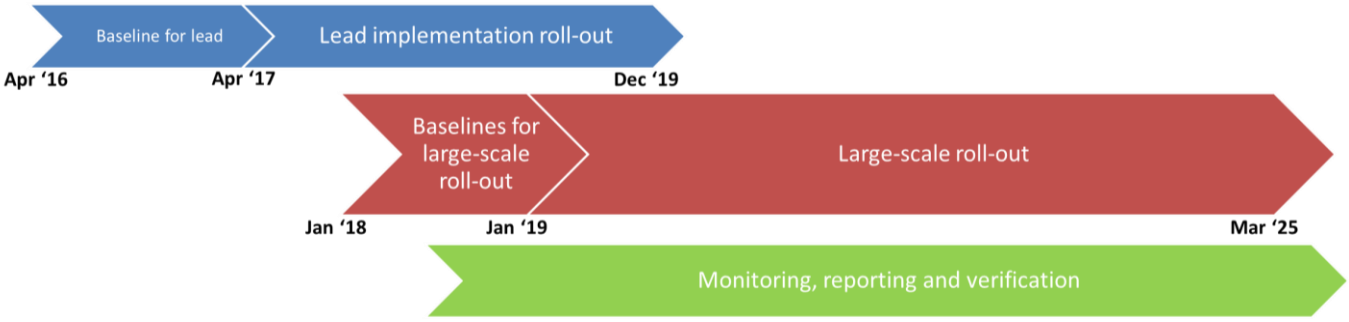


Figure 4: Concept schedule for the implementation of air quality offsets in the Nkangala District Municipality

The dates shown in the implementation concept (Figure 4) are preliminary and have been developed from available desktop information. The schedule will be refined and submitted for approval per project once on-the-ground information has been obtained through community meetings and household surveys in each area.

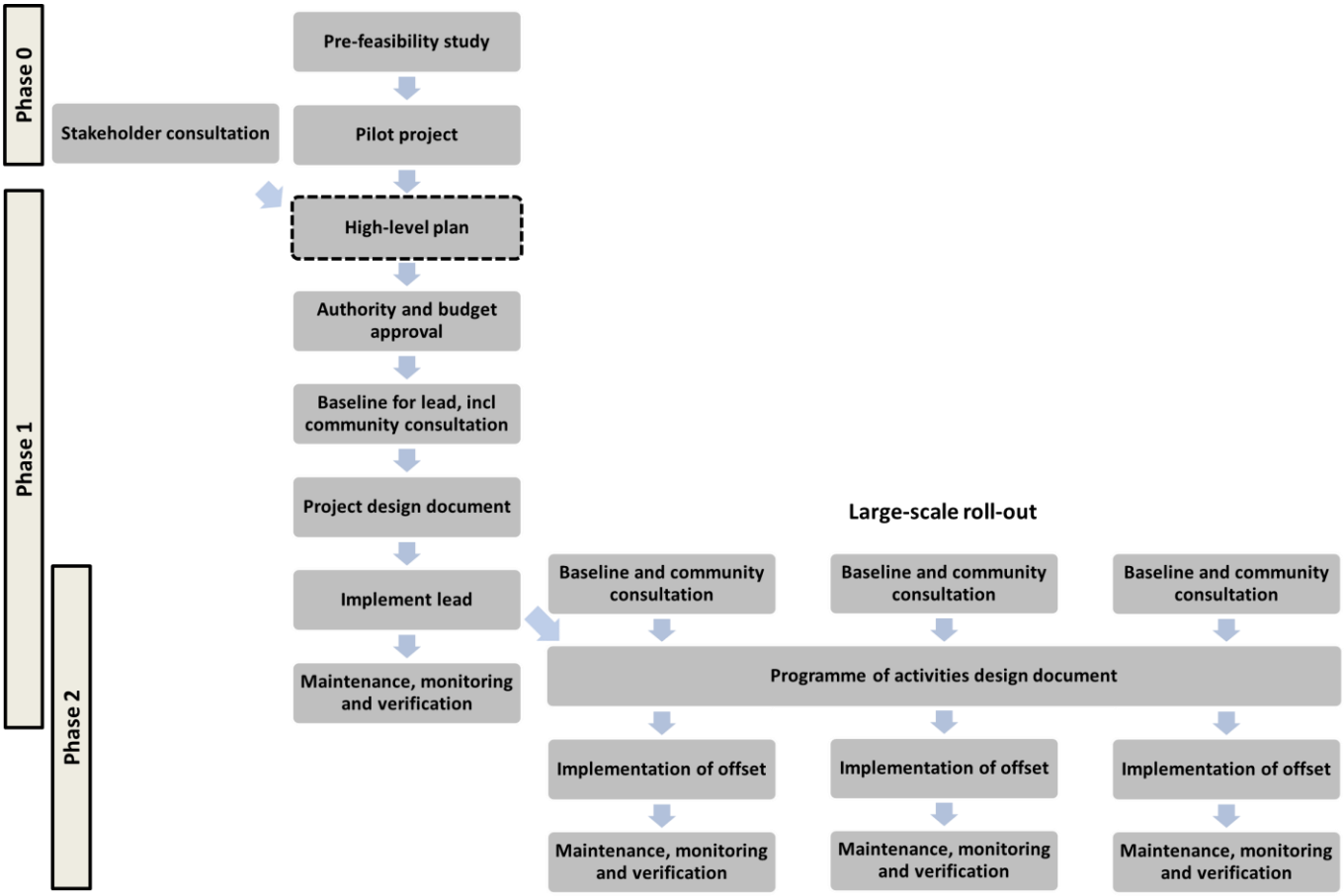


Figure 5: Stages in the development and implementation of the Nkangala Air Quality Offsets Programme

5.2 FOCUS ON REDUCING DOMESTIC BURNING EMISSIONS

Scientific studies have repeatedly shown that, in areas where households burn coal or wood for cooking and heating, the emissions from this domestic burning make the greatest contribution to ambient levels of particulate matter. For example, 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 6). 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.

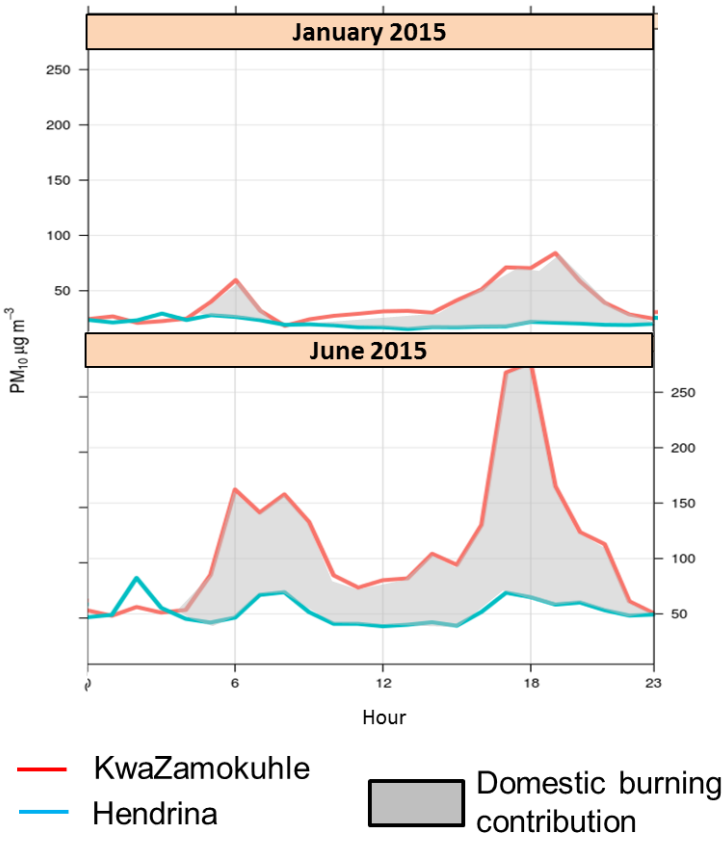


Figure 6: Average diurnal ambient PM10 concentrations (µg/m^3) measured in KwaZamokuhle and neighbouring Hendrina in summer (January 2015) and winter (June 2015). The difference in concentration between the two areas, shaded in grey, is mainly due to domestic burning in KwaZamokuhle.

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 7).

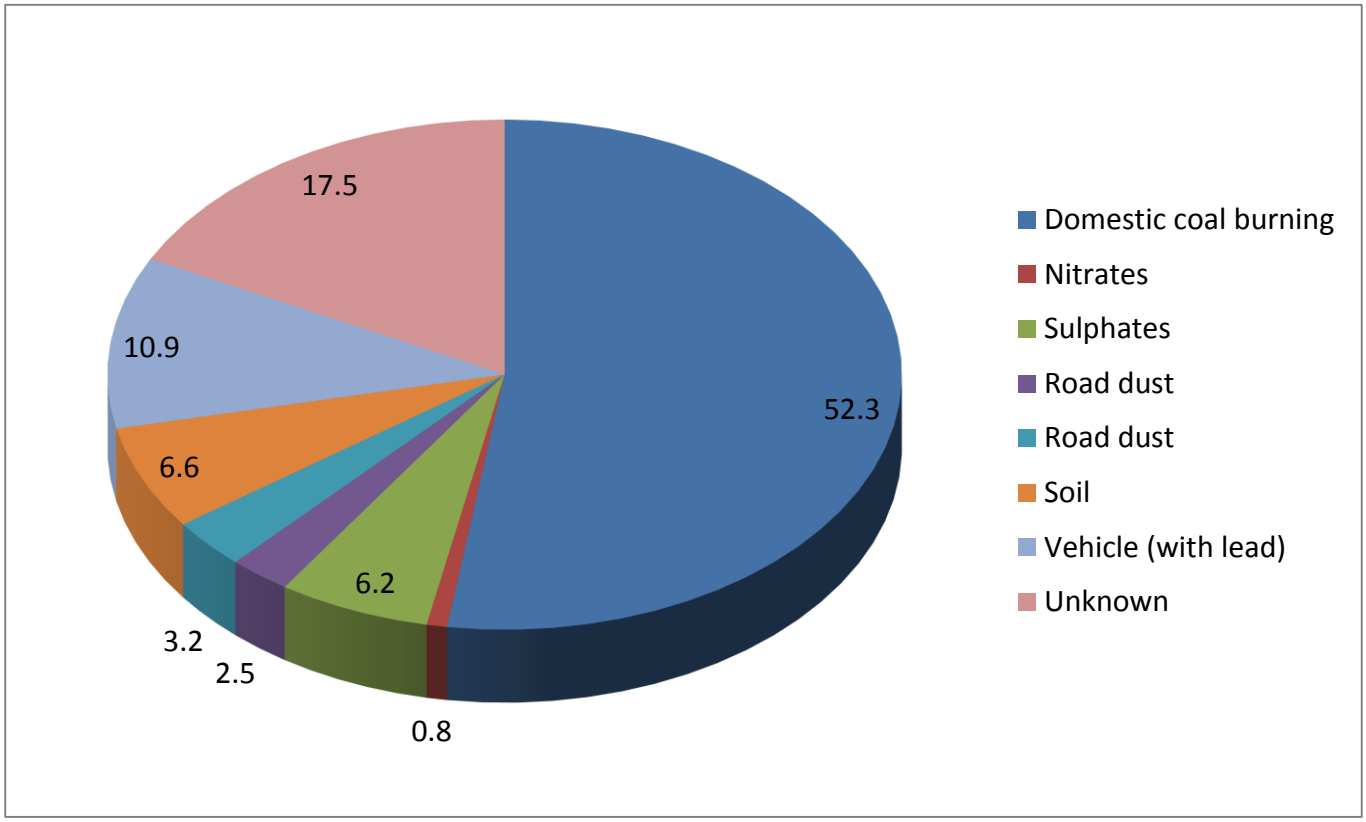


Figure 7: Source apportionment of the fine particulate matter (PM2.5) in KwaZamokuhle in winter 2015

Furthermore, modelling conducted for the FRIDGE Report (Scorgie et al., 2004b) showed that on the Mpumalanga Highveld, highest ambient PM10 levels from domestic burning are around 7-8 times higher than those from power generation (Table 2). Indeed, ambient PM10 levels from domestic fuel burning are around an order of magnitude higher than from any other source (other than a few industries, notably brickworks and a steel factory). The proximity of people to domestic burning also plays a crucial role in exposure since they are directly near the source. Additionally, the fact that the source is often indoors further exacerbates the impact.

Table 2: Predicted air pollution concentrations due to domestic burning and power generation in the Mpumalanga Highveld 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	1041	131	162
	Daily	139	16	20
	Annual	29	3	4

5.3 OFFSETS IMPLEMENTATION PROCESS PER COMMUNITY

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

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

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 offsets also need to be implemented there as far as is feasible.

5.4.1 Farmsteads

Farms in the vicinity of power stations need to be candidates for offsets, provided there is non-compliance with ambient air quality standards and opportunities for offsetting exist. A customised offsets intervention will need to be designed for each qualifying farmstead, based on the type of dwellings and energy use. It is likely that only households which mainly use wood, coal or a similar fuel for cooking and heating will be included in Eskom's offsets roll-out programme.

5.4.2 Rural settlements

Rural settlements are also considered candidates for offsets provided ambient air quality standards are exceeded. The intervention will need to be tailored based on dwelling type and fuel use. For example, there is not much scope to switch communities which use freely available wood to a cleaner but more expensive energy source. A low emission wood-burning stove may be the most suitable intervention in this case.

5.4.3 Informal areas

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 areas. Areas 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

The main thrust of Eskom's offsets programme will be reducing emissions from domestic solid fuel burning, based on scientific evidence that shows that of all sources of air pollution in South Africa, domestic burning has by far the greatest impact on human health (FRIDGE, 2004; MRC, 2008; Lim et al. (2012)). This finding is supported by ambient air quality measurements collected during Eskom's air quality offsets pilot study in KwaZamokuhle, which showed that domestic burning accounts for a significant amount of ambient PM. Household emission offsets will be complemented by initiatives to address other important local sources of pollution (such as landfill sites), as well as education and awareness relating to air pollution.

This Air Quality Offsets Implementation Plan is based on a **Programme of Activities**, comprising of:

i) *Household interventions*: Emissions from the domestic burning of coal/wood will be reduced through one or more of the following:
   - Assisting 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. 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 implementation in KwaZamokuhle, 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.

ii) *Community emission interventions*: In some areas, there are significant local non-household sources of emissions which affect the air quality in the area, for example waste burning or smouldering landfills. These sources will be identified in the baseline phase of the roll-out through engagements with the community and air quality monitoring, and then a solution designed for the implementation phase.

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 heaters are not run throughout the day or with closed windows, and cooking methods are adapted to suit an electric stove), 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 9 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:

- Informal housing pilot: This will be conducted in KwaZamokhule from 2018, 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.
- Non-household intervention pilot: This will be conducted in the Vaal, also from 2018, and will test ways of reducing emissions from local waste burning through improving waste collection and/or recycling.
- 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, for example)
- The housing structures and permanence thereof (insulation may not be a viable option for all housing structures, for example)

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 (although they would potentially be candidates should there be a future 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 in the Vaal). 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) and energy use 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

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.

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

Where interventions are conducted in farm homesteads and small settlements, air quality monitoring will not be undertaken, as it is considered that:

- The success of the interventions in improving air quality has been demonstrated in other areas
- The costs of the air quality monitoring will be greater than the costs of the offset intervention

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) Create awareness as to how air pollution affects health and what can be done to stay healthy
iv) Educate the community members on how to best employ and maintain the offset
v) 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: 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.

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

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. The project team can help to establish a locally owned company which can assist with the maintenance of the installations in the longer term.

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 Nkangala 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. The KwaZamokuhle PDD for formal dwellings is the first such PDD which has been developed.

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
   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) 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 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).

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. It is therefore proposed to establish a partnership with a reputable research institution to determine the health impacts of the air quality offsets roll-out in one area (which will not necessarily be the Nkangala District Municipality).

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 PLANS PER POWER STATION

The communities which have been proposed for offsets for each power station and the timeline for implementation are described in this section. Figure 8 to Figure 14 show the area of impact of the emissions from each power station (annual average concentrations in $\mu g/m^3$) and are extracted from the Atmospheric Impact Reports submitted in support of Eskom's application for postponement of the Minimum Emission Standards compliance timeframes for each of the power stations (uMoya-NILU 2014a-2014g).

6.1 HENDRINA POWER STATION

Hendrina Power Station is a coal-fired power station with an installed capacity of 1893 MW. Hendrina was originally commissioned between 1972 and 1976. Hendrina is situated around 50 km south-east of Emalahleni, Mpumalanga. Fabric filter plants were retrofitted in the late 1990s and early 2000s to improve the efficiency of the ash removal from the flue gas before it exits to the atmosphere. The Hendrina units reach their 50-year life between 2020 and 2027.

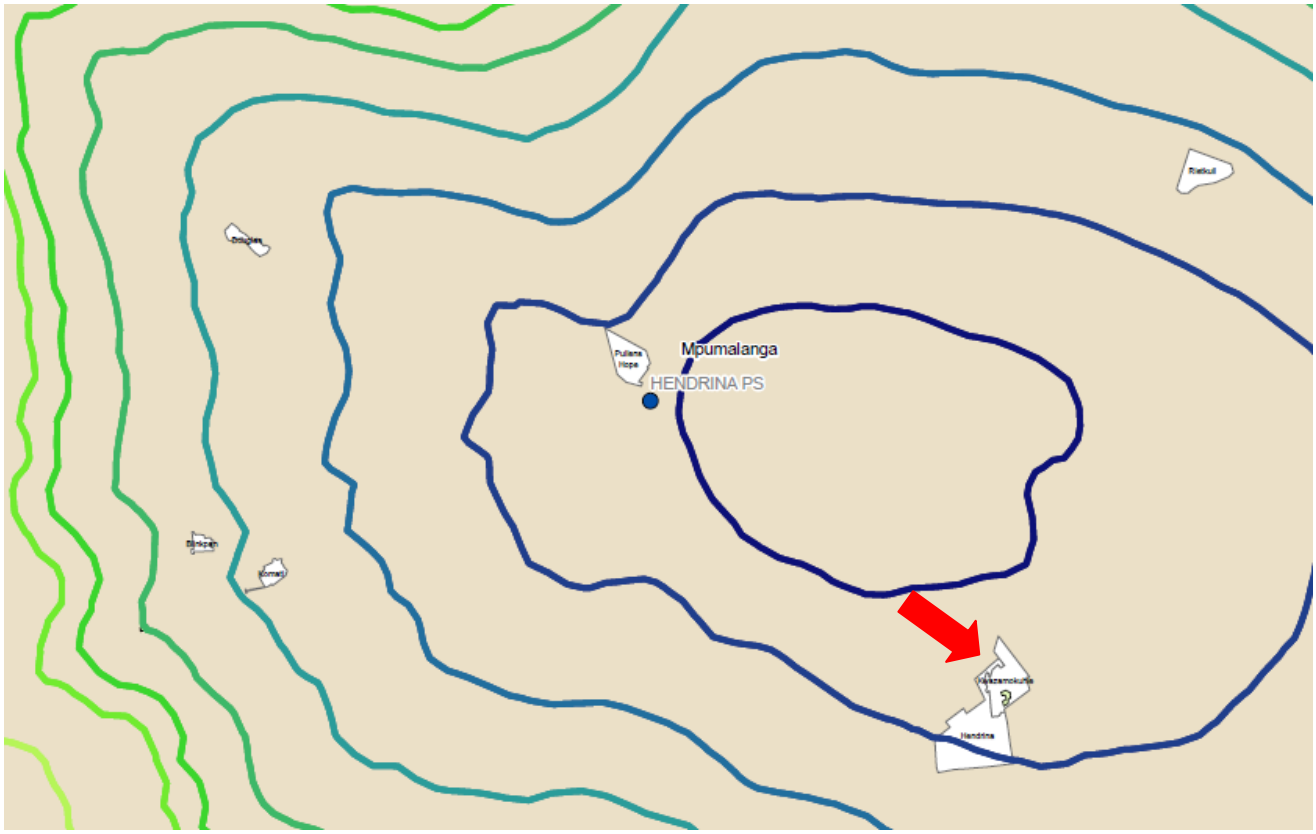
6.1.1 Target areas and interventions

The settlements in the vicinity of Hendrina which are most highly impacted by Hendrina's emissions (Figure 8) are, in order of highest emissions impact:

- Pullens Hope, the power station village. Households in Pullens Hope use electricity as their main energy source, so there is no opportunity for offsets there.
- KwaZamokuhle has a high rate of domestic coal use and is an ideal candidate for air quality offsets
- Hendrina does not have opportunity for offsets

KwaZamokuhle has been selected as the area for Hendrina's offsets roll-out. KwaZamokuhle was the site of Eskom's pilot project in 2015, and is proposed to be the lead implementation for the Nkangala District Municipality. During the pilot project, it was found that domestic burning emissions make a significant contribution to ambient PM levels in KwaZamokuhle, and that around 65% of households use coal (Table 4).

Neighbouring farms where there is poor air quality due to domestic burning and opportunities for offsets exist will also receive offsets.



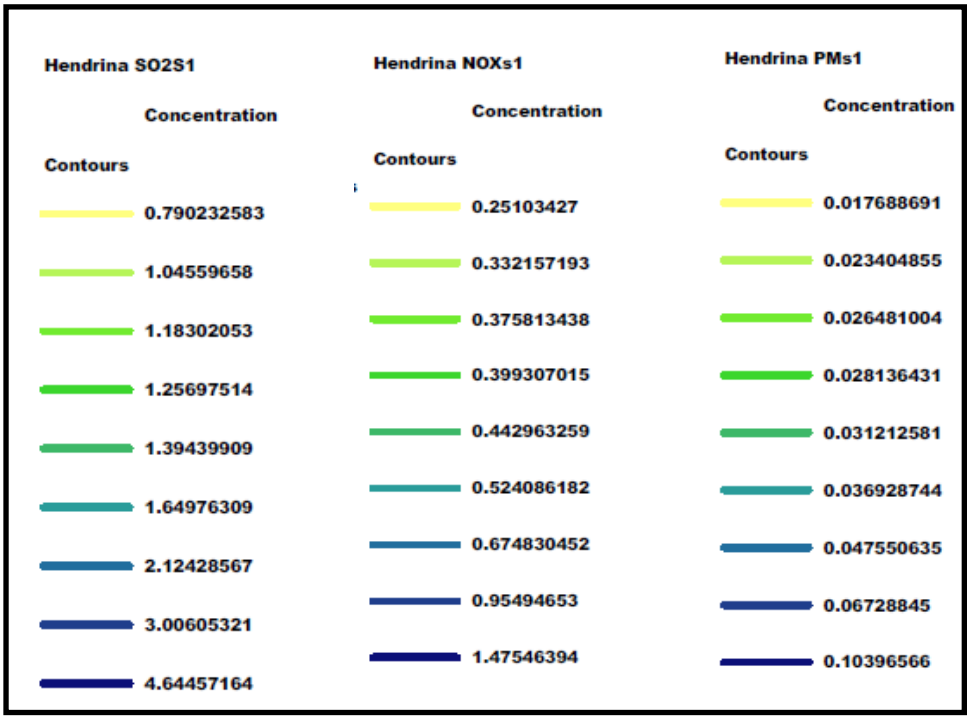


Figure 8: Area of impact of Hendrina Power Station's emissions (annual average concentrations in μg/m^3 from uMoya-NILU, 2014a), Kwazamokuhle, selected for the offsets programme, is indicated with a red arrow.

Table 4: Total population, energy usage patterns and indicative number of households that are potentially candidates for Hendrina's offsets programme

Settlement	KwaZamokuhle
Population	20427
Number of households	5877
Number of households using coal according to pilot study	3617
Number of households using wood according to Census 2011	41
Indicative number of households for offsets	3255*

* assuming 90% of coal-users choose to participate in the programme

6.2 ARNOT POWER STATION

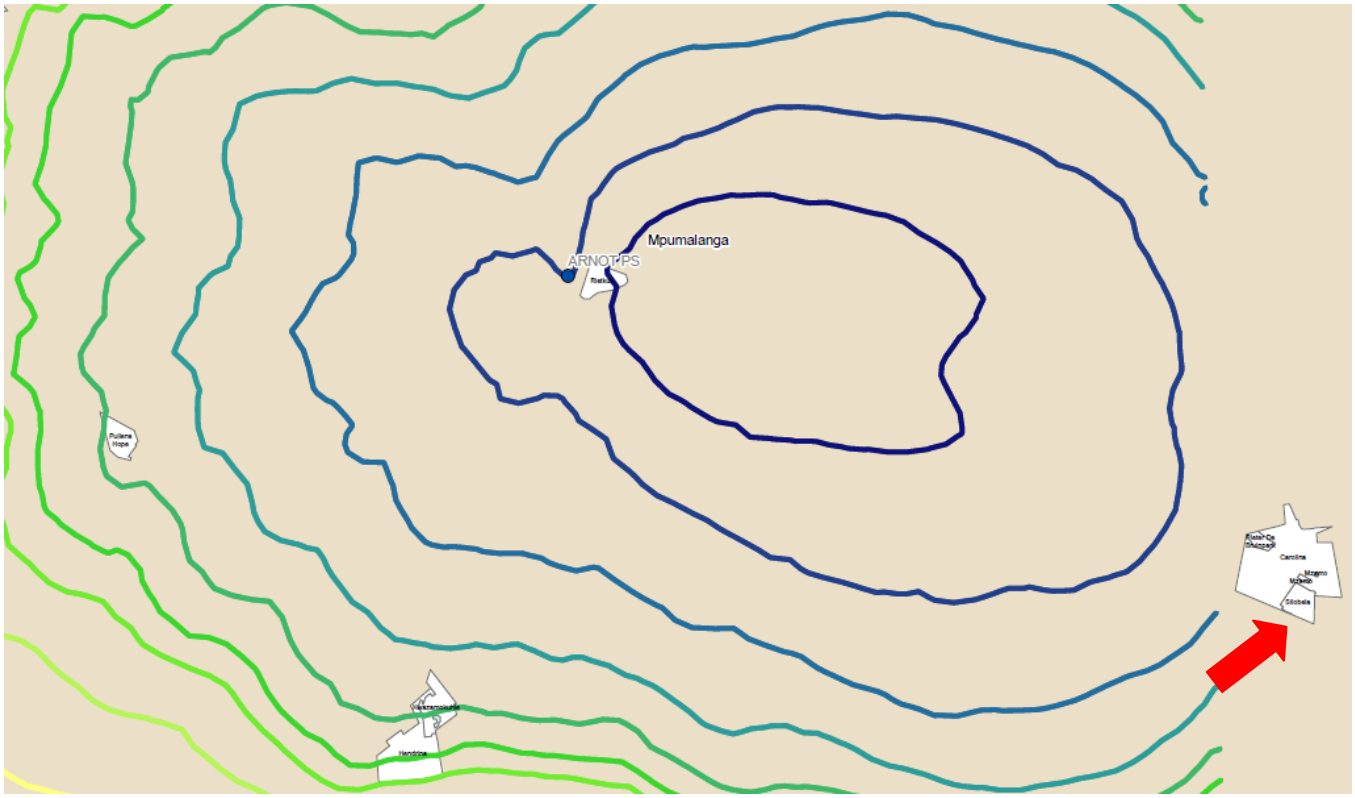
Arnot Power Station is a six-pack coal-fired power station with an installed capacity of 2352 MW and was originally commissioned between 1971 and 1975. Arnot Units 4-6 were mothballed for 4 years and Units 2-3 were put in deep coal reserve for 3.5 years in the times of excess capacity. The units were returned to service between 2008 and 2009. Arnot is situated around 50 km south-east of Middleburg, Mpumalanga. A fabric filter plant was retrofitted on Units 4-6 in 2001 and on units 1-3 in 2006 to improve the efficiency of the removal of the ash from the flue gas before it exits to the atmosphere.

6.2.1 Target areas and interventions

The areas most highly impacted by emissions from Arnot Power Station (Figure 9) and their potential for offsets are, in order of highest impact:

- Rietkuil is the power station village, established for employees of Arnot. There are no significant local sources of pollution in Rietkuil, and so no opportunities for offsets.
- Carolina. Again, residents of Carolina use electricity as their main energy sources and there is no opportunity for offsets
- *Silobela*. Most households use coal and wood as their main energy source (Table 5), so Silobela is the highest priority settlement for offsets
- KwaZamokuhle is also an excellent candidate for offsets, and has been allocated to Hendrina Power Station
- Pullens Hope is Hendrina's power station village, and does not have opportunity for offsets
- Hendrina also does not have opportunity for offsets as most households use electricity.
- *Neighbouring farms* affected by Eskom's emissions and subjected to poor air quality are also candidates for offsets

Silobela and qualifying neighbouring farms have been selected for Arnot's offset roll-out (Table 5).



Arnot SO2S1 Concentration Contours		Arnot NOXs1 Concentration Contours	
	0.399406916		0.199185925
	0.543239356		0.270916133
	0.625426009		0.311903171
	0.672387917		0.335323392
	0.75457457		0.37631043
	0.898407009		0.448040638
	1.15012393		0.573573563
	1.59064629		0.793265037
	2.3615915		1.17774062

Figure 9: Area of impact of Arnot Power Station's emissions (annual average concentrations in μg/m^3 from uMoya-NILU, 2014a), and locations of Silobela and Caropark (indicated with a red arrow)

Table 5: Total population, energy usage patterns and indicative number of households that will participate in the offsets roll-out in the target areas for Arnot's offsets programme

Settlement	Silobela
Population	11364
Number of households	3497
Number of households using coal according to Census 2011	15
Number of households using wood according to Census 2011	846
Indicative number of households for offsets	2504*

* assuming 75% of households are coal/wood users, and of those 90% choose to participate in the programme

6.3 KOMATI POWER STATION

Komati Power Station is a nine-unit coal-fired power station with an installed capacity of 1000 MW. Komati is situated around 35 km south-east of eMalahleni, Mpumalanga. Komati was originally commissioned between 1964 and 1966; it was then mothballed in the times of excess capacity and returned to service between 2009 and 2013. During the return to service, the electrostatic precipitators were refurbished, SO_3 plants were installed on all the units to improve the performance of the electrostatic precipitators, and a taller stack was built to aid the dispersion of the emissions.

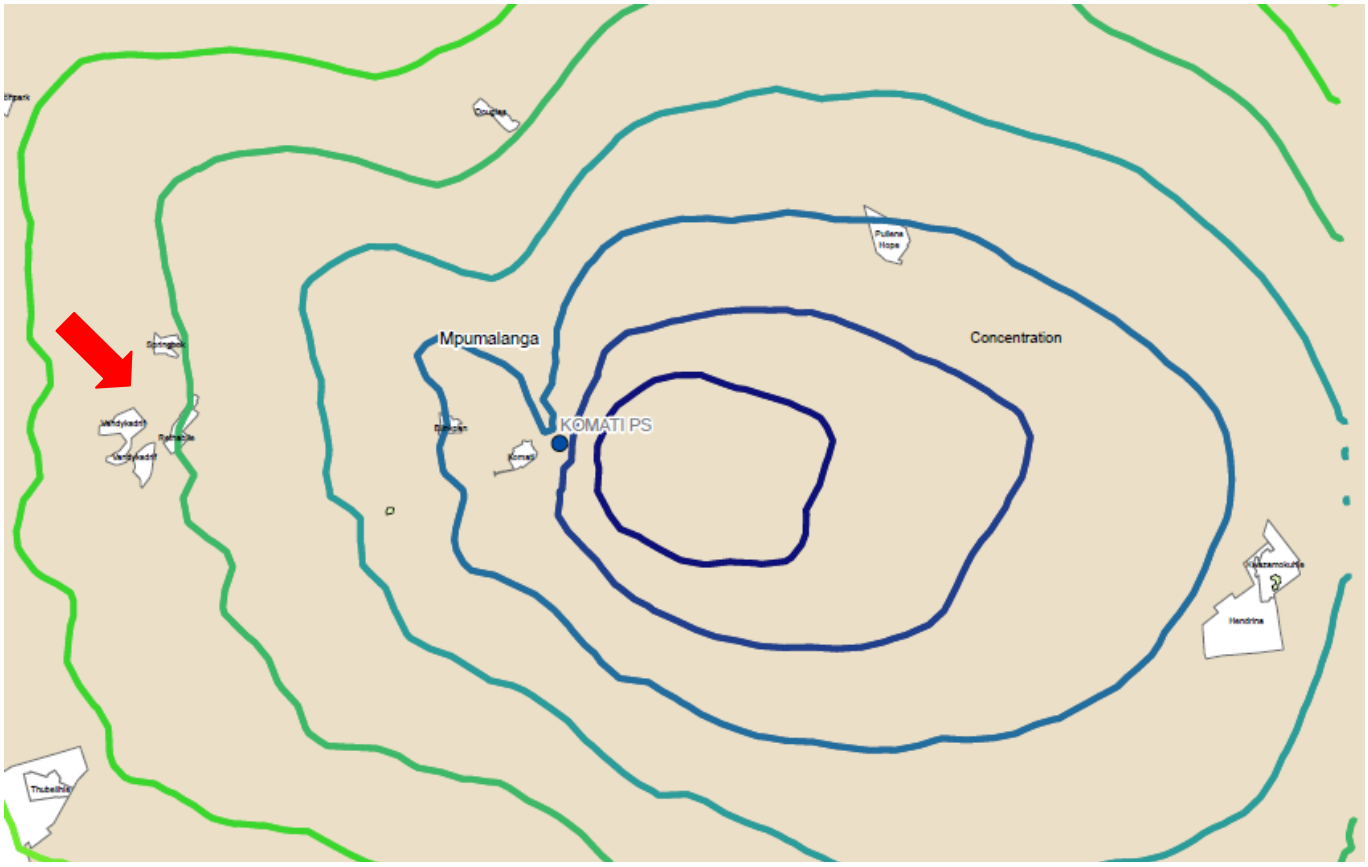
6.3.1 Target areas and interventions

The areas impacted by emissions from Komati Power Station are, in order of highest impact (Figure 10):

- Komati, the power station village. Households use electricity, so there is no opportunity for offsets there
- Pullens Hope, Hendrina's power station village. There is no potential for offsets here.
- Blinkpan, a mining town, where there is no potential for offsets
- KwaZamokhule will have offsets implemented by Hendrina Power Station
- Hendrina does not have potential for offsets
- Rethabile, where the potential for offsets will need to be verified with surveys
- Vandyskdrif, where the potential for offsets will need to be verified with surveys

In addition to Rethabile and Vandyksdrif, offsets will be implemented where possible (i.e. when potential for offsets exist and when dwellings are legally established) at (Table 6):

- Neighbouring farms (including Schoeman - 500m away, and Gelyk - 3 km away)
- Big House informal settlement (Ward 4) (Broodsny Farm)
- Emahlathini informal settlement (Ward 6) - 10 km away
- Goedehoop informal settlement - 15 km away
- Kamfefe (Driffontein)
- Van Drykdrift
- Rethabile



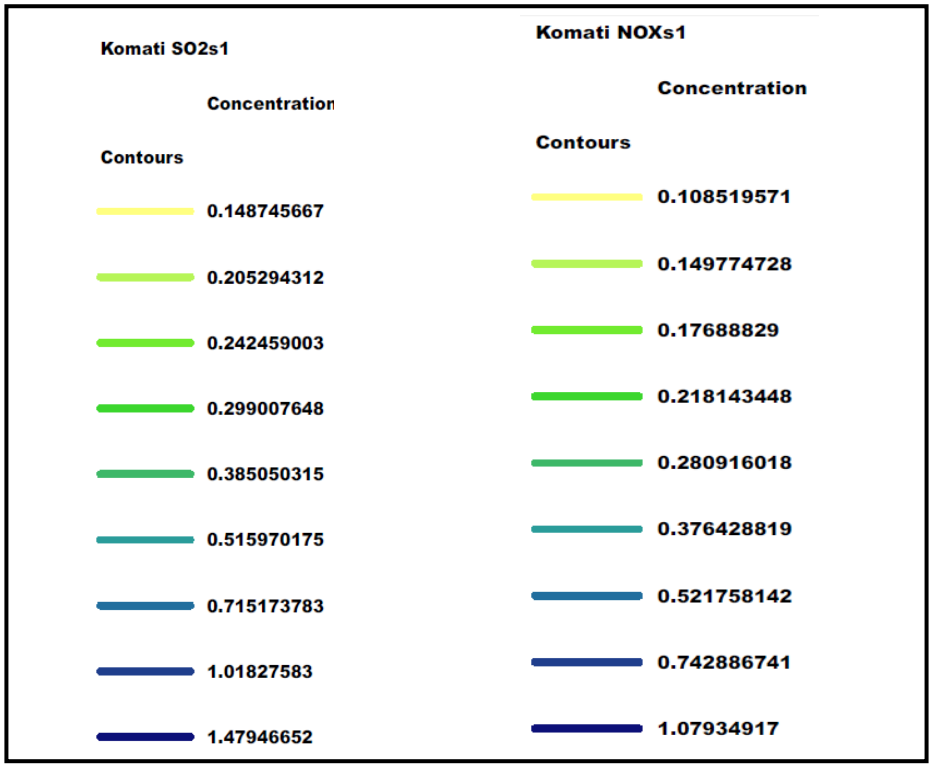


Figure 10: Area of impact of Komati Power Station's emissions (annual average concentrations in μg/m^3 from uMoya-NILU, 2014c), and locations of Rethabile and Vandyksdrif

Table 6: Total population, energy usage patterns and indicative number of households that will participate in the offsets roll-out in the target areas for Komati's offsets programme

Settlement	Population	Number of households	Indicative number of households for offsets*
Neighbouring farms (Schoeman, Gelyk)	8	6.4	6
Big House (Ward 4) - informal settlement (Broodsny Farm)	100	80	72
Emahlathini (Ward 6) informal settlement	300	240	216
Goedehoop informal settlement	300	240	216
Kamfefe (Driffontein)	45	36	32
Van Dyksdrif	233	163	146
Rethabile	172	120	108

* assuming 70% of households in Rethabile and Van Dyksdrif use coal and 80% of households in the other places use coal, and of those 90% choose to participate in the programme

6.4 KRIEL POWER STATION

Kriel Power Station is a six-pack coal-fired power station with an installed capacity of 3000 MW. It was commissioned between 1976 and 1979. Kriel is situated around 10 km east of Kriel Town, Mpumalanga. Kriel currently has functional electrostatic precipitators as well as flue gas conditioning plants, to reduce PM emissions stemming from the power station.

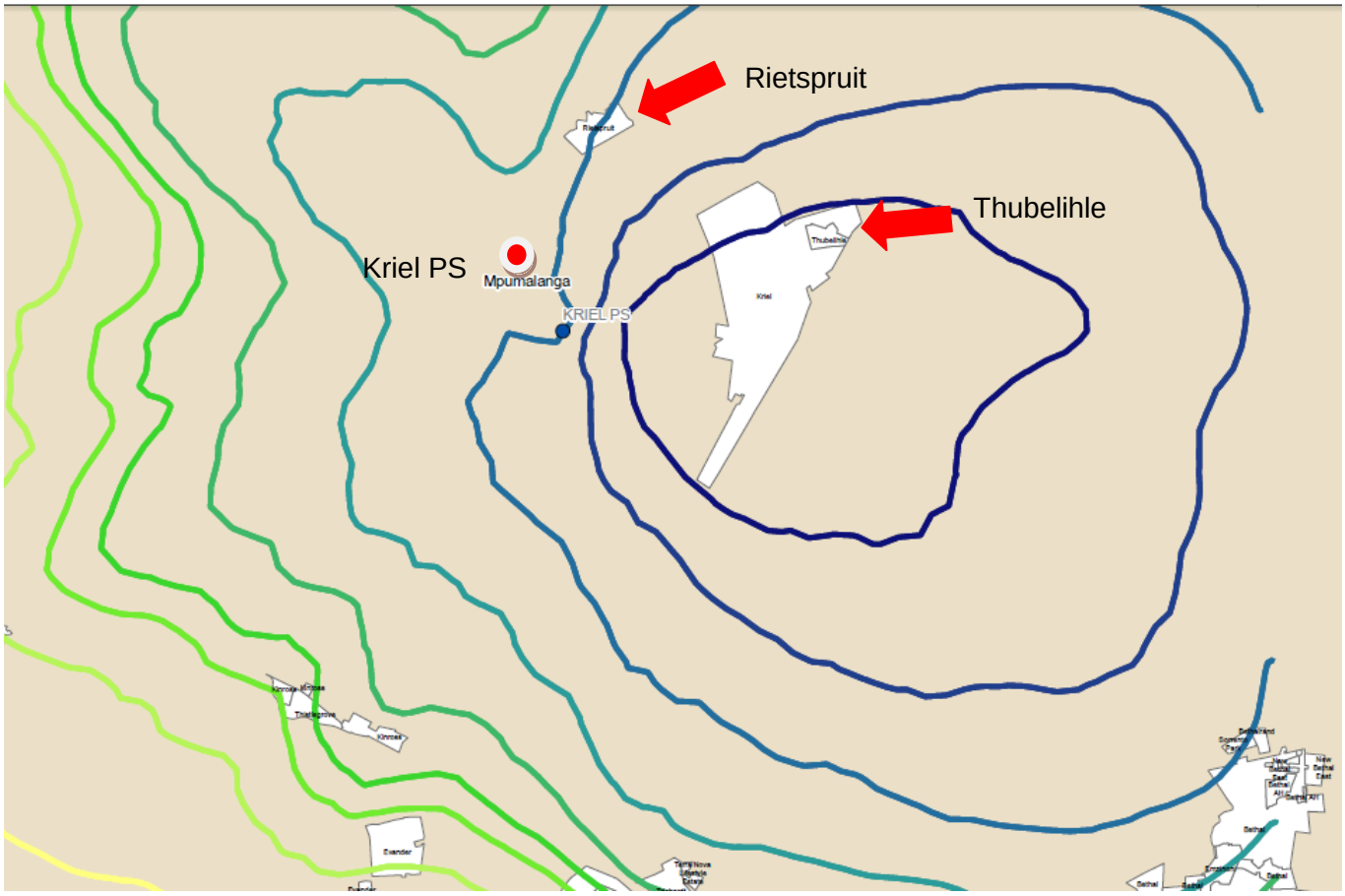
Kriel has committed to retrofit a fabric filter plant on all units as well as low NOx burners between 2019/20 and 2024/25 to ensure compliance with the new plant PM and NOx Minimum Emission Standards.

6.4.1 Target areas and interventions

The areas affected by emissions from Kriel Power Station are, in order of highest to lowest impact (Figure 11):

- Kriel, where there is no potential for offsets
- Thubelihle
- Rietspruit

Thubelihle and Rietspruit have thus been selected for Kriel's offsets programme (Table 7).



Kriel SO2s1		Kriel NOXs1		Kriel PMs1	
Concentration Contours		Concentration Contours		Concentration Contours	
	0.537191196		0.360605185		0.07278282
	0.716767497		0.481151859		0.097113165
	0.81937839		0.550032897		0.111015658
	0.878010822		0.589391903		0.11895962
	0.980621715		0.65827294		0.132862114
	1.16019802		0.778819615		0.157192459
	1.47446921		0.989784799		0.199772279
	2.02446598		1.35898876		0.274289967
	2.98699911		2.00512172		0.404701179

Figure 11: Area of impact of Kriel Power Station's emissions (annual average concentrations in $\mu g/m^3$ from uMoya-NILU, 2014d), and locations of Thubelihle and Rietspruit

Table 7: Total population, energy usage patterns and indicative number of households that will participate in the offsets roll-out in the target areas for Kriel's offsets programme

Settlement	Thubelihle	Rietspruit
Population	13 251	5 385
Number of households	4 425	1 584
Number of households using coal according to pilot study	21	
Number of households using wood according to Census 2011	833	
Indicative number of households for offsets	2 987	1 069

* assuming 75% of households use coal, and of those 90% choose to participate in the programme

6.5 MATLA POWER STATION

Matla Power Station is a six-pack coal-fired power station with an installed capacity of 3600 MW. Matla was commissioned between 1979 and 1983 and is situated around 12 km west of Kriel, Mpumalanga. Matla currently has functional electrostatic precipitators and flue gas conditioning plants to reduce PM emissions stemming from the power station.

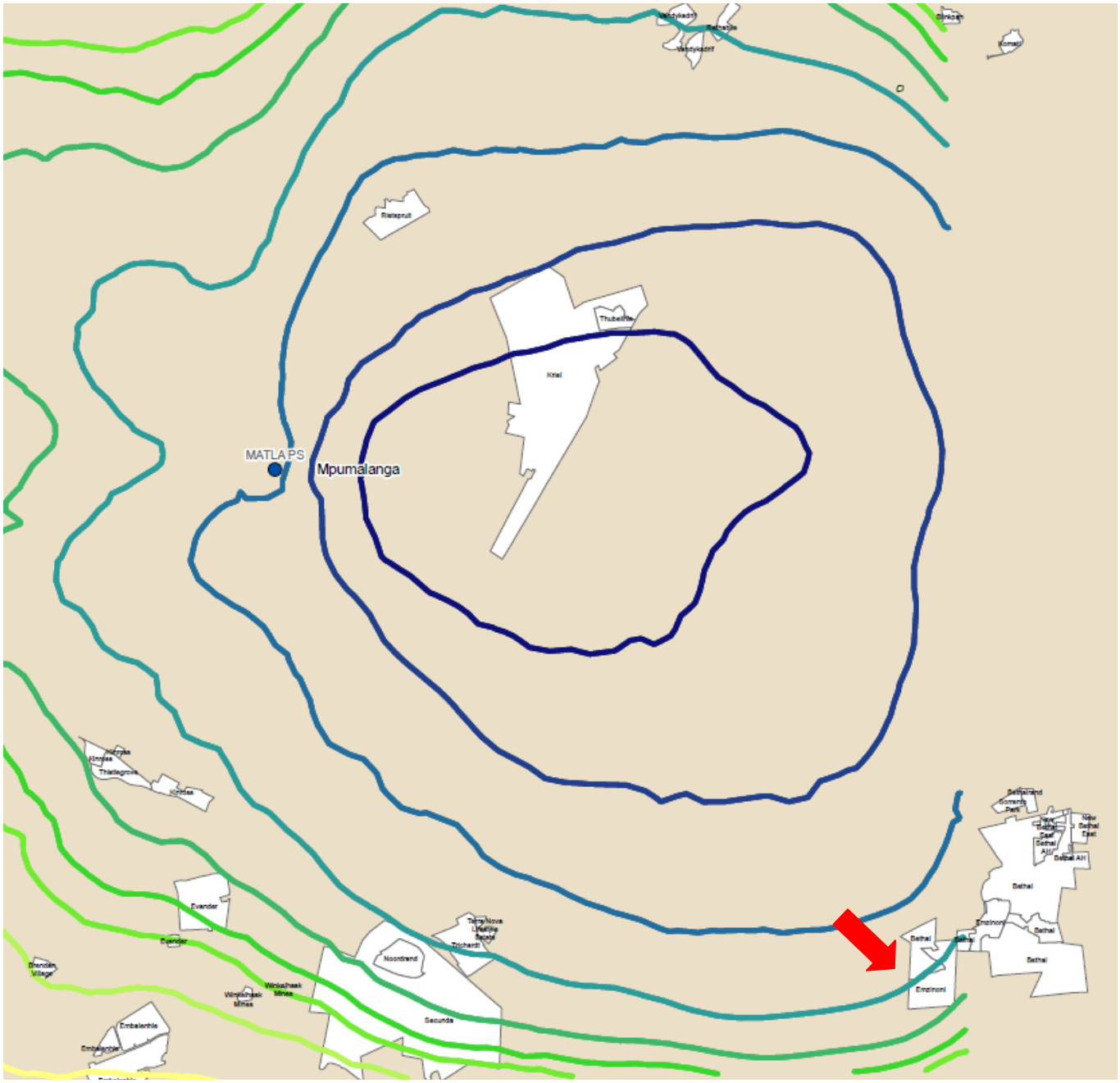
Matla has committed to retrofit a fabric filter plant and low NOx burners on all units between 2020/21 and 2024/25 to ensure compliance with the new plant PM and NOx Minimum Emission Standards.

6.5.1 Target areas and interventions

The following areas are impacted by emissions from Matla Power Station, in order of highest to lowest impact (Figure 12):

- Kriel, where there is no potential for offsets
- Thubelihle, which is part of Kriel Power Station's offsets programme
- Rietspruit, which is also part of Kriel Power Station's offsets programme
- Bethal, where there is no potential for offsets
- Vandyksdrif and Rethabile, which are part of Komati's offsets programme
- Emzinoni

Emzinoni and eligible neighbouring farms have thus been selected for Matla's offsets roll-out (Table 8). There are very roughly around 9 200 households in Emzinoni and adjacent areas that may participate in an offsets roll-out. Matla will implement offsets at 4 300 of these households prior to April 2025. The remainder of the households will be the first priority if there is a subsequent phase of offsets. All households unfortunately cannot be addressed in the current phase due to financial constraints.



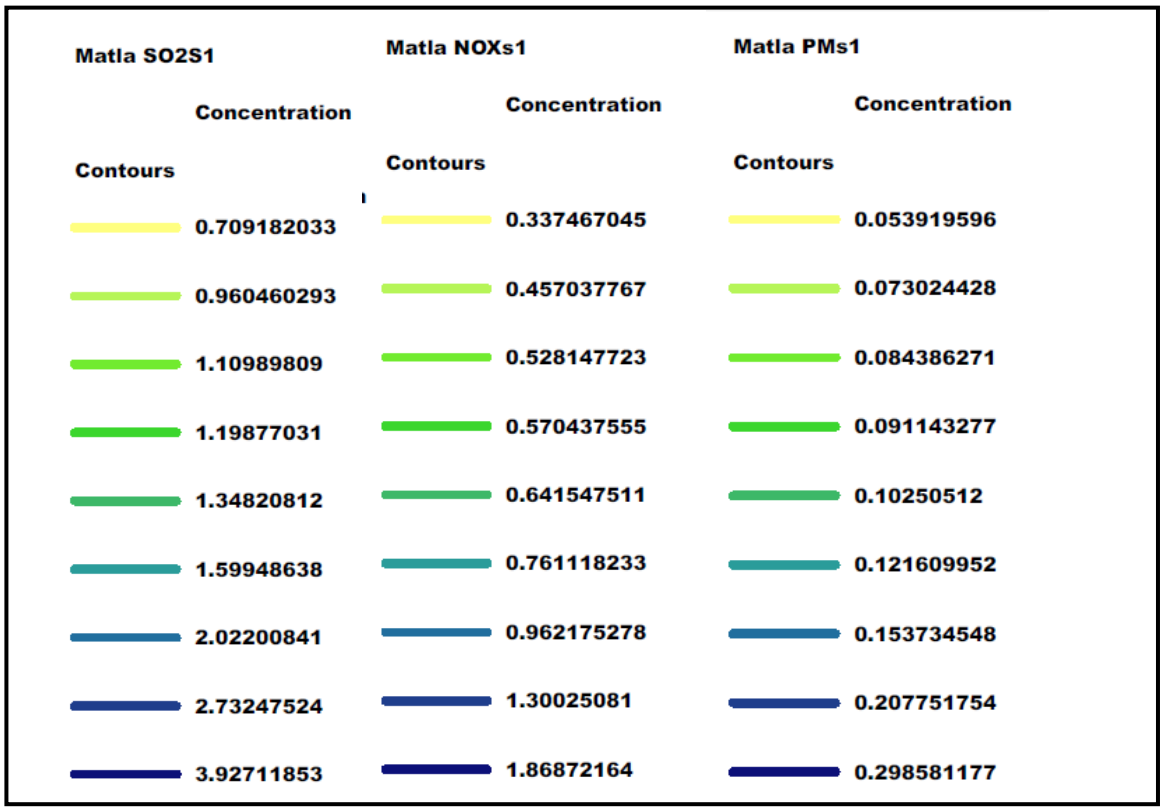


Figure 12: Area of impact of Matla Power Station's emissions (annual average concentrations in μg/m^3 from uMoya-NILU, 2014e), and locations of impacted areas in and around Bethal.

Table 8: Total population, energy usage patterns and indicative number of households that will participate in the offsets roll-out in the target areas for Matla's offsets programme

Settlement	Number of households	Number of households using wood according to Census 2011	Number of households using coal according to Census 2011	Number of households using coal according to NOVA's Carbon Monitoring Report	Indicative number of households for offsets*
Chris Hani	405	3	332	304	274
Emzinoni	1402	3	607	995	896
Emzinoni Ext 2	2832	3	919	2162	1945
Emzinoni Ext 3	1820	7	658	1394	1255
Emzinoni Ext 4	580	3	233	408	368
Emzinoni Ext 5	2561	0	1277	1779	1601
Kananna Ext 6	871	7	553	612	551
Milan Park Ext 13	393	0	137	188	0
Milan Park Ext 21	880	11	145	494	169
Milan Park Ext 22	811	6	355	468	445
Milan Park Ext 23	1408	15	652	939	421
Thambo	610	16	264	454	845
TOTAL	14573	74	6132	10197	9178

* assuming 90% of coal users choose to participate in the programme

6.6 KENDAL POWER STATION

Kendal Power Station is a coal-fired power station with an installed capacity of 4116 MW. Kendal was commissioned between 1988 and 1993 and is situated around 30 km south-west of eMalahleni, Mpumalanga. Kendal currently has functional electrostatic precipitators as well as flue gas conditioning plants to reduce PM emissions from the power station.

6.6.1 Target areas and interventions

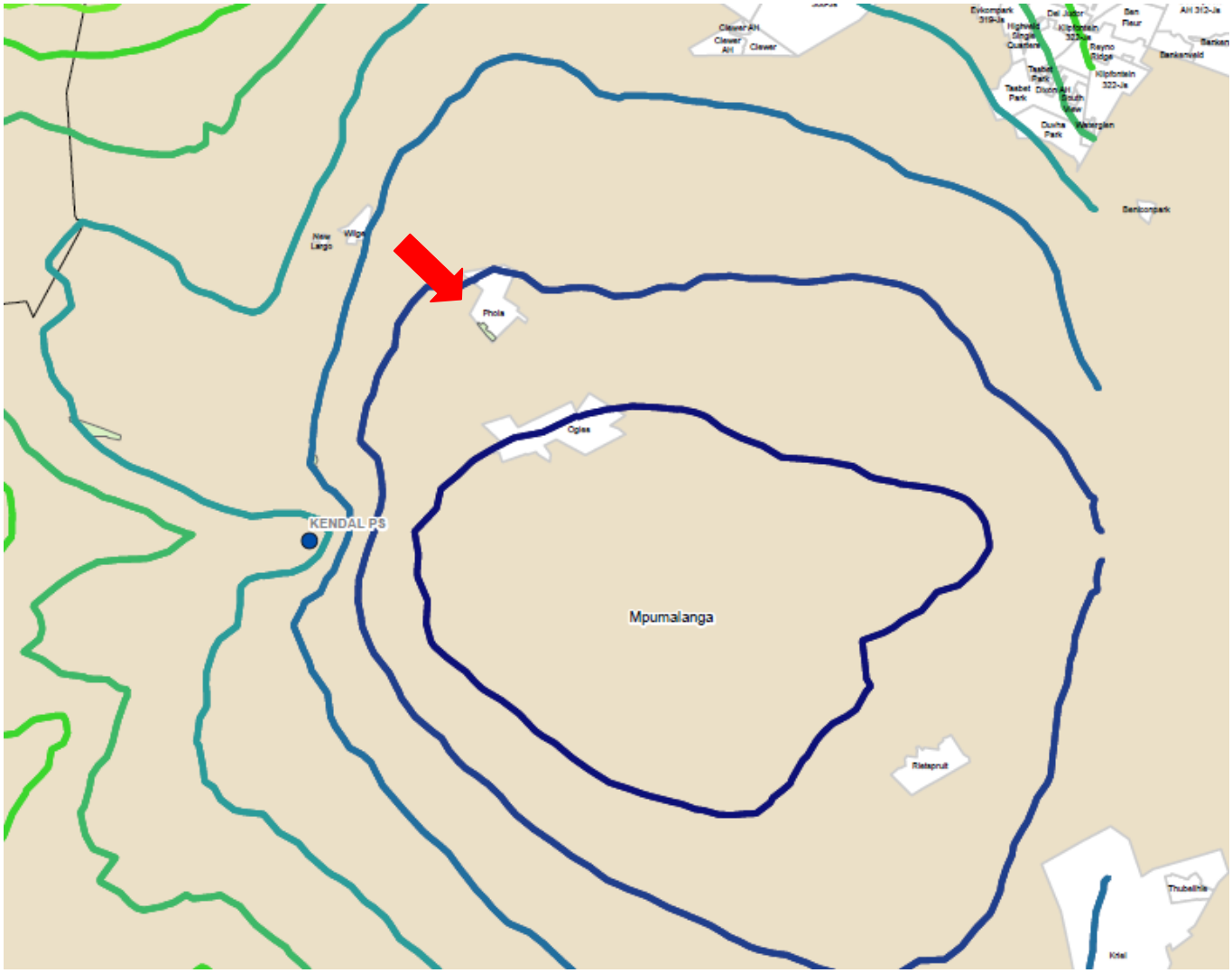
The areas impacted by emissions from Kendal Power Station are, in order of highest impact (Figure 13):

- Ogies, where there is not much potential for offsets
- Rietspruit, which is included in Kriel's offsets programme
- Phola, where domestic coal use is prevalent

Phola has thus been selected for Kendal's offsets programme.

In addition, the following smaller settlements in the vicinity of Kendal will be included in Kendal's offsets programme, if there is potential to implement offsets (Table 9):

- Eskom Triangle
- Khayalethu Village
- Olympic community
- Makhosi community
- Arbor
- Neighbouring farms



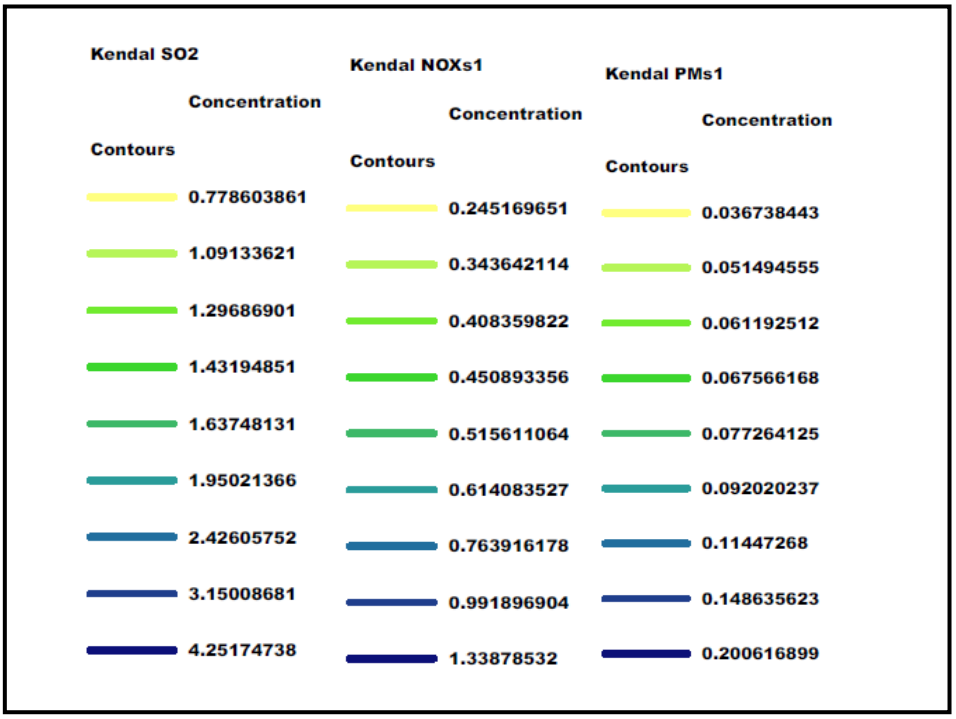


Figure 13: Area of impact of Kendal Power Station's emissions (annual average concentrations in μg/m^3 from uMoya-NILU, 2014f), and location of Phola

Table 9: Total population, energy usage patterns and indicative number of households that will participate in the offsets roll-out in the target areas for Kendal's offsets programme

Settlement	Population	Number of households	Indicative number of households for offsets*
Phola	8913	6685	6016
Eskom Triangle	68	14	9
Khayalethu Village		15	10
Olympic community		60-80	47
Makhosi community		200-250	152
Neighbouring farms		TBC	TBC
Arbor		TBC	TBC

* assuming 75% of households use coal, and of those 90% choose to participate in the programme

6.7 DUVHA POWER STATION

Duvha Power Station is a six-pack coal-fired power station with an installed capacity of 3600 MW, commissioned between 1980 and 1984. Duvha is situated around 25 km south-east of Emalahleni, Mpumalanga. Ash is removed from the flue gas before it exits to the atmosphere through a fabric filter plant at units 1-3 (retrofitted in the early 1990s) and through electrostatic precipitators at units 4-6. The efficiency of the electrostatic precipitators was improved by the installation of SO_3 plants in the early 2000s.

Duvha has committed to retrofit a fabric filter plant on units 4-6 between 2021/22 and 2023/24 to ensure compliance with the new plant PM Minimum Emission Standards.

6.7.1 Target areas and interventions

The area most highly affected by emissions from Duvha is to the east of the power station (Figure 14). This zone is relatively sparsely populated, and the small settlements in this zone (like Douglas, Pullens Hope, Komati and Blinkpan) do not have potential for offsets. As a result, the areas for Duvha's offsets programme have been allocated on the basis of proximity to the power station. This decision is supported by modelling of SO_2 emissions from all power stations which shows that the impact of Eskom's power stations on eMalahleni is greater than that on Middelburg (Figure 15).

The following areas have thus been selected for Duvha's offsets programme (Table 10):

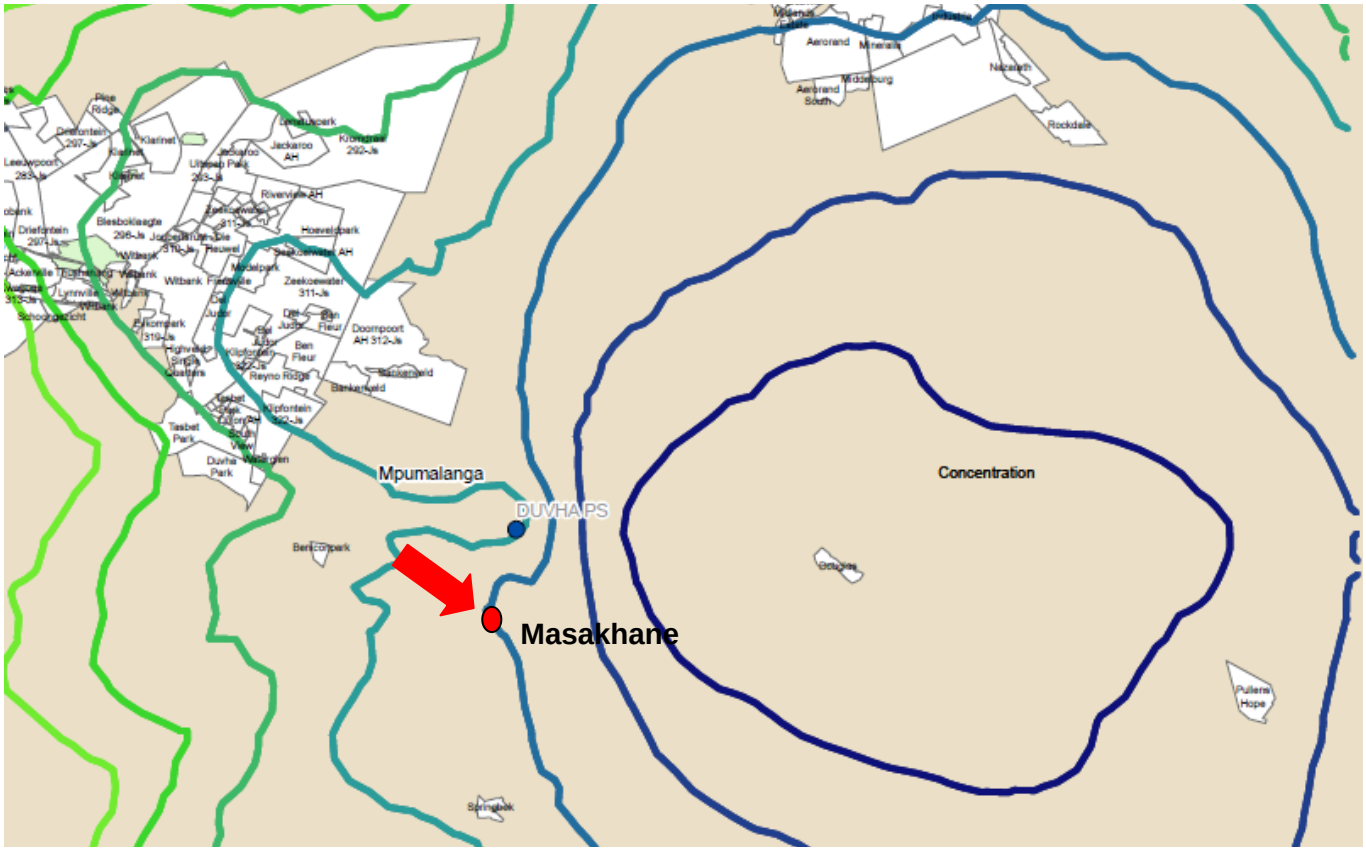
- Masakhane, which is situated 3 km west-south-west of Duvha Power Station
- 2 000 households in eMalahleni in the area closest to Duvha where there is potential for offsets.

The number of households in the greater eMalahleni area that can participate in this phase of the offsets project is capped at 2 000 due to Eskom's financial constraints. Should there be another phase of offsets, the implementation will continue through the rest of eMalahleni.

Table 10: Total population, energy usage patterns and indicative number of households that will participate in the offsets roll-out in the target areas for Duvha's offsets programme

Settlement	Masakhane	eMalahleni
Population	3 740	
Number of households	1 642	
Number of households using coal according to Carbon Monitoring Report		
Number of households using wood according to Census 2011		
Indicative number of households for offsets*	1 108*	2 000

* assuming 75% of households use coal, and of those 90% choose to participate in the programme.



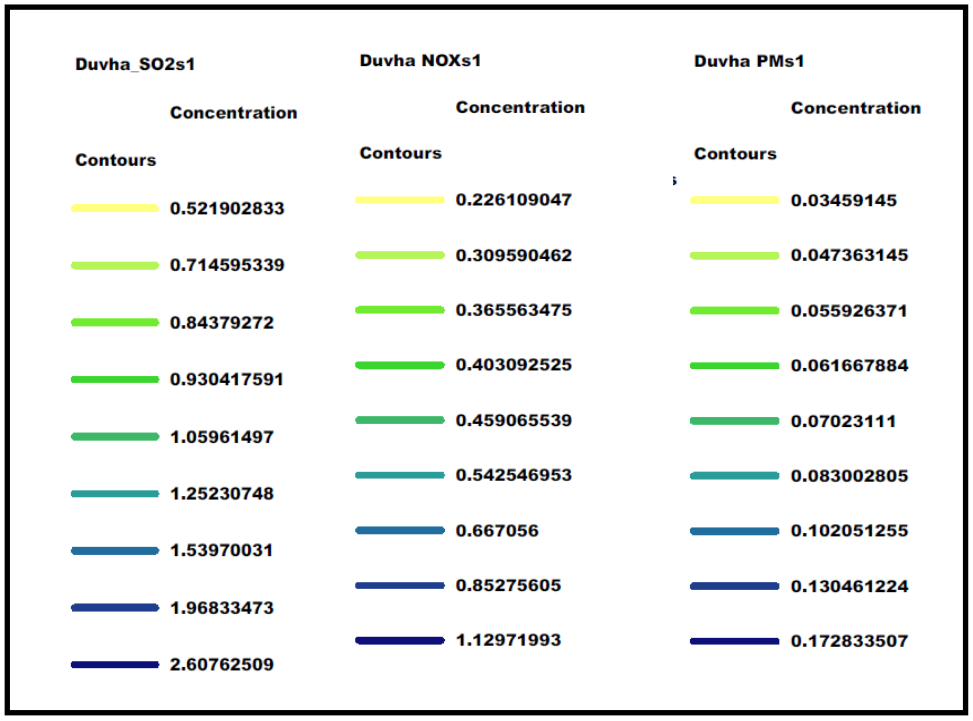


Figure 14: Area of impact of Duvha Power Station's emissions (annual average concentrations in µg/m^3 from uMoya-NILU, 2014g), and locations of Masakhane (indicated with red arrow) and eMalahleni

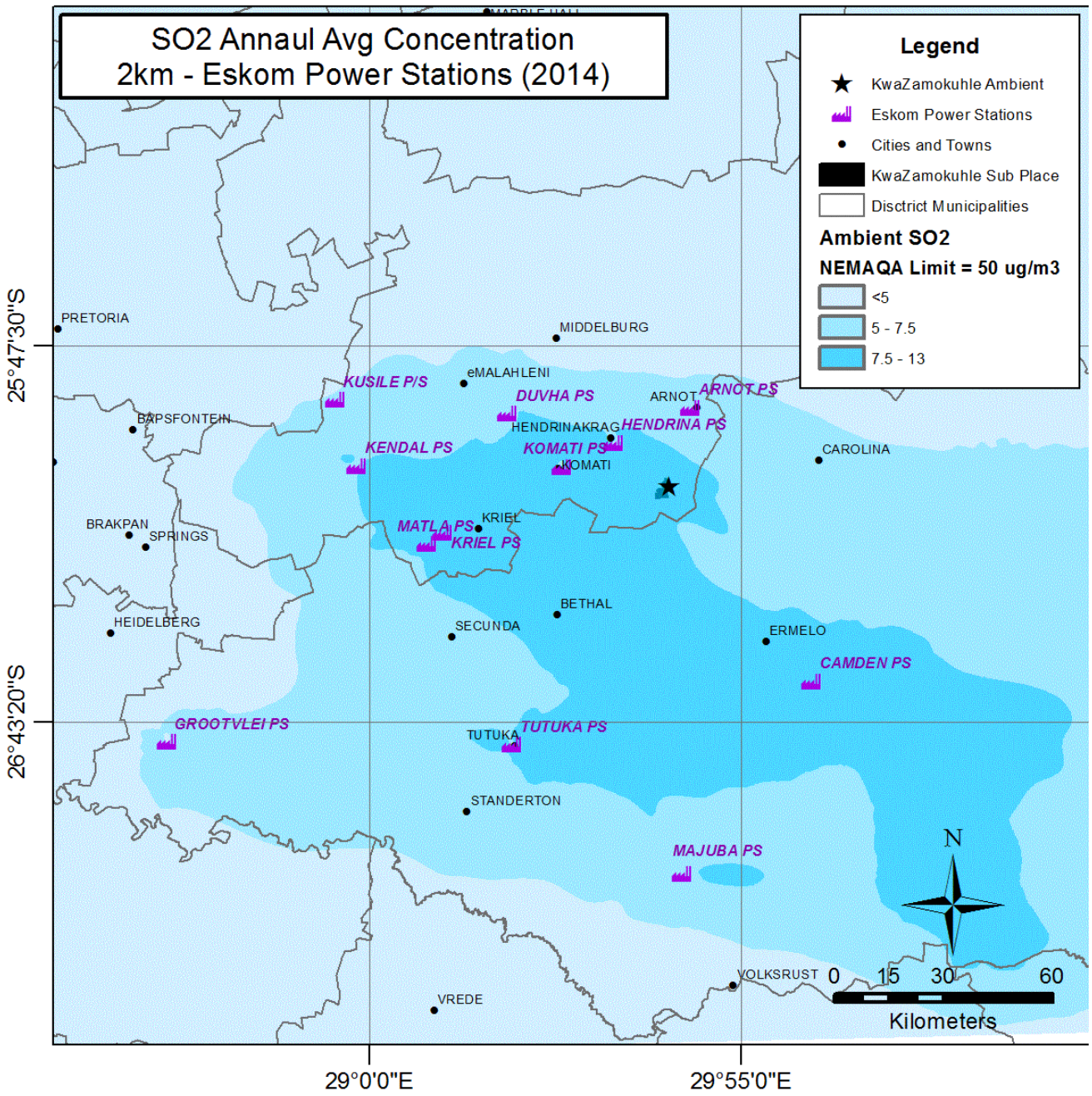


Figure 15: Annual average SO_2 concentrations ($\mu g/m^3$) resulting from SO_2 emissions from all Eskom's coal-fired power stations in Mpumalanga.

6.8 TIMELINE FOR IMPLEMENTATION

This offset plan covers 2017 to March 2025. It is envisioned that each power station should have completed rolling out an intervention at at least one decent sized settlement by end March 2025 (a farm homestead, for example, is not considered to be a sufficient offset for a power station).

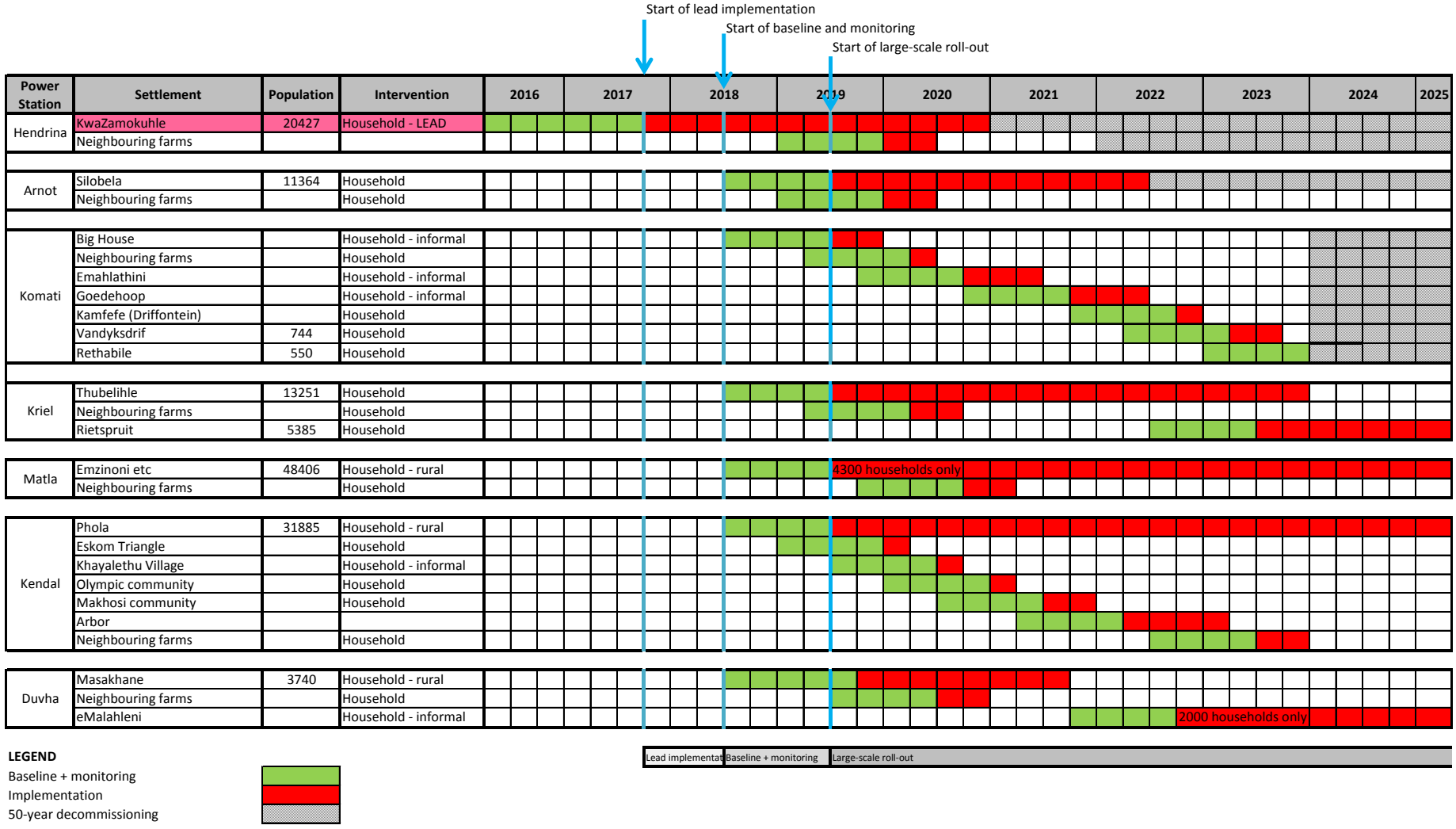


Figure 16: Preliminary schedule for the roll-out of the air quality offsets in each selected area. This schedule will be refined after community engagements. The timelines are dependent on procurement processes, authority approvals and budget allocation.

This schedule depends on budget being made available. Should there be a cut 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.

6.9 LEAD IMPLEMENTATION

KwaZamokhule has been selected as the lead implementation for the Nkangala District Municipality due to its appropriate size (not too big that the full roll-out will take too long, but big enough to allow testing of key aspects of the roll-out at scale), the prevalence of domestic coal burning, and the fact that a baseline survey and establishment of a local office have already been completed as part of the pilot project.

The interventions will be tailored to suit the type of household (informal or formal structures; access to electricity; solid-fuel using or not).

The following interventions have been selected for formal dwellings for the lead implementation:

- Replacement of existing coal/wood stoves with electric heaters and stoves
- Insulation of housing to raise indoor temperatures in winter and reduce the need for space heating.

The previous version of this Air Quality Offset Implementation Plan stated that households would be switched from coal to LPG. However, households will now be switched to electricity, which is the cleanest source of energy for domestic use, and is a more logical energy source to be promoted by Eskom.

The implementation will be phased, so that “simpler” households with a readily available intervention can be addressed first, while interventions are tested for more “complex” households. Pilot studies will be conducted to test interventions on informal dwellings and mixed formal/informal dwellings. Households that do not burn solid fuel will be addressed later in the project as they do not have an impact on ambient air quality (Figure 17).

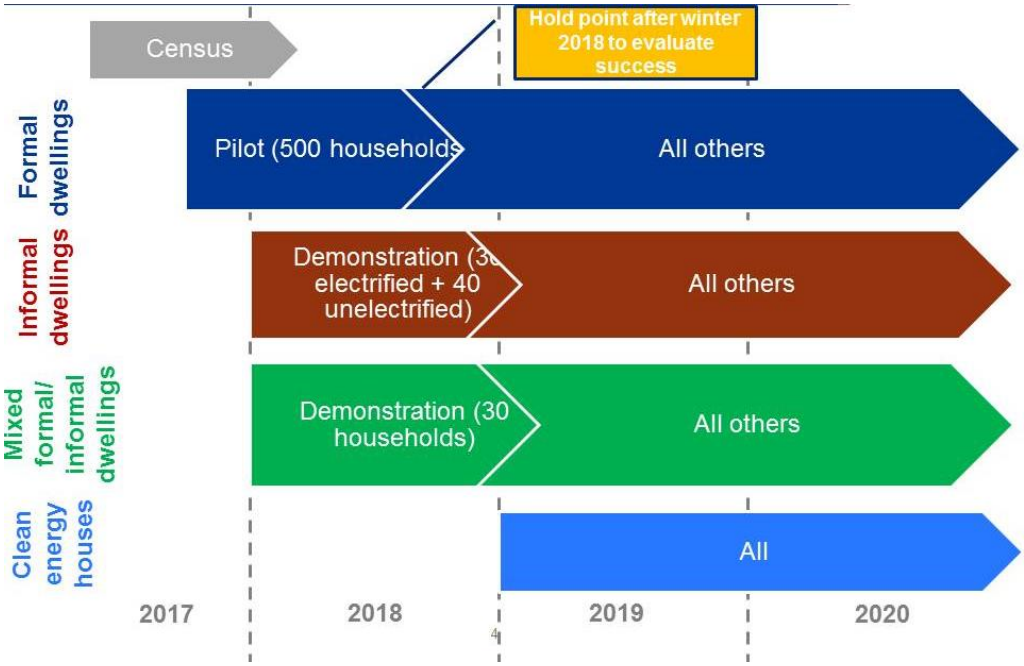


Figure 17: Timeline for the implementation of air quality offsets in KwaZamokuhle. The timelines are dependent on procurement timelines, and of the success of the pilot and demonstrations

Key concerns with electricity and the way these will be addressed are:

- An electric heater is not sufficient to heat a house on a cold Highveld night. Houses will be insulated to reduce the need for space heating.
- Electricity is more expensive than coal. The reduced need for space heating due to the housing insulation should mean that the R200-R300/winter month that households use to buy coal should be sufficient for their electricity needs.
- Low income households have a 20A circuit breaker, which is not sufficient for the load of the appliances to be supplied to the households. The 20A circuit breaker will be upgraded, probably to a 60A circuit breaker, which the electric appliances are installed
- Many households have municipal debt, and money for the repayment of this debt is subtracted when households buy electricity. This means that much of the money which a household allocates to electricity cannot in fact be used to buy electricity. Eskom will engage with the local municipality to see whether a solution to this problem can be found.
- In many low income households, the electric wiring was not done by a professional and may be unsafe. The project team will ensure that the electric wiring is safe in each household that receives the electric heater and stove once the installation is complete.

All solid fuel using households will be invited to participate in the roll-out. Unfortunately, households only using electricity will not qualify for the full intervention. Although there will be no local air quality benefit to providing an intervention to these houses, they will still be offered a ceiling, should they not already have one, to improve the energy efficiency of their homes.

Key questions to be answered during the lead implementation include:

- What percentage of households is willing to participate in the project?

- How sustainable is the switch to electricity?
- Is an electricity subsidy needed to make the switch from coal to electricity sustainable?
- Can the electricity distribution network support the increased load of all the electric appliances?
- How are the coal merchants affected by the declining use of coal and how do they react?
- How can the insulation and electric appliances and installation be improved for future roll-outs (and does another approach entirely need to be considered?)
- How can a locally owned company be set up towards the end of the roll-out to assist with maintenance?
- How can the recruitment and training of local community members to conduct surveys and implement the offsets be best arranged?
- How can a database be set up to archive the information?
- What is the most suitable format and frequency of reports?
- How do non-qualifying households react to the offsets roll-out?
- How do households react in the event of an electricity outage?
- By how much does ambient air quality (especially PM2.5 and SO_2) improve as the offsets are rolled out?

7. RISK MITIGATION

Risks and unintended consequences of an air quality offsets programme which switches households from coal to electricity, and the way in which Eskom proposes to mitigate these risks, are as follows:

Table 11: Risks of air quality offsets and proposed mitigation

Risk	Risk rating	Mitigation already in place	Planned mitigation
Money used by households to buy electricity will be used instead to pay off **municipal debts.**	High		Engagements will be held with the local municipalities to see if an agreement can be reached regarding the payment of household debts.
Funding constraints: Funds have been allocated for offsets implementation but they may be cut	Medium	Funding requirements for the MYPD3 tariff period (until April 2018) have been limited by only having three lead implementations initially.	Funding will be requested through Eskom's Multi-Year Price Determination 4 (MYPD4) tariff application.
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		It will be investigated whether a back-up energy source is required.

Risk	Risk rating	Mitigation already in place	Planned mitigation
Safety: Electric wiring in many houses is unsafe. Injuries may be caused by electric heaters or stoves.	Medium	-	The project team will ensure the wiring is safe after installation of the electric heater and stove. Members of the local community will be trained in safe operations of the new apliances prior to the installations. Health and safety requirements of Eskom's procurement process will be adhered to.
Objections from households which do not use solid fuels	Low	-	Households which do not use coal will also be provided with a ceiling. An understanding of the objectives of the offsets roll-out and the secondary benefits for non-participating households will need to be conveyed through community consultation and awareness initiatives.

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 Nkangala District Municipality. This document is the first such update
- Annual progress reports. See the annual progress report also submitted in March 2017.
- Bi-annual (twice a year) meetings between Eskom and the authorities. A meeting was held in September 2016 and another will be held in April 2017.

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 18: KwaZamokhule (and Hendrina)

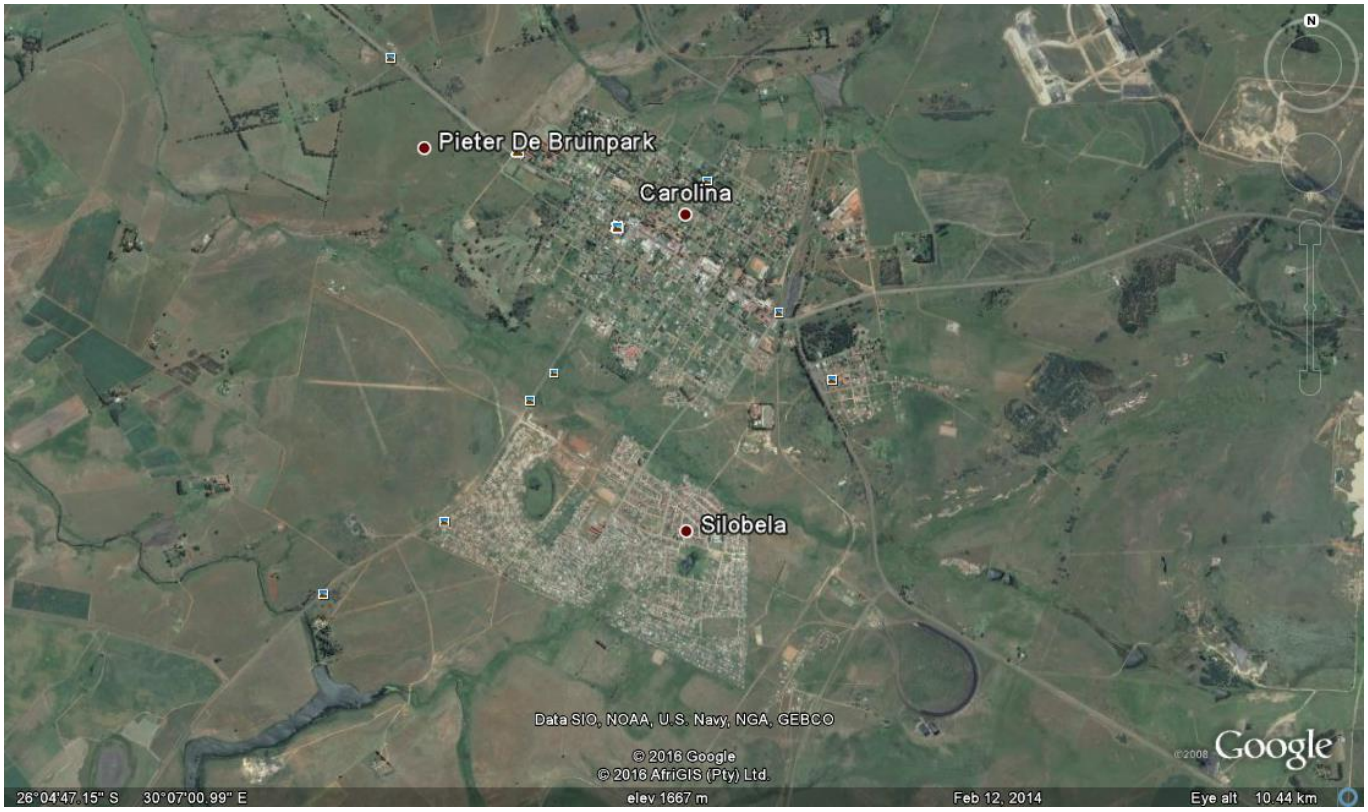

Figure 19: Silobela (and Carolina)

Figure 20: Big House informal settlement and farms adjacent to Komati Power Station

Figure 21: Thubelihle

Figure 22: Rietspruit

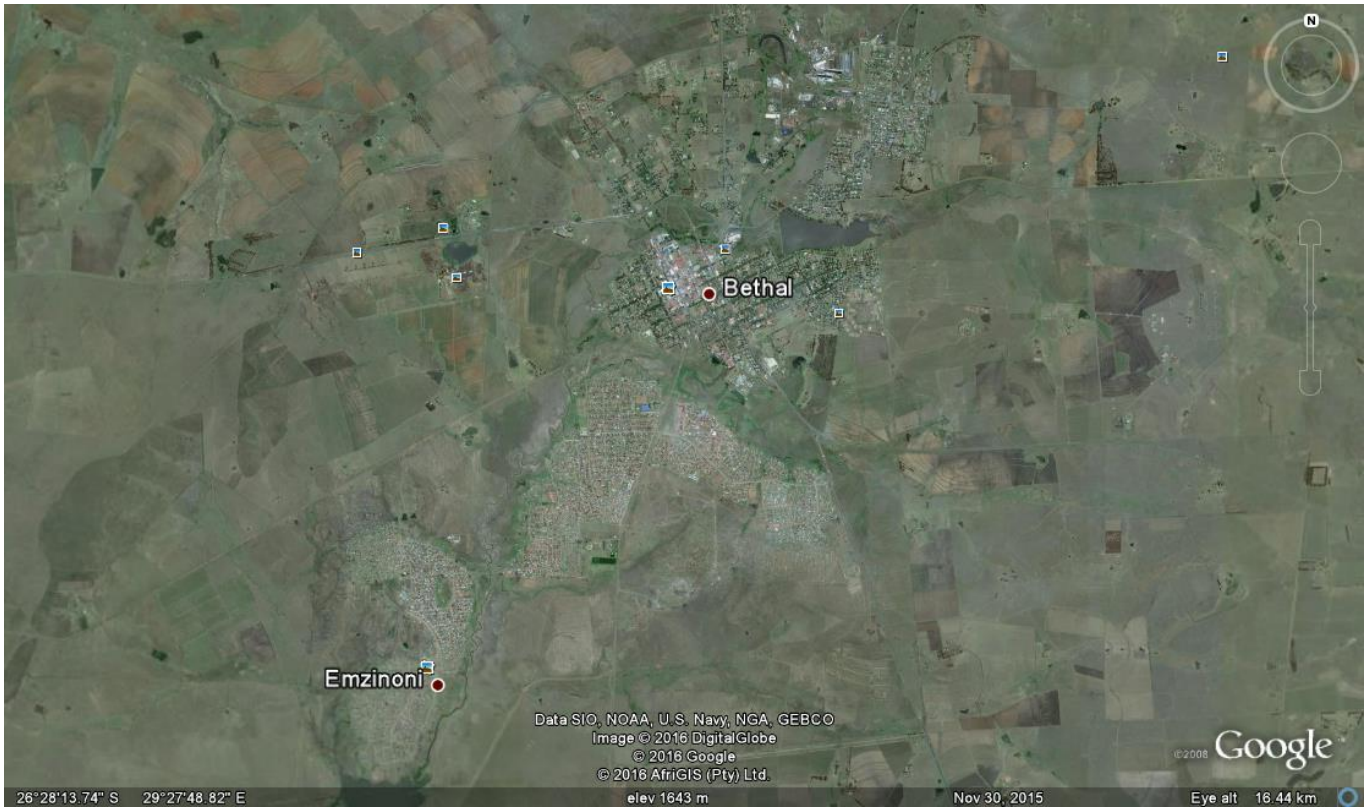

Figure 23: Emzinoni and extensions, Chris Hani, Kananna ext 6, Milan Park extensions, Thambo

Figure 24: Phola

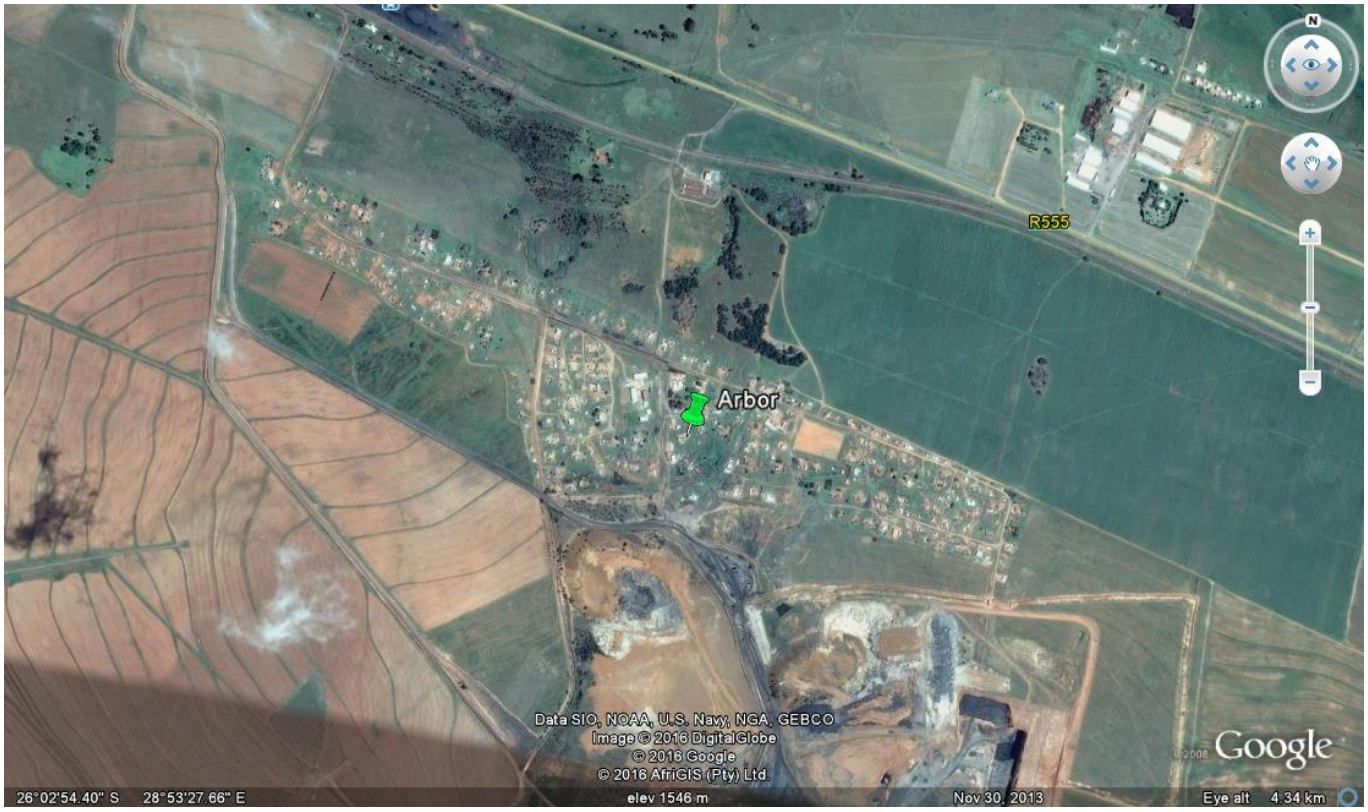

Figure 25: Arbor

Figure 26: Masakhane

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 27):

- 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)

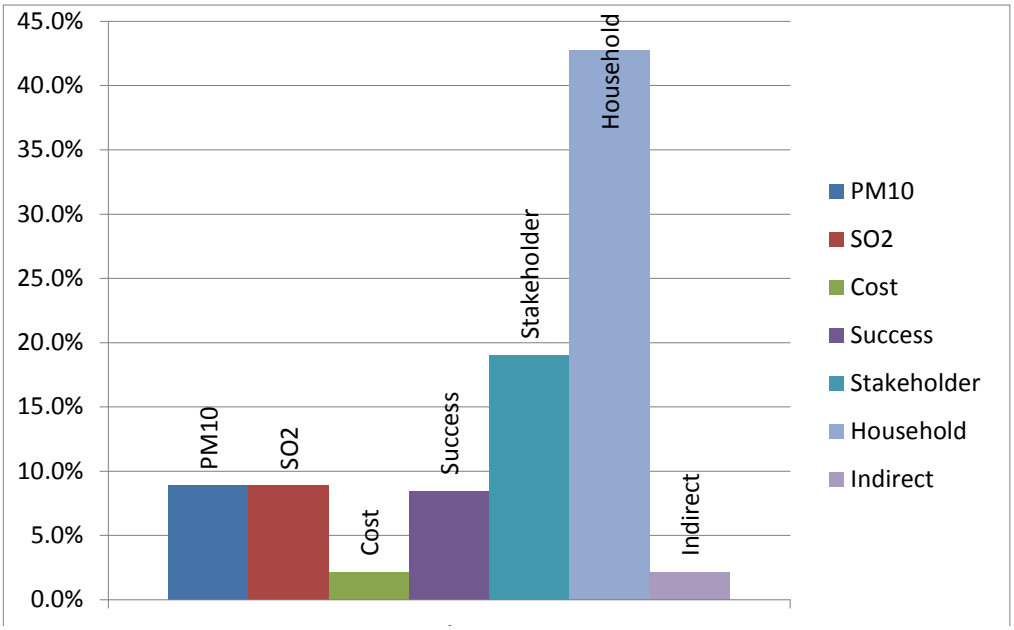

Figure 27: Weighting of the criteria used to evaluate the proposed offset interventions

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 28) 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]

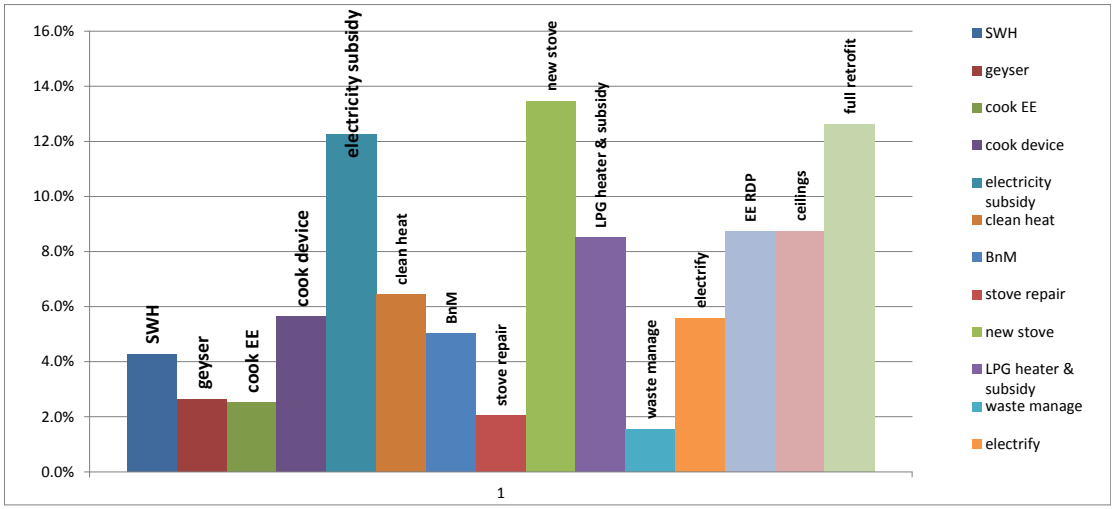

Figure 28: Result of applying the evaluation criteria (relative weighting on the y-axis)

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.