Case study summary
The Appropriate Rural Technology Institute (ARTI), India

2006 Ashden Award

ARTI is a charitable trust which develops new technologies appropriate for both rural and urban areas.

Pune is an affluent city in South India, but waste food is often discarded at the side of the road, attracting vermin and creating a public health hazard. ARTI's 2006 Ashden Award highlighted its research and development of a compact biogas plant, which enables urban households to dispose of food waste and supply biogas for cooking.

- ARTI compact biogas systems take kitchen waste, or other food waste into an air-tight tank, where bacteria break down the material and release biogas. Digestion takes only 1–2 days, compared with 30 to 40 days for a manure-based biogas plant.
- Each plant is made from two adapted plastic water tanks, with pipes to add waste food (feedstock), remove liquid effluent and transport biogas to the kitchen.
- 700 plants supplied and installed by ARTI and trained entrepreneurs, and design manual has enabled many others to construct plants.
- ARTI plant plus biogas stove costs about US$200, paid for in full by owner.
- For a typical urban household using just kitchen waste in their plant, biogas halves the use of kerosene or LPG and saves the equivalent of 0.3 and 0.6 tonnes/year CO_2.
- Some families who use a pressure cooker for cooking and collect food waste from their neighbours have replaced all their LPG use .
- Indoor air pollution reduced by cooking with biogas rather than wood or kerosene, which is better for the health of those in the kitchen.
- Liquid effluent can be used as fertiliser.
- A family using just kitchen waste can pay back the cost of the biogas plant through LPG savings within two years.

Update

- Since their 2006 Ashden Award, ARTI has developed other pilot installations such as the 'balcony' biogas plant for apartments with very limited space; and a wood burning gasifier stove.
- More detailed analysis confirms that an ARTI biogas plant used for household food waste disposal in an urban area saves approximately 0.3 tonnes/year CO_2.
- Currently working on design improvements to minimise methane leakage.
- ARTI has supplied about 1,000 biogas plants (2009) in urban and rural households in Maharashtra, and a number elsewhere.

ARTI is a charitable trust, founded in 1996 by a group of scientists, technologists and social workers. It focuses on developing new rural technologies, and on enabling other people to promote them, and has around 10 projects in progress at any time. Between 2006 and 2009, ARTI staff numbers grew from five to 29.

India statistics 2004/5

(UNDP)

GDP: US$736/year per person

CO_2 emission: 1.2 tonnes/year per person

80% of people live on less than US$2/day

44% of people lack grid electricity

Location

"I use my waste food to make biogas and ask my neighbours to give me theirs. The area is much cleaner now; the street dogs do not come to scavenge and there are no flies."
Mrs Salunka, biogas user, Pune

In urban areas where space is at a premium ARTI biogas plants can be sited on the roof.

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Case study
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Background

Pune is an affluent city in south India. However waste food is often discarded at the side of the road, attracting stray dogs, flies and rats and creating a public health hazard. ARTI has developed a biogas plant which uses food waste to supply biogas for cooking, replacing liquid petroleum gas (LPG) or kerosene. The plant is sufficiently compact to be used by urban households.

The organisation

ARTI is a charitable trust, founded in 1996 by a group of scientists, technologists and social workers. It focuses on developing new rural technologies and on enabling other people to spread such technology to those who will benefit. The biogas project, begun in 2003, is one of over ten different projects run by ARTI. Many staff are involved in more than one project so there is continuous cross-fertilisation of ideas. Between 2006 and 2009, staff numbers grew from five to 29.

The technology

How does it work?

Biogas systems take wet organic material (feedstock) into an air-tight tank, where bacteria break down the material and release biogas – a mixture of methane with some carbon dioxide. A pipe takes the biogas to the kitchen, where it is used to cook with a biogas stove or for other purposes.

Most biogas plants in India and elsewhere are designed to use animal manure as their main feedstock, and are therefore only used in rural areas. ARTI developed a compact biogas plant which uses organic materials available in urban areas, such as waste flour or kitchen waste, as feedstock. This feedstock has a higher energy density compared to manure, and digestion takes place much more quickly (typically 1 to 2 days, compared with 30 to 40 days for a manure-based plant), so a smaller quantity of decomposing material needs to be held in the plant at any one time. One kg (dry matter) food waste feedstock produces about 0.25 kg of methane, whereas 20 kg of cattle dung feedstock would be needed to produce the same quantity of methane.

How much does it cost and how do users pay?

US$1 = Rs 47 (Indian Rupees) [November 2009]

A compact biogas plant with a biogas stove costs about US$200 (Rs 10,000) to buy, but costs nothing to run if it uses only food waste. Even if waste flour is bought for feedstock, the running cost is only about US$0.04 (Rs 2) per day. There are no subsidies, so owners pay the full cost of the plant, although some suppliers accept payment in instalments.

How is it manufactured and maintained?

ARTI trains local entrepreneurs also representatives of other NGOs to produce and install biogas plants. By 2006, 30 people had been trained and ten had established themselves as entrepreneurs.

Benefits

About 700 biogas plants were in use in 2006, in both urban and rural households in Maharashtra. A few have been installed in other parts of India and elsewhere in the world.

The technology in more detail

The ARTI compact biogas plants are made from cut-down high density polythene (HDPE) water tanks, which are adapted using a heat gun and HDPE piping. The standard plant uses two tanks, with volumes of 0.75 m^3 and 1 m^3. The smaller tank is the gas holder. It is inverted and attached to the larger tank which holds the mixture of decomposing feedstock and water (slurry). An inlet is provided for adding feedstock, and an overflow for removing the digested effluent. Because the feedstock is almost completely digested, the effluent contains a much smaller amount of solid matter than the residue from a manure-based plant, and ARTI recommends that the liquid is mixed with the feedstock and recycled into the plant. The gas holder gradually rises as gas is produced, and sinks down again as the gas is used for cooking.

ARTI has found that the gas produced by these plants has a higher methane concentration than is found using manure-based plants, and thus has a higher energy content. This is probably because the CO_2 produced by the bacteria dissolves in the very liquid slurry. The methane concentration is further increased when weights are used on the gas holder, because more CO_2 dissolves under the increased pressure. This has the advantage of increasing the gas pressure

"We use the effluent as a fertiliser for the plants. We also don't have any odour problems (from the biogas plant)."
Mohan Kate

Environmental benefits

ARTI estimated that using only household food waste in a biogas plant halves the use of LPG or kerosene for cooking, saving a typical urban household 100 kg/year of LPG or 250 litres/year of kerosene. This is equivalent to 300 to 600 kg/year CO_2 . Further reductions in fossil fuel use and CO_2 emissions arise from not having to transport LPG cylinders to be re-filled.

Social benefits

Indoor air pollution is reduced by cooking with biogas rather than wood or kerosene. This reduces respiratory and eye problems for those in the kitchen, most of whom are women.

Using food waste in a biogas plant means that less of it is now discarded by the roadside, reducing the public health hazard.

Economic benefits

An ARTI biogas plant and stove costs about US$200 (Rs 10,000), compared with only about US$100 (Rs 5,000) for an LPG bottle and stove. However, LPG costs about US$0.60 (Rs 30) per day. If biogas halves the amount of LPG used, then the cost of a complete biogas system is saved within two years. Some families who use a pressure cooker for cooking and collect food waste from their neighbours have replaced all their LPG use.

Potential for growth and replication

ARTI estimates there are 500,000 potential users of compact biogas plants in Maharashtra State alone, and several other states in India have expressed an interest in the technology. ARTI has produced a CD showing how the plants are made, to encourage widespread adoption of the technology.

The plant can be used anywhere provided that there is enough space and the temperature is sufficiently high – anything above 30ºC. ARTI has looked at ways to insulate biogas plants to increase gas production in the coolest months.

Update: what happened next?

Since their 2006 Ashden Award, ARTI have developed other pilot installations such as the 'balcony' biogas plant for apartments, where space is limited; and a wood burning gasifier stove.

In partnership with GERES, the French NGO, ARTI has carried out a preliminary assessment of greenhouse gas savings from biogas plants in urban areas. The analysis assumes CO_2 savings as a result of cleaner rubbish disposal and partial substitution of LPG as cooking fuel, and estimates that the average biogas plant saves approximately 0.3 tonnes/year CO_2. However, the floating dome structure of the plant can result in leakage of methane, thus reducing CO_2 savings. ARTI is currently working on design improvements to minimise the methane leakage without compromising user friendliness.

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The technology in more detail continued

The plant is provided as a kit which needs a space about 2 ^{m} square and 2.5 ^{m} high for installation. The plant is filled with a starter mix: either cattle dung mixed with water and waste flour, or effluent from an existing biogas plant mixed with flour. The feeding of the plant is built up over a few weeks until it provides a steady supply of about 0.25 kg/day gas from one kg/day (dry matter) of feedstock. The feedstock can be waste flour, vegetable residues, waste food, fruit peelings and over-ripe or rotten fruit. Feedstock with large lumps (more than 20 mm) can be broken up with a food blender. A biogas plant can become acidic and fail if it is over-fed, and this is a particular problem with a plant using food waste. If this happens, ARTI has found that the plant can be recovered by ceasing feeding, partially flushing out the contents with fresh water, and then building up the feed rate again slowly.

"I only use the LPG for heating bathwater now – I cook all our meals using just biogas."
Meena Salunkhe