

***DEPARTMENT FOR INTERNATIONAL
DEVELOPMENT***

CONTRACT:

**RESEARCH DEVELOPMENT AND
DESIGN OF A SIMPLE SOLID
WASTE INCINERATOR, GLOBAL**

CONTRACT NO: CNTR 98 5698

Revised Inception Report

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1 SUMMARY OF ACTIVITIES CARRIED OUT TO DATE

1.1 PROGRESS AGAINST WORK PLAN

The following table gives details of workpackages that have been undertaken to date. Additional information on the preliminary findings of the socio-economic /environmental, technical and in country review is included in the next section.

Work Package	Details	Comments and Progress
1.1.1 Inception Meetings with DFID	Negotiate TOR, project budgets and schedule.	This meeting took place on 6 th November and was attended by all team members. A follow up meeting took place on 18 th Dec attended by Ray Holland and Nick Crick
1.1.2 Team Meeting	Define detailed roles and responsibilities, set out work packages, agree inputs, activities and outputs.	This meeting took place on 10 th December and was attended by all team members. The project work plan was discussed and revised. Action plans for implementing work packages 1.1.3 to 1.1.7 were put together.
1.1.3 Socio-economic, environmental review	Desk study using telephone, internet, literature review.	This study has been completed and a draft report submitted by Nick Crick to the project team. Sections of the report are currently being revised after discussion with team members. The findings will be presented at the review meeting with DFID on 17 th May.
1.1.4 Technical Review	Desk and local field study using telephone, internet, literature review to research; <ul style="list-style-type: none"> • current technologies • historical technologies 	This study has been completed and a draft report has been submitted by Roberto Vogel and Andrew Russell to the project team. Sections of the report are currently being revised as a result of discussion. Certain areas of particular importance have been identified for further research. This is currently being carried out by Roberto Vogel. The findings will be presented at the review meeting with DFID on 17 th May.
1.1.5 In-country research	Field study in four countries to include checklist appraisals of; <ul style="list-style-type: none"> • local municipal waste stream composition • local waste management strategies • locally available manufacturing techniques and facilities, • likelihood of co-operation and commitment from national and local government • Arrange meetings with local ministry officials, local government officials, and waste disposal sites. 	In-country research has taken place in a number of the countries on the "long-list". This has been conducted mainly through telephone interviews and fax correspondence. The information from the research has led to the short-listing of five countries; Kenya, Tanzania, Malawi, Zimbabwe and The Gambia. In these countries our contacts have been used to help determine the likelihood of co-operation and commitment from national and local government and to arrange meetings with local ministry officials, local government officials, and waste disposal sites.
1.1.6 Country Selection visit	Country visits to include <ul style="list-style-type: none"> • meetings with Ministry officials • meetings with Local Authority officials • visits to waste disposal sites • meetings with local manufacturers 	Country selection visits have been carried out in Kenya, Malawi, and Zimbabwe and the Gambia. The visit to Tanzania was cancelled after contacts failed to co-ordinate the necessary visit arrangements. A recommendation for a partner country has been made as a result.

1.2 RESULTS OF SOCIO ECONOMIC AND ENVIRONMENTAL REVIEW

A comprehensive report on the methodology and the results of this part of the survey are available in Project Report – Review of Demand and Selection of Partner Country. The following is a summary of the activities and findings.

The purpose of this phase of the project was to identify whether small scale, low cost incineration (LCI) has a valid role to play in waste management in Medium and Low Income Countries (MLICs) and then to select a partner country in which to construct a pilot plant.

The process has been undertaken in two phases. In the first phase the need and demand for LCI in MLICs was assessed. The second phase was then devoted to the identification of a suitable partner country. The countries visited were then ranked in order of preference in terms of partnership potential.

The following assumptions have been made in order to carry out the evaluation:

1. *The small scale incinerator will have a throughput of 10-20 tonnes per day*
2. *The cost to construct it will lie in the region of £10-20,000*
3. *This cost will be no more than that for an engineered landfill for an equivalent sized community*
4. *LCI on the scale proposed will not create significant adverse environmental impacts*
5. *The main component of the waste to be incinerated will be MSW*
6. *The plant will require a waste mix with a relatively high calorific value MSW in order to be self sustaining*

1.2.1 SURVEY OF NEED AND DEMAND

The criteria used for establishing a need for LCI were:

- 1 *Open burning and uncontrolled dumping presents a major health hazard through degradation of water and air quality.*
- 2 *Sufficient communities exist producing waste at the rate of 10-20 tonnes per day to justify the development of LCI*
- 3 *The waste is collected and delivered to a central point*
- 4 *The cost of engineering controlled landfill, especially for smaller communities is prohibitively expensive*
- 5 *MSW must have a reasonably high CV or else suitable industrial waste (e.g. waste oil, timber etc.) must be available to improve the overall CV of the overall waste mix.*

The criteria used to establish the existence of demand were:

- 1 *An awareness of health and environment issues in government and the general population*
- 2 *Acceptability of LCI as an appropriate component of a waste disposal strategy*

The results of the survey are presented in the following tables;

Review of Need						
Country	Burning/ Dumping	Community Size	Collection	Landfill too expensive	MSW CV	NEED
Caribbean						
Antigua	✓	?	✓	✗	?	✗
Grenada	✓	?	✓	✗	?	✗
Jamaica	✓	✓	✓	✗	?	✗
St Lucia	✓	?	✓	✗	?	✗
St Vincent	✓	?	✓	✗	?	✗
Trinidad	✓	✓	✓	?	?	?
Asia						
Bangladesh	✓	✓	✓	✓	✗	✗
India	✓	✓	✓	✓?	✗	✗
Indonesia	✓	✓	✓	✓?	✗	✗

Malaysia	✓	✓	✓	*	*	*
Nepal	✓	✓	✓	✓	*	*
Philippines	✓	✓	✓	✓?	*	*
Sri Lanka	✓	✓	✓	✓?	*	*
Africa/M East						
Botswana	✓	✓	✓	*	✓	*
Egypt	✓	✓	✓	✓?	✓?	✓?
Eritrea	✓	✓	✓	✓	✓	✓
Ghana	✓	✓	✓	✓	✓?	✓?
Kenya	✓	✓	✓	✓	✓	✓
Malawi	✓	✓	✓	✓	✓?	✓?
Morocco	✓	✓	✓	✓?	✓?	✓?
Palestine	✓	✓	✓	✓?	✓?	✓?
Tanzania	✓	✓	✓	✓	✓	✓
The Gambia	✓	✓	✓	✓	✓?	✓?
Zimbabwe	✓	✓	✓	✓	✓	✓

Review of Demand				
Country	Environmental Awareness	Acceptability	Affordability	DEMAND
Egypt	✓	?	✓	✓?
Eritrea	✓	✓	?	✓?
Ghana	✓	✓	✓	✓
Kenya	✓	✓	✓	✓
Malawi	✓	✓	✓	✓
Morocco	✓	?	✓	✓?
Palestine	✓	?	✓?	✓?
Tanzania	✓	✓	✓	✓
The Gambia	✓	✓	✓	✓
Zimbabwe	✓	✓	✓	✓

1.2.2 SELECTION OF PARTNER COUNTRY

The key criterion for selecting the short list was that the central government of the country - in the form of the ministry responsible for waste management issues - showed a **positive interest in participating** in the project. One measure of the degree of interest was whether they were prepared to set up a visit programme.

A number of other criteria, however, were also considered. These are described below:

- Political Factors
- DFID advice
- English Language Capability

The results of the Country Selection Process were as follows;

Short List Selection				
Country	Political Stability	DFID Advice	Language	Visit Programme
Egypt	✓	✓	✓	
Eritrea	*	✓	✓	
Ghana	✓	*	✓	
Kenya	✓	✓	✓	✓
Malawi	✓	✓	✓	✓
Morocco	✓	✓	*	
Palestine	*	*	✓	
Tanzania	✓	✓	✓	
The Gambia	✓	✓	✓	✓
Zimbabwe	✓	✓	✓	✓

1.2.3 SHORT LIST EVALUATION

The short listed countries were visited for periods of some three days each, in order to establish further detail about the situation in each. A clear preference emerged for the partner country, as will be seen, but some of the other countries visited also appeared to be promising candidates for future use of the technology and displayed a keen interest. This indicates that there is strong potential for replication – in Africa at least. Proposals are therefore included for the maintenance of the momentum generated to maximise the replication opportunities.

The main purpose of the country visits was to identify a suitable municipality in which to construct the pilot plant and to gather as much relevant information as possible about the countries visited in the time available. In each country, recommendations for selection of suitable municipalities were accepted from the responsible central government ministry - in most cases the Ministry of Local Government. The recommended municipalities were then visited, to assess their suitability for locating the pilot plant.

The results of the country visits are as follows;

Ranking of Partner Country Candidates				
Criterion	Kenya	Malawi	Zimbabwe	Gambia
Willingness to take ownership at central/local government level (10)	7	5	9	9
Evidence of existing reliance on uncontrolled dumping (10)	10	10	10	10
Waste composition (10)	8	5	10	7
Quality of management at selected municipality (10)	5	5	9	7
Willingness to invest in waste management improvements (10)	5	3	10	5
Existence of cost recovery mechanisms (5)	0	0	3	0
Quality of refuse collection service in selected municipality (5)	2	4	5	3
Existence of suitable local manufacturing partners (5)	5	2	4	4
Depth of existing manufacturing base and availability of supplies (5)	4	2	5	4
TOTAL	49	36	65	49

It seems clear from Table 6.2 that Zimbabwe will be the best choice as partner country and it is recommended that Zimbabwe be selected.

Zimbabwe showed great enthusiasm for the project, at both central and local government levels. Furthermore, there was a clear understanding of its benefits and an impression that other towns might wish to replicate the system, when it is proven to be effective. Waste disposal is by uncontrolled dumping. In Harare, this is causing significant political problems.

The waste composition, especially in the selected municipality (Marondera), appears to indicate a high CV. A preliminary analysis of a single refuse collection vehicle has now been undertaken, showing 36% by weight of paper and board and 14% of plastics. This municipality also has a good appreciation of waste management issues and the Senior Environmental Health Officer has a masters degree in environmental health, having studied waste management as part of this course. He is also extremely enthusiastic about the project. The collection system is efficient and a new vehicle has recently been purchased. A cost recovery system is in place (Zim\$33/household) which appears to cover the entire cost of the current level of service provision, even allowing for only 70% actual payment (figures for this are available).

Time was not available to visit potential manufacturing partners, but it is believed that they exist – foundry manufacturers being particularly interesting candidates.

1.3 RESULTS OF TECHNICAL REVIEW

1.3.1 INTRODUCTION

The objective of this initial technical review was to identify the current European state-of-the-art in waste incineration, to review current waste incineration practices in developing countries and to review historic incineration projects. The ultimate goal was to extract any lessons for this project (i.e. to build and operate a low cost incinerator).

The following deliverables were produced as part of this review:

A questionnaire for the socio-economic review (concerning any important questions to ask prospective partner countries)

The present report

A number of sources of information were used to derive this information, some of which are listed below:

- Internet (see useful sites in key web sites)
- UK IWM
- AEA Library
- WEDC Library and discussion with staff
- Institute of Chemical Engineers Library
- Coventry University Libretto
- SKAT – Solid Waste Management Directory of English Language Publications for low and middle income countries
- R'99 Conference (posting of call for information and individual discussions with delegates)
- Telephone and written discussions with informed individuals

A general paucity of data is noted which may be attributed to the low position incineration takes in the waste hierarchy and the assumed failure of a number of incineration projects.

However a change of attitude with guarded optimism was observed for low cost incineration with acceptable environmental standards fitting into an integrated waste management policy.

1.3.2 TECHNICAL REVIEW

Outline design specifications were drawn up as a basis of the investigation. Construction characteristics, emission standards and capital cost for an equivalent size incinerator (0.5 – 1 t/h) complying with EU emission legislation were presented (capital cost £1 – 1.7m). It was concluded that the emissions from this EU standard incinerator should be used as guidance for the low cost incinerator and that any discrepancy between the two should be subjected to detailed scrutiny.

When looking at incineration in Middle and Lower Income Countries (MLICs) evidence showed that practices ranged from open burning and primitive combustion infrastructure to purpose built small-scale combustion plants. However there is a lack of research and reporting on this area of waste management and we had to rely mainly on anecdotal evidence.

Open burning and primitive combustion infrastructure are inefficient and are causes of air, land and water pollution. Purpose built combustion plant was identified in South Africa and India. Although detailed information on the schemes is still outstanding we conclude that design and implementation of most of the schemes probably leave room for improvement.

The following problems with incineration in MLICs were identified:

- Low net Calorific Values (CVs) (3,400 – 7,500 kJ/kg)
- Use of inappropriate technology
- Pollution, fear of pollution and a general negative attitude as a consequence

Historic incinerators (or waste destructors as they were known) in the UK were studied to take advantage of experience gained with 'low tech' processes (cheap and common materials, low degree of automation etc.) early this century. A site visit tookplace at the 'Cambridge Destructor' (a technology museum) and the team reviewed two books on the subject. It was concluded that some of the information gained could be useful in this project. However before transferring any of this information to the project a number of test questions must be applied in order to exclude and polluting or otherwise inappropriate techniques.

1.3.3 INFORMATION FROM PAST INCINERATOR PROJECTS

A number of developing country incinerator projects have been identified, some of which seem to have been failures. These include a World Bank project in Dar Es Salaam, a Danida project in New Delhi and a local authority owned plant at Surabaya in Indonesia. Information on the performance of the Indonesian plant is included as an annex to the Technical Report while information on the World Bank and Danida projects has been singularly difficult to collect despite repeated attempts to invoke a response from the relevant agencies. It is

possible that DFID through their network of contacts may prove to be a more successful route in collecting sensitive information on these projects.

The survey has also identified an existing manufacturer (Johnston Thermal engineering) and at least one operating facility in South Africa (Ixopo township council). The plant is of a similar scale to that proposed in the current project and data on costs and performance has been collected. We hope to visit this installation in order to gather further information and learn from their experience.

1.3.4 INTERFACE WITH THE BIGGER PICTURE

Incineration is only one building block of a waste management strategy and is situated towards the lower end of the waste management hierarchy. It is therefore important that the low cost incinerator interfaces with the existing and planned provisions for waste management. Account has to be taken of collection practices, existing potential for re-cycling and re-use, composting and disposal of residues. Under no circumstances should the scheme displace existing practices and cause the loss of livelihood or other benefits to existing stakeholders. Other background considerations are with regard to existing and potential energy resources and background air quality.

1.3.5 PRE-CONCEPTS FOR PHASE 2

Based on the technical review and taking into account the bigger picture a pre-concept for the low cost incinerator has been presented, to be carried over into Phase 2 (design) of this project. No 'best option' was identified; therefore the pre-concept consists of a number of concepts and elements that make up an incineration process. The following headings were included: Front-end sorting and treatment, waste storage and feeding, combustion air pre-heat, forced or natural draft combustion air, stoking and de-ashing, combustion, flue gas cooling and cleaning, stack, instrumentation and monitoring, and residuals handling and disposal.

1.3.6 CONCLUSIONS AND RECOMMENDATIONS

There is a place in the waste management strategy of MLICs for a low cost incinerator scheme which is affordable, has a low pollution potential and fits into existing waste management provisions

Areas of concern are:

- Low calorific values
- performance of "low cost" incineration
- Displacement of existing stake-holders

Environmental performance will probably be below the EU standards; this shortcoming must be addressed e.g. with an Environmental Impact Assessment (EIA) including a 'no action' scenario. Lessons may be learned from historic UK incineration but excluding environmentally unsound concepts. The pre-concept presents a number of solutions for each element of the low cost incinerator and the final choice of technology will be based mainly on environmental considerations and cost.

The following key recommendations were made:

- 1 The design and development of the incinerator should take full account of the waste management hierarchy and local waste management systems already in place in potential partner countries.
- 2 Further detailed research into the composition of waste should be undertaken in the project area
- 3 Current waste management systems should be further researched in the project area
- 4 Current energy requirements within the vicinity of the project should be Identified
- 5 The potential of using the incinerator as part of a waste to energy plant for the potential project area should be assessed
- 6 Existing environmental law and background pollution of the potential project area should be researched.
- 7 An Environmental Impact Assessment (EIA) Assess should be conducted in the project area
- 8 Lines of research where useful information is still expected should be pursued
- 9 More detailed information on appropriate capital and running costs should be produced
- 10 An evaluation of the technical and environmental performance that can be expected at these costs should be carried out

1.4 IN-COUNTRY RESEARCH

This work is still on going. Work, which is currently being carried out by Local Consultants, is summarised as follows;

1.4.1 KENYA

ITDG Kenya has been commissioned to obtain further details about the local incinerator manufacturer and the plant that has been identified. They will also carry out a waste analysis at Limuru.

1.4.2 MALAWI

A member of the Ministry of Environment staff has been commissioned to carry out a waste analysis in Lilongwe.

1.4.3 ZIMBABWE

ITDG Zimbabwe has been commissioned to carry out a waste analysis at Marondera. The results of this are now available.

1.4.4 GAMBIA

A member of the National Environment Agency staff has been commissioned to carry out a waste analysis in Banjul and Kinangifing.

2 ISSUES ARISING

2.1 CALORIFIC VALUE OF WASTE

The existence of sufficiently high calorific value waste is an issue, which may well influence the ultimate success of the technology (despite the fact that in some African countries the CV may be high enough for the success of a pilot project). The ability to include lower calorific value wastes will increase the replicability of the technology and build in flexibility for seasonal variations and variations due to upstream resources recovery.

The calorific value of wastes should be analysed as extensively as possible (trials are underway in Kenya, Gambia, Malawi and Zimbabwe). Provision should also be included for forced air drying (see Pre-concept) and drying while in storage

2.2 ENVIRONMENTAL PERFORMANCE AND CHOICE OF TECHNOLOGY/COST TRADE-OFF

The team is now in possession of some data from release monitoring of small-scale incinerators actually operating in the field in South Africa. This data will give a comparison point to the EU Directive values and will help in assessing where the major problems are. This in turn will help to build a more informed view on the overall merits of the project.

An underlying assumption is that the plant will be designed so that the air emissions do not have a significant adverse effect on ambient air quality and that it will offer an improvement over a situation where open burning takes place.

The scale, however, is important. The actual emissions, as measured at the stack, are unlikely to meet the requirements of, for example, EU legislation – which has been designed with large plants (and with a consequent greater volume of emissions) in mind. Whereas a single LCI plant may result in acceptable emission levels, a larger plant of the same type, or several similar sized plants placed in the same location may lead to overall air emissions that are not acceptable.

In order to ensure that any designed plant is appropriate in terms of acceptable emissions, a comprehensive EIA will be carried out at the proposed site - in two stages. The first study will take place once the site has been selected and will measure the present impact on the environment of waste disposal – (the “do nothing” scenario). A second EIA will be carried out once an outline design is available in order to provide a comparison. We anticipate that an appropriate design will greatly improve the impact on the environment at the site.

In many of the countries considered there is at present no clear legislation on emission standards. Whereas it is unlikely that any affordable plant will meet strict standards such as those in Europe or America, there is evidence to suggest that reasonable standards can be achieved at moderate cost (based on information from South African manufacturers). An appreciation of the overall improvement to levels of pollution as a result of simple, controlled incineration as opposed to uncontrolled open burning will be crucial to the acceptance of the technology.

Achieving a balance between the cost of the technology, and its environmental performance is expected to be a difficult process. The team should begin to assess the costs of different solutions according to the headings in Section 5 of the technical report (Pre-concept) as soon as possible.

2.3 APPROPRIATENESS OF TECHNOLOGY

A number of cases have been brought to light during the research, where the performance of low-cost, clinical waste incinerators has declined as soon as the sponsor/construction organisation has left the site. There are no

concrete suggestions on how to address this concern at present - the appropriateness of the design is already written into the project.

3 ENVIRONMENTAL CONCERNS

The following releases need to be considered:

Releases to air:

- Visible smoke, particulates, odour
- HCl, SO₂, NO_x
- Organic micro pollutants (e.g. dioxins and furans)
- Heavy metals (e.g. Hg, Cd, Pb etc.)
- CO, VOCs

Releases to land:

- Bottom ash and fly ash (and gas cleaning residuals if any)
- Streams removed from incineration waste stream (e.g. batteries, special waste)

Releases to water:

- Leaching from releases to land
- Direct releases to water

Moreover the impact of any of these releases will also depend on local circumstances, e.g. the potential for dispersion, the presence of vulnerable receptors and background pollution. All of the above releases can be minimised and rendered harmless given the technical means and a certain standard has to be achieved for all of them. However, how exactly to allocate resources will have to be determined at a later stage and with a knowledge of local background data.

4 APPROPRIATE TECHNOLOGIES PROPOSED

During this technical review we have not been able to identify a “best option” or concrete existing design to take into Phase 2.

Therefore the pre-concept cannot be specific with regard to concrete features of the design. We will present a number of features and concepts which contribute to the incinerator design and discuss different options for implementation, thus opening the discussions on the design choices to be made in Phase 2.

(For purposes of brevity, some technical shorthand is used in the following.)

4.1 FRONT-END SORTING AND TREATMENT

The removal of PVC (if contained in the incoming waste) if successful will drastically reduce the need for a “chemical scrubber” to remove HCl. Similar pre-sorting may be considered for rubber (SO₂ reduction). Separation of other fractions to reduce pollution potential, e.g. batteries and other heavy metal bearing waste components. A separate re-cycle or disposal route for this waste stream needs to be determined. Removal of glass may be necessary to avoid clogging of the grate.

Separation of some organic fractions may be implemented to feed into a composting process (or anaerobic digester) for soil improver. Alternatively some fraction may be used to feed animals. Separate collection and sorting by householders is an alternative to on-site sorting. This requires good communication with and participation by the householder.

Separation of other fractions for separate disposal or as secondary raw materials on a case by case basis may be used to raise revenue, increase CV_{net} etc. Front end sorting may be carried out by the traditional scavengers, who can be integrated into the project. The drying of waste may be necessary to raise the CV_{net} of incoming or “rest waste” after removal of value fractions. Air drying or forced draft drying can be considered (use heat from the incinerator).

4.2 WASTE STORAGE, HANDLING AND FEEDING

The storage of waste should be carried out at the same place as the delivery and as near as possible to the feeding position in order to reduce internal transport. If the delivery is carried out at a raised point advantage can be taken of gravity in bringing it to the point of feeding. Storage could be combined with drying if the storage surface could be moderately heated. Handling should be carried out manually.

Top feeding normally involves storage of the waste on a platform, which also forms the furnace roof. I.E. feeding through a refractory lined charging door in the furnace roof by gravity (like Cambridge). 500 – 1,000 kg/h (8 – 16 kg per minute) is a big volume of waste to shift. Top loading involves the lowest amount of labour to achieve this. However top loading may cause lighter waste fractions to volatilise and be carried away with the combustion gases. Moreover the introduction of cold air when opening the sliding door is detrimental to good combustion.

Side, back or front feeding involves more labour than top feeding. There is a case for developing (or copying) a low-tech mechanical feed system, where waste can be fed from the side without large amounts of cold air entering the combustion chamber.

4.3 COMBUSTION AIR PRE-HEAT

Combustion air should be pre-heated due to the expected low CV_{net} of the waste. Heat exchangers with the exhaust gases are required, estimated degree of pre-heat: 100 – 250 °C. This may be done in combination with forced draught waste pre-drying (see above).

4.4 FORCED OR NATURAL DRAFT COMBUSTION AIR

Very probably natural draft is not an option for the following reasons:

- Pre-heating in heat exchangers cause high-pressure drops not normally sustainable with natural draft.
- High quality burnout on the grate (primary air) and in post combustion (secondary air) is greatly enhanced by air velocity, which cannot be sustained by natural draft.

Therefore an electrical drive will probably be required for forced draft combustion fan.

4.5 STOKING AND DE-ASHING

Hydraulically driven grates are probably out of the question, as this would involve some costly high-tech equipment. Manual stoking and de-ashing should be done in a way, which avoids excessive ingress air, and without compromising the operators' health and safety and comfort. It is also recommended to arrange the de-ashing in such a way that clinker and ashes fall by gravity into wheeled containers.

4.6 COMBUSTION

The main combustion chamber may be modelled on the Cambridge destructor, incorporating a drying grate and a bar grate with under grate air injection (primary air). Combustion and post combustion chamber geometry need to be determined with good mixing and turbulence in mind. A (costly) alternative to grate combustion is the fluidised bed technology.

A post-combustion chamber with secondary air injection is strongly recommended to avoid problems with black smoke. The inclusion of burners to achieve satisfactory temperatures in post-combustion must be considered.

4.7 FLUE GAS COOLING AND CLEANING

Flue gases must be cooled before gas cleaning can take place; from 850 °C down to a temperature consistent with gas cleaning. The cheapest way to do this is gas to air heat exchangers (see above Section 5.3). Attention must be paid in tube heat exchangers to high temperature corrosion. Other options are boilers and water injection. Temperatures should be below 300 °C to allow for condensation and agglomeration of some volatilised aerosols (PCDD/PCDF danger due to temperature window!).

Gas cleaning options considered at this stage is limited to de-dusting (removal of particulates). Two techniques are proposed.

- 1 Cyclonic gas cleaning systems have a lower cost and recent developments in hot cyclone designs may ensure a sufficient gas cleaning efficiency. With a high stack the natural draft may be sufficient to overcome the pressure drop across a cyclone.
- 2 Baghouse filters (fabric filters) are the high-tech solution to particulate abatement. However recent developments may indicate lower than expected prices and simple solutions. The great advantage of these filters is the high efficiency in removing particulates to levels below 1 mg/Nm³. Visible smoke plumes will be virtually eliminated, leaving only the gaseous species as a major concern. (Temperatures above 250 °C are a problem.)

One further element, which may need inclusion, is the Induced Draft (ID) fan. In combination with the bag house filter it is probably unavoidable.

4.8 STACK

The following considerations apply to the stack:

4.8.1 HEIGHT

Increased dispersion and natural draft from high stacks (30 m to 40 m may be considered high in this context). Visual impact needs to be considered.

4.8.2 MATERIAL

Steel stacks (two concentric tubes with lagging in between) can be manufactured off-site and assembled on a foundation. Masonry may be a more appropriate material where local skills and materials are available.

4.9 INSTRUMENTATION

The following instrumentation is considered for inclusion in the project:

- Temperature sensors for combustion air, main chamber, post-combustion chamber, after gas cooling, after gas cleaning (before stack)
- O₂ sensor after gas cooling (expensive)
- CO sensor after gas cooling (expensive)
- Supervision of primary and secondary air (flow or pressure instrumentation)

4.10 MONITORING PORTS/FACILITIES

Monitoring ports in the clean gas duct must be installed according to the envisaged monitoring protocols (i.e. British Standard, ISO, DIN or EPA)

4.11 RESIDUALS HANDLING AND DISPOSAL

Bottom ash handling may take advantage of gravity and fall directly into a wheeled container (see above, Stoking and De-ashing) which is then either driven directly to the point of disposal or to a point of further treatment. Alternatively the bottom ash may be directly conveyed to the point of further treatment by gravity. Scope for re-use of the bottom ash or some of its constituents may be explored (e.g. Fe metals recovery or as building material).

Other waste streams like fly ash or separated heavy metal bearing fractions need to be land filled. As this is part of the overall process it is part of this project to establish environmentally appropriate guidelines for this activity.

5 RECCOMENDATIONS FOR WORK IN PARTNER COUNTRY

Assuming that confirmation of Zimbabwe as the partner country is forthcoming, it is proposed that the next visit will take place in the second half of May 1999, The main objectives of this visit will be:

- Further background data gathering
- To obtain firm commitment from central government and the partner municipality
- Create a shortlist of potential manufacturing partners

Selection of local consultants to:

- carry out “do nothing” EIA
- provide technical support
- encourage implementation and replication

Hold problem/objective analysis workshop with all stakeholders

- Identification of design requirements
- Finalisation of agreements with partner municipality and other partners

6 SIGNIFICANT CHANGES TO ACTIVITES AND EXPENDITURE PROFILE

At this stage there are no significant changes anticipated to the project activities.

The log-frame and the work plan shown in Annex 2 show activities already carried out.

7 PROPOSED ACTIVITIES UP TO THE NEXT REPORTING PERIOD

Remaining tasks in Work Packages 1.1.1 to 1.1.6 in Phase one stage one will be completed.

Activities to take place during the period up to the next reporting period are detailed in the following extract from the workplan spreadsheet

Waste Incinerator Phase 1 Stage 2 - In Country Research	Activities	Outputs
1.1.7 Review meeting	Presentation of country selection visits report. Refine Logical Framework.	Partner Country identified. Revised Logical framework.

		Outline designs discussed.
1.2.1 Field studies in country	Detailed field studies to include; <ul style="list-style-type: none"> • detailed waste stream analysis • appraisal of rainfall and climatic features • further study of existing waste management strategies • locally available skills and capabilities • locally available technologies and fabrication methods • the availability of suitable support fuels 	Action oriented field study report to include; <ul style="list-style-type: none"> • key social, environmental and technical requirements for the incinerator • a detailed programme of activities for a pilot project • monitoring, evaluation and reporting criteria for the pilot project
1.2.2 Inception meeting in-country	A series of meetings in-country to; <ul style="list-style-type: none"> • Hold negotiations with Government Authorities to obtain their firm commitment to the project • Identify a broad location for the project • Identify potential local partners including local authority officials, with capabilities in general construction, mechanical and electrical engineering, metal fabrication and waste management • Identify any other interested and affected parties, e.g. NGOs, community groups, recyclers and scavengers, other Government departments in country. 	
1.2.3 Preliminary EIA	Carry out Environmental Impact Assessment (EIA) with reference to the "Do nothing" scenario	EIA report
1.2.4 Participative planning workshop	The aims of the workshop will be to meet with local partners and together; <ul style="list-style-type: none"> • identify and clearly define the problems associated with existing solid waste management systems • establish a hierarchy of cause and effect relationships for negative features of the existing systems • define strategy objectives, linked within a hierarchy of means-ends relationships • define and agree strategic priorities and objectives for the project • Express the above using a structured problem analysis tree 	Workshop report which includes; <ul style="list-style-type: none"> • plan of action • assignment of roles and responsibilities for stakeholders and local partners • revised time schedule for build and test • draft memorandum of understanding between stakeholders

8 ANNEX ONE

EXPENDITURE PROFILE

Financial year	1998/99	1999/00	2000/01
Personal emoluments	28,890	178,910	70,275
Capital costs	0	30,000	20,000
Other charges	4,450	19,888	45,272
Total	33,340	228,798	135,547
VAT	5,835	40,040	23,721
Total costs (Inc VAT)	39,175	268,837	159,268

PERSONAL EMOLUMENTS

NAME			PERIOD		PERIOD		PERIOD	
			1998/99		1999/00		2000/01	
	GRADE	RATE	Days	,	Days	,	Days	,
Ray Holland	3	400	1.5	600	12.0	4,800	0.0	0
Kieron Crawley	10	400	12.0	4,800	48.5	19,400	20.0	8,000
Andrew Russell	51	400	10.0	4,000	176.5	70,600	50.0	20,000
Nick Crick	32	400	35.5	14,200	28.0	11,200	5.0	2,000
Roberto Vogel	51	400	13.0	5,200	67.5	27,000	31.0	12,400
UK Technician	54	150		0	30.0	4,500	0.0	0
Local Consultants	52	225	0.4	90	139.6	31,410	35.0	7,875
UK specialist consultants				0		10,000		0
On -site engineer	52							20,000
		Total	72.4	28,890	502.1	178,910	141.0	70,275
		VAT		5,056		31,309		12,298
		TOTALS		33,946		210,219		82,573

ANNEX ONE (CONTD)**CAPITAL EQUIPMENT**

Detailed specifications should be given for all items Including details of suppliers and catalogue numbers where known and the financial year in which they will be required.		
Item	Financial year	Cost
Phases 1.1	1998/99	
Sub Total		0
Phases 1.2,2	1999/00	
Test-rig materials		15,000
Portable Gas monitoring Equipment		5,000
Negotiating and supervising any building or environment protection work on test-rig site as required by UK environment agency legislation.		10,000
Sub Total		30,000
Phases 3,4,5	2000/01	
Incinerator pilot plant materials		20,000
Sub Total		20,000
	Cost ,	50,000
	VAT	8,750
	TOTAL ,	58,750

ANNEX ONE (CONTD)

OTHER CHARGES	PERIOD	PERIOD	PERIOD
	1999/00	2000/01	2001/02
Research Materials			
Research Materials	300	100	
Report Binding, Operators Manual			200
Video Dissemination (see details attached)			16,272
Fares			
International (@ £1200 per trip)	2,116	12,884	16,500
UK (@ £60 per trip)	418	1,082	0
(For details of travel see attached workplan)			
Subsistence			
UK consultant overseas subsistence (@ £100 per day)	1,600	4,400	5,300
Local consultant subsistence (@ £13 per day)	0	1,438	0
Accommodation			
Relocation and rent (on-site engineer, Zimbabwe)			7,000
Totals	4,434	19,904	45,272
VAT	776	3,483	7,923
Totals (Inc VAT)	5,210	23,387	53,195

ANNEX TWO

UPDATED LOGFRAME

Narrative Summary	Verifiable Indicators	Means of Verification	Important Assumptions
<p>GOAL</p> <p>Reduced degradation in the quality of water resources and pollution to air due to uncontrolled dumping and open burning of waste.</p>	Better access to clean air and water by householders, farmers and business users.	Surveys and health reports. Environmental Impact Assessments	That open burning of waste is a significant contributor to the degradation of ground water and pollution of air.
<p>PURPOSE</p> <p>Research, development and design of a simple solid waste incinerator.</p>	Municipal waste volume reduction. Reduction in demand for land for waste landfill.	On site surveys. Local records of land allocation and use.	Incinerator will be used and operated as intended. Dumping of waste (and open burning) can be controlled.
<p>OUTPUTS</p> <p>Proven incinerator design able to safely dispose of ten tons per day of waste. Adoption of unit by Local government to promote incineration as an alternative to landfill.</p> <p>Local manufacturers in partner country are able to design and build incinerators.</p>	<p>Incinerator built locally, installed and operating to specified performance criteria.</p> <p>Successful operation of incinerator by local partner as part of wider waste management strategy.</p> <p>Further orders received by manufacturer to build such incinerators.</p>	<p>Technical reports from monitoring and testing phase on completion of building and again after 3 and 6 months.</p> <p>Follow up survey and report 6 months after incinerator commissioning.</p> <p>Order book reports and sales records after one year.</p>	<p>Appropriate technology can be acquired to dispose of required volume of waste to the required standard at a price, which is affordable, by local authorities.</p> <p>Adequate resources exist in MLIC's to locally manufacture, operate and maintain incinerator technology.</p> <p>Local government is committed to improving the environment and reducing use of land for landfill.</p> <p>Availability of simple incinerator technologies that can be locally reproduced. Market incentives exist to build and sell incinerators.</p>
<p>ACTIVITIES</p> <p>(Underline indicates that activities that are underway or completed)</p> <p><u>Phase 1 – Research</u></p> <p>Phase 2 - Design and Test-Rig</p> <p>Phase 3 - Pilot Test in country</p> <p>Phase 4 - Documentation and Training</p> <p>Phase 5 - Final Reporting</p>	<p><u>Partner country selected.</u> <u>project partners selected.</u></p> <p>Test rig designed, built and tested.</p> <p>In-country unit built and tested.</p> <p>Training package designed and delivered.</p> <p>Project and design documented.</p>	<p><u>Technical Report, Socio-Economic report, Country Selection Report.</u> Workshop report.</p> <p>Detailed design report, Test report, Construction project plan</p> <p>Build report,</p> <p>O&M Training manual and training report.</p> <p>Final report and construction notes, information video pack.</p>	

ANNEX TWO CONTD,

GOAL

ASSUMPTION

That open burning of waste is a significant contributor to the degradation of ground water and pollution of air.

MEANS OF ADDRESSING ASSUMPTION

Current expert opinion holds that in the majority of instances, this is indeed the case. In Phase one Stage 2, EIA studies will be carried out in the partner country to measure the existing level of pollution to air and water at the selected site.

PURPOSE

ASSUMPTION

Incinerator will be used and operated as intended.

Dumping of waste (and open burning can be controlled)

MEANS OF ADDRESSING ASSUMPTION

Phase 4 of the project deals with the design and delivery of a training package for operators and managers of the plant . This is regarded as a crucial component of the project if correct use and operation of the plant is to be maintained.

In selecting the partner country emphasis has been placed on identifying a municipal council which has the resources and capacity to manage and operate the plant effectively. One important factor in determining long term sustainability is the existence of a cost recovery mechanism for waste disposal services. The existence of such a mechanism has been an important factor in selecting a suitable local authority.

Written commitment will be sought from the selected Local Authority during the next stage of in-country work to ensure that operating staff and other utilities are made available.

OUTPUTS

ASSUMPTION

Appropriate technology can be acquired to dispose of required volume of waste to the required standard at a price, which is affordable, by local authorities.

MEANS OF ADDRESSING ASSUMPTION

Initial findings from the Socio Economic review and the Technical review suggest that this is possible (See south African information) and the partner country that has been recommended offers the best opportunity to realise this. A definitive answer to this question in the selected country will only be available once the next stage of in country survey work has taken place. During this stage the likely required standard for emissions will be investigated and an in depth analysis to estimate the likely increase in cost recovery necessary to fund the operation of the incinerator will be carried out.

ASSUMPTION

Adequate resources exist in MLIC's to locally manufacture, operate and maintain incinerator technology.

MEANS OF ADDRESSING ASSUMPTION

Again the initial findings of the phase-one survey work would appear to bear this out. Information gathered from the selected partner country during the initial selection visit and subsequent inception visit, will feed directly into the design process to ensure that any resulting plant is appropriate for manufacture, can be properly operated and maintained there.

ASSUMPTION

Local government is committed to improving the environment and reducing use of land for landfill.

MEANS OF ADDRESSING ASSUMPTION

The survey of need and demand for LCI includes a criterion which measures the level of commitment at both national and local government level to improving the environment. The short-listed countries and the recommended partner country demonstrated a clear commitment to this.

ASSUMPTION

Availability of simple incinerator technologies that can be locally reproduced. Market incentives exist to build and sell incinerators.

MEANS OF ADDRESSING ASSUMPTION

Information which has come to light through the technical review suggest that this is the case. Aspects of Technologies available in historical plants (such as the Cambridge destructor) as well as current plant in South Africa can all be reproduced in many of the countries reviewed. The existence of commercial manufacturers in South Africa also suggests that there are commercial incentives to build and market such technologies.

