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ENTREPRENEURSHIP AT GRASSROOTS: DIFFUSION OF BIOMASS DEVICES IN INFORMAL INDUSTRIES IN INDIA

Towards an 'Energy Plus' approach for the poor: A review of good practices and lessons learned from Asia and the Pacific

Case Study 15

ENVIRONMENT AND ENERGY

We would like to take this opportunity to recognize the partners who have made financial and other contributions to the energy sector project described in this report. These include Technology Informatics Design Endeavour (TIDE), the India-Canada Environment Facility (ICEF), the Swiss Agency for Development and Cooperation (SDC), the Department of Science and Technology (Government of India), the Global Environment Facility (GEF), the ETC Foundation and the Deshpande Foundation.

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TIDE

SGP The GEF Small Grants Programme

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Cover photo courtesy of UNDP/Energy Access for Poverty Reduction

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Acronyms

APRC	Asia-Pacific Regional Centre
CO_2	carbon dioxide
GHG	greenhouse gas
ICEF	India-Canada Environment Facility
INR	Indian rupee (currency)
kg	kilogram
MAMCOS	Malanadu Arecanut Growers Cooperative Society
MDG	Millennium Development Goal
MNRE	Ministry of New and Renewable Energy
MW	megawatt
NGO	non-governmental organization
ppm	parts per million
PTD	participatory technology development
RE	renewable energy
SDC	Swiss Agency for Development and Cooperation
SPV	solar photovoltaic
TERI	The Energy and Resources Institute
TIDE	Technology Informatics Design Endeavour
UNDP	United Nations Development Programme
USD	United States dollar (currency)

Synopsis

Project title: Dissemination of biomass utilization technologies in the informal industries in Karnataka, Kerala, Tamil Nadu and Andhra Pradesh

Country and region of implementation: The Republic of India (states of Karnataka, Kerala, Tamil Nadu and Andhra Pradesh)

Focus area (technology/energy service): The use of biomass for energy in micro-, small and artisanal industries

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Duration: 1998-2009

Costs: INR 41.2 million (approximately USD 876,596)[1]

Project brief: Traditional biomass such as fuelwood is the major source of primary energy in most small, micro- or artisanal industries in small towns or rural areas of India. Since the 1990s, Technology Informatics Design Endeavour (TIDE) has been promoting energy-efficient technology in these industries. TIDE applies a demand-driven entrepreneurship model to technology dissemination, working to meet the energy needs of these industries while improving their productivity and profitability. By transferring technical expertise and business know-how to young people with otherwise limited income-generating opportunities, the model develops technically competent, business-savvy grassroots entrepreneurs who become the agents of technology delivery. The model also promotes a system of participatory technology development.

Between 1998 and 2009, TIDE developed and disseminated 11,840 industrial stoves, dryers and kilns among a wide range industries. In doing so, it improved the livelihood options, comfort levels and health of at least 135,000 men and women.

[1] USD 1= INR 47.0 as of 13 September 2011 (www.xe.com).

Acknowledgments

Entrepreneurship at the grassroots: Diffusion of biomass devices in informal industries is one of17 case studies which, together with a report titled 'Towards an 'Energy Plus' approach for the poor: A review of good practices and lessons learned from Asia and the Pacific' and an Action Agenda Note, comprise a review of good practices and lessons learned in energy service delivery to the poor. Commissioned and facilitated by the United Nations Development Programme Asia-Pacific Regional Centre (UNDP APRC), this case study identifies key characteristics that have helped poor households and communities gain access to modern energy services, and to derive valuable lessons for future energy access activities. This case study is the product of an intensive collaborative process and we wish to acknowledge the many contributors, without whose generous support this work would have been impossible.

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Preface

Asia-Pacific has achieved remarkable economic growth and socio-political progress in the past two decades, with almost every country in the region experiencing a concomitant decline in poverty.

Despite this progress, 800 million people in the region remain without access to electricity and almost 2 billion rely on the traditional use of biomass for cooking. India accounts for a significant share of the global population who are deprived of access to modern energy services. And the issue is more serious in rural areas, where almost 70 percent of India's population lives.

The poor often live in subsistence economies that do not generate cash surpluses, limiting their purchasing power and opportunities to shift to modern energy services. As a result, they have to invest more of their income and time in obtaining energy, and tend to use traditional energy services and fuels. Women and children are particularly affected, spending many hours a day collecting fuelwood and preparing meals in the kitchen. Smoke from inefficient stoves in poorly ventilated homes kills 1.6 million people worldwide every year; the majority of victims are women and children younger than five years. Indoor air pollution is the fourth-biggest killer in the developing world.

Asia-Pacific countries have applied many cutting-edge practices in providing energy access to the poor, including innovative financing mechanisms. Apart from satisfying basic needs, energy services can act as an instrument to empower women and disadvantaged communities; as an entry point to mobilize communities to take charge of their own development; and, most importantly, as a means to livelihood enhancement and poverty reduction. However, the scale of expansion of energy access projects has been far from sufficient.

UNDP has been working with its country partners to address these energy poverty issues, aiming to meet user needs, broaden energy supply options and link these efforts in achieving the Millennium Development Goals. Between 2009 and 2011, the UNDP APRC reviewed 17 energy access programmes and projects implemented by various development agencies and the private sector in the region. These projects were documented as 17 case studies (including this report), a report titled 'Towards an 'Energy Plus' approach for the poor: A review of good practices and lessons learned from Asia and the Pacific' and an Action Agenda Note. Together, these documents provide practical guidance for policymakers and development practitioners in designing and implementing future programmes and projects that ensure the delivery of low emission, affordable and reliable energy services for poverty reduction.

This case study documents an entrepreneurship model applied by Technology Informatics Design Endeavour (TIDE) to meet the energy needs of informal industries in the states of Karnataka, Kerala, Tamil Nadu and Andhra Pradesh (India). The model and disseminated energy-efficient technologies seek to improve end user productivity, profitability and the employee working environment. During 1998-2009, TIDE disseminated 11,840 energy-efficient industrial stoves, dryers and kilns, improving the life of at least 135,000 people.

Nicholas Rosellini

Deputy Assistant Administrator & Deputy Regional Director
Regional Bureau for Asia and the Pacific

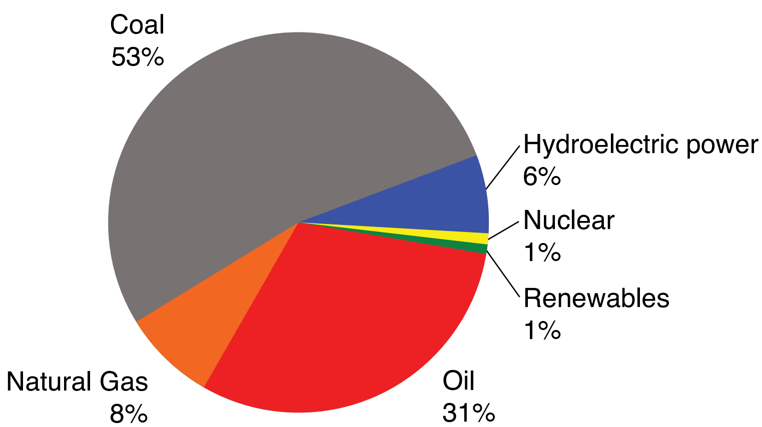
1. Background

1.1 The energy sector in India

India makes up more than 15 percent of the world's population (1.2 billion people) and has the second-largest labour force in the world (516.3 million people). Its economy is among the fastest growing in the world, having achieved an average annual growth rate of 5.8 percent for the past two decades.

Energy consumption. Fast economic growth and a large population make India a significant consumer of energy resources. India's energy consumption is dominated by fossil fuels, with coal accounting for more than half the country's total energy consumption in 2006 (see Figure 1). Imports supply 30 percent of India's total energy needs.[2]

Figure 1: Total energy consumption in India by fuel type, 2006



Source: EIA International Energy Annual 2006

India's energy sector is dominated by public utilities, which are responsible for production and distribution of 88.4 percent of India's electricity. Household electrification levels are 88 percent in urban areas and 43 percent in rural areas. About 855 million people rely on fuelwood, animal dung and agricultural residues for cooking and heating.[3] This heavy dependence on biomass fuels has serious consequences for peoples' health, with women and children being most vulnerable.

Policy and planning. The National Planning Commission's Integrated Energy Policy (2005) states that India needs to address all aspects of energy security: access, availability, affordability and efficiency.

The 11th Five-Year Plan (2007-2012) foresees an investment of more than USD 100 billion in the energy sector. To deliver sustained economic growth of 8 percent over 2007-2012, the primary energy supply needs to increase by three to four times and electricity supply by five to seven times of the current consumption.[4]

Renewable energy (RE). The annual turnover in India's RE industry is an estimated USD 500 million. 3,500 MW of the total estimated 100,000 MW potential is currently being used.[5]

RE sources are expected to play a significant role in meeting future energy demand. The Ministry of New and Renewable Energy (MNRE) is working to increase access to energy in rural areas through a range of RE technologies – including smokeless stoves, biogas plants, solar photovoltaic (SPV) lighting – and village-level power systems (decentralized hydro, biomass and SPV). India is the only country in the world with a ministry dedicated to the promotion of RE technologies.

[2] US EIA, 2011.

[3] International Energy Agency, 2010.

[4] Majumdar, 2008.

[5] Majumdar, 2008.

1.2 Biomass energy use in informal industries: issues and challenges

Biomass energy sources account for 34-41 percent of total primary energy requirements in India.[6] Rural populations in India and most other South Asian countries rely on biomass for most of their domestic and industrial energy needs, using traditional low-efficiency wood-burning technologies.[7] In 2000, South India alone had about 8 million people directly or indirectly employed in micro-, small and artisanal industries[8] where fuelwood is the major energy source.[9]

This traditional use of biomass has numerous negative environmental, social and economic impacts. These include the loss of forest resources due to unsustainable harvesting of fuelwood, low business profitability due to inefficient use of fuel, and worker exposure to hazardous working conditions (including extreme heat and harmful pollutants). For example, discussions with sericulture units revealed that, due to exposure to smoke and fumes, a worker in a silk reeling unit has a productive life of only about 10 years.

Insufficient support for alternative biomass fuels and devices. India's biomass resource base is comparable to its fossil fuel reserve, and offers the additional benefit of being a potential RE source. Unfortunately, there have been no systematic studies of biomass use in India's informal industries, in terms of efficiency and needs. Efforts to improve efficiency of stoves used by informal industries have also been small, with governments and donors instead focusing on households (by promoting energy-efficient household stoves). Furthermore, such efforts by The Energy and Resources Institute (TERI) and the Indian Institute of Science have been fraught with challenges, including:

- **Overcoming fears of change.** Switching to a new energy product carries risks (as well as potential benefits) for businesses. Most informal businesses operate with very little capital, and proposals for relatively large investments in energy-efficient stoves or dryers are often met with skepticism. There is often a need to identify more affluent 'pioneers' to make the first transition; and

- **A lack of awareness of technological solutions to workplace pollution.** The adverse health impacts on workers from long-term exposure to pollutants are well recognized. However, attention has focused largely on treatment, neglecting the potential for preventive measures such as technological improvements.[10]

2. Overview: Technology Informatics Design Endeavour (TIDE)

Background on the organization. Established in 1993, Technology Informatics Design Endeavour (TIDE) is a not-for-profit organization promoting sustainable development through technological interventions. TIDE's principles include:

- meeting the needs of the poor with minimal environmental impact;
- encouraging grassroots participation in projects;
- using local resources; and
- building local capacity.

TIDE seeks to improve the efficiency and environmental impact of biomass use in informal industries in India by promoting the use of energy-efficient biomass stoves, dryers and kilns.

UNDP/Energy Access for Poverty Reduction

Using improved stove for herbal medicine preparation.

[6] Reddy, 2000.
[7] Sarvekshana, 1995; Smith, 2002.
[8] This report will use a collective term 'informal industries' from here onwards.
[9] Reddy, 2000.
[10] Shastri et al., 2002; Mande et al., 2000.

Targeted industries. TIDE primarily targets rural or semi-rural industries, including:

- cardamom and coconut drying;
- arecanut boiling and drying;
- tobacco curing;
- production of jaggery, khova and herbal and ayurvedic medicine;[11]
- cashew processing;
- silk reeling;
- brick, tile and pottery making;
- lime burning;
- rubber-band vulcanizing;
- textile bleaching and dyeing;
- commercial cooking (e.g. hotel, bakery); and
- water heating and community cooking.

Promoted devices. TIDE disseminates three types of energy-efficient biomass utilization devices: stoves, dryers and kilns. TIDE's stoves deliver a fuel-utilization efficiency level of 30 percent (compared to 8-10 percent in conventional systems) and have a use life of about five years. All devices were developed by the Centre for Sustainable Technologies (Indian Institute of Science), a research institution. Equipment design focuses on:

- reducing heat loss;
- optimizing the air-to-fuel ratio;
- achieving an effective compromise between high generation temperatures and flue gas velocities;
- maximizing the contact area between vessel and hot flue gases; and
- ensuring that the equipment is user-friendly and that operators do not have to modify their established practices drastically.

The industrial use of each device is described in Table 1.

Table 1: TIDE's energy-efficient devices and applicable industries

Device	Applicable industry
Stoves	Water heating and community cooking, commercial cooking, arecanut boiling and drying, jaggery and khova production, rubber-band vulcanizing, ayurvedic medicine production, silk reeling, textile bleaching and drying, cashew processing.
Dryers	Cardamom and coconut drying, herbal medicine production.
Kilns	Brick making, lime burning, tile and pottery making, tobacco curing.

This case study documents TIDE's work with several projects and donors during 1998-2009. These include:

- the India-Canada Environment Facility (ICEF), which provided TIDE's initial funding of INR 32.7 million;[12]
- the SERI-2000 programme of the Swiss Agency for Development and Cooperation (SDC);
- the Department of Science and Technology, Government of India;
- a UNDP-GEF Small Grants Project in Tamil Nadu, implemented by TIDE (USD 34,264);[13]
- the ETC Foundation (the Kingdom of the Netherlands); and
- the Deshpande Foundation.

TIDE's total funding over the period was INR 41.2 million (about USD 876,596).

[11] Jaggery is unrefined sugar made by boiling raw sugarcane juice or palm sap. Khova is milk thickened by heating in an open iron pan.

[12] ICEF was a bilateral grant-making organization.

[13] The project was titled 'GHG emission reductions through the use of energy-efficient technologies by textile processing units in Tamil Nadu' (SGP/GEF/IND/OP3/02/06 KAR 11).

Activities to date. A brief summary of TIDE's activities during 1998-2009 is provided in Box 1.

Box 1: TIDE's work with biomass technology, 1998-2009: partnerships and milestones

1998-1999: TIDE commences its survey phase (described in more detail in Section 3.1) in Kerala and Karnataka, focusing on arecanut boiling and tobacco curing industries.

2000: The Department of Science and Technology (Government of India) awards TIDE an ongoing core grant, enabling it to engage in innovation and product development for biomass stoves.

1999-2002: TIDE engages in technology demonstration; participatory technology development; entrepreneur identification and capacity-building; and introduction of entrepreneurs in selected industries.

2001: The SERI-2000 programme supports TIDE's project which targets silk reeling businesses in Karnataka and Andhra Pradesh. By 2004, the project delivers 2,500 silk reeling stoves.[14]

2002: The entrepreneur mechanism starts delivering efficient stoves in selected industries on a commercial basis. Phased withdrawal of financial support to entrepreneurs.

2003: TIDE ventures into new states, with surveys and installation of units in Uttarakhand (herbal medicine, commercial cooking), Chattisgarh (silk reeling), Andhra Pradesh (tobacco curing, silk reeling) and Tamil Nadu (textiles). TIDE establishes entrepreneurs in textile units in Tamil Nadu and Andhra Pradesh, but distance, inadequate human resources and poor transport links prevent expansion in Uttarakhand and Chattisgarh.

The ETC Foundation commits support to TIDE's activities in women's technical and micro-enterprise training.

2007: UNDP-GEF Small Grants Project launches energy entrepreneurship with textile bleaching and dyeing stoves Tamil Nadu.

The Deshpande Foundation supports a TIDE project to initiate masons as producers and entrepreneurs of jaggery stoves in north Karnataka.

3. Implementation strategy

When TIDE began working with industrial biomass stoves in the 1990s, government energy planners were focusing on household stoves, in a belief that the scope for informal-business intervention was limited. TIDE therefore had to develop its own implementation strategy, which was then followed in its projects. The strategy consists of two phases, described below.

3.1 Phase I – survey and participatory technology development

Survey. TIDE conducts an exhaustive survey of biomass-consuming informal industries in a particular region, collecting data on biomass consumption, existing production methods and efficiency of various stove types used. This data is then consolidated into *taluk*-level map of industries.[15] As an illustration, the extent of biomass use in the states of Karnataka and Kerala (gathered by TIDE during 1998-1999) is shown in Table 2.

[14] The SERI-2000 programme on energy efficiency in the silk reeling industry brought several SERI project partners together in a peer review of projects. TIDE was thus able to access the knowledge gathered from other SDC-supported projects.

[15] *Taluks* are administrative sub-divisions in India that reflect revenue management. Each state is divided into districts, and every district is further divided into taluks, each representing a revenue region.

Table 2: Biomass use in informal industries, Karnataka and Kerala, 1998-1999

Industry	Number of units	Annual consumption of biomass (tonnes)
Karnataka		
Arecanut boiling and drying	22,255	51,020
Jaggery production	21,995	1,974,870
Tobacco curing	17,565	126,490
Silk reeling	17,291	71,770
Brick making	2,867	449,850
Lime burning	1,435	27,990
Cardamom drying	417	19,790
Cashew processing	170	9,550
Kerala		
Commercial cooking	2,545	46,278
Rubber-band vulcanizing	1,790	54,770
Cardamom drying	1,030	57,167
Coconut drying	770	8,550
Brick making	685	27,500
Ayurvedic medicine production	646	16,529
Tile and pottery making	249	120,100

TIDE then conducts an assessment of demand for energy-efficient biomass technologies in these industries (including social and financial constraints) and an assessment of entrepreneurship potential for the distribution of these technologies. In light of this information, TIDE then designs a prototype energy-efficient product and a dissemination strategy.

Participatory technology development (PTD). TIDE demonstrates the prototype product to an influential local opinion-maker and targeted businesses. It then collects their responses on the quality, operator comfort and convenience of the product and, through a process of consensus, adjusts the design to meet user requirements.

3.2 Phase II – implementation

After the design of the product is finalized, TIDE conducts wider device demonstrations at user locations. Simultaneously, it identifies potential entrepreneurs for product dissemination and provides them with technical and business development training. It then forms a pool of trained masons, engineers, welders and entrepreneurs to provide a local supply of the product. After entrepreneurs commence delivering the product to end users on a commercial basis, TIDE provides them with ongoing support (e.g. setting up production centres, business development, strengthening the supply chain and order delivery). TIDE then institutes a phased withdrawal in all entrepreneur activities.

3.3 Financing mechanisms

The TIDE model uses the following approach in meeting costs and providing support to end users and entrepreneurs.

Costs for end users. End users pay at least 115 percent of the device cost – actual cost plus a 15 percent profit for entrepreneurs – for all types of equipment except the silk reeling stove (described under 'subsidies' below). Even with a demonstration unit – provided its performance was satisfactory – the user has to pay at least 50 percent of the cost.

Irrespective of stove type and industry, the improved stoves deliver a minimum 30 percent savings in fuel. Through these savings alone, a standard payback period is less than one year of operation, and sometimes as little as six months.

Loans. TIDE does not offer loans to end users or entrepreneurs. However, in the arecanut industry, TIDE has negotiated for the Small Industries Development Bank of India to provide a loan to the industry association, Malanadu Arecanut Growers Cooperative Society (MAMCOS, based in Kerala), which is then re-lent to MAMCOS' members.

Subsidies. TIDE generally does not extend subsidies for device production or purchase. Purchases of silk reeling stoves were initially subsidized at 50 percent by TIDE under the project funded by the Seri-2000 programme. TIDE was gradually phasing out the subsidy, reducing it to 30 percent, when the Department of Sericulture (Government of Karnataka) began extending its own subsidy for silk reeling stoves. The TIDE subsidy was consequently abolished.

The Coconut Board extends an INR 10,000 subsidy per coconut dryer built in Kerala.

Repayment schemes. Many entrepreneurs devise staggered or layaway payment options for customers (usually 50 percent as an advance, and the balance in one or two installments within one month of installation). The robustness of the product and associated economic returns ensure that fewer than 5 percent of device purchasers default on payments.

Financial support for entrepreneurs. All identified entrepreneurial candidates are initially offered employment as TIDE staff and provided with sales incentives (commissions). Once they are earning sufficient income through sales, they are relieved of their staff positions but continue to receive a retainer fee and sale commissions. Once a critical mass of devices has been sold, the retainer fee and commission are also discontinued, with entrepreneurs receiving TIDE assistance only by way of generic market development support (e.g. newspaper advertisements, vehicle promotional campaigns) or occasional rewards.[16] The end goal is to ensure that entrepreneurs can sustain themselves solely from profits on sales.

3.4 Local participation

TIDE has forged links with local communities, seeking their involvement in market development and, wherever feasible, in the supply chain. Apart from PTD, local participation has proven effective at several levels as described below.

Engaging local youth as agents of dissemination. Selected entrepreneurs are typically local entrepreneurial youth with a background in selling agricultural products or consumer goods. The entrepreneurs generally have a good knowledge of other players in the industries they serve and display a good understanding of local markets. Typically, an entrepreneur employs local masons for installation work and places orders with local welders for metal components (see Box 2 for more detail).

Using local networks to produce and transport the technology. Most targeted industries, particularly those operating the year around (e.g. silk reeling), cannot shut down for the week needed for the installation of new equipment. TIDE consequently redesigned the stoves as a set of components that could be assembled on site, thereby reducing time and money spent on transition. In the PTD spirit, this approach involved local tradesmen (welders and masons), transporters and suppliers of raw materials such as bricks.

Using local networks for promotion and market development. Market promotion and consumer awareness is pursued by TIDE through industry associations, village fairs and vehicle campaigns.

[16] For example, TIDE shared part of its Ashden Award money by allocating each entrepreneur INR 10,000 for marketing support.

Box 2: Identifying entrepreneurs – a key to successful technology diffusion

The TIDE model views the entrepreneur, supported by local networks in various production and installation tasks, as responsible for business development and managing revenues. Traditionally, stove construction businesses for informal industries are run by local masons. The latter learn their craft on the job, with no formal knowledge of such concepts as heat transfer and insulation. Initially, it was assumed that a potential entrepreneur, as a minimum prerequisite, should be technically qualified and capable of acquiring business skills. Experience showed, however, that the most successful entrepreneurs were those who, aside from business acumen, had good interpersonal and selling skills.

In smaller industries, it was assumed that masons could themselves become the entrepreneurs. Later, it became clear that the skill sets of masons did not always lend themselves to entrepreneurship. In principle, a mason can function both as a labourer and an entrepreneur, but most lack competence in the necessary marketing and entrepreneurial skills. So TIDE entrepreneurs are usually local entrepreneurial youth, while masons and other skilled workers play a supporting role.

3.5 Capacity development

Developing entrepreneurs. Capacity development does not constitute a discrete component of the TIDE model. However, establishing entrepreneurs in rural and small-town areas does require considerable financial investment and other capacity-building inputs. Investing in capacity-building is seen as an investment in sustainability of technology and a recipe for sustained profits for entrepreneurs after TIDE's withdrawal.

The entrepreneurs learn their skills on site by participating in the survey phase of the project and in PTD, and through interaction with the project team. Capacity-building focuses on training in technical matters such as features of the disseminated technology, construction methods, principles of heat transfer, measurements of energy efficiency in the field and trouble-shooting.

Once trained, entrepreneurs can either construct the devices on site or manage a facility for preparing prefabricated device components for on-site installation. They are trained to follow drawings and make accurate measurements, and are instructed not to deviate from technical instructions. In fact, freedom to experiment at the project site is strictly discouraged as the slightest deviations in design can result in large efficiency losses.

Prior to developing local entrepreneurs, TIDE decided to experience the dissemination process first-hand. It obtained the necessary sales permits and conducted all the activities that an entrepreneur would eventually perform. This reduced risk perception among entrepreneurs and bolstered TIDE's confidence about delegating these responsibilities.

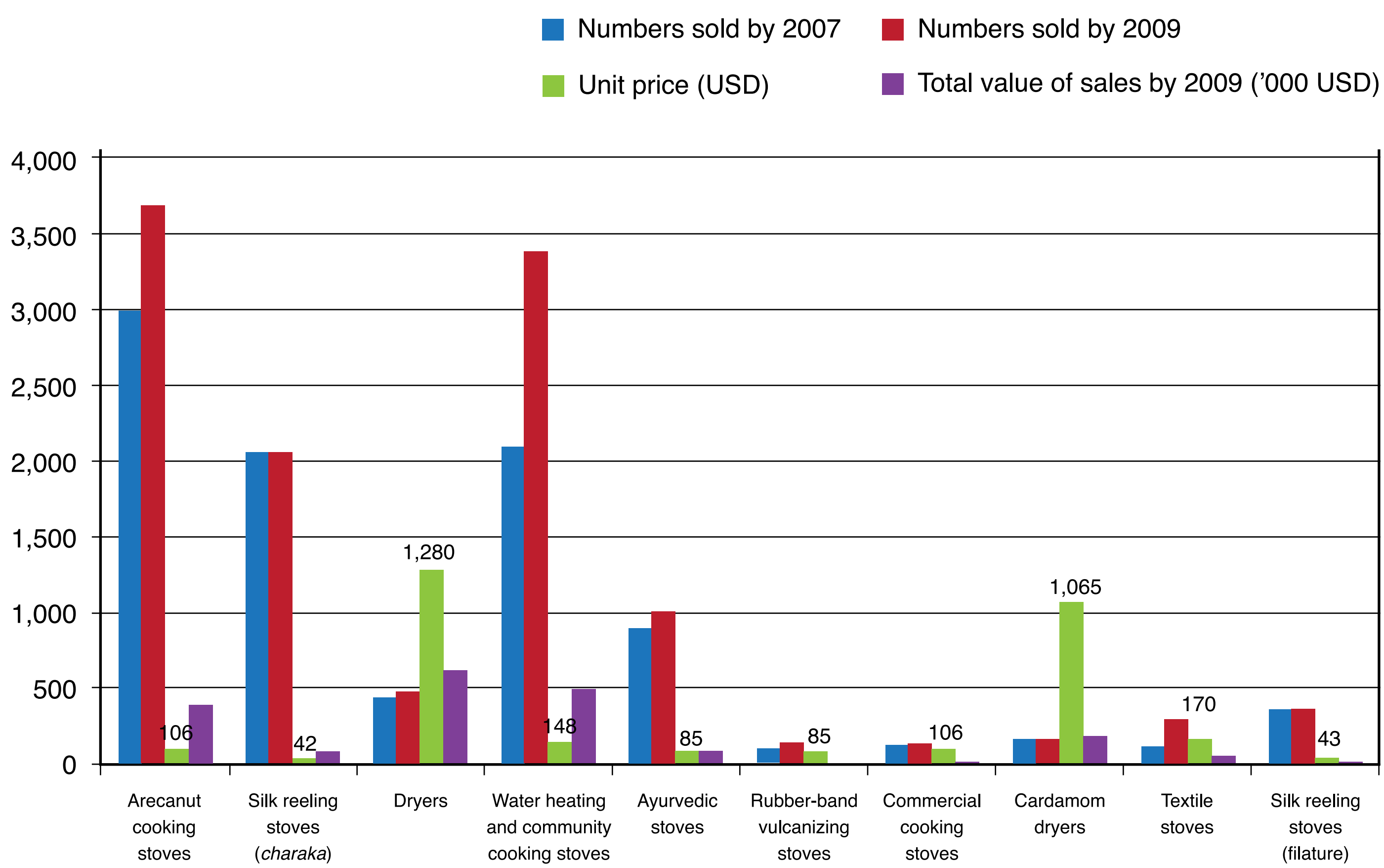
Training of TIDE staff. TIDE staff were encouraged to participate in meetings, seminars and training programmes in rural marketing and entrepreneurship. The most effective learning, however, comes from interactions with the local community and efforts to understand their needs.

4. Impacts

4.1 Implementation to date

The technologies installed or sold by TIDE by 2007 and by 2009 are presented in Figure 2. Overall, TIDE installed 11,840 industrial stoves, dryers and kilns in informal industries. In addition, around 7,000 domestic stoves were constructed by women entrepreneurs in an unsubsidized mode (not displayed in Figure 2).

Figure 2: Energy-efficient devices sold by TIDE, 2007 (cumulative) and 2009 (cumulative)[17]



Examples of milestones achieved for specific devices and regions include the following:

- 95 percent of rubber-band vulcanization enterprises in Kerala adopted new stoves;
- 76 percent of ayurvedic medicine enterprises in Kerala adopted new stoves;
- 40 jaggery stoves were constructed in north Karnataka; and
- 300 textile stoves were sold in Tamil Nadu under the UNDP-GEF Small Grants Project.

An estimated 135,000 people have directly or indirectly benefited from TIDE's work, which includes end users, entrepreneurs and device operators. An estimate of the number of beneficiaries for each device is given in Table 3.

The contribution of TIDE's projects towards India's attainment of its Millennium Development Goals (MDGs) is described below.

[17] *'Charaka'* refers to a non-mechanized, wheel-based silk reeling. 'Filature' refers to machine-based silk reeling.

Table 3: Estimated number of beneficiaries from device installations, as of 2009

Device	Average number of beneficiaries
Arecanut cooking stoves	55,335 (@ 15 people/stove)
Silk reeling stoves (*charaka*)	29,148 (@ 12 people/stove)
Water heating and community cooking stoves	20,274 (@ 6 people/stove)
Ayurvedic stoves	15,150 (@ 15 people/stove)
Textile stoves	6,000 (@ 20 people/stove)
Dryers	5,526 (@ 8 people/dryer)
Commercial cooking stoves	2,760 (@ 20 people/stove)
Rubber-band vulcanizing stoves	1,740 (@ 12 people/stove)
Jaggery stoves	400 (@ 20 people/stove)
Kilns	250 (@ 6 people/kiln)

4.2 Improved income and livelihoods (MDG 1)

Increased income for end users. Improved quality of the final product allowed end users in some industries to raise prices by as much as 10 percent, leading to higher profitability.[18] Reduced processing time of the energy-efficient devices increased productivity, also leading to higher profits.

Profits were also increased by lower fuel consumption. TIDE's devices deliver a minimum of 30 percent savings in fuel, irrespective of stove type and industry; these savings can be as high as 60 percent (e.g. for rubber-band vulcanization stoves).[19] The ability of some stoves to use alternatives to fuelwood also reduces costs.[20] Generally, the device cost was recovered within a year through fuel savings alone.

The introduction of energy-efficient devices has made the working environment cleaner, safer and smoke-free. This has indirectly improved worker efficiency, resulting in more labour hours. It has also resulted in fewer person-days of work lost to illness.

Overall, the adoption of energy-efficient devices has resulted in savings of INR 29 million for informal industries. An example of TIDE's impact on rural livelihoods is provided in Box 3.

[18] For example, the price of dried coconut is determined by its colour. Conventional dryers involve a long drying time, and sulphur needs to be burned as an anti-bacterial agent inside the dryer. With the new improved dryer, this treatment is not needed. The dried coconut therefore retains its natural colour and hence commands a premium price.

[19] The project developed an in-house method of fuel accounting. The key input to the system was the amount of fuel saved by shifting from conventional to fuel-efficient equipment. Measurement of fuel saved per stove was conducted by the Central Power Research Institute, a government organization. The institute's data and TIDE's fuel-accounting method were then used to aggregate the fuel savings. An independent assessment compared fuel consumption – defined as kg of fuel required to obtain 1 kg of finished product – in representative conventional and improved equipment. The assessment combined a survey questionnaire for equipment users, telephone interviews and inputs from field staff and entrepreneurs. Together, these sources provided the data required to calculate equipment utilization hours (the number of hours per day and number of days per year when the equipment is in regular use) for each industry. Each entrepreneur also compiled detailed data on the number of units sold every year. Amount of fuel saved annually per item of equipment was obtained by multiplying the fuel saved per day by the number of days that the stove was used in a year. Weight of fuel saved by each unit was calculated by multiplying the annual fuel savings by number of years the stove had been in field operation. The same procedure was repeated for each industry.

[20] For example, TIDE's arecanut stove can burn areca husk, which is an agricultural residue with no other apparent use. Similarly, TIDE's coconut dryers use coconut husk instead of coconut shells; the shells can be sold to makers of activated carbon, thereby increasing incomes for end users.

Box 3: Energy-efficient lime kiln improves a woman's livelihood

Fatimabi lives with her five children in a remote village in Bellary District, Karnataka, operating a seasonal lime-burning business. Prior to her engagement with TIDE (following a recommendation by the Family Planning Association of India), she operated a lime kiln with a 250 kg per batch capacity, the income from which was not sufficient to feed her family.

At first, TIDE provided Fatimabi with an improved lime kiln demonstration unit. It was estimated that, in order to generate a sufficient income, she would need a kiln twice the size of the one she was using. TIDE subsequently designed and built a 500 kg kiln, and developed a stacking system for loading fuelwood and limestone in layers. Fatimabi's conventional kiln consumed 2.5 kg of fuel per kg of lime produced; the improved kiln reduced this to 0.9 kg. In addition, Fatimabi can now produce 250 kg of lime from every 500 kg batch of limestone. The new design therefore doubles production while reducing fuel consumption.

Fatimabi saves 400 kg of fuelwood per batch, which translates to savings of INR 600. One hundred days of kiln operation delivers an estimated additional income of INR 50,000. This increase in income has allowed Fatimabi to employ other women to crush limestone, giving her more time to spend with her children.

Box 4: Harnessing an unemployed graduate's entrepreneurial skills

Bal Murugan, a science graduate, was 25 years old when the project team spotted his self-confidence, good communication skills and willingness to work hard. Murugan was earning around INR 5,000 per month through masonry contracts, despite not having any masonry skills.

TIDE invited Murugan to market textile stoves in the Erode District, Tamil Nadu. When he demonstrated his selling abilities, he and his mason were put through intensive stove-construction training and further supported with construction manuals. Unlike earlier entrepreneurs who were initially offered employment in TIDE, Bal Murugan was only offered market-development support and a travel allowance.

To date, Bal Murugan and his mason have constructed 300 textile stoves and expanded their operations to six districts in Tamil Nadu. Despite all project support being withdrawn, they continue to build and sell four types of industrial stoves and earn INR 10,000 per month.

Increased income for entrepreneurs and local tradesmen. Data collected from 14 entrepreneurs showed a collective turnover of INR 66.6 million from 2000 to 2007, and a collective profit of INR 10 million.[21] In general, entrepreneurs' incomes were about twice what they would have earned when employed conventionally. An example of TIDE's impact on an entrepreneur's earnings is provided in Box 4.

TIDE has also developed new income-generating opportunities for masons, welders and transporters. It has generated an estimated 1,000 person-months of employment within TIDE and about 7,600 person-months of employment outside the organization.

4.3 Gender equality and women's empowerment (MDG 3)

TIDE's model was not conceived to promote gender equality. However, the organization has capitalized on every opportunity to promote this cause. Although there have been no women entrepreneurs in the lead project to date, women have benefited in the following (largely unforeseen) ways:

[21] Internal TIDE data.

- in the design of its silk reeling stove, TIDE has incorporated seats to enhance silk reeler comfort. About 1,000 women silk reelers have benefitted from this improved design, which has also won the technology greater acceptance;

- TIDE's devices are also contributing to the development of innovative sustainable-energy projects by women. In coastal Kerala, five women's groups are successfully using TIDE's dryers to establish profitable fish- and prawn-drying enterprises. Branding their product as 'biomass-dried fish and prawns', their claims of quality assurance and hygienic drying have helped to market these products. At the time of reporting, about five tonnes of dried fish had been sold, earning women a profit of INR 120,000 and much national attention;

- supported by funding from the ETC Foundation, 15 women stove builders have installed almost 7,000 stoves, helping them to generate additional income; and

- three women's groups have started cashew processing using biomass energy.

4.4 Environmental sustainability (MDG 7)

Fuelwood savings and reduced greenhouse gas (GHG) emissions. The installed energy-efficient devices are saving an estimated 47,480 tonnes of fuelwood annually, which entails a mitigation of 85,464 tonnes of CO_2 per year.[22] Wherever possible, TIDE attempted a fuel shift to agricultural residues to further save fuelwood.

Reduction of indoor air pollution. By equipping all stoves with chimneys, TIDE ensured that flue gases were expelled outdoors, reducing indoor air pollution. These chimneys made an effective selling point among stove users. Random checks of carbon monoxide during the initial stages of stove launch showed levels of <20-50 ppm, compared to 1,000-2,000 ppm before the stoves were introduced.[23]

4.5 Developing partnerships and linkages (MDG 8)

As the TIDE team learned more about energy entrepreneurship in rural and small-town locations, it realized that – particularly if its activities were to expand to new industries – partnership building was critical, particularly with industry associations and opinion leaders.

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A rubber glove factory using improved stove for vulcanization process.

Research institutions. TIDE has forged a partnership with the Centre for Sustainable Technologies (Indian Institute of Science) to ensure that a broad portfolio of energy products could be offered.

Parallel projects in other states. ICEF, the first donor of TIDE's activities, encouraged TIDE to extend its operations beyond the original states (Kerala and Karnataka) into Uttarakhand, Chattisgarh, Andhra Pradesh and Tamil Nadu.

In expanding into these states, TIDE applied the following criteria to partner selection:

- commitment to TIDE's objectives;
- primary focus on developing entrepreneurs and the relevant industry, rather than making profits for themselves;
- competence and commitment to sustainable energy solutions; and
- good networks at the grassroots level.

[22] Avoided annual carbon dioxide emissions were calculated by using an emission factor for fuelwood expressed in terms of kg of CO_2 per kg of fuelwood.

[23] Internal TIDE data.

Because only a few potential partners satisfied all of these criteria, compromises were made. For the most part, however, recommendations of partners by funding agencies were accepted, since they were based on previous experiences.

TIDE managed to forge local partnerships in Andhra Pradesh and Tamil Nadu. For various reasons (including distance, inadequate human resources and poor transport links), efforts at partnerships in Uttarakhand and Chattisgarh were not very successful. In hindsight, forging linkages directly with entrepreneurs and limiting the role of non-governmental organizations (NGOs) would have been a more effective strategy.

Industry associations. In some industries, TIDE has linked end users with respective industry associations. For example, MAMCOS is a strong industry association in a dense industry that offers entrepreneurs good profit potential. TIDE cultivated the good will of MAMCOS by building demonstration stoves, monitoring stove performance in influential arecanut growers' units and instituting a loan scheme for MAMCOS' members through the Small Industries Development Bank of India (as discussed in Section 3.3). However, since technology costs were already affordable, the loan scheme was not very popular.

Generating further donor support. TIDE received grants from several organizations to support its work, and initiated energy entrepreneurship in eight industries. This includes the 'Energy efficiency in tea processing units in South India' project, supported by UNDP-GEF. Its work on energy-efficient products for street-food vendors has attracted the interest of the Confederation of Indian Industry (CII-Green ventures), the World Resources Institute, and the Washington and Villgro-Lemelson Foundation, as well as social investor interest with support from the Ashden Awards.

4.6 Expansion impacts

TIDE's spin-off projects facilitated device dissemination in several new industries. These include textile stoves in Tamil Nadu, jaggery and khova stoves in north Karnataka, and energy-efficient brick kilns in north Karnataka. Lessons learned have enabled TIDE to spin off a for-profit company with a vision of replication for energy-efficient products for industries not covered to date.

5. Project sustainability – challenges and solutions

Neutralizing prevalent expectation of government subsidies. Most RE and energy efficiency programmes in India have been subsidy-based. Thus, in the 1990s, when the TIDE initiative was launched as a market-based approach, expectations of government subsidy among end users posed a challenge. Nonetheless, market-based promotion of energy-efficient devices has been the cornerstone of TIDE's approach.

Start strategically. TIDE's strategy of starting implementation in arecanut boiling and tobacco curing (the more affluent industries) was a judicious one, as it allowed the project team to avoid being hindered by limited purchasing power. It also helped to establish credibility for the TIDE model and the promoted devices.

Profitability as key to sustainability. Ensuring a sustainable market for TIDE's devices depended most of all on profitability of entrepreneurs, for whom pursuing environmental sustainability was only a secondary goal. The entrepreneurs were indeed able to establish and sustain profitable businesses. For example, a post-project review of the arecanut industry showed that entrepreneurship was still flourishing and, in some instances, the entrepreneurs had also diversified into other eco-friendly businesses.[24]

In the prevailing situation of rising biomass-fuel prices, the TIDE model continues to be viable in all industries. Entrepreneurs continue to prosper in the arecanut, herbal medicine and textile industries, and are emerging in jaggery production, street foods and brick making.

[24] The review was conducted three years after TIDE's withdrawal from the area and two years after the physical and financial closure of the project.

Appropriate entrepreneur selection and support. TIDE selected commercially minded youth as candidate entrepreneurs because of their understanding and experience in local markets. These individuals saw the potential of improving energy efficiency and were open to small modifications to equipment that helped them to increase profits. TIDE's entrepreneurial entry and exit strategy (discussed in Section 3.3) has also been effective, allowing it to spin off enterprises in different industries in a phased manner about a year before the project formally ended.

Improving affordability for end users. After TIDE's withdrawal, several entrepreneurs increased stove prices. In certain regions, prices rose beyond the reach of the very poor end users (TIDE's primary targets). As mentioned in Section 3.3, TIDE did not create financial linkages for end users, either because particular industries could not attract bank lending (e.g. silk reeling) or because they traditionally arranged their own finances (e.g. by borrowing from relatives).[25]

In hindsight, a more systematic approach to monitoring the quality and prices of devices, and a more structured development of financing linkages for end users would have been useful. With the support of MNRE and the Indian Renewable Energy Development Agency, TIDE is currently trying to establish financial support for end users through banks. The aim is to stimulate unsubsidized purchases in all regions where biomass is the main energy source.

Communicating complex technical information in overcoming resistance to change. Appropriate device design requires detailed knowledge of the processes in the industry where it will be used. TIDE's device dissemination was most successful in industries where production processes were easy to define. Thus, stoves for arecanut boiling and rubber-band vulcanizing were readily accepted by end users, whereas stoves for silk reeling or jaggery production required more lead time. Similarly, coconut dryers were easily developed and accepted, whereas getting acceptance for cardamom dryers (where the process is more complex) took much longer.

6. Lessons learned and good practices in expanding energy services for the poor

6.1 Support for entrepreneurs developing their own businesses

During the project implementation period, eight of the 14 newly developed entrepreneurs continued to sell energy-efficient devices either as a full-time or part-time activity (depending on seasonality in the segment to which they catered). Once a market development process was underway, it acquired a momentum of its own: the entrepreneurs sought to maximize profits, even if it meant expanding to other geographic areas or products. For example, one entrepreneur involved in manufacturing commercial cooking stoves shifted over to the production of soil-cement blocks and hollow concrete blocks when he found that this would increase his income.

In such situations, TIDE continued to support the entrepreneurs with marketing support (e.g. advertisements and promotional campaigns). Sometimes TIDE brought in reporters to publicize these activities, further stimulating sales and end user interest in the products.


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Fuel efficient biomass dryer in operation.

[25] There were several reasons that the project did not focus on developing financing mechanisms during its initial years. The project was implemented relatively early in TIDE's operation, and the project team (primarily engineers) lacked the foresight and the capacity to design end user financing. Other challenges included the fact that the device was locally made; as a result, pricing varied considerably across industries, making it difficult to establish a uniform loan structure. End user ability to pay also varied significantly: most of the poorest stove users (largely in silk reeling units) did not have bank accounts, and many were already defaulters with bank loans.

6.2 Building on partners' comparative advantages

TIDE worked with multiple partners, including grassroots NGOs, industry associations and individual entrepreneurs. TIDE's assessment was that most NGOs are effective at awareness raising, data collection and training, but not as adept at building markets. Consequently, the project team's activities focused on developing entrepreneurs.

TIDE's work with industry associations showed that market penetration is best accomplished through demonstration units, meetings with members and vehicle campaigns. These activities also increased the industry associations' awareness of and commitment to energy conservation.

6.3 Capitalizing on government support

In some cases, government support was seen by device users as akin to government endorsement of the product. For example, the INR 10,000 subsidy for coconut dryers extended by the Coconut Board in Kerala stimulated their acceptance because it created a perception that the government was supporting the product and the entrepreneur. This belief was reinforced when the government recommended the use of fuel-efficient stoves for its Good Manufacturing Practices certification in the herbal medicine industry.

On the other hand, the changing government subsidy policy can create uncertainty in the minds of entrepreneurs and hinder market development. For example, the subsidy on silk reeling stoves extended by the Department of Sericulture in Karnataka damaged a potentially flourishing entrepreneurship after only 2,000 stoves were constructed.

In summary, TIDE's experiences with government support have been mixed. Effective monitoring of existing and upcoming government policies is crucial in ensuring that TIDE's activities are supported rather than challenged by government subsidies.

7. Conclusions

TIDE's promotion of biomass stoves, dyers and kilns in informal industries in 1998-2009 was innovative and bold. These industries are inherently traditional, averse to change and poorly endowed – and, as a result, are generally avoided by other development agencies. The most innovative feature of the TIDE model was a dissemination strategy that focused on income generation for a disadvantaged target segment (local entrepreneurial youth).

Project implementation often required overcoming unforeseen gaps and barriers without recourse to precedents and lessons learned. The gaps lay mainly in capacity-building and creation of the diffusion infrastructure; the barriers were technological and related to awareness creation. TIDE addressed these gaps with the following measures:

- developing energy-efficient devices for specific informal industries;
- identifying rural youth with marketing skills and business acumen;
- building their capacity as entrepreneurs to fabricate, install and service the energy-efficient devices; and
- providing them with long-term support to set up, build and sustain their businesses.

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