# Making a difference

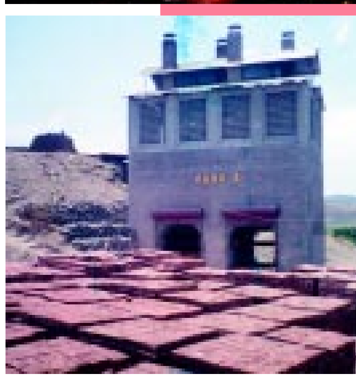
through

# cleaner technologies

foundry

glass

brick



gasifier

SWISS AGENCY FOR DEVELOPMENT AND COOPERATION SDC

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## A programme to address global environment concerns while meeting the urgent needs of the intervention sectors

In 1994, the SDC (Swiss Agency for Development and Cooperation) initiated its India programme in the energy sector in collaboration with Swiss consultants and Indian institutions.

The **long-term goal** of this programme is to generate dynamics to achieve significant energy savings and, consequently, reduction in carbon dioxide emissions in select energy-intensive, small-scale industry sectors. This programme is in agreement with the commitment of the Swiss Confederation – a signatory to the Montreal Protocol and the United Nations Framework Convention on Climate Change – to address global environmental concerns.

At the same time, the SDC programme responds to the **immediate concerns** of the intervention sectors. The demonstrated technologies will allow the industry (subject to stringent environmental pressure) to comply with the statutory environmental regulations and will help it in the following areas.

- Compliance with Supreme Court orders (in Firozabad, Howrah, and many other clusters)
- Improvement in energy efficiency and productivity, leading, in turn, to improved competitiveness
- Substantial improvement in the workplace environment
- Sustenance of jobs by meeting environmental regulations.

**Beyond energy and the environment**, this energy technology intervention is seen as an entry point for socio-economic activities, as revealed by improvement of the working conditions and sustenance of jobs by meeting environmental standards as well as enhancing long-term competitiveness.

**Four sectors of intervention**

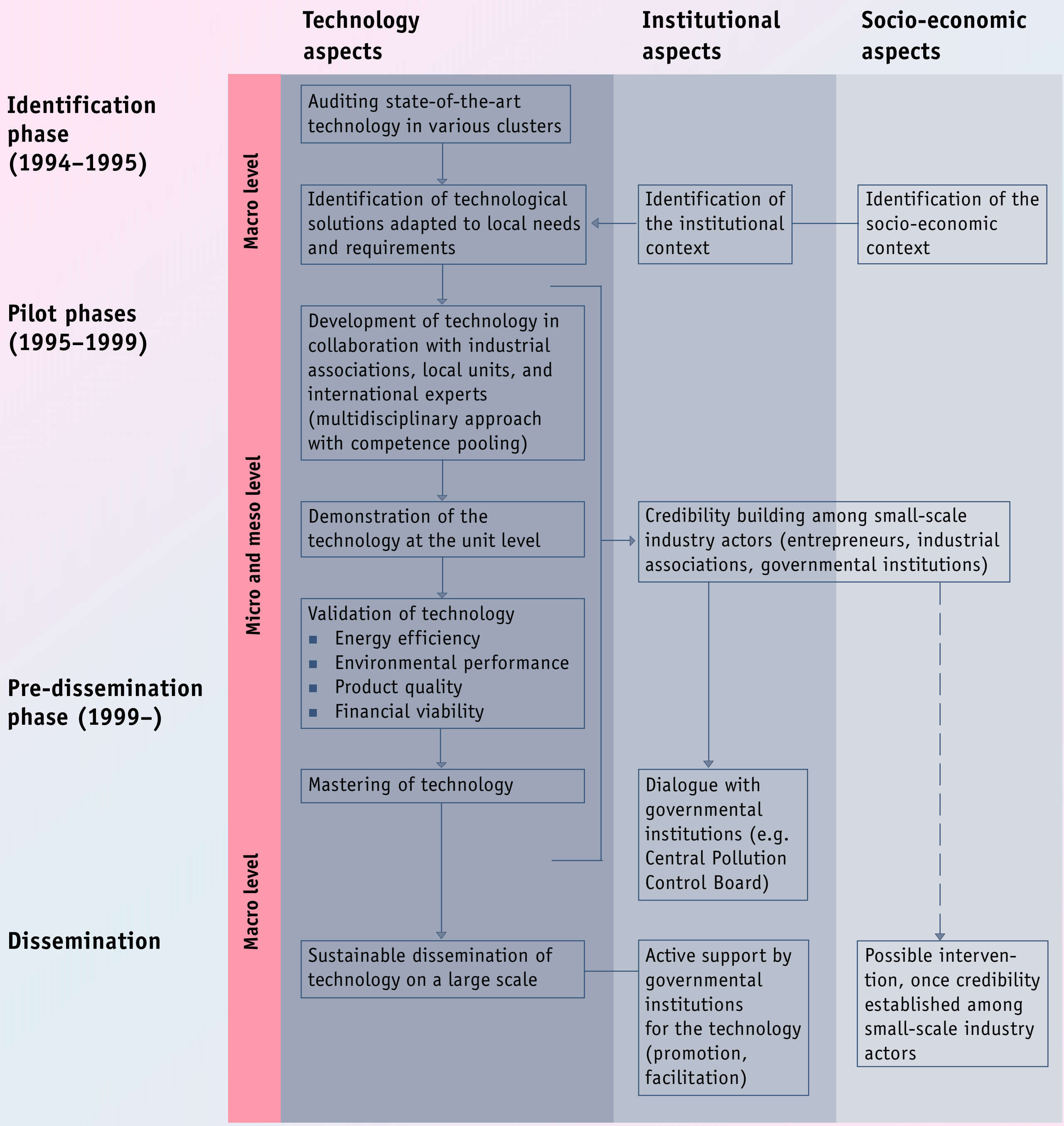
1 Foundries (cupola)
2 Small-scale glass units (pot and muffle furnace)
3 Brick kilns (Vertical Shaft Brick Kiln and Bull's Trench Kiln)
4 Biomass gasifier for thermal applications

The sectors of intervention were selected on the basis of a **macro-level study**.

- Promising components were examined in collaboration with Indian institutions in the small-scale industry, building and land-use sector, and in the area of renewable energy.
- The following **criteria** were considered.
  - Energy intensiveness
  - Potential for energy savings
  - High replicability potential
  - Techno-economic viability of proposed measures
  - Linkages and synergy to SDC's India Country Programme
  - Socio-economic importance of the sector
  - Sustainability of the sector
  - Willingness of potential partners to cooperate
  - No duplication with existing programmes
  - Cost-effectiveness of donor support
  - Handling capacity of SDC India staff
- **Energy audits** were performed in representative small-scale industrial units, where no or inadequate data existed.
- **Technological solutions** were proposed.
- A **stakeholder workshop**, the first of its kind in India, was organized in New Delhi, during 8–9 December 1994, to share the concepts and ideas with various stakeholder and expert groups and to define the future course of action. The workshop also helped in identification of new potential partners.
- Efforts were made to implement the identified technologies with industry associations as partners in the process and integrate concerns of the local industry into the project design.
- Full-scale **demonstration plants** were set up; these are not only energy-efficient but also meets Supreme Court guidelines and the country's most stringent emission norms to provide long-term energy/environment solutions to the small-scale industry.
- **Training** of operators was carried out so that they effectively manage the technological change.

# A bottom-up participatory approach with competence pooling

**The common features of the four sectors of intervention are summarized in the figure below.**



# foundry

## Context and initial diagnosis

### *Socio-economic importance*

- Most important secondary metallurgical processing industry in the small-scale sector
- About 6000 units, mostly located in disparate geographical clusters
- Primarily family-owned-and-managed
- Highly labour-intensive operations, due to low level of mechanization
- Direct employer of about 0.5 million people
- Annual production of about 3 million tonnes of grey iron castings at affordable prices, for essential items like electric motors, irrigation pumps, and sanitaryware (semi-finished goods, which are further machined in small mechanical workshops and large industries; important end-users include the automobile, mini-steel, sugar, and other industries)
- Low-value-added castings, like manhole covers and sanitary fittings, account for a substantial share of the total production.

### *Technology*

- Outmoded technology employed, resulting in inefficient resource utilization
- Cupola is the predominant melting furnace used
- Melting is the most energy-intensive process in foundries, resulting in emission of major air pollutants
- High energy consumption and poor environmental performance of operating cupolas due to improper design
- Inadequate off-the-shelf technological solutions to industry.

### *Institutional aspects*

- Industry associations at national and cluster levels
- Numerous foundries not registered with any association
- Limited role of associations in helping upgrade the technology level of member units.

### *Environmental pressures*

- Need to comply with stringent emission standards, due to stricter enforcement by regulatory authorities
- Closure for not installing proper gas cleaning systems.

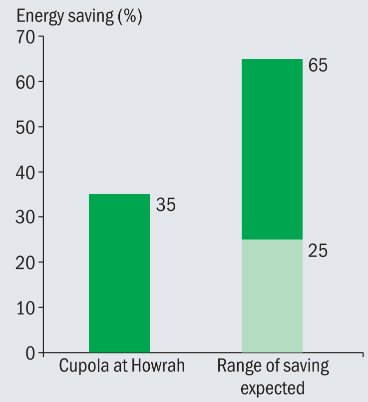
## Proposed technological solution

- Demonstration of divided blast cupola, an attractive technological option to reduce energy consumption with modest investment
- Demonstration of pollution control device to enable units to comply with existing emission norms and ensure their survival
- Training of operators in best operating and maintenance practices.

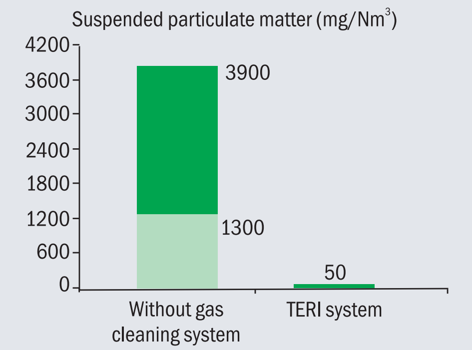
## Technology development

- Demonstration plant set up at Howrah (India's largest foundry cluster) at a unit nominated by the Indian Foundry Association

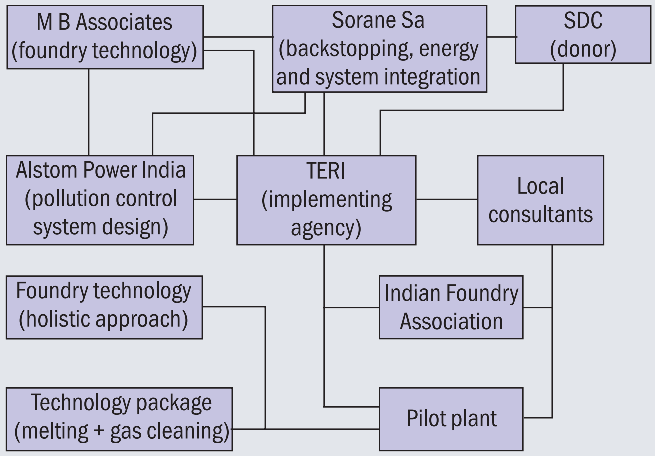
Demonstration plant at Howrah




Coke saving with TERI design




Comparison of emission levels




Competence pooling set-up for the foundry component

- Right-the-first-time approach helps establish project team's credibility
- SDC's flexible approach helps adapt the action plan to suit the rapidly changing environment and needs of the target group.

## Partners and institutional set-up

- Bottom-up participatory approach with the industry association as the central actor was the guiding principle in project planning and implementation activities.
- Long-term partnership ensured better transfer of technology and know-how.
- Competence pooling among a multi-disciplinary project team brought together international and local expertise in diverse areas—project management, foundry technology, energy management, environmental sciences, and social issues.


Environmental Excellence Award
2000–2001
West Bengal Cleaner Production Centre
a collaborative effort of
West Bengal Pollution Control Board
Indian Chamber of Commerce
confers the Environmental Excellence Award, 2000–2001
on
M/s. Bharat Engineering Works
Kona, Howrah, West Bengal
for their proactive and appreciable environmental management practices during the year, 2000-2001
A. V. Lodha
President
Indian Chamber of Commerce
Manabendra Mukherjee
Minister-in-Charge
Environment and Information Technology
and
Chairman, West Bengal Pollution Control Board

TERI's demonstration plant bags the Environmental Excellence Award

## Results of pilot installation

### *Energy performance*

Savings in coke translate to 35%, compared to the most energy-efficient plant, and 65%, compared to the least energy-efficient plant audited by the team

### *Environmental performance*

Suspended particulate matter emissions brought down to much below the most stringent norms prevailing in India

### *Costs/investment/payback*

- Coke saving of about 270 tonnes per year
- Payback on investment on the new cupola is only 1.5 years; payback on total investment, including pollution control device, is 5 years

## Long-term strategy and expected benefits of the intervention

- The focus of future activities in the technology area is on replication of the demonstrated designs, information dissemination, and capacity building of stakeholders.
- It is proposed to create a pool of industry mentors, through replication among a small group of progressive foundries, who will then be used for large-scale proliferation in subsequent years.
- The intervention model proposed in the next phase aims to strike a balance between the technological and social dimensions.
- Poor networking and lack of communication channels among small units inhibits their preparedness to the changing economic environment. An information exchange platform called ForeCASTING is being launched to address issues concerning market, social, and regulatory aspects.

## Context and initial diagnosis

### *Socio-economic importance*

- The Firozabad glass cluster, located 40 km from Agra (Uttar Pradesh), accounts for 70% of the total glass production in the small-scale sector.
- There are about 150 units for glass melting (tank and pot furnaces) and about 400 muffle furnace units (colloquially called *pakai bhattis*) for baking bangles (glass bracelets, popular in India). Actual numbers cannot be ascertained, as these are not registered; an estimate is that there might be around 1000 such units operating in the cluster. The pot and muffle furnaces are part of the bangle production chain. In addition, these units produce decorative, coloured glass items. The tank furnaces are mainly involved in producing tableware, headlight covers, laboratory-ware, thermos flasks, etc.
- The entire city of Firozabad is built around the glass industry, which provides livelihood to 0.5 million people.
- The workers are exposed to high levels of pollution due to inefficient coal burning.

A conventional coal-fired pot furnace

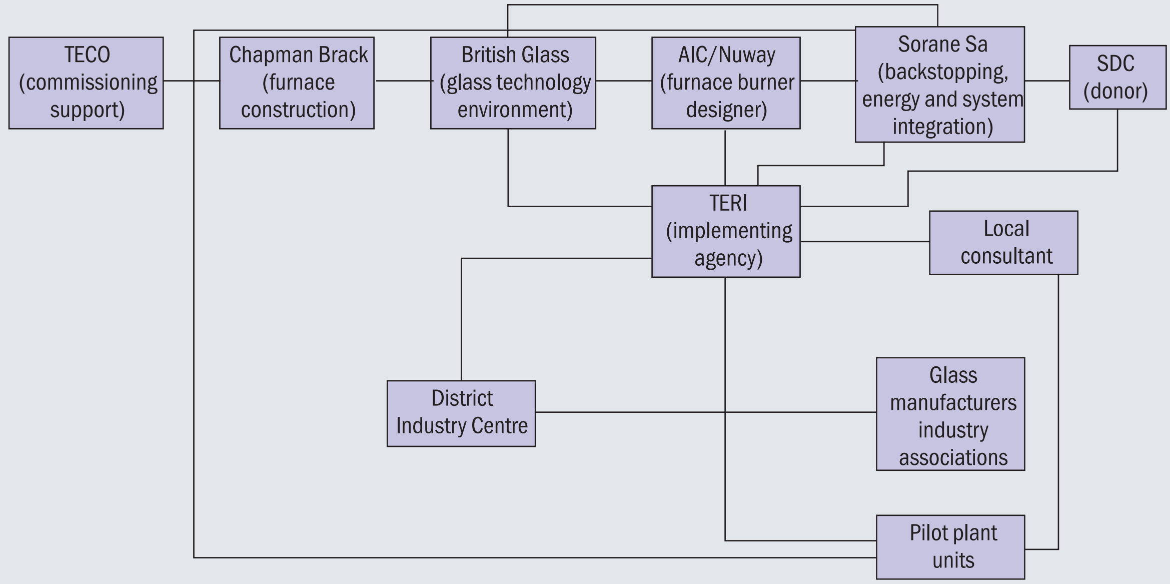
### *Supreme Court judgement*

- On a long-standing public interest litigation case, seeking protection of the Taj Mahal from environmental pollution, the Supreme Court passed a landmark judgement in December 1996, banning the use of coal in the Taj Trapezium Zone, an area of 10 400 sq. km around the Taj Mahal, within which Firozabad is located.
- GAIL (Gas Authority of India Limited), a public sector organization responsible for the transportation and distribution of natural gas on an all-India basis, was directed to supply piped natural gas to this region. Local industry was mandated to switch over to natural gas within a definite time frame.
- Firozabad's glass industry traditionally used coal as its main fuel. The fuel mix has, however, changed in the recent past after GAIL commenced supply of natural gas to the cluster. The present situation shows that almost all tank furnaces use natural gas; pot furnaces use both coal and natural gas; while muffle furnaces have just started changing over to natural gas.

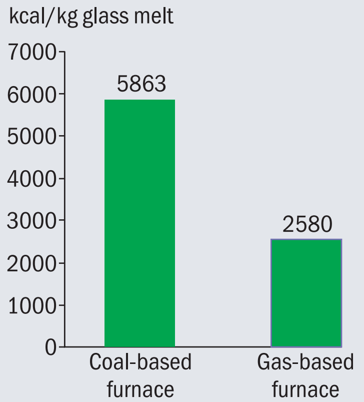
### *Technology*

- The designs of the coal-fired pot and muffle furnaces are outmoded, resulting in very poor energy efficiency. TERI's energy audits in traditional coal-fired furnaces showed a very low level of operating efficiency, especially for pot and muffle furnaces.
- Additionally, there was no off-the-shelf technology available for facilitating the shift to natural gas.

Gas-fired pot furnace




Competence pooling set-up for the glass component




Comparison of specific energy consumption

## Proposed technological solution

- Action research on pot and muffle furnaces was carried out, with the objectives of reducing energy consumption and improving the environment by developing gas-based models.
- The energy-efficient, gas-fired demo pot furnace set up in the cluster incorporates a waste heat recovery system for utilizing the heat in flue gases. Independent control of gas and air flows ensures proper combustion and reduced energy consumption.
- The major considerations in designing the gas-fired muffle furnace were to ensure faster acceptance, operational ease, and low capital cost. The gas-based demonstration *pakai bhatti* provides better heat transfer material, prolongs furnace life, and ensures reduced emissions of carbon monoxide and particulate matter.

## Technology development

- Participatory design sessions were organized in the cluster to solicit industry feedback on different designs. The inadequacy of ready-made solutions in Firozabad necessitated a dynamic design process in which the local industry played a central role. In case of the muffle furnace, a national design competition was organized. Various versions of gas-fired *pakai bhattis* were fabricated and operated for long durations, along with the local muffle furnace operators. The bottom-up participatory approach ensured that the finalized designs were acceptable to local industry.
- For the pot furnace, the local industry association was requested to nominate a unit where the demonstration plant could be set up while in the case of the muffle furnace, the help of the local District Industries Centre was taken to select a site where the demonstration furnace could be set up.

## Partners and institutional set-up

- An important element of TERI's intervention is proper competence pooling to address the issues that required multidisciplinary expertise.
- TERI provides the lead in terms of overall project implementation. Coordination, backstopping, and energy and system integration is provided by Sorane Sa. Other international and local agencies provide synergized technical support to help achieve appropriate solutions.

Conventional coal-fired muffle furnace

## Results of pilot installation

### *Energy performance*

- The demonstration pot furnace yielded energy savings of about 50% as compared to traditional coal-fired pot furnaces.
- The savings potential of the demo muffle furnace is about 30% as compared to the coal-based muffle furnace.

### *Environmental performance*

- The shift towards energy-efficient and environment-friendly technological solutions has significantly reduced emissions of particulate matter and carbon monoxide.
- Most muffle furnaces in Firozabad are located in congested localities. High emissions of suspended particulate matter and carbon monoxide from these furnaces puts the workers and people inhabiting surrounding areas at a very high risk of respiratory infections. The shift to cleaner fuel is expected to considerably improve the local environment and overall living conditions in the cluster.

### *Costs/investment/payback*

- The investment required for an energy-efficient, gas-based pot furnace is higher compared to coal-based furnaces—of the order of about Rs 2.5 million with a payback of around one year.
- The capital cost required for setting up a gas-based muffle furnace is between Rs 15 000 and Rs 30 000, depending upon the construction material. This investment is on par with the existing coal-fired systems.

Gas-based demonstration muffle furnaces

## Long-term objectives

- The long-term objective is to improve the energy and environmental performance of the Firozabad glass industry cluster, which would lead to better working environment and reduced health hazards for the workers in the factories and also for the general people living in Firozabad.
- The project will also help in the sustenance of the workforce by helping the local industry implement the Supreme Court mandate.
- Strategies towards better socio-economic conditions of the workforce would also be developed and tested.

# brick

Brick making in rural India

## Context and initial diagnosis

### *Socio-economic importance*

- More than 1 00 000 units, producing around 140 billion bricks per year
- Indo-Gangetic Plains covering the states of Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, and Assam produce around 65% of the bricks and the units are relatively large in size (2 million bricks per year or more)
- Peninsular (central, south, and west) India has more than 50 000 small brick manufacturers
- Energy consumption in excess of 20 million tonnes of coal per year in addition to several million tonnes of biomass
- Employs about 8 million people.

### *Technology*

- Outmoded technology with very low energy efficiency (10%–40%); BTKs (Bull's Trench Kilns) in Indo-Gangetic Plains having specific energy consumption of 1.2–1.75 MJ/kg fired bricks while clamps in peninsular India have specific energy consumption of 1.5–3.0 MJ/kg fired bricks
- Lack of technical solutions, particularly for small brick units; sector bypassed by technological development.

### *Institutional aspects*

- Unorganized sector
- Most brick units not registered
- Weak industry associations.

### *Environmental pressure*

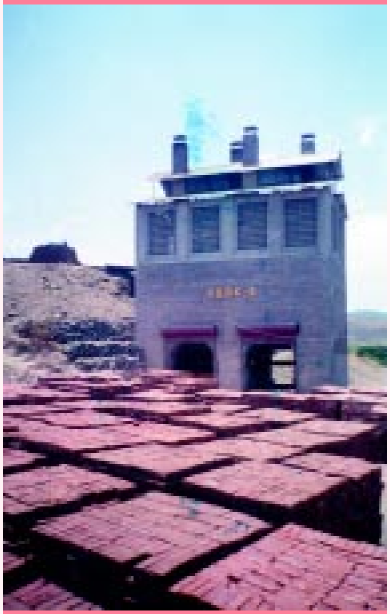
- Sector under pressure to comply with stringent emission standards and ban on moving chimney BTKs
- Large brick kiln clusters located in peri-urban areas under pressure to shift or close down

### *Proposed technological solution*

- VSBK (Vertical Shaft Brick Kiln) technology for small and medium brick manufacturers in peninsular India
- Best practice of operation for large BTKs in the Indo-Gangetic Plains.

### *Technology development and transfer*

#### Vertical Shaft Brick Kiln



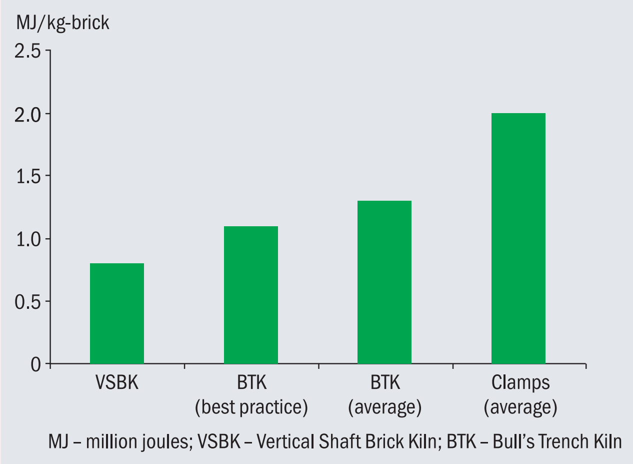
A vertical shaft brick kiln

- Transfer and adaptation of VSBK technology from China to India
- First pilot plant constructed at Datia (Madhya Pradesh) in 1996, followed by construction of three pilot plants in peninsular India by 1999

- Improvements in energy and environment performance of VSBK
- Validation of energy and environment performance of VSBK under Indian conditions
- Phased move from technology demonstration under controlled conditions to technology validation under market conditions.

Bull's Trench Kiln

- Awareness generation in BTK owners regarding potential energy savings
- Validation of energy savings and pollution reduction by following best practices in BTKs.




Comparison of specific energy consumption

## Partners and institutional set-up

- Private entrepreneurs
- Industrial associations: All India Bricks and Tiles Manufacturers' Federation
- Indian institutions: Development Alternatives, TERI, Gram Vikas, MITCON Ltd, Damle Clay Structurals Pvt. Ltd, Comtrust Ltd
- Donor: Swiss Agency for Development Cooperation

## Long-term strategy and expected benefits of the intervention

- Large potential energy and environmental impacts
- Replication potential in several parts of the country and abroad
- Potential social benefits include improved working conditions and ensured survival of small brick units
- Provision of a platform for interaction among stakeholders
- Influencing environmental and credit policy for the promotion of clean technologies in the sector.


Training programme for brick-makers

Traditional cottage basin

## Gasifier for thermal applications

### Case 1
### Energy efficiency in the silk reeling industry

*Context and initial diagnosis*

Socio-economic importance

- India, the second largest raw silk producer after China, with an annual production of 13 000 tonnes valued at 17 billion rupees
- Large number of small units in clusters: 26 000 cottage basin ovens and 35 000 *charka* ovens (registered)
- Over 2 million persons in the workforce involved in reeling
- Marginal/low profitability, high sensitivity to fluctuations in cocoon/silk prices, which are beyond the control of reelers
- Continued dependence on biomass, as commercial fuels are either expensive or scarcely available (coal)
- Overall low productivity of the sector, as there have been almost no attempts at technology upgradation, energy conservation, or by-product recovery.

*Technology*

- Traditional *bhattis* used for stifling and cooking cocoons
- Biomass used exclusively as fuel for stifling and cooking of cocoons; estimated annual fuel consumption of 1 45 000 tonnes of fuelwood and 1 70 000 tonnes of loose biomass
- Usage of a variety of biofuels—tamarind wood, *neem* wood, groundnut shells, paddy husk, etc.
- Overall energy efficiency of the ovens only around 10%.

*Institutional aspects*

- Relatively unorganized sector

*Environmental pressure*

- Sector largely dependent on unsustainable sources of firewood
- High level of carbon monoxide emissions and smoke due to poor fuel combustion.

Gasifier-based silk reeling oven

*Proposed technological solution*

Two broad options were considered.

1 Retrofitting of existing ovens for improving efficiency
2 Use of gasification technology.

After field trials, it was found that gasification is superior both in terms of technology and marketability potential. Hence, most efforts were concentrated on developing gasifier-based ovens.

Gasifier-based system in operation at dyeing unit

### *Technology development*

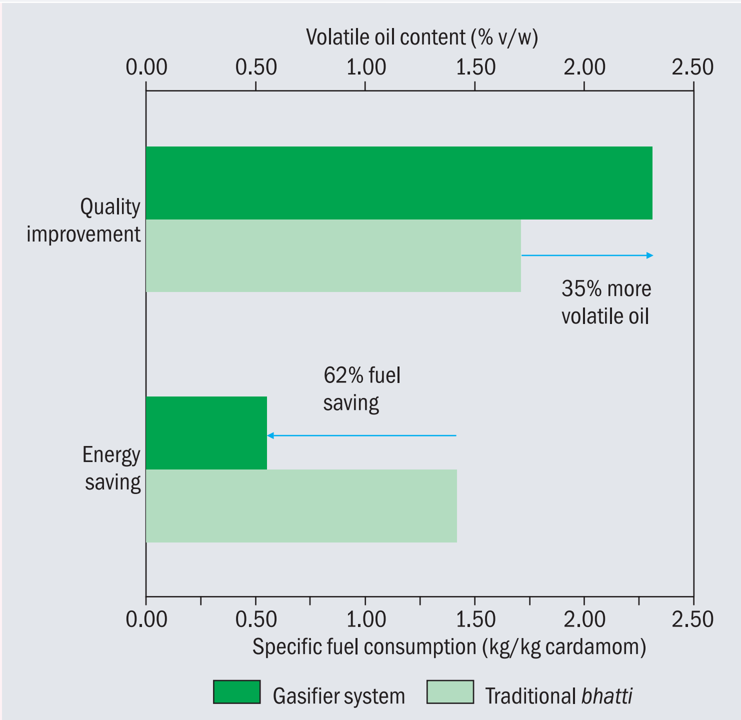
The progressive evolution of the commercial system was accomplished by the following activities.

- Assembling of Mark 0: proof of concept
- Laboratory prototype Mark 1: long-duration testing in the laboratory for operational reliability and assessment of maintenance requirements
- Field prototype Mark 2: installation and testing at a silk reeling unit in Hindupur, which is a low exposure area, followed by a design review workshop involving inputs from reelers, silk experts, and design consultants
- Improved field prototype Mark 3: installation and testing of two units in Ramanagaram, which is a dense reeling cluster and hence a high exposure area
- Extensive collection of data for quantifying benefits due to increased yield (lower renditta) and better quality yarn
- Cluster-level study to assess market size
- Regular meetings with reelers and silk experts to assess user satisfaction and incorporate improvements
- Evolution of Mark 4 system with inputs from design consultants and manufacturers
- Design and testing of industrial prototype – Mark 4 – at Ramanagaram
- Field performance study of Mark 4 in Ramanagaram
- Preparations of technology transfer package for manufacturer
- Selection of manufacturers for commercialization
- Test marketing.

### *Partners and institutional set-up*

- Private entrepreneur
- Silk experts
- Design consultants
- Entrepreneurs
- Users
- TERI (lead agency)
- International experts
- Donor (SDC)

Gasifier for rubber drying unit




Benefits of gasifier-based cardamom drying

## Case 2
## Energy efficiency in curing and drying of large cardamom

### *Context and initial diagnosis*

#### Socio-economic importance

- India, the largest producer of large cardamom, with 54% share in the world
- Main cash crop in Sikkim, which produces about 3850 MT annually
- Cardamom is small farmers' business (more than 85% have area under two hectares)
- Huge fuel wastage, estimated at 20 000 MT in Sikkim alone.

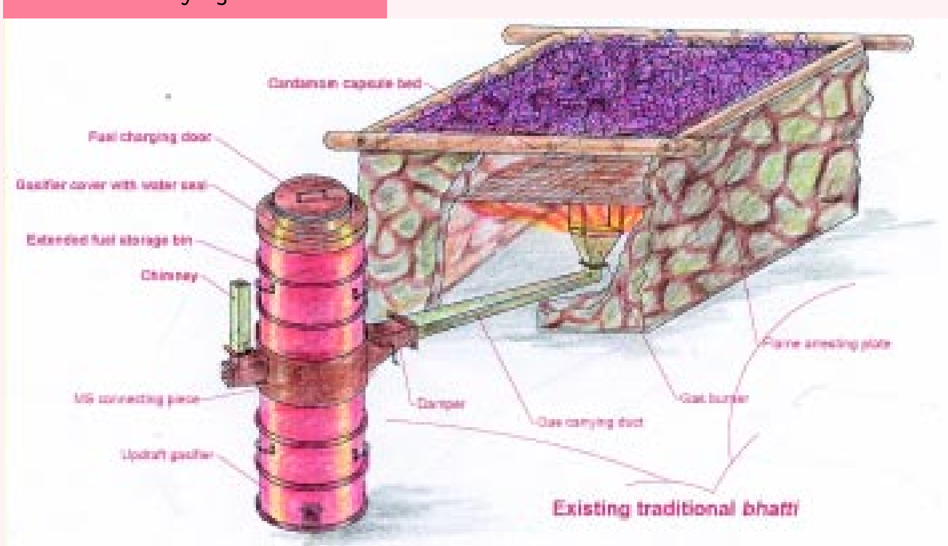
### *Technology*

- Primitive smoking method still used for curing, resulting in poor quality product
- Traditional *bhattis* used for cardamom drying
- Overall low energy efficiency of *bhattis* (5%–10%).

### *Benefits*

- 60% reduction in fuelwood consumption
- 35% more volatile oil in final produce.

Gasifier-based cardamom drying unit



## TERI: global vision, local focus

A dynamic and flexible organization with a global vision and a local focus, TERI was established in 1974.

While in the initial period the focus was mainly on documentation and information dissemination activities, research activities in the fields of energy, environment, and sustainable development were initiated towards the end of 1982. The genesis of these activities lay in TERI's firm belief that efficient utilization of energy, sustainable use of natural resources, large-scale adoption of renewable energy technologies, and reduction of all forms of waste would move the process of development towards the goal of sustainability.

A unique developing-country institution, TERI is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy problems to helping shape the development of the Indian oil and gas sector; from tackling global climate change issues across many continents to enhancing forest conservation efforts among local communities; from advancing solutions to growing urban transport and air pollution problems to promoting energy efficiency in the Indian industry, the emphasis has always been on finding innovative solutions to make the world a better place to live in. However, while TERI's vision is global, its roots are firmly entrenched in Indian soil. All activities in TERI move from formulating local- and national-level strategies to suggesting global solutions to critical energy and environment-related issues. It is with this purpose that TERI has established regional centres in Bangalore, Goa, and Guwahati, and a presence in Japan, Malaysia, Russia, and the United Arab Emirates. It has set up affiliate institutes: TERI-NA (Tata Energy and Resources Institute-North America) Washington, DC, USA, and TERI-Europe, London, UK.

TERI hosts the annual Delhi Sustainable Development Summit, which is swiftly gathering momentum as a major forum for the convergence of globally renowned leaders and thinkers dealing with the issue of sustainability.

With a staff strength of over 500, drawn from multidisciplinary and highly specialized fields, offices and regional centres equipped with state-of-the-art facilities, and a diverse range of activities, TERI is the largest developing-country institution working to move human society towards a sustainable future. Well on its way to becoming a cybercorp, TERI makes effective use of the latest developments in modern information technology in both its in-house and outreach activities.

TERI lays great emphasis on training, capacity building, and education. In 1999, it set up the TERI School of Advanced Studies, recognized as a deemed university by the University Grants Commission, India. The School is evolving as a research university, offering doctoral programmes in bioresources, biotechnology, energy, environment, and regulatory and policy studies.

Having celebrated its silver jubilee in February 2000, TERI is now poised for future growth, driven by a global vision and outreach, with a philosophy that emphasizes and assigns primacy to enterprise in government, industry, and individual actions.

## SDC India's involvement in global environment issues

The Swiss Agency for Development and Cooperation – SDC – is part of the Swiss Federal Department of Foreign Affairs. Its mandate is based on the Swiss Federal Law on International Development Cooperation and Humanitarian Aid of 1976. Sustainability, together with reducing poverty, forms the orientation of SDC's development assistance. Responding to the initiative of a number of civil society organizations, the Swiss Parliament approved in 1991 a special contribution on the occasion of Switzerland's 700th anniversary. This enabled SDC to develop a concrete response in the form of a GEP (Global Environment Programme) to support developing countries in implementing UN conventions concerned with the global environment. The GEP emphasizes measures to avoid further degradation of the global environment, through efficient use of resources, reduction of pollution levels, etc.

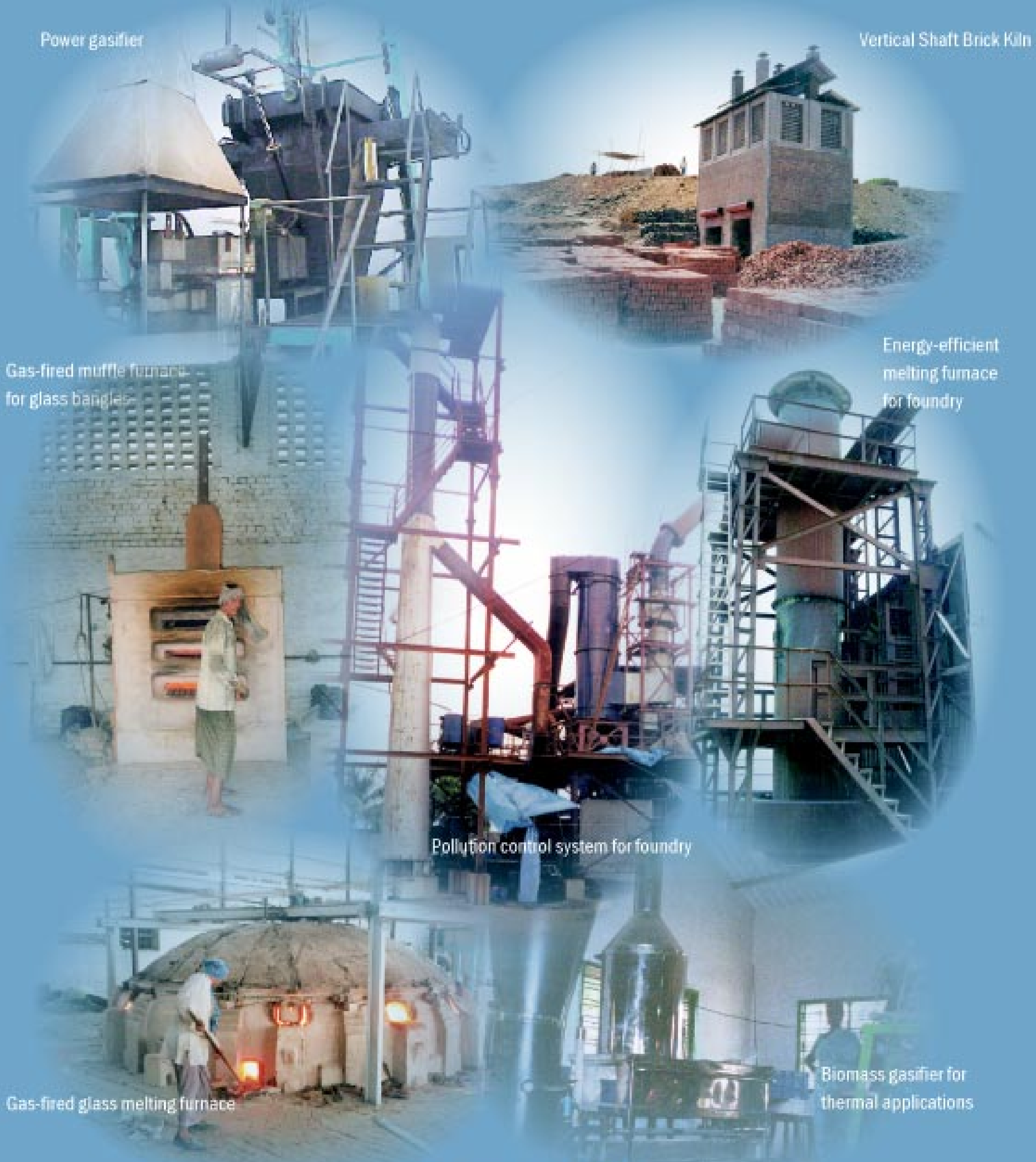
During 1996–2002, the SDC India Programme on Energy and Environment aimed at providing disadvantaged sectors of the population the opportunity to benefit from affordable, environment-friendly technologies that make it possible to save energy, use renewable sources of energy, and reduce pollution and facilitate the application of global environmental instruments that promote both local and global sustainability. The SDC and its partners were especially concerned with the effects of liberalization, with questions on how environmental regulations can be better enforced, and with supporting the participation of project partners in various international environmental protocols. Procedures and strategies in different projects were influenced by factors like the ever-changing context, the ability of Indian partners to lead projects themselves, and the realities of their everyday lives.

The three most important general approaches in the different projects described in this brochure were as follows.

1 *Building networks with project partners* Emphasis was put on achieving common goals, despite the different interests involved.
2 *Risk-taking* It is known that the Indian industrial sector is reluctant to take risks; this is especially true for small-scale industries. Therefore, projects – in developing more appropriate technologies – provided support and protection for certain risks.
3 *Planned withdrawal* Eventual withdrawal of external support was planned right from the outset of the projects. Hence, the programmes were conceived as the beginnings of a process of change and not as endeavours for facilitating change *per se*.

In its new Country Programme 2003–2010, SDC India intends to support processes that render rural development in India sustainable, equitable, as well as people-initiated, people-owned, and people-controlled. This overall goal provides an orientation to integrate social dimensions while capitalizing on interventions in the energy and environment field, based on technology improvements. For example, the approach of initiating human and institutional development processes in a sector like brick production has a potential of addressing the causes of poverty in a very sustainable manner. In the coming years, it is foreseen that opportunities provided under the international protocols on climate change and biodiversity will be explored for anchoring them in poverty reduction strategies in semi-arid, rural India.

Cleaner technologies for small-scale and rural industries

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