Application of past lessons in the dissemination of modern energy technologies in Africa: Selected recent cases

M C Mapako
CSIR Natural Resources and Environment, Pretoria, South Africa

ABSTRACT

Projects and programmes to disseminate energy technologies in Africa have been undertaken for decades with little success. These have included initiatives to promote and disseminate family and community biogas digesters, improved woodstoves, solar home systems, gasifiers, and biomass briquettes. The predominant causes of failure in most cases have been around flawed approaches to scale up and dissemination.

This paper is based on a review of the literature on past energy service delivery initiatives, interviews with key informants and field visits to energy service delivery project in Rwanda, Tanzania and Malawi during 2008.

The review found evidence that lessons from past failures are being significantly applied in current efforts to disseminate modern energy services. Among the key lessons are the need to establish sector-wide capacity covering suitable financing mechanisms, technical training and retraining, operation and maintenance, customer information, local buy-in and ownership, and integration with other ongoing development programmes.

1. INTRODUCTION

There have been many modern energy service delivery projects in Africa, in many cases these have repeatedly failed [1]. Many lessons can be learnt from these experiences and studies looking at such lessons have been conducted and have identified certain critical factors that influence the outcomes of these initiatives. These include needs identification, institutional and financial factors, operation and maintenance capacity, market research and quality control. There have been recent initiatives that seem to have taken heed of the lessons from past failures and may fare better. This paper presents the biogas programme in Rwanda. The programme is supported by the Netherlands Development Organisation (SNV)[1]. SNV has extensive experience and notable successes in Asia, Nepal being a case in point. Of course Asian experiences cannot be simply transplanted unchanged into different African contexts. The papers then discusses, more briefly, promising projects in two other countries, charcoal ovens in Tanzania and improved commercial and household stoves in Malawi. The reason for the greater focus on Rwanda is the fact that the Directorate General for International Cooperation (DGIS) of the Netherlands Ministry of Foreign Affairs is funding this programme as part of a wider African initiative.

[1] SNV Supports organisations in the South committed to fighting poverty and improving local governance.

A tour to selected bioenergy projects in Rwanda, Tanzania and Malawi was undertaken in 2008. Tanzania continues to make sustained efforts to promote modern energy services and Malawi is pioneering in some respects, for example its sustained production and blending of ethanol with petrol. Table 1 summarises the programmes visited.

Table 1: Summary of projects covered by the field visits

	Rwanda	Tanzania	Malawi
Technology reviewed	Biogas	Charcoal ovens	Stoves and briquettes
Lessons incorporated	Bottom-up approach to needs identification, private-public partnerships, quality control, maintenance and operation capacity. Provision of suitable financing.	Importance of partnerships, enterprise-focus, training, maintenance and government support and commitment, and suitable financing.	Value of policymaker interest and involvement on the ground, importance of involving SMEs in programmes and the bottom up approach.

2. THE RWANDA BIOGAS PROGRAMME

The target for the Rwanda national biogas programme was given as 15 000 units by 2011. At the time of the visit in late September 2008, some 175 household biogas plants had been completed, including 100 initial demonstration units, and 185 contracts for new biogas digesters had been signed by farmers. Ten private companies were undertaking construction. More would be trained in order to reach the set 2011 target. A minimum of 2-3 cattle are required for the typical $6m^3$ digester, and fertilizer from biogas digesters was sometimes sold.

The biogas digesters were more expensive than in Asia, with a 6m3 family digester costing around US$1 200 in Rwanda compared to US$250-$400 in Nepal. Cement cost in Rwanda was about $13 per bag, and 18 bags were required for the average digester. In Nepal cement cost about US$2 per bag. The designs being promoted in Rwanda were based on the Nepalese model with modification to reduce cement use. In Rwanda the walls were constructed with stones (due to the ban on using wood for brick firing), and the dome with cement. The farmer's in-kind contribution was labour and material including sand, stones and water.

Biogas had benefits at the individual and community levels, and if carbon emission reduction was considered, the benefits are greater. Users saw smoke reduction as a greater

benefit than financial benefits as minor. The promotional message includes the highlighting of benefits to users.
A feasibility study was completed in 2005 and an Agreement between SNV and MININFRA was signed in 2006. DGIS (Netherlands) agreed to fund the programme as part of a wider African programme. SNV was providing technical assistance for market development. There were important lessons from Nepal, also a hilly country like Rwanda. SNV felt that at this stage the numbers installed was a less important indicator of success than development of a biogas sector. The aim was to have a self-sustaining programme; the numbers would come later.

The capacity to pay for biogas digesters is not seen as a constraint. It is estimated that 100 000 farmers had the capacity to pay for the biogas digesters, hence the plan for 15 000 units by 2011 is seen as realistic. The zero grazing of cattle also made the choice of biogas technology favourable since all dung and urine was collected. The digested dung can still be applied to the fields and does not lose its fertiliser value since only carbon compounds, carbon dioxide (CO_2) and methane (CH_4) are removed. Besides biogas, wind, PV, hydro projects were also being implemented in Rwanda.
Implementation of the programme started in January 2008 following the training. The steps involved in a successful application for a biogas digester are as follows:

1. Farmer submits application form.
2. Installer inspects/certifies site as suitable.
3. Farmer and company sign contact.
4. Contract endorsed by MININFRA.
5. Company builds digester.
6. First inspection by MININFRA, and payment of first portion.
7. Second payment disbursed after digester is operational.
8. A balance of 7.5% is paid at 12 months, after 3 compulsory visits at 2, 6, and 12 months have been completed.

2.1 Needs identification:

A gap was perceived in the Rwanda domestic cooking fuel market in view of the very high population density, high power tariff and deforestation. Biogas was not being offered as the sole solution, but rather as one option.
A major pitfall in many rural development projects has been the top down approach where the interventions are developed with little or no understanding of the priority needs of the recipient communities. In Rwanda, there were district level plans for all sectors. Coordination was via local structures, such as the farmer organisations. Leaders had performance contracts for each year.
Institutional biogas digesters were installed in response to critical sanitation and energy needs due to prison overcrowding. Schools copied from the prisons and funded themselves or found sponsors.
To avoid disillusionment it was crucial to be up-front with users about limitations. There were some misplaced expectations that the technology could power radios and mobile phone chargers. Mantle lamps were problematic due to the fragility of the mantle. Users prioritised lighting very highly, in some cases above cooking.

2.2 Economic/financial factors:

The financing for the biogas digesters was structured as follows: [2]

- 1/3 subsidy from programme (split government 25% and programme 75%).
- 1/3 farmer contribution in labour and materials (sand, stone, water).
- 1/3 cash by farmer, this can be through a loan, normally payable over three years.

The biogas loan interest was 13% per annum, which is the same as for agricultural finance. In case of default, there was the risk that the biogas digester could not be repossessed. However the agricultural loan record was good and the culture of paying back loans was well established.[3] Banks did not see the extension of credit for biogas as problematic since the criteria for installation link the digesters to income generating activities, especially milk sales.
Eligibility for payment was restricted to trained and certified builders, and refresher courses included the rectification of existing faults. The financing arrangement had ensure that participating companies had sufficient initial capital for costs such as labour to start operating.

2.3 Maintenance

Ease of maintenance was seen as a make or break issue for the programme and the user perspective was important. The user had to be trained to deal with minor maintenance issues like leaks in pipes, and the installing company had to undertake the required maintenance visits. User manuals had to be in the local language with contact details for both the installing company and the programme. This was a condition for the involvement of companies in the programme.
Installing companies were contractually bound to train local maintenance technicians, and there were refresher courses for technicians, funded by MININFRA. Records books were kept at the client's premises for inspection when necessary.

2.4 Transfer of knowledge and skills

This was informed by looking at pre-existing capacity at KIST, in regional programmes, and among experienced masons. Management skills training would be provided to companies using modules adapted from other countries. Companies were encouraged to cluster installations to minimise costs through phased simultaneous construction of digesters in one area. Specifically the following training components were in place:

- User training courses held. Training capability was enhanced. Asian trainers were hosted in Rwanda for some time
- User manuals under development, drafts completed.
- Entrepreneurship and management training provided to the installing companies.

- School curricula also have renewable energy component.

2.5 Institutional issues

Government and institutional acceptance was an important criterion for SNV to decide to become involved. Government responded well and engaged additional personnel as needed. A memorandum was signed, showing government's commitment. Despite similar conditions in Burundi, government reception there was not as strong and consequently SNV did not start a programme there. Many stakeholders including the Kigali Institute of Technology (KIST), SNV and the private sector bring in technical capacity. A need was seen for a national body to oversee both institutional and domestic biogas initiatives.

The programme latched onto the Rwandan idea of model farmers who adopt and pioneer new ideas. These early adopters receive visitors who can see new ideas in action. The initial farmers for the biogas demonstration phase were chosen on this basis. The idea is that biogas digesters will sell on the basis of clients seeing working digesters and happy, satisfied users. To avoid unhappy users, construction should not proceed where the basic conditions were not met, for example minimum number of cows next to house and availability of sufficient water.

Companies seeking business act as champions. Local conditions such as poverty, ability to afford the digesters, and cattle ownership culture contribute to easier acceptance.
The pilot sites were selected through farmer organisations.

Institutional plants were selected on the basis of availability of funds, for example through the parent ministry for prisons, and donor support for schools. 13 of the 20 prisons have biogas digesters. These large digesters cost thousands of dollars each and schools would not be able to afford them unaided. Schools have lower concentrations of pupils and cook more meals per day. For this reason their biogas is insufficient for the cooking demand and it would be ideal to supplement the feedstock with cowdung. It is not feasible to cook with electricity because of the relatively high tariff at US$0.27/kWh. For this reason charcoal use is widespread in urban households.

2.6 Other enabling factors

The easy availability of dung was assured due to two other projects whereby selected farmers got a free heifer together with veterinary and artificial insemination services. These projects were run by Heifer Project (USA) and Send a Cow (UK) and required each recipient of a free heifer (or other animal) to pass on for free the first female calf to another farmer as a way to propagate heifer ownership. These farmers sold milk from their cattle and in most cases the loans for the biogas digesters were being paid off with the proceeds of the milk sales. The cattle were zero-grazed and the farmers grew the fodder for their cattle. Indeed one of the major problems cited by farmers was the lack of sufficient land for fodder production, a constraint to the expansion of their dairy farming activities.

2.7 Impacts

Environmental impacts include firewood savings, erosion control, management of effluent, and impact on GHG emissions. Social impacts include livelihood improvement; provision of good light is highly prized. Economic impacts include the improved fertiliser for own crops and possible sale, and avoidance of the health problems caused by smoke.
Some farmer families were too large and the 6m3 digester proved inadequate. Since the farmer has to pay part of the cost of the biogas digesters, rural farmers with large families may end up under-served. There is therefore need for research into cost-reduction measures.

3. MALAWI

The visit to Malawi highlighted several examples of public-private partnerships where private companies were involved on a commercial basis in the production and marketing of different sizes of stoves, from small briquette stoves that had a ceramic liner to the industrial Rocket stoves produced by larger metalwork factories. The approaches showed the potential synergies between public and private sector stakeholders and the value of close involvement of senior policymakers in the development and refinements of initiatives to provide modern energy services to small enterprises. In Malawi the department of Energy was working hand in hand with GTZ, the oil companies, sugar refineries (ethanol producers) and SMEs in the various programmes. A number of the programmes are outlined below.

3.1 Comments on reasons for past failures by the Acting Director, Department of Energy (DoE)

It was important to acknowledge the existence of indigenous knowledge in communities and to avoid blind imposition of new ideas. It was better to build up from what was already known and to work together. Often donor-led projects impose without involvement of the local target population and insufficient government involvement and commitment. In these cases there was no long-term sustainability – collapse usually ensued soon after project support ended. Monitoring and evaluation should ideally start and continue with projects.

3.2 New energy centres planned

A new technologies initiative would see new energy centres[2] set up in urban areas and would focus on providing alternatives to charcoal. They would sell all feasible energy carriers. LPG was being promoted in collaboration with the petroleum importing companies and was generally available at filling stations. If petrol stations would also stock briquettes this would be even better from DoE's point of view.
The liquid ethanol stoves were meant to be used on local ethanol and ideally should be manufactured locally.

[2] This concept seems to be similar to the South African Integrated Energy Centres programme.

Ethanol gel was included in the new technologies initiative, and enjoyed tax rebates.

3.3 Urban charcoal use and deforestation

The major thrust by the DoE was to tackle the widespread use of charcoal in urban areas. This had been encouraged earlier by the World Bank and those efforts had succeeded, but charcoal use was no longer seen as acceptable by government. In principle government did not have a problem with programmes promoting the efficient utilisation of charcoal as long as that charcoal was from wood grown sustainably. There were several dense spots of charcoal making to supply Blantyre and government needed to provide practical alternatives before attempting to discourage the charcoal producers and users.

3.4 Briquettes and briquette stoves

Manually pressed sawdust briquettes were being produced by small enterprises. The manual machines made 18-24 low density briquettes simultaneously. The machines cost Malawi Kwacha (MWK) 37 000 each in 2007. The government had distributed 20 machines with the intent that recipients would make money and buy further machines. The machines were designed and manufactured by the Malawi Industrial Research and Development Centre (MIRDC), a government technology development parastatal. The components of the stoves used with the briquettes were made by different groups including tinsmiths (cladding), potters (ceramic liner) and assemblers who assembled and marketed the stoves.

3.5 The Rocket stove

This was a metal stove aimed at large institutions and businesses such as tobacco curing. There were several different stove technologies being promoted and aimed at different end users as summarized in Table 2. The Rocket stove brochure claims that 14kg of wood in a rocket stove would accomplish the same cooking task as 170kg wood on an open fire. Rocket stoves had been introduced for tobacco curing with good results, and the local sawdust briquettes had been successfully used in the rocket stove.

Table 2. Different stove technologies and the different target groups in Malawi. [4]

1	Clay stoves	Low income households
2	Rocket stoves: Household fixed	Institutions with staff houses e.g. Tea estates Individual households
3	Rocket stoves: Institutional, portable	Hospitals, schools, prisons etc
4	Tobbacco curing barns	Small scale farmers of at least 1 acre grouped into clubs of at least 10

Rocket stove producer: Kensteel Engineering, Blantyre

Kensteel is a metal fabricating company which originally focussed on window and door frames. The company was approached by the GTZ ProBEC project with a proposal to go into production of the institutional Rocket stove. Stoves were produced under license from GTZ and the Ministry of Energy Affairs. GTZ makes regular visits to check for consistency in the products. The company produced 2000 stoves in 2007. There were similar arrangements with 4 other companies in Lilongwe, Dedza, Mzuzu and Mulanje.

Problems

The stoves were seen as to expensive for individuals, a single plate household model would cost MWK8000 and a two plate model MWK140 000[3] from the factory.

For industry in general the costs of input materials was high and electricity supply was erratic with many interruption that disrupted production. The company felt government should subsidize the cost of steel to help stove fabricators in the same way that gas is being subsidised. It was acknowledged however that targeting a specific sector with such a subsidy would not be easy.

Impacts

The business grew much larger after going into stove production. The number of employees was 4 before going into stoves and now stood at 52 because of the high level of stove demand. Stoves were generally manufactured to order because the sizes were specific to customer needs.

3.6 Tobacco barns

The rationale for efficiency improvement in tobacco barns was the large scale wood use in tobacco curing. The demonstrations were to show farmers the benefits of the rocket stove for tobacco curing. The rocket stove provided good drying control. The rate of drying was critical to the quality of tobacco.

There were three sub projects, Alliance 1, Alliance 2 and Total Land Care (TLC). For Alliance 1 the target was 500 barns for 2008 and 2000 for 2009. TLC was a reforestation organisation, and ProBEC had provided seed funding and technical training, TLC was to provide more funding.

40 field test stoves had been built in 2007 and the total for 2008 was expected to be 200. Quality checking was by ProBEC. Field supervisors worked with Alliance 1 farmers. No marketing training had been provided.

Champion:

Alliance 1 advertised the project and identified the farmers. Adoption was 100% because the farmer paid a high price for the rocket barn. In the past the emphasis was on retrofitting barns but this had changed. The demand was currently for new barns, not retrofits.

Finance:

The project negotiated for short loans (1-2years) with a commercial bank for farmers to acquire the stoves. There were no direct subsidies at the user level, but programme costs were a subsidy.

Builders were identified through involvement with technical colleges and the National Industry Council of Malawi (NICM). Clients contracted the builder and met subsistence costs.

[3] Exchange rate approx MWK140 per US$

Impacts included reduction in wood use, enhanced incomes, and exposure to less heat than with a traditional kiln. Issues included the complications of coordination with the numerous different partner organisations and their diverse interests. There had been troubleshooting meetings to deal with problems as they arose.

3.7 Chigwirizano township. Briquette stove production (Wellington Banda)

This stove producer had diversified into briquette stove production from his original tinsmith business. He was also producing cans, bins and doing repairs. He was trained two months prior to the time of the visit and had sold 15 briquette stoves at MK550 each on a cash basis. He produced the tin cladding and purchased the ceramic liners at MK30-60 from women potters who had been trained by DoE. Customers seemed to like the briquette stove since it lasted well; about 6 years in the experience of the seller.

Problems

The problems in this township included an unreliable water supply even though communal water supply taps were installed. The fact that DoE had not yet carried out briquette demonstrations in the area constrained sales of the briquette stoves.

4. CHARCOAL OVENS FOR ENTERPRISES IN TANZANIA

The Tanzania Traditional Energy Development and Environment Organisation (TaTEDO) is promoting several renewable energy technologies, including charcoal stoves. TaTEDO is one of the key rural/renewable energy development organizations in Tanzania. It is a coalition of individuals, professionals, artisans, farmers, community based organisations (CBOs) and micro enterprises involved in the development and promotion of Renewable Energy Systems (RES) for enhancing sustainable environment and socio-economic development of communities. The organisation was registered in 1990 as a national non-governmental, non-profit energy and environment organisation [5]. The Tanzanian case illustrates the roles that partnerships between NGO's, small scale entrepreneurs, and financial institutions can play in the successful development of small enterprises through training, financing, and technical backup. It shows that it is not always necessary for government departments to take the lead, though their support and commitment is important.

Field visit: Small bakery using charcoal ovens. Bomang'ombe area. (Mrs Beatrice Exaud)

Mrs Exaud had a small bakery business at the small Bomang'ombe business centre. She was producing cakes and rolls and at the time of the visit had one assistant. She was kneading the dough manually and struggling to keep up with demand. She had two charcoal ovens; both bought from TATEDO after she was trained and offered a loan following the training.

Problems facing the business:

Competition from large commercial bakers who also supplied the local shops meant prices could not be raised to cover rising input costs without risking market share. Profit margins were therefore thin.

The business was struggling to keep up with demand and would need to buy a kneading machine (quoted at KSh10 000 or US$1 000), and extra ovens.

Maintenance:

Maintenance was provided by TaTEDO technicians for a fee. The second, newer oven from TATEDO was much less durable that the first, older model that Mrs Exaud had. TATEDO had changed the materials used to build the oven to lighter gauge metal and ended up with a flimsier oven which needed repairs already. Mrs Exaud had reported the problem but a technician from TATEDO had yet to come. TATEDO used a cost-sharing formula to assist customers with maintenance backup.

Training:

Mrs Exaud had paid for training at TATEDO and a technician had been sent to provide basic training. There were other small scale bakers who were active but a number was not provided at the time. Initially pilot ovens were given away for demonstration.

Costs:

The oven costs were US$150 in Dar-es-Salaam, and US$250 landed in Moshi. The husband, Mr Exaud who worked in Dar-es-Salaam had bought the first oven for $280 in Moshi and Mrs Exaud had bought the second oven from profits of the business. Delivery of the second oven was easy because a TaTEDO agency had opened in Bomang'ombe by the time the second oven was purchased.

Impacts:

Prior to the wife starting a bakery, the husband was the sole breadwinner and the family was staying in rented accommodation. Following the establishment of the bakery, the extra cash had allowed the family to build their own house and to purchase two cows.

Another example which was described but not visited was of another baker named Regina who operated about 10km outside the town of Moshi. She bought her first oven on a loan from TATEDO in 2002 after attending a training course. She paid off the loan in three months. She was not new to baking, but had been using local traditional ovens prior to purchasing the TATEDO oven. She had gradually bought more ovens and currently had 10, and employed 6 people. She had landed a contract with a major supermarket chain, Shoprite for the supply of 5000 cakes a day [6].

5. CONCLUSION: Factors that may be crucial for successful market development from the cases described

The foregoing discussion points to a number of important that should be borne in mind in market development around modern energy service delivery. These may be summarised as follows:

- Demonstration phase that targets opinion leaders in communities and is large enough to have impact with units that work and produce happy users.
- Introducing new energy conversion device manufacturing business into existing enterprise active in a sector where the basic skills are already in place, example welding or pottery.
- Introducing new production technology into existing enterprise that may be using more traditional and less efficient technology. Example: charcoal bread ovens.
- Training in technical aspects for installers and end users. Managerial and financial management skills for the companies involved.
- Enforcing long-term maintenance support for clients and ensuring availability of technicians locally, with refresher courses to keep level of competence high.
- Suitable finance scheme in place. Repayments not always monthly, incomes sometimes seasonal.
- Market development process to be part of a national sector development strategy.
- Importance of ongoing training given the high incidence of dropouts among trainees.

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AUTHOR:

Maxwell Mapako holds an MSc degree in Energy Studies from the University of Cape Town, a BSc (Hons) degree in Biochemistry and Environmental Studies from the University of Wales, Cardiff, UK, and a Postgraduate Diploma in Renewable Energy Engineering from Sogesta, Urbino in Italy. He is currently a Senior Energy Specialist at the CSIR in Pretoria, South Africa and is pursuing his PhD at the Energy Research Centre, University of Cape Town. His address is: CSIR Natural Resources and the Environment, P O Box 395. Pretoria 0001. South Africa. Email: mmapako@csir.co.za

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