The Ashden Awards for sustainable energy

Technology Informatics Design Endeavour, India

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Wood-saving stoves for small businesses in South India

Summary

The widespread use of biomass for cooking in developing countries, and its associated problems for the environment and health, is well documented. What is less well known is how many industries and businesses also rely on wood and other types of biomass. In South India alone, it is estimated that eight million people work in small and tiny businesses (including food processing and preparation, textiles, ayurvedic medicine and brickmaking) where wood and other biomass is the source of process heat. Most of these businesses operate with low overheads, so fuel efficiency has not been a priority. This use of fuelwood by industry has contributed to de-forestation, a serious problem in the ecologically sensitive Western Ghats. It also has serious impacts on the health and safety of workers, who may work long hours over open fires or inefficient stoves.

TIDE has therefore developed a programme specifically to improve the efficiency of wood use in small and tiny businesses, initially in Karnataka and Kerala, but now expanding to Tamil Nadu and Andhra Pradesh as well. Many of the stove designs originated at the Centre for Sustainable Technologies (formerly ASTRA) at the Indian Institute of Science, Bangalore. Improved efficiency is achieved through better heat transfer and combustion of the fuel and improved insulation to minimise the heat losses. Each stove which TIDE develops and promotes is designed around a specific current sector of use, and with user participation, so that the existing process requires minimal modification. In addition, TIDE will commercialise a system only if it will be affordable without subsidy in the industry which it is designed for. This need to balance cost, functional design and efficiency inevitably leads to compromises, but means that the stoves are viable commercial products.

The stoves save at least 30% of biomass use, and more in some sectors. TIDE estimates that the 10,500 stoves installed up to the end of 2007 are saving 43,000 tonnes/year of biomass, and that a cumulative 150,000 tonnes of biomass has been saved since the scheme started in 2000. These savings in biomass use represent significant savings in the production of greenhouse gases, estimated at about 77,000 tonnes/year CO_2.

Nearly all users pay the full economic cost of the stove, which ranges from about IRs 2,000 (£25) for a simple silk-reeling stove to over IRs 65,000 (£820) for a large drier. The cost of the stove is usually paid back within one year from savings on buying fuelwood or biomass. For some industries the payback time is less than two months. An assessment carried out by TIDE at the end of 2006 suggested that the stoves then in use were saving IRs 39 million (about £0.5 million) per year in fuel costs, and since then the price of wood has increased.

Employees, many of whom work over the stove all day, benefit from decreased indoor air pollution, with its associated impact on respiratory and eye diseases, also from the decreased risk of burns and cooler working conditions.

One of the really impressive features of the work is the extension model used. Each time a new industrial sector or geographical area is targeted, TIDE trains extension workers, who are sometimes University graduates, in the technical development and dissemination of the technology. Trainees are also prepared for setting up their own enterprise, focussed on a particular sector and geographical area, when the training period of up to two years is completed. TIDE collects sales data from all entrepreneurs and checks quality, but allows the entrepreneurs to develop businesses in their own ways.

The organisation

Technology Informatics Design Endeavour (TIDE), established in 1993, is a non-profit organisation which seeks to apply appropriate technology to rural situations. It works through a network of extension agents who learn about a new technology from TIDE and then move to another area to manufacture and market this technology. TIDE employs 24 staff and about nine volunteers. It is funded through grants from government departments, funding agencies and private clients, and had an income of £105,000 in 2007.

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Context

The widespread use of biomass for cooking in developing countries, and its associated problems for the environment and health, is well documented. What is less well known is how many industries and businesses also rely on wood and other forms of biomass. In South India alone, it is estimated that eight million people work in small and tiny businesses where wood and biomass is the source of process heat. These businesses include jaggery processing; areca nut (betel) cooking and drying; preparation of ayurvedic medicine; drying nuts, coconut, cocoa and fish; silk reeling; textile processing; brick, tile and pottery making; and food preparation. Most of these businesses operate with low overheads, so fuel efficiency has not been a priority. The use of fuelwood by industry has contributed to de-forestation which is a major problem, especially in the steeply sloping Western Ghats, an ecologically sensitive area and a major biodiversity hotspot. Here erosion and landslides add to the misery during the monsoon.

TIDE has therefore developed a programme specifically to improve the efficiency of wood use in small and tiny businesses, initially in Karnataka and Kerala, but now expanding to Tamil Nadu and Andhra Pradesh as well.

Statistical Information - India	
Population (2005)	1134.4 million
Urban population	28.7%
GDP per capita US$ (2005)	$736
- at purchasing power parity	$3452
Population living on less than $1 a day (2005)	34.3%
Population living on less than $2 a day (2005)	80.4%
Population with access to grid electricity (2005)	56%
Annual electricity consumption per person (2004)	618 kWh
Annual CO_2 emissions per person (2004)	1.2 t
Population undernourished (2002-2004)	20%
Population with access to an improved water supply (2004)	86%
Source: *UNDP*	

Technology and use

Many of the stove designs which TIDE promotes were initially developed at the Centre for Sustainable Technologies (CST, formerly ASTRA) at the Indian Institute of Science, Bangalore. CST encourages other organisations – including NGOs, government agencies and entrepreneurs – to disseminate these technologies.

Although the basic concepts of the stove design are universal, each stove which TIDE develops and promotes is designed around a specific current sector of use, so that the existing process requires no modification. For instance, TIDE is currently working on a multi-purpose cook stove for restaurants. Each new stove development is based on a survey of need, current usage, and interest in a particular sector, and users are involved in the detailed design.

Improved efficiency is achieved through better heat transfer and combustion of the fuel, and improved insulation to minimise the heat losses. Each stove is designed to burn the fuel (wood or loose biomass) as completely as possible and with high flame temperatures, by optimising the internal geometry and the air-to-fuel ratio. The optimised rates of air flow ensure that there is adequate air to completely burn all the fuel. The area of contact between the hot flue gases and the heated vessel is maximised in order to increase the heat transfer to the process. A layer of good insulation surrounds the combustion area in order to minimise heat loss and reduce the risk of burning from direct contact. All stoves incorporate chimneys to take smoke away from the users, producing a cleaner and safer working environment.

To operate the stove, the fire is lit in the combustion chamber just before heat is needed, because the improved stoves heat up more quickly than the old systems. The fuel door is opened when required to feed in further fuel and kept closed the rest of the time. Users have to be trained not to over-feed the stoves, because they are used to less efficient models. Because the improved stoves have high thermal mass and are well insulated, the fire can be allowed to go out before the operation has finished, and the stored heat used to complete the process.

In most sectors, wood was the main type of biomass used before the improved stoves were introduced, and still is. However, some sectors are making increasing use of other biomass residues. A number of areca nut processing businesses previously used areca husk, and most now do so with the improved stoves. For coconut drying, the shift is from coconut shell to coconut husk. Users in other sectors also burn agricultural residues, briquettes and even cardboard at times. Recently some food retailers have switched from using LPG stoves to improved biomass stoves, because of the increasing price of LPG.

The stoves are manufactured locally, in the town nearest to where they are to be used, using as far as possible locally-available materials. For most stove designs, TIDE has worked with small-town fabricators such as masons (for mud and ceramic parts) and smiths (for metal parts). Usually large equipment (for instance, bleaching vats or jaggery stoves) is constructed on site by masons who source the components from local fabricators, while smaller equipment (like silk-reeling or areca-boiling stoves) is designed as a set of components for on-site assembly. However, recognising the urgency of the fuelwood problem and the need to achieve scale, TIDE has started to adapt certain designs for prefabrication in production centres, which will also help with quality control. This has worked successfully for the manufacture of efficient wood-burning water-heaters, where one producer (Phoenix Products) can now manufacture and install over 300 per year. A biomass drier is also now factory manufactured.

The entrepreneurs who install the stoves offer a one-year warranty, and after that will service and provide parts for payment. The life of the stoves has not been specifically tested, but appears to be about four to five years with basic maintenance. Some care is needed in operation, for instance making sure that furnace doors are kept closed as much as possible to prevent rusting.

How users pay

£1 = 79 Indian Rupees [April 2008]

TIDE will develop and commercialise a biomass heating system only if it will be affordable without subsidy in the industry for which it is designed. Some initial designs have not been taken further, even though they were technically successful, because the initial cost was too high, and there was no financing mechanism available – for example, an improved lime kiln.

TIDE provides initial support for awareness-raising and marketing, and usually subsidises initial demonstration units, but customers must pay a price which covers the cost of the stove and provides the entrepreneur with a reasonable profit. Normally a deposit is required when a stove is ordered, with a further payment when the construction starts and the balance on completion, although some entrepreneurs will wait a month for the final payment. Industries using several heating units will often replace one at a time, and thus spread the capital cost over a period.

TIDE has arranged loans through financial and industry associations for the areca stove purchasers. However there has not been a wide uptake on loans, because the stoves are affordable without them and many people are cautious about using credit. Occasionally a subsidy may be available for a particular industry. For instance, the Department of Sericulture in the Government of Karnataka provide a 40% subsidy for silk-reeling stoves, which is paid to the entrepreneur when the user has paid their 60% contribution.

The size of the devices, and thus the price, varies greatly. Some examples are:

- Silk-reeling stove IRs 2,000 (about £25).

- Ayurvedic medicine stoves IRs 4,000 (£50).
- Areca stove IRs 5,500 (£70) for one-pan model, IRs 10,000 (£130) for two-pan model.
- Small heated dyeing vat IRs 15,000 (£190).
- 100 litre water-boiler, IRs 15,000 to 17,000 (£200).
- Improved tava cookstove (for dhosa, rotis, omelettes) IRs 17,000 (£220).
- Large bleaching vat IRs 25,000 (£320).
  Fixed brick kiln IRs 40,000 (£510).
- Portable metal drier IRs 65,000 (£820).

Training, support and quality control

The extension model used by TIDE has been very effective, supporting the development of independent entrepreneurs while maintaining good control of quality

TIDE trains extension workers, who are sometimes university graduates, to take technology into new areas. Initially this training lasted for two years, but shorter programmes are now used. Trainees are prepared to become a private entrepreneurs, to develop their own marketing approaches, and to work in a specific geographical area with a controlled degree of competition. If competition becomes a problem, they are encouraged to work with different clients. Some entrepreneurs leave the TIDE network to set up other businesses, such as promoting solar-PV technology.

The small industries with which TIDE works are understandably cautious about taking on new technology, and changing their working patterns. It is for this reason that the TIDE stoves are designed to directly replace existing equipment, with minimum disruption to users and their routines. New customers usually help the entrepreneurs to construct their stoves, and the entrepreneur helps them to understand how to use the stove properly. TIDE arranges courses which are attended by stove users from a wide area, allowing them to learn from each other.

Entrepreneurs offer a one-year warranty for the equipment they have installed. Following this, they carry out servicing and repairs on a chargeable basis, and also follow-up customers informally to check that equipment is working well. The stoves are expected to last for four to five years. On-going support can be arranged via a contract.

Quality control is an important factor for TIDE. The Central Power Research Institute (CPRI) of the Government of India tests the efficiency of all the products. The Centre for Sustainable Technologies at the Indian Institute of Science (CST,IISc) sometimes collaborates in the development process, carrying out field testing and data collection. The entrepreneurs are required to keep detailed records of where stoves are installed and provide this data to TIDE, and must also keep a complaints register. TIDE makes random spot checks on its own systems and those installed by entrepreneurs, and finds that they are generally working well.

Benefits

By the end of 2007 10,500 stoves or other heating appliances, all fired by biomass had been supplied by TIDE, mainly in the South Indian states of Kerala and Karnataka and to a small extent in Tamil Nadu and Andhra Pradesh. This number includes equipment supplied directly by TIDE and or through their network of entrepreneurs.

Environmental benefits

TIDE has developed an accounting methodology for assessing biomass savings, based on testing done by an independent organisation, the CPRI. The methodology involves:

- Independent assessment of the biomass saving of each improved stove, by comparing the specific fuel consumption of the improved stove with the conventional equipment. The specific fuel consumption is the mass of wood needed to produce 1 kg of output (e.g. reeled silk, cooked food).
- Survey of how much the stove is used with a sample of users in each sector, carried out by questionnaire and telephone.
- Using the above data to estimate the typical annual biomass saving for a stove in each sector. For instance, an average silk reeling saves about 2.5 tonnes/year of wood, an ayurvedic medicine stove 2.4 tonnes/year, and a textile dyeing stove 25 tonnes/year.
- Combining the estimates of typical biomass savings with data on sales (by both TIDE and entrepreneurs) in each sector.

On average, the stoves save at least 30% of biomass use, although in some sectors the savings are higher – for instance, 40-50% for textile stoves and community cookstoves. This may not seem exceptional, given the savings which have been achieved with some types of domestic wood stove. However, TIDE insists that stoves must be affordable and fit with current usage so that they will sell commercially. This need to balance cost, physical shape and efficiency inevitably leads to compromises.

From the methodology above, TIDE estimates that the stoves installed up to the end of 2007 are saving 43,000 tonnes/year of biomass, and that a cumulative 150,000 tonnes of biomass has been saved since the scheme started in 2000.

These savings in the use of wood and other types of biomass represent significant savings in the production of greenhouse gases. The pressure on wood supply means that wood production in Karnataka and Kerala appears to be largely unsustainable. TIDE therefore estimates that the greenhouse gas saving based on the number of stoves in use at the end of 2007 is about 77,000 tonnes/year CO_2. There are also savings from the reduced need for diesel to transport wood, but these have not been quantified.

Direct benefits to users

Owners of small businesses say that the main advantages of the improved stoves are saving money and improving productivity. An assessment carried out by TIDE at the end of 2006 suggested that the stoves then in use were saving IRs 39 million (about £0.5 million) per year in fuel costs, based on a fuel cost of IRs 1 per kg.

The price of fuelwood is increasing rapidly in South India, and is currently about IRs 2 (£0.03) per kg. On this basis, the owner of a silk-reeling stove (costing IRs 2,000) saves about IRs 5,000 (£60) per year on wood, and can pay back the cost of the stove in less than six months. For a textile stove costing IRs 25,000 the wood savings of IRs 50,000 per year give a similar payback time. For an ayurvedic medicine stove costing IRs 4,000 the payback time is an impressive two months, because the savings on wood are about IRs 25,000 per year. Agricultural residues (like coconut shells) cost a similar amount to wood, per kg, but because they are more compact and have a lower moisture content, they burn more efficiently and less is needed.

Productivity is improved because the stoves generate more heat and retain it, and can be easier to use. In some cases this speeds up production substantially: for instance, the improved areca nut stoves can process four batches per day, instead of two. Increased productivity increases the profitability of the enterprise, and may also bring direct benefits in wages in those sectors (like silk reeling) where wages are based on the amount of output a worker produces.

In addition, the environment for the workers directly using the stoves is healthier, safer and more comfortable. Smoke is largely removed by the stove chimney, reducing the risk of respiratory and eye diseases. The insulation around the stoves means that they are cool to touch, and thus reduce the risk of burns. In addition the working environment does not get so hot, which is a real benefit for workers in the tropical climate of South India. These benefits are similar to those which are found with improved domestic stoves, but may be more significant because workers in small industries will often be working directly with the stove for eight hour per day or more, and the power levels are higher. Since between six and 20 people work in each small business, TIDE estimate that 110,000 workers benefit directly from these stoves

Economic and employment benefits
TIDE employs 24 full-time staff and nine volunteers. Currently 14 entrepreneurs trained by TIDE are running businesses, which employ about 40 skilled and 90 semi-skilled workers to make the stoves. These include masons, plumbers, construction assistants and transporters. For some entrepreneurs the work is seasonal (for instance, based round an agricultural cycle) so they offer other services like general masonry as well. They also have the opportunity to develop new types of stove, or improve the ones which they currently sell. The indirect employment from stove production is estimated to be about 9,000 person-days per year, including the supply of materials and metal components.

Increased productivity, through quicker operation and better working conditions, brings direct economic benefits to workers in sectors like silk reeling, where wages are based on the amount of silk that a worker produces.

Some systems have been supplied specifically to women's self-help groups, to increase income-generation. The activities of these groups include fish-drying; cashew nut processing; and drying of coconuts, spices and other food products

Although difficult to quantify, TIDE thinks that by becoming involved with improved stoves, small businesses recognise the potential of new technology and become more adaptable and innovative.

Potential for growth and replication

In 1998, TIDE made a survey of small and tiny industries using biomass fuel in Karnataka and Kerala. In these two states alone, this identified about 125,000 industries using an estimated 3 million tonnes/year of biomass (average 24 tonnes/year each). There is therefore a huge potential market for the types of efficient stove which TIDE develops.

TIDE and its entrepreneurs are currently installing about 1,300 stoves per year. Once trained, entrepreneurs develop their own businesses, actively market the stoves and compile their own records of potential customers. Entrepreneurs may source loans for business development. From the viewpoint of TIDE, finding the right people to become entrepreneurs, and providing them with training, is a limiting factor in the expansion of the work, and for this reason TIDE has recently streamlined the training programme. Another constraint is the resource to develop new technologies, because a specific stove is needed for each type of industry.

The improved stoves are highly applicable wherever biomass is the usual heating fuel, provided that minor design modifications are made to suit different local practices. Thus the work of TIDE in both technical innovation and business extension could easily be replicated throughout India and elsewhere. TIDE is increasingly publicising its work, and raising awareness of the energy

needs of small businesses. It was recognised as an outstanding social entrepreneur at the India Economic Summit of the World Economic Forum. The Chief Executive of TIDE has been invited to speak about its work to the Confederation of Indian Industry, at events for social entrepreneurs, and in academic institutions.

Management, finance and partnerships

TIDE is run by a five-person Council of Management, headed by NV Krishna, Managing Director of Microsense Software Pvt Ltd. The Council directs and reviews the work. Svati Bhogle as Chief Executive and head of the energy technologies team is responsible for day to day operations and technology development. In addition to the industrial biomass work, TIDE works on hydropower, waste-water treatment, and domestic stoves.

TIDE currently has 24 staff, and also uses a range of independent consultants. For periods of time the number of staff may increase to around 35 when a new project is launched, as extra extension workers are brought in for training. These extension workers then become established as independent entrepreneurs and leave TIDE to make a living on their own. After this the role of TIDE is limited to networking and helping them to form linkages with other organisations.

TIDE is funded by grants which help in developing new technologies for specific applications. Grant funders have included the India-Canada Environment Facility, The Swiss Agency for Development and Co-operation, the Science and Society Division of the Department of Science and Technology, Government of India, ETC Foundation Netherlands and the UNDP-GEF small grants programme.

TIDE has a technology co-operation agreement with CST, IISc (formerly ASTRA, IISc), and some of the products disseminated have their origins there. Two retired faculty from CST, IISc are key partners for TIDE. Professor Lokras is the main designer of the stoves and Professor Jagadish has designed the kilns for TIDE. TIDE owes its success to the voluntary contributions of these eminent scientists.

This report is based on information provided to the Ashden Awards judges by TIDE, and findings from a visit by one of the judging team to see its work in South India.

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