HOUSEHOLD EMISSION OFFSET PRE-FEASIBILITY STUDY FOR ESKOM

EXECUTIVE SUMMARY

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1 PURPOSE AND SCOPE OF THIS DOCUMENT

This document provides a management summary of the report of the pre-feasibility study conducted for Eskom into an envisaged PM10 and SO_2 offset scheme, where tall stack emissions from Eskom Power stations are offset by household emission reductions. The project objective, methods and results are presented in summary form for stakeholder feedback and comments.

The pre-feasibility study was undertaken to determine the feasibility of a PM10 and SO_2 offset programme in order to meet ambient air quality standards in the area of Eskom air quality impact, in such a way, that the offset programme leads to reduced human exposure of harmful pollution within the airsheds of existing Eskom generating power plants. The offset programme is to be implemented in such a manner as to maximise the contribution to the health and well-being of households within the impact area of Eskom; with special reference to low income households.

2 OBJECTIVE

This pre-feasibility study seeks to identify the most feasible interventions and provide supporting information which can be used to decide whether an offset programme is viable and whether there is sufficient scope for such an offset programme. The study furthermore seeks to incorporate the input of key stakeholders like various government departments and academia. The study will furthermore design the required field test project phases going forward where key design parameters for the most feasible interventions can be determined.

3 OFFSET TARGET AREA

The target area for interventions must logically correspond to an area associated with Eskom air quality and related health impacts. The area of impact varies by pollutant as well as the standard against which pollution exposure is measured (in this study only impacts relating to SO_2 and PM10). Offset interventions are most optimally located in areas where significant air quality impacts arise from emissions from both Eskom and from Households.

The prioritisation of settlements in terms of offset potential is achieved through mapping the highest aggregate frequency of exceedance (a basic air quality index based on the aggregate of respective frequency of exceedance of SO_2 24 Hour and PM10 24 Hour model data sets) as shown in Table 1.

Table 1: Offset potential intersect matrix

	Eskom AQ impact Index (FOE SO_2 24Hr Index)				
HH AQ Impact Index (FOE PM10 24Hr Index)	Very high	High	Medium	Low	Very Low
Very high					
High					
Medium					
Low					
Very Low					

The maps included below (Figure 1) give the modelled 24hr PM10 and SO_2 concentrations from households and Eskom. Figure 2 shows the frequency of exceedances of SO_2 standards from Eskom and the frequency of exceedances of PM10 standards from the households. The cumulative frequency of exceedances shown in Figure 3 indicates the offset target areas for the interventions.

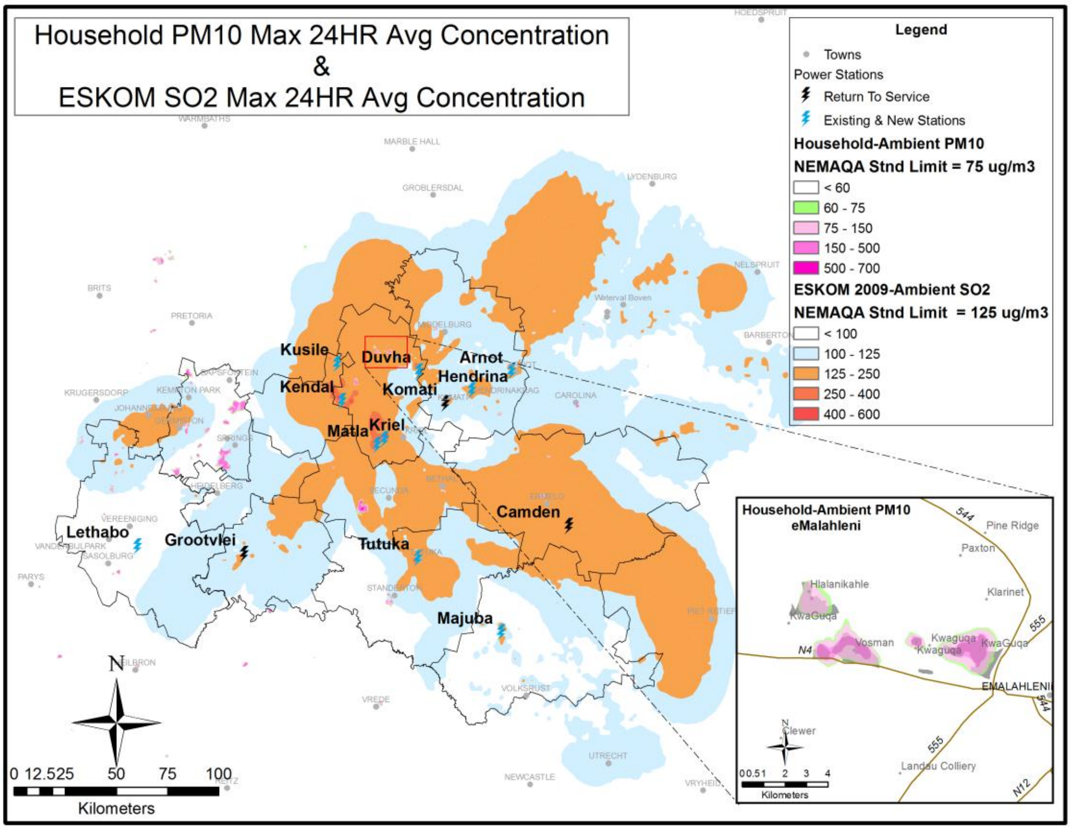


Figure 1. Households PM10 Max 24HR Average Concentration and ESKOM SO_2 Max 24HR Average Concentration (2009)

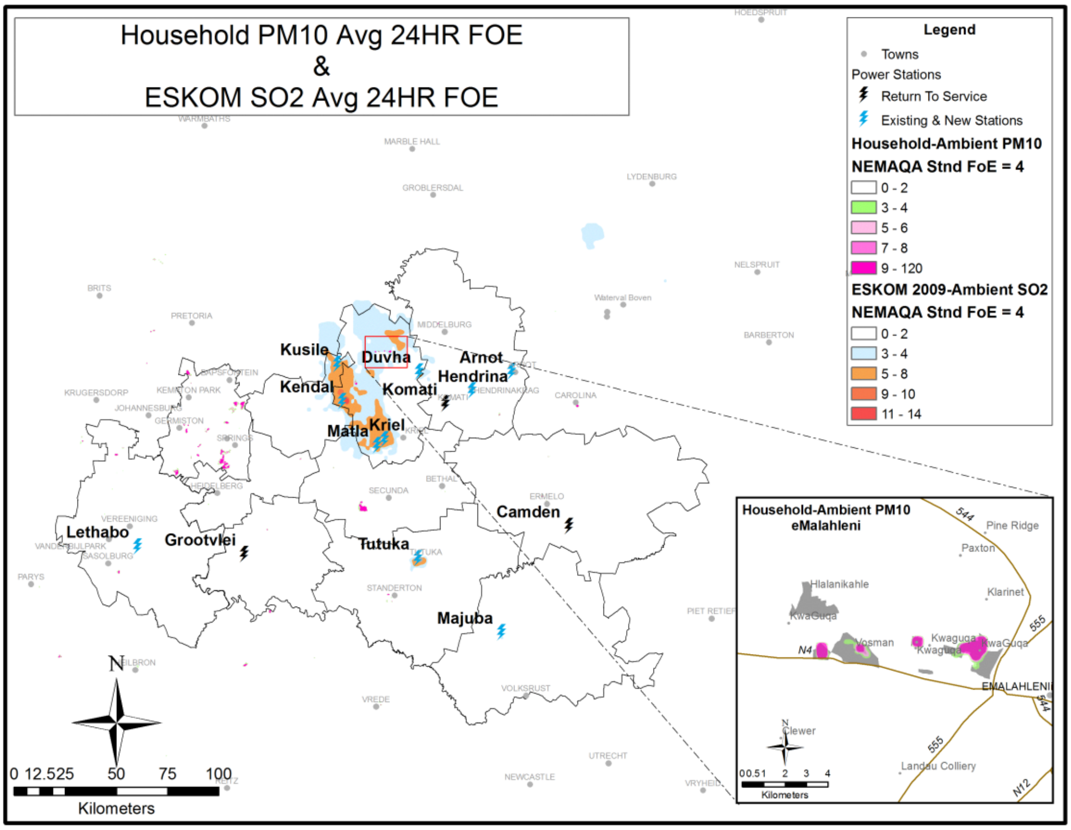


Figure 2. Households PM10 24HR Average Frequency of Exceedances and ESKOM SO_2 Average 24HR Frequency of Exceedances (2009)

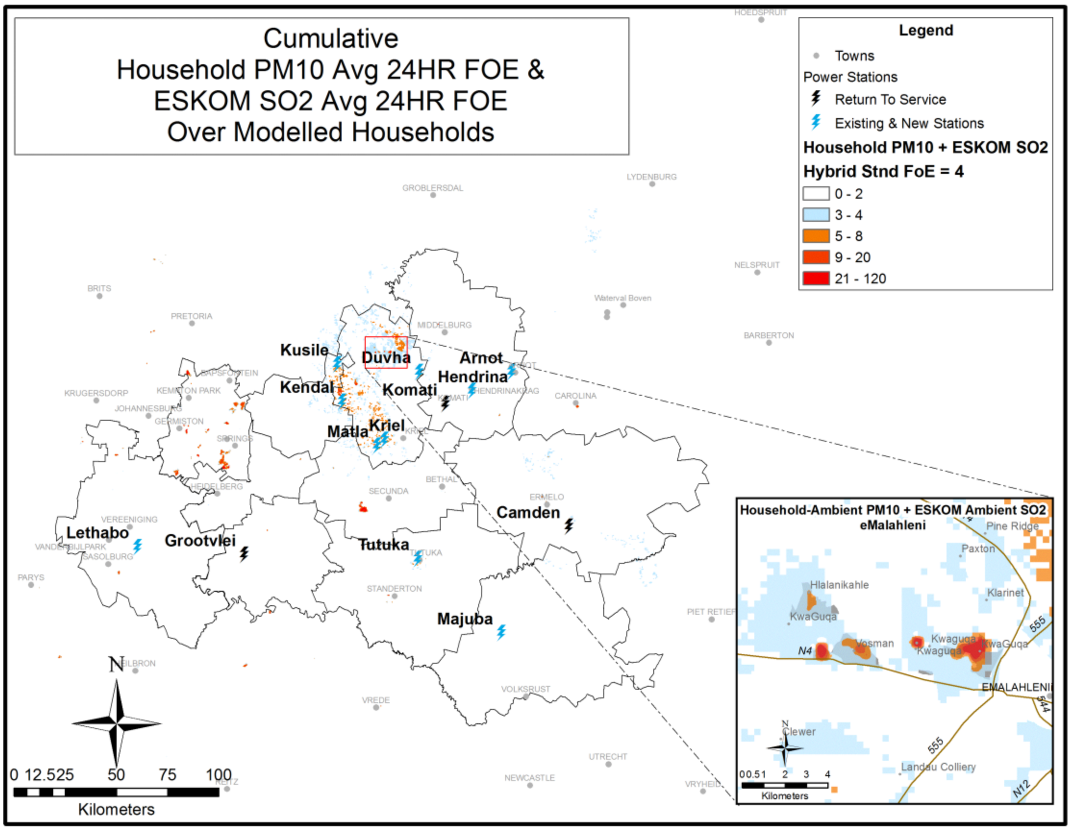


Figure 3. Cumulative Household PM10 24H Average Frequency of Exceedances and Eskom SO_2 24HR Average Frequency of Exceedances (2009)

4 STAKEHOLDERS

The envisioned offset scheme will operate within an institutional environment, determined in part by the policy decisions of the DEA, NERSA and the Eskom's stated purpose "To provide sustainable electricity solutions to grow the economy and improve the quality of life of people in South Africa and the region," and using the precedent established by international greenhouse gas offset projects.

A stakeholder analysis has been conducted at the start of this project to rate the importance of the stakeholders and consider their needs and priorities, as the involvement of key stakeholders is crucial to the success of the envisioned programme.

The most important stakeholders are the households who will participate in the envisioned offset interventions. The second highest ranked stakeholders are the licencing authorities. A Multi-Stakeholder Reference Group (MSRG) and a Technical Working Group (TWG) comprising representatives from various tiers of government, academic institutions and from within Eskom have been established to guide and support this programme.

5 IDENTIFICATION OF CRITERIA FOR EVALUATING OFFSET INTERVENTIONS

Potential emission offsets projects were evaluated based on the following criteria:

- 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 & short term)

Household acceptance of the proposed offset projects 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.

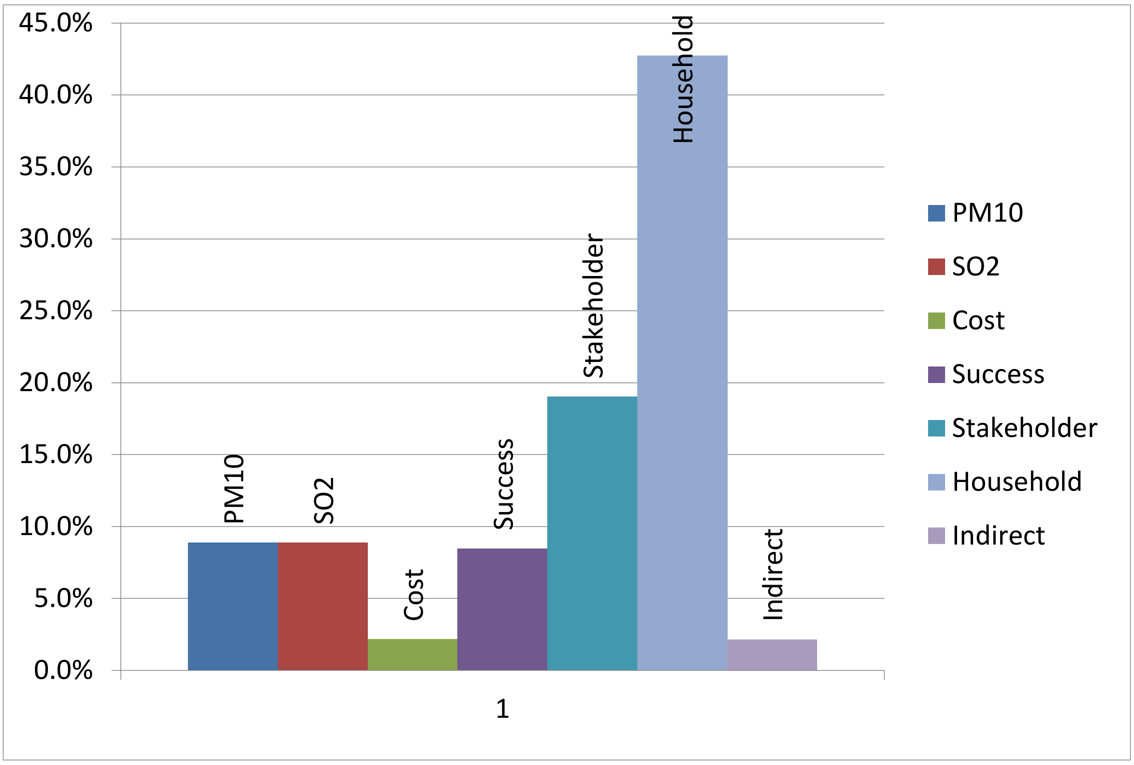


Figure 4. Weighting of the criteria used to evaluate proposed offset. (Relative % weight on y axis per criterion)

6 LONGLIST AND SHORTLIST OF INTERVENTIONS

A long list of possible interventions was compiled starting with household practices associated with emissions such as cooking, space heating and body washing in combination with the various artefacts and practices that may be employed in these activities.

Kick-out criteria were then agreed on and applied to the long list to reduce the list for further detailed evaluation.

The evaluation criteria were applied to this shortened list of offset interventions by the core Technical Work Group using the Analytical Hierarchy Process (AHP or Saaty method) and feedback given to the larger Technical Work Group. The AHP is typically used by knowledgeable teams to obtain evaluation results where subjectivity plays a role, without having to conduct expensive research. It has been shown that the results are very close to the research outcomes.

A final list of 6 potential offset interventions was the result and used for the pre-feasibility literature study.

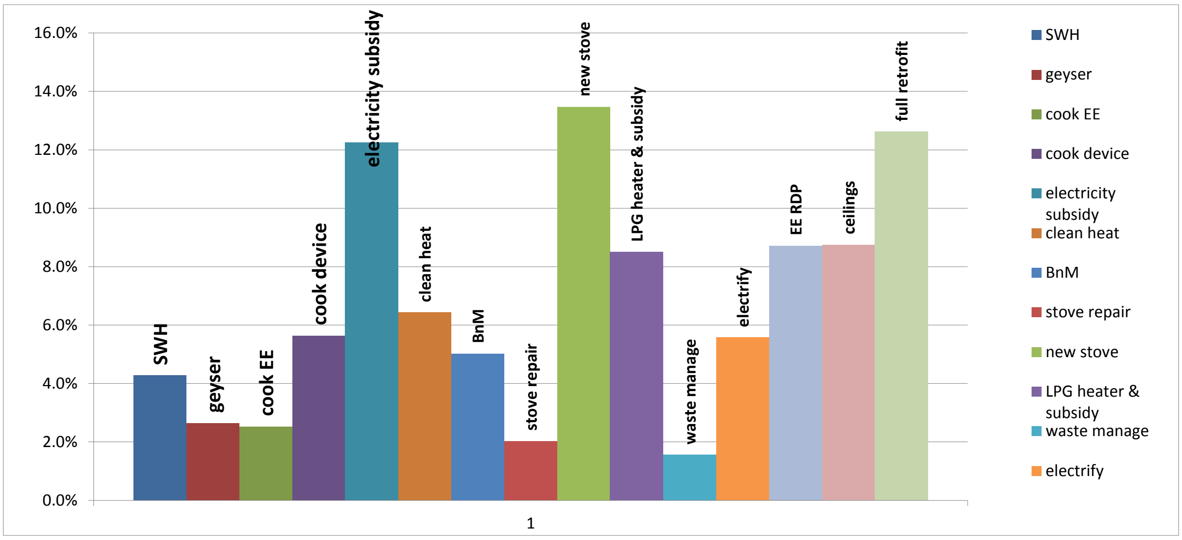


Figure 5.Result of applying the evaluation criteria. (Relative weighing on y-axis)

7 LIST OF CANDIDATE INTERVENTIONS

The interventions chosen for further study are:

- Retrofit full suite of thermal shell insulation (ceilings and walls), draft proofing and Trombe wall on all existing subsidy houses [Full retrofit]
- Install ceilings in all 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]

The TWG recommended that the absolute ranking of offset interventions is not important, as the alternatives could be implemented in schemes combining more than one off-set intervention. This may be the case due to different community needs in different areas of the programme scope.

These interventions will be discussed in the sections 9 to 14.

The 'number of qualifying households' are potential houses where the offsets could be implemented; however, the actual number of households that need to be part of one, or more, off-set interventions will have to be determined by further feasibility studies, and will depend on negotiations with the licencing authorities for a fair dispensation concerning reduction of household PM10 in lieu of Eskom SO_2 exceedances. Preliminary indications are that it may be quite possible to derive such fair exchange relationships as the common impact is health related.

8 TARGET GROUP ASSUMPTIONS

Different approaches to identification of the target households leads to different results. However, the unit costs remain more or less the same. The difference between targeting households exposed to SO_2 exceedances from

Eskom power stations and targeting households exposed to high levels of PM10, mainly from domestic sources, is demonstrated below.

8.1 SO_2 24H Limit exceedance approach

The SO_2 exceedance approach is where the target households are those households which are submitted to 5 or more SO_2 exceedances of the 120 µg/m^3 standard in any 24 hour period.

The solid fuel burning households in the same sub-places would be the first target for offset interventions. Depending on the "health impact exchange rate" that is eventually legalised/negotiated the numbers can be updated.

8.2 PM10 24H Limit exceedance approach

With this approach the exchange rate between SO_2 and PM10 is not important as the target is to reduce the household air pollution to below the standard for all the sub-places who are affected by SO_2 concentrations caused by Eskom above the standard of 125 µg/m^3, irrespective of the number of exceedances.

The PM10 exceedance approach is where the target households are those households which are exposed to 5 or more exceedances per year of the 24 hour standard for PM10, which is 75 µg/m^3.

8.3 Combined SO_2 24H and PM10 24H Limit exceedance approach

A combined exceedance approach is where the target households are those households which are exposed to the highest cumulative frequency of exceedances (sum of exceedance of SO_2 24 hour and of the PM10 24 hour limits).

8.4 The solid fuel reduction approach

Another more social responsibility approach is to reduce the burning of solid fuels in the priority areas. The sub-places with 50+% coal and wood as prime energy source were selected.
The job creation numbers in the discussion that follows are from the solid fuel reduction approach.

9 FULL RETROFIT

9.1 Background

The *full retrofit* intervention entails the retrofit of a full suite of thermal shell insulation (ceilings and walls), draft proofing and Trombe walls on potentially all existing RDP houses and other suitable formal houses in the target area.

The major driver for air pollution by households is space heating. A reduction in the need for space heating through increased thermal comfort is expected to lead to a reduction in the use of solid fuels and therefore to a reduction in household PM10 and SO_2 emissions.

The intervention is in principle applicable to all formal houses but should focus in the first place on high solid fuel use areas. There are 211 754 houses in areas on the Highveld in high solid fuel use areas (defined for our purposes as areas where more than 50% of the households used coal in 2001, of which perhaps 70% may be retrofitted (i.e. 148 228 households). If an elegant way of selecting households who use solid fuels cannot be found (e.g. through a stove-for-retrofit exchange), it may be necessary to retrofit a whole suburb at a time. The conservative assumption for the budget was to assume that all the households need to be refitted in the target areas.

The unit NPV cost per house is estimated to be in the order of R11 000.

9.2 Emission reduction due to the implementation of the offset project

It is expected that the fuel consumption of the households that use solid fuels will decrease significantly after the full retrofit due to fewer days where the temperature inside the house will be within the thermal discomfort range. The reduction in coal consumption, for the group who is expected to continue solid fuel use, is estimated in the order of 50%.

The estimation of the effect of this intervention in equivalent households who discontinue solid fuel use is given in Table 2.

Table 2: Assumptions and impact: Full retrofit

	Households			Reduction		
Short name	**Solid fuel use**	**Qualify**	**Take-up**	**Emission**	**Discon tinue**	**Impact**
New stove	60%	70%	85%	90%		63.0%

Where the baseline scenario includes a large proportion of coal users who use Basa njengo Magogo (BnM), the effective emission reduction will be much less.

The intervention is expected to have a very positive impact on quality of life (QoL) aspects, as it will lead to an improvement on most of the chosen *quality of life* indicators. They are indicators for health, standard of living and subjective well-being. This is summarised in Table 3 below.

Table 3: Full retrofit: Assumptions and effect

QoL Indicator	Comment
Population using solid fuels	Expected reduction of 35%
Mortality and burden of disease attributable to household air pollution	Reduction of up to 50% in emissions from coal burning in the target area
Household income	Temporary job creation during implementation phase
Proportion of household income spent on energy	Drastic reduction in space heating cost regardless of current or future energy carrier
Ownership of durable goods related to energy consumption	Improved quality of housing
Proportion of household expenditure spent on respiration related health cost	Expected reduction especially among the ~35% of the population expected to stop using solid fuels (indoor exposure) but also among the population in general (ambient exposure)
Overall satisfaction	Increased thermal comfort Aesthetic improvement
Satisfaction with living conditions	See above
Satisfaction with means of cooking and heating	Improvement in minimum indoor temperature
Satisfaction with house	Expected to improve, see above

The intervention will result in significant short-term job creation in the construction industry with up to 5371 short-term employment opportunities, if all possible houses are retrofitted. The impact on job creation and GDP contribution for this offset intervention are as follows:

Table 4: Full retrofit job creation estimates

Full retrofit job creation	
Direct (temporary)	5 371
Direct (permanent)	40
Indirect	2 771
Gauteng & Mpumalanga GDP contribution	0.005%

The intervention would lead to a long-term reduction in household energy requirements. The benefits of this intervention will likely outlast the use of coal. Even if coal is replaced by electricity, the intervention will reduce the peak demand for electricity compared to the baseline scenario.

The external costs (including local health impacts but excluding the global warming effect) from the use of coal has been estimated in 2000 at R 4.7 /GJ and at R25.7 /GJ for wood (Winkler et al. 2000:10). Based on these assumptions, the total benefit from a reduction in coal and wood use from the *full retrofit* intervention would be above R500 million per annum.

Reference baseline and monitoring methodologies for this intervention are available in the international carbon market. These are AMS-I.C. *Thermal energy for the user*, AMS-II.C. *Demand-side energy efficiency programmes for specific technologies* and AMS-II.E. *Energy efficiency and fuel switching measures for buildings.* Data that has to be monitored include the baseline energy carriers and devices used for cooking and heating by each household as well as energy carriers (by quantity) and devices used by the household after the installation of the insulation and Trombe wall.

It is possible to combine this intervention with improved top-down ignition, solar water heaters and energy efficient lighting as well as the introduction of LPG for cooking. Such a combination of interventions would further enhance the air quality, quality of life and economic advantages.

There are three aspects that are of critical importance for the effect of this intervention that are uncertain. They are:

- The number of households who will be willing to participate
- The number of solid fuel using households who will stop using solid fuels after the intervention
- The reduction in solid fuel use for those households who continue to use solid fuels

Empirical values for these variables will have to be obtained from an in-use evaluation before a large scale implementation can be considered.

10 CEILINGS

10.1 Background

The retrofit of ceilings and ceiling insulation to existing formal houses is intended as minimal variant of the full retrofit intervention. Although it will be less effective, it is cheaper and faster to implement. If emission reductions are proportional to the improvement in thermal comfort inside the structure, it expected to be approximately 70% of the emission reduction that can be achieved by a full retrofit. Ceilings can potentially be implemented in all formal houses that do not have ceilings.

It is assumed that, when compared to the full retrofit, a higher proportion of houses can be fitted with ceilings (80% of houses assumed, as opposed to 70% of houses for the full retrofit).

Table 5: Assumptions and impact: Ceilings

	Households			Reduction		
Short name	**Solid fuel use**	**Qualify**	**Take-up**	**Emission**	**Discon tinue**	**Impact**
Ceilings	60%	85%	95%	35%	40%	50.2%

The unit cost per house is approximately R4000.

Both the economic and quality of life benefits will be similar in nature to the full-retrofit intervention but less intense since the indoor temperature improvement will be lower and the investment will be smaller.

Table 6: Ceiling offset intervention job creation estimates

Ceiling job creation	
Direct (temporary)	1 933
Direct (permanent)	40
Indirect	1 213
Gauteng & Mpumalanga GDP contribution	0.002%

The same uncertainties also apply as is the case with the full retrofit intervention. Empirical data from an evaluation implementation will enable a comparison between these interventions.

11 ENERGY EFFICIENT SUBSIDY HOUSES

11.1 Background and cost

The *energy efficient subsidy houses* intervention aims to facilitate the building of all new subsidy houses in the target area to a high standard of thermal performance by optimising shell insulation, ventilation, orientation, surface to volume ratio and solar heat absorption in the design and construction.

This is in essence similar to the full retrofit intervention but will be of better quality because more thermal factors can be manipulated (orientation and surface-to-volume ratio cannot be changed by the retrofit). The thermal performance of these structures is expected to be higher than that of a retrofitted existing house. Table 7 summarises the assumptions and projected effect of the intervention.

Table 7: Assumptions and impact: EE RDP

	Households			Reduction		
Short name	**Solid fuel use**	**Qualify**	**Take-up**	**Emission**	**Discon tinue**	**Impact**
EE RDP	60%	15%	100%	60%	80%	13.8%

This intervention can be implemented together with the *full retrofit* and *ceiling* interventions because it applies to new houses only, while the latter applies to existing structures.

The unit cost associated with this intervention is very similar to that to the *full retrofit* intervention at about R11 000 per unit.

It is envisaged that Eskom can subsidise the relevant RDP construction contractors for the additional material and labour costs. A further requirement could be that additional job seekers be recruited and trained from the respective community. The estimated temporary jobs over a 10 year period could add up to 12 500.

Table 8: EE RDP offset intervention job creation estimates

EE RDP job creation	
Direct (temporary)	12 500
Direct (permanent)	40
Indirect	2 488
Gauteng & Mpumalanga GDP contribution	0.008%

12 NEW FUEL BURNING STOVE

12.1 Background

The *new stove* intervention is to implement a stove exchange programme where old stoves are replaced with a new smokeless model. This new stove should perform cooking, water heating and space heating tasks similar to the cast iron and welded stoves currently in use.

The *new stove* intervention can potentially be implemented in all areas where coal is used. Areas where a large proportion (e.g. >50%) of households use coal will be especially suited since these areas are likely to have an air pollution problem and the identification of coal-using households would be more cost effective. The 2001 Census Main Places where more than 50% of households use coal for space heating has a combined population of 211 754 households, of these, a total of 126 085 households used coal. It is assumed that 80%, of coal-using households will qualify and that 60% participate in a coal stove exchange programme if the replacement stove is of sufficient quality. The NPV cost of implementation is estimated at R6 500 per unit. Table 9 summarises the assumptions and assumed effect of the *new stove* intervention.

Table 9: Assumptions and impact: New stove

	Households			**Reduction**		
Short name	**Solid fuel use**	**Qualify**	**Take-up**	**Emission**	**Discon tinue**	**Impact**
New stove	60%	70%	85%	90%		63.0%

12.2 Emission reduction due to the implementation of the offset project

The new high quality clean burning stove is expected to reduce TSP emissions from the stove by 80%-90% and SO_2 emissions by 30%-40% if coal is still used. The use of alternative fuels such as biomass will lead to much larger SO_2 reductions compared to the coal stoves currently in use. It should be noted that similar improvements can also be achieved through using the alternative top-down ignition technique and that in cases where this technique is the baseline scenario; the emission reduction will be small to negligible.

12.3 The impact of baseline trends

The proportion of households who use coal and wood for cooking has been declining steadily for a number of decades. It is likely that other technologies will replace coal and wood for cooking since solid fuels are not very efficient. The proportion of coal and wood use for heating has always been higher than that for cooking but is also declining.

The introduction of a durable fuel-burning stove to large numbers of households will likely slow down this trend quite significantly. The roll-out and maintenance of the alternative top-down ignition technique in many of the same areas by the Nova Institute is another baseline trend that has to be considered. Since the uptake of the alternative ignition technique in areas where Nova operates can be in excess of 50% and the emission reduction in PM10 and SO_2 is very similar to that on a new stove, a new stove programme in those areas will likely lead to little additional emission reductions.

The possibility, of the unintended consequence, that solid fuel use will be stabilised for a decade or more into the future, whereas it would have decreased over time to insignificant proportions, plus the fact that in the additional emission reduction benefit would be smaller in high coal use areas where the implementation of the top-down ignition technique is already taking place, pose a risk to the implementation of this intervention that needs to be better understood.

12.4 Quality of life impact

The project has significant quality of life benefits.

Table 10: *New stove* intervention quality of life impact

QoL Indicator	Comment
Population using solid fuels	The introduction of high quality solid fuel burning devices may? stabilise the proportion of households that use solid fuel. Since the baseline trend is downward, over time this statistic will be higher for the project scenario than that for the baseline scenario
Mortality and burden of disease attributable to household air pollution	Reduction of 48% in emissions for coal burning in the target area
Household income	A few jobs are created during implementation phase
Proportion of household income spent on energy	Possible reduction in fuel costs
Ownership of durable goods related to energy consumption	Increase
Proportion of household expenditure spent on respiration related health cost	Expected reduction due to drastic reduction in indoor and ambient air pollution
Overall satisfaction	Increased efficiency of cooking and heating
Satisfaction with living conditions	See above
Satisfaction with means of cooking and heating	Increased efficiency of cooking and heating
Satisfaction with house	No change

12.5 Economic impact

The fuel saving per households is expected to be very similar to that achieved by the alternative top-down ignition technique, i.e. in the order of 40% of coal used. At an average baseline coal use of 200kg per winter month, households would save 80kg of coal per winter month which amount to about R100 per month in winter. The estimated 75 651 potential users would therefore collectively save about R7.5 million over the winter months each year.

The coal merchant turnover is expected to decrease by an amount similar to the savings incurred by households.

Some temporary job creation will take place during the initial roll-out phase.

Table 11: New stove offset intervention job creation estimates

New stove job creation	
Direct (temporary)	329
Direct (permanent)	12
Indirect	2 771
Gauteng & Mpumalanga GDP contribution	0.002%

12.6 Monitoring

The main difficulty related to monitoring the baseline and project emissions for the new stove intervention is the determination of emission factors for the existing solid fuel burning devices. A series of field tests will have to be done to determine the emissions from baseline devices in real use conditions. The number of device types and the inter-device variability will determine the difficulty of this process.

Variables to be monitored:

- The proportion of households using solid fuels
- The proportion of households who use alternative top-down ignition technique.
- The proportion of households who use improved stove
- Number of stoves distributed per year
- Number of scrapped stoves by type
- Proportion of project stoves still serviceable by year of installation
- Current solid fuel use in kg for winter and summer

Variables to be determined once but not monitored continuously

- Population
- Carbon content of fuel by origin
- Sulphur content of fuel by origin
- Oxidation factor
- PM10 emission factor per device type (through field tests)
- SO_2 emission factor per device type (through field tests)
- PM10 levels in the house before and after the new stove

13 ELECTRICITY SUBSIDY

13.1 Background and cost

The electricity subsidy intervention is to provide adequate free electricity to render solid fuel use uneconomical for heating. Current estimates are that 240 kWh per month will have to be provided. It may be necessary to include subsidised or free electrical appliances (especially heaters) in this intervention. An electricity subsidy is a very politically contentious issue, and it will be difficult to justify giving a significant electricity subsidy to a relatively small number of households in South Africa.

The NPV of the unit cost is estimated at R11 000.

The assumption is: that the subsidy is for space heating alone and thus only given during the cold months of winter (4 months). Furthermore, the subsidy will be given for 10 winters. Therefore, the NPV calculation for comparison with other off-set interventions applies.

The intervention can be implemented in all electrified areas. Approximately 90% of current coal users also have access to electricity.

The baseline trends that will impact on the efficiency of this intervention are the following:

- On-going electrification
- Rapid household formation
- On-going urbanisation
- Decline in the use of coal

The emission reduction due to the implementation of the offset project will depend on the uptake rate of the scheme and the extent to which solid fuel use is discontinued. If a stove-for-electricity exchange programme is implemented and supported by the availability of appliances, the emissions from cooking and heating from participating households will fall to practically zero. The number of households who will participate in such a scheme must be determined through controlled field tests. A stove-for-electricity exchange scheme and subsidised appliances will provide more certainty that solid fuel use is discontinued but there may be significant hesitation by households to participate. Table summarises the assumptions for the scenario, for all main places where more than 50% of households who used solid fuels in 2001, are given the electricity subsidy and where a stove exchange is implemented.

Table 12: Assumptions and impact: Electricity subsidy (heater exchange scenario)

	Households			Reduction		
Short name	**Solid fuel use**	**Qualify**	**Take-up**	**Emission**	**Discon tinue**	**Impact**
Electricity subsidy	60%	80%	90%	100%	100%	72.0%

13.2Quality of life impact

The quality of life impact of the intervention is potentially drastic.

Table 13: Electricity subsidy intervention quality of life impact

QoL Indicator	Comment
Population using solid fuels	There will be a drastic decrease in the proportion of the population who use solid fuels if 74 114 households in the target area can be convinced to exchange solid fuel for electricity
Mortality and burden of disease attributable to household air pollution	Indoor emissions from cooking and heating for the estimated 74 114 will decrease to practically 0. Ambient air pollution will drastically decline
Household income	The subsidy represents an income to the households
Proportion of household income spent on energy	Uncertain
Ownership of durable goods related to energy consumption	Likely increase in electrical appliances over time
Proportion of household expenditure spent on respiration related health cost	Drastic decline
Overall satisfaction	Expected increase
Satisfaction with living conditions	Expected increase
Satisfaction with means of cooking and heating	Expected increase
Satisfaction with house	No change

The number of temporary jobs created during this intervention is relative small due to the existing programme of free electricity to qualifying households. Permanent jobs will be required to monitor on-going solid fuel burning which need to be a pre-requisite to qualify.

Table 14: Electricity subsidy offset intervention job creation estimates

Electricity subsidy job creation	
Direct (temporary)	200
Direct (permanent)	40
Indirect	4 718
Gauteng & Mpumalanga GDP contribution	0.003%

The provision of free electricity as project activity for this intervention will be fairly easy to monitor as the amount of electricity provided and the number of households benefitting are centrally determined. The critical question will be whether users retain or fall back on solid fuels after the subsidy has started. This has to be monitored on an annual basis.

The variables to be monitored will be:

- The proportion of households using solid fuels
- The proportion of households who receive subsidy
- Number of scrapped stoves by type (if exchange option is taken)
- Current solid fuel use in kg for winter and summer (if any)

Variables to be determined once but not monitored continuously will be:

- The proportion of households who use alternative top-down ignition technique at the start of the project

14 LPG SUBSIDY AND HEATER

14.1 Background and cost

This intervention will provide subsidised Liquefied Petroleum Gas (LPG) and heating and possibly cooking appliances to households within the target area. One implementation option is to implement a stove-for-LPG exchange programme. This would provide more certainty that households discontinue solid fuel use.

LP gas is a clean energy source but has never been used by a large proportion of households in South Africa. Significant market penetration has been achieved in other developing countries. In South Africa success has been achieved on small scale with introducing LPG as energy source for cooking in low-income communities. The critical uncertainty that has to be addressed in the evaluation phase for this intervention is whether (or under what conditions) households will use LPG as an energy source for space heating in the place of solid fuels.

The NPV per unit for providing and subsidised LP gas and a heater is R8 500. Again the assumption was that the subsidy is only given during the 4 winter months for 10 winters as it is for space heating.

The use of LP gas depends on the establishment of a distribution network to provide refills and other services to end-users. The current distribution network is not developed in the Highveld townships mainly due to low volumes and low profit margins. Intermittent supply problems will not allow for an immediate large-scale implementation of this intervention.

14.2 Emission reduction due to the implementation of the intervention

The emission reduction due to the implementation of this offset intervention primarily depends on the uptake that can be achieved, since the emission from the fully participating households will be practically zero. There are very few indications as to what the level of uptake will be because of the low levels of use of LPG as an energy source in low-income communities. Although LPG is much safer than paraffin, the fear of LPG explosions is pervasive. This LPG fear factor has to be understood and quantified much better before this intervention can be rolled out on a full scale.

Initial assumptions about the intervention are summarised in Table 15.

Table 15: Assumptions and impact: LPG subsidy and heater

	Households			Reduction		
LPG subsidy	60%	80%	70%	100%	100%	56.0%

14.3 Quality of life impact

Because there are no examples initiatives to promote the use of LPG for space heating in low-income communities on a large scale, there are uncertainties around the quality of life impact.

Table 16: Quality of life impact of LPG subsidy and heater

QoL Indicator	Comment
Population using solid fuels	45% decrease if 90% of solid fuel burning households qualify and the uptake is 50%
Mortality and burden of disease attributable to household air pollution	Drastic decrease in indoor exposure for participating households. Ambient exposure decease depends on uptake
Household income	Subsidy is a *de facto* income
Proportion of household income spent on energy	Likely increase due to subsidy but increased energy consumption
Ownership of durable goods related to energy consumption	Increase due to appliances provided by intervention
Proportion of household expenditure spent on respiration related health cost	See 2

Overall satisfaction	Uncertain, expected to increase
Satisfaction with living conditions	Uncertain, expected to increase
Satisfaction with means of cooking and heating	Expected increase
Satisfaction with house	No change

14.4 Economic impact

Table 17: LPG subsidy offset intervention job creation estimates

LPG subsidy and heater job creation	
Direct (temporary)	400
Direct (permanent)	40
Indirect	1 573
Gauteng & Mpumalanga GDP contribution	0.001%

14.5 Monitoring

As with the other subsidy intervention, the monitoring of this intervention will focus on the real reduction in the use of solid fuels associated with the intervention.

Should the stumbling blocks and challenges of this intervention be resolved it may be an ideal combined off-set and an Eskom demand management success story. Brazil has a success story on LPG use by low income households.

15 SUMMERISED CONCLUSIONS AND RECOMMENDATIONS

Ideally an air quality index that normalises the health effect of each pollutant across different exposure periods (short term acute impacts vs. long term chronic effects) should be developed toward a common health end point, by normalising to a common unit (SO_2 and PM10 concentrations arising from both Eskom and Households respectively), a basis for offsetting emissions from different pollutants across different exposure periods will be made possible, this was however not possible within the scope of Phase 1 of the study. It is recommended that such an index be developed within the subsequent phases.

During the formulation of the criteria for evaluating the offset-projects, the households were identified as the most important stakeholder. This implies that the interventions must be tailored to the households' needs and preferences and that there can be no one-size-fits-all solution. It is therefore likely that in the final implementation, interventions will be implemented in parallel and households given choices between energy carriers and energy saving mechanisms.

Different approaches to identification of the target households leads to different results. Ideally an air quality index that normalises the health effect of each pollutant across different exposure periods (short term acute impacts vs. long term chronic effects) should be developed toward a common health end point, by normalising to a common unit (SO_2 and PM10 concentrations arising from both Eskom and Households respectively), a basis for offsetting emissions from different pollutants across different exposure periods will be made possible, this was however not possible within the scope of Phase 1 of the study. It is recommended that such an index be developed within the subsequent phases.

Although, the households have been identified as the most important stakeholder, there has to date not been direct interaction between the project and households, due to the early phase of the work. As the project progress towards new phases, the interaction with households will have to increase drastically.

Two aspects that have to be formulated in interaction with a representative group of households from the target area are the formulation of qualification rules and terms for exchanging existing coal stoves, which can potentially form a part of all the interventions with the exception of *EE RDP*.

The three structural interventions that relate to thermal comfort of the house (*full retrofit, ceiling and EE RDP*) can be implemented in parallel depending on the conditions and individual household preferences.

In the same way the interventions relating to energy provision (*new stove, electricity subsidy* and *LPG subsidy and heater*) all provide the same service namely domestic cooking and space heating. Households may be given a choice between all or some of these.

The structural interventions and the energy provision interventions can off course also be implemented together. Especially LPG or electricity for cooking compliments the *EE RDP* or *full retrofit* interventions.

All the evaluated interventions have potential of drastically reducing emissions from households but all face uncertainties. Since there are no examples of large-scale implementation of any of the interventions, the parameters that determine the potential uptake are not known for any of the proposed interventions and must therefore be determined empirically in a controlled and well-monitored in-use evaluation.

The emissions from the new stove intervention are fairly well known and the emissions from LPG and electricity can be assumed to be zero at the point of use. What is unknown is the extent to which mixed energy carrier use will still continue even after the implementation of the intervention, especially as far as space heating is concerned. The *new stove* intervention is the closest to the current usage pattern in solid fuel using households and may therefore be expected to be the least disruptive, easiest to implement and having the least risk of fall-back because a stove exchange (new-for-old) is likely to be attractive to households.

The actual reduction in the use of space heating sources due to an improvement in thermal comfort needs to be determined for South African circumstances.

For most of the interventions the implementation areas will be the urban areas with high solid fuel use within Eskom's area on air pollution impact.

Monitoring procedures for all interventions can be developed based on international best-practice examples. Baseline and on-going fuel use can be determined through annual household surveys. An element of on-going ambient air monitoring and modelling will be essential throughout the monitoring period.

Before the interventions can be implemented, an in-use evaluation has to take place where the interventions are implemented on a small scale (~50 households) and detailed information is gathered on the perceptions and practices of the households over time as well as on the real costs and the real emission reductions achieved. The objectives of in-use evaluation phase will be:

- To interact with a group of representative households to obtain intervention design parameters
- To obtain technical parameters for air pollution reduction of the interventions
- Revisit draft intervention designs
- To evaluate household responses to draft interventions
- To take the pre-feasibility assumptions to feasibility accuracy and reporting

After such an evaluation the following should be known:

- The parameters that determine user preference for new stoves, LPG and electrical appliances as means of space heating and cooking
- The conditions under which households will agree to a stove exchange
- The perception of households and the fairness of qualification rules for interventions
- The real thermal comfort impact of the ceiling, full retrofit and EE RDP intervention
- The real fuel use reduction associated with improved thermal comfort
- The real effect of free electricity by baseline energy carrier for cooking and heating and house type

In order to achieve the ultimate aim of the project, the following milestones have to be reached:

- In principle agreement by the MSRG with the pre-feasibility results and recommendations
- The formulation of a *South African PM10 and SO_2 Offset Protocol* including buy-in from key stakeholders
- The finalisation of design parameters for intervention through an in-use

evaluation of interventions (EE RDP can go ahead already)

- Confirmation from the Licencing Authorities that Eskom (and other industries) can offset tall stack emissions with household emission offsets.
- Final decision by Eskom top management to include offsetting in the business strategy

Eskom proposes to proceed by conducting an in-use evaluation project in order to assess the effectiveness of the interventions identified in this pre-feasibility study to be most feasible. This would include conducting a socio-economic assessment of the community prior to implementing the offsets, and monitoring ambient air quality before and during the implementation of the offsets.

16 MAIN CONCLUSIONS AND RECOMMENDATIONS

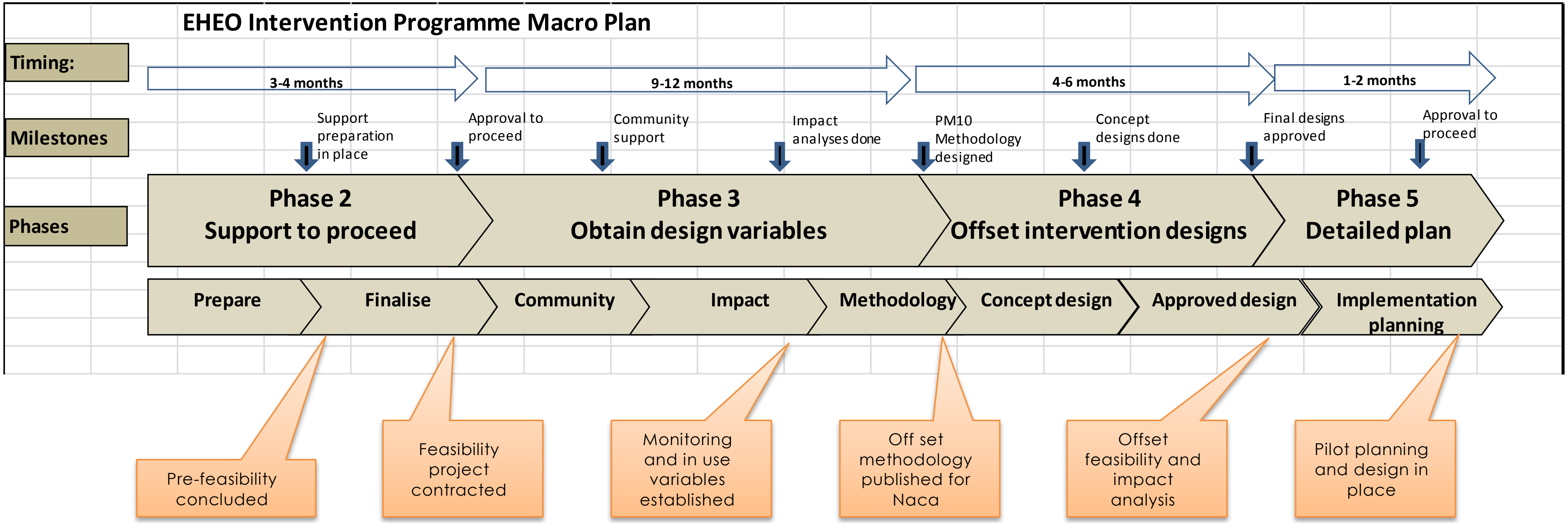
16.1 Main conclusions

1. The pre-feasibility study confirms the viability of a PM10 SO_2 offset scheme but the complexity of such an undertaking should not be underestimated
2. The identified interventions are suitable on their own or in combination

16.2 Main recommendations

1. The MSRG to be requested to give their support to Eskom to proceed with the offset programme design and development
2. The households and stakeholders are the most important role-players in this programme. Thus the design variables have to be determined in interaction with them
3. The programme development (institutional, legal, health, air quality etc.) and intervention designs can then be finalised and budgeted for Eskom Management approval
4. The feasibility of the interventions has to be confirmed through in-use evaluation in suitable area(s) before the pilots can commence

APPENDIX 1: DRAFT PLAN FOR NEXT PHASE



Main recommendations

1. The **MSRG** was requested to give their **support** to Eskom to proceed with the offset programme design and development
2. The households and stakeholders are the most important role-players in this programme. Thus the **design variables** have to be determined in interaction with them
3. The programme development (institutional, legal, health, air quality etc.) and intervention **designs can then be finalised** and budgeted for Eskom Management approval
4. The **feasibility** of the interventions has to be confirmed through in-use evaluation in suitable area(s) before the pilot schemes can commence