Kigali Institute of Science, Technology and Management (KIST), Rwanda

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Biogas plants providing sanitation and cooking fuel in Rwanda

Summary

The Kigali Institute of Science, Technology and Management (KIST), has developed and installed large-scale biogas plants in prisons in Rwanda to treat toilet wastes and generate biogas for cooking. After the treatment, the bio-effluent is used as fertiliser for production of crops and fuelwood.

Large prisons, each housing typically 5,000 prisoners, are a legacy of the troubled past of Rwanda. Sewage disposal from such concentrated groups of people is a major health hazard for both the prison and the surrounding area. The prisons also use fuelwood for cooking, putting great pressure on local wood supplies.

Using biogas digesters to manage animal or human sewage is not a new idea, but in Rwanda has been applied on an enormous scale, and with great success. Each prison is supplied with a linked system of underground digesters, so the sight and smell of the sewage are removed. KIST staff manage the construction of the system, and provide on-the-job training to both civilian technicians and prisoners. The biogas is piped to the prison kitchens, and halves the use of fuelwood. The fertiliser benefits both crop production and fuelwood plantations.

The first prison biogas plant started operation in 2001, and has run with no problems since then. Biogas plants are now running in six prisons with a total population of 30,000 people, and KIST is expecting to install three more each year.

The Ashden judges were highly impressed with the scale of these biogas plants, and the benefits which they provide in a difficult environment - sanitation, fuel and new skills for prisoners. They also recognised the significant potential for using such systems in other institutions like schools, hospitals, and on dairy farms - work which KIST has started to undertake.

The organisation

KIST is a public Institute of Higher Learning, which was established in 1997 to replace professional manpower that had been lost from Rwanda. The main focus is on technology and management. Within KIST, the Center for Innovations and Technology Transfer (CITT) is mandated to transfer technical innovations, managerial, and entrepreneurship skills into community applications. CITT has about 50 staff, 20 of whom are technical. The biogas programme within CITT was initiated by Albert Butare, former Vice-Rector of KIST. The technical leader is Ainea Kimaro, a Tanzanian engineer who had previously worked on biogas with the German Development Agency (GTZ). Key to the success of the programme are William Owino, and William Mollel, technicians who have been involved in all the installations.

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Technology and use

Biogas systems take organic material such as manure into an air-tight tank, where bacteria break down the material and release biogas - a mixture of mainly methane with some carbon dioxide. The biogas can be burned as a fuel, for cooking or other purposes, and the remaining material can be used as organic compost. The systems installed in Rwanda have an impressive international heritage: the original design came from China, was modified by GTZ, and finally scaled up and refined by a Tanzanian engineer working in Rwanda.

The biogas system uses a number of individual digesters, each 50 or 100m3 in volume and built in an excavated underground pit. Toilet waste is flushed into the digesters through closed channels, which minimise smell and contamination. The digester is shaped like a beehive, and built up on a circular, concrete base using bricks made from clay or sand-cement. The sides taper gradually and eventually curve inward towards a half-metre diameter man-hole at the top. It is crucial to get the bricks laid in exactly the right shape, and to make the structure water-tight so that there is no leakage of material or water out of the digester. Biogas is stored on the upper part of the digester. The gas storage chamber is plastered inside with waterproof cement to make it gas-tight. On the outside, the entire surface is well plastered and backfilled with soil, then landscaped. The biogas system is finally inspected and, when approved, it is certified for operation.

From the manhole cover, the gas is piped underground towards the kitchen where it is used for cooking porridge, beans and maize in enormous (500 litre) pots, and in stoves that are insulated with a brick lining. A 100m3 plant can store 20m3 of gas, but may generate up to 50m3 per day, so it is important that the gas is consumed regularly.

A particular feature of the plant design is a compensating chamber that acts as a reservoir of methane bacteria for enhanced gas generation. At first, gas pressure displaces the liquid to the compensating chamber. Consumption of gas leads to backflow of the waste from the compensating chamber into the bio-digester; this agitates the waste, circulates the bacteria, and releases trapped gas.

The continuous input of waste, and the gas pressure, push digested effluent out of the bio-digester to a stabilising tank, and from there, to a solid/liquid separation unit. The stabilising tank allows additional gas production. The solids are composted for three months and then used as fertiliser in the prison gardens and woodlots. Great care is taken to ensure that the effluent is safe to use in this way, with regular laboratory checks on samples for viruses, bacteria and worms. As an additional precaution, the fertiliser is used only for crops that stand above ground, such as papaya, maize, bananas, tree tomato and similar tree crops.

The scale of these biogas systems is enormous: a prison with a population of 5,000 people produces between 25 and 50 cubic metres of toilet wastewater each day. Using a 500m3 system (five linked digesters), this produces a daily supply of about 250m3 of biogas for cooking.

How users pay

The biogas plants are purchased for the prisons by the Ministry of Internal Security. The cost of a 500m3 plant is about 50 million Rwandan francs (£50,000). A system of phased payments is used, with the final 5% paid only after 6 months of satisfactory operation.

Training and support

There is great emphasis on quality and reliability in the design and construction of the biogas plants, and they are expected to last for at least 30 years. Prisoners are trained to operate the systems, with support from the KIST team, and are very diligent in this task. Their work includes regular checks on the digester seals, emptying condensate bottles, guiding the flow of the bio-effluent, and application of the compost on the farm. It is also advisable to completely de-sludge the digesters every seven years.

Benefits of the project

The initial reason for using biogas systems was to improve the sanitation in prisons, reducing health risks and smell for both prisoners and the neighbouring residents. The Ashden judge who visited this project noted the overflowing septic tanks and dreadful odour at a prison where the biogas plant was still being installed, and the remarkable lack of odour (even from the output effluent) at a prison with an operating plant. Some prisons have used the effluent to make gardens over their underground biogas system.

Large institutions put enormous demands on fuelwood for cooking, and can cause local deforestation even in a generally well-wooded country like Rwanda. A prison of 5,000 people consumes about 25 m3 (approximately 10 tonnes) of fuelwood per day. Using all the biogas from their sewage system can save about half of this fuelwood. The overall prison population served by biogas plants is now about 30,000 people, so the annual fuelwood saving is about 27,000 m3.

The project saves greenhouse gas emissions by reducing the unsustainable use of fuelwood, and also by preventing the uncontrolled emission of methane from overloaded septic tanks and sewage pits. Both these savings are site-specific and difficult to quantify. As an indication of savings, if 50% of the fuelwood saved is unsustainable, then the greenhouse gas saving from the current systems is about 10,000 tonnes of CO2 equivalent per year. Similarly if 20% of the biogas production would have occurred with unmanaged sewage disposal, then an additional 1,000 tonnes of CO2e per year would be saved.

A significant benefit from the project is the technical and business training that is provided to the civilian technicians, prisoners, and even KIST graduates on-the-job at each installation: the technicians often come from the neighbouring population. To date, over 30 civilians and 250 prisoners have received training, and three private biogas businesses have been started. CITT has employed one of the released prisoners as a trainee.

Through their training programmes, CITT have started the development of private biogas companies in Rwanda. These will install plants with CITT acting as the certification body, and thus keeping quality standards high. Failures (as have occurred in other countries) would damage the biogas sector as a whole.

There is clear potential for widespread replication of these biogas plants, in Rwanda and many other countries. Many other large institutions which are remote from mains sewage services also have problems with sewage disposal, and housing developments could also benefit. CITT has already undertaken smaller installations in three residential schools: here the percentage of fuelwood replaced is less (around 20% rather than 50%, because more cooked food is provided) but still a significant benefit

Management, finance and partnerships

When a biogas system is requested, a team from CITT make a site inspection along with a representative of the Ministry for Internal Security and the Director of the Prison. Technical and financial staff at CITT produce a detailed specification and contract. All site work is managed by a manager and site engineer from CITT, with materials supplied through a tender system, often from local sources. The Ministry also has a project controller on site, to supervise installation.

The International Committee of the Red Cross (ICRC) has been a key partner throughout the biogas programme, because they see the benefits which it brings to health and welfare in prisons. Both the ICRC and the government of the Netherlands have assisted the government of Rwanda in financing the programme.

Use of the Ashden Award

After its successful work with large-scale biogas plants at prisons, KIST wanted to look for ways to improve the performance of these plants and the treatment of the effluent produced. Since winning the Ashden Award, KIST has worked in a variety of areas towards these goals:

- They have begun work on a research project to investigate the use of porous volcanic rock inside the digesters. It is hoped that the rock will increase the surface area available for the anaerobic bacteria.

- They have constructed of a drainage line to take effluent from a prison biogas plant to a test site where experiments will be conducted into growing water hyacinth in the effluent treatment ponds. The water hyacinth will be harvested and added to the biogas plants to increase gas production above the rate possible using sewage alone. Rainwater harvesting will be used to dilute effluent as it enters some of the treatment ponds, allowing fish to be farmed there as well.

- 150 prisoners and 25 civilians have been trained in the construction of biogas plants. From the group of civilian trainees three construction groups have emerged, and KIST has sub-contracted the building of biogas plants to them. Other trainees have continued building biogas plants independently, although KIST is encouraging and helping them to form registered companies that will operate as part of a network of biogas plant installers.

This report is based on information provided to the Ashden Awards judges by KIST; findings from a three-day visit by one of the Ashden judges to see their work in Rwanda; and presentations by Ainea Kimaro at Ashden Awards seminars in London.

Dr Anne Wheldon, Technical Director of the Ashden Awards, November 2005.