BRICK BY BRICK: THE HERCULEAN TASK OF CLEANING UP THE ASIAN BRICK INDUSTRY

A SAGA NARRATED BY URS HEIERLI AND SAMEER MAITHEL
FOREWORD BY WALTER FUST

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Authors: This saga of "Brick by brick: the Herculean task of cleaning up the Asian brick industry" has had many contributors over many years, working on the different brick programmes in India, Nepal, Vietnam, Afghanistan and Pakistan. Please see the list of all the people involved on the inside back cover.

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The Asian brick industry is an important economic sector, employing some of the world's poorest people. Will this child of a brick-moulder family have a better future?

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SELECTED ACRONYMS AND ABBREVIATIONS USED

BTK	BULL'S TRENCH KILNS
BVPS	BHATTA PARIVAR VIKAS SANGATHAN
CaF_2	CALCIUM FLUORIDE
$CaSO_4$	CALCIUM SULFATE
CCC	CHILD CARE CENTRE
CDCF	COMMUNITY DEVELOPMENT CARBON FUND
CDM	CLEAN DEVELOPMENT MECHANISM
CER	CARBON EMISSIONS REDUCTION (CERTIFICATE)
CO_2	CARBON DIOXIDE
CO	CARBON MONOXIDE
COMTRUST	COMMONWEALTH TRUST INDIA, LTD
DA	DEVELOPMENT ALTERNATIVES
DAMLE	DAMLE CLAY STRUCTURALS
DANIDA	DANIDA – DANISH INTERNATIONAL DEVELOPMENT ASSISTANCE
DCSI	DEPARTMENT OF COTTAGE AND SMALL INDUSTRY
DOC	DEPARTMENT OF CONSTRUCTION
DONRE	DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENT
ECBC	ENERGY CONSERVATION BUILDING CODE
ENTEC	ENTEC CONSULTING & ENGINEERING
FC-BTK	FIXED CHIMNEY BTK
GEF	GLOBAL ENVIRONMENT FACILITY
GTZ	*GERMAN AGENCY FOR TECHNICAL COOPERATION*
GV	GRAM VIKAS
HF	HYDROGEN FLUORIDE
IBMST	INSTITUTE OF BUILDING MATERIAL SCIENCE AND TECHNOLOGY
ICEF	INDIA-CANADA ENVIRONMENT FACILITY
IEM	INSTITUTE OF ENVIRONMENTAL MANAGEMENT
INR	INDIAN RUPEE
IPCC	INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
IZF	*BRICK AND TILE RESEARCH INSTITUTE ESSEN, GERMANY*
MC-BTK	MOVEABLE CHIMNEY BTK
MJ	MEGA JOULE
MOC	MINISTRY OF CONSTRUCTION
NM^3	NORMAL CUBIC METER
MSME	MICRO, SMALL AND MEDIUM ENTERPRISES
NPR	NEPALESE RUPEE
NRE	NATURAL RESOURCES AND ENVIRONMENT
NREG	NATIONAL RURAL EMPLOYMENT GUARANTEE
R&D	RESEARCH AND DEVELOPMENT
RCC	REINFORCED CEMENT CONCRETE
ROI	RETURN ON INVESTMENT
SDC	SWISS AGENCY FOR DEVELOPMENT AND COOPERATION
SEC	SPECIFIC ENERGY CONSUMPTION
SGP	SMALL GRANTS PROGRAMME
SHG	SELF-HELP GROUPS
SKAT	SWISS RESOURCE CENTRE AND CONSULTANCIES FOR DEVELOPMENT
SO_2	SULPHUR DIOXIDE
SOE	STATE-OWNED ENTERPRISE
SPM	SUSPENDED PARTICULATE MATTER
TERI	THE ENERGY AND RESOURCES INSTITUTE
UNDP	UNITED NATIONS DEVELOPMENT PROGRAMME
VAT	VALUE-ADDED TAX
VER	VOLUNTARY EMISSION REDUCTIONS
VND	VIETNAMESE DONG
VSBK	VERTICAL SHAFT BRICK KILN
VSBP	VIETNAM SUSTAINABLE BRICK PROJECT
VTTSA	VIETNAM THERMAL TECHNOLOGY AND SCIENCE ASSOCIATION

FOREWORD BY WALTER FUST

Is economic development compatible with the fight against climate change? Can small traditional enterprises adopt cleaner technologies and improve social standards? Can international cooperation play an effective role and can technology interventions also be a tool to reduce poverty?

These seemingly difficult and often divergent objectives can be met; this is what this story on the Herculean task of cleaning up the Asian Brick industry tells us. The traditional brick making sector in Asia is thousands of years old and provides livelihoods to hundreds of thousands of poor people. The task of upgrading many small and medium brick industries in South and East Asia is indeed Herculean – yet highly feasible. The stakes are massive. Between 35 % and 45 % of brick production costs are in energy. India is, after China, the world's second largest producer of bricks (140 billion). It uses 24 million tons of coal for this – a significant part, alongside cement, of the 17 % of national carbon emissions which the country's construction sector represents. In Pakistan, brick production accounts for 54 % of all coal consumption. And in the Kathmandu valley of Nepal, it is the largest single source – one-third – of air pollution.

Way back in 1993, SDC launched a global environment programme in India focusing on energy efficiency in small and medium scale industries. The VSBK project in India owes its origin to this programme. There are easier jobs to do than the task of modernising these small and medium industries: modern industrial plants can purchase technologies almost ready off the shelf. Easier, but perhaps not as noble and necessary as this adaptation process in the small-scale brick industries of Asia. Here, solutions must first be developed, made appropriate and viable, and leveraged into a restricted business space. With margins in these industries often wafer-thin, only highly efficient and low-cost solutions are suitable.

The Vertical Shaft Brick Kiln (VSBK), developed in China, is the most energy efficient kiln, despite it looking rather more like an old building and not at all like a high-tech installation. It consumes only 110 grams of coal to produce one brick, rather than 250-700 grams used in traditional clamp kilns. It even outshines the modern Western tunnel kiln that uses the equivalent of around 200 grams of coal for making the same brick. The first phase of the project involved the transfer of VSBK technology from China to India, which was accomplished through a multi-partner, multi-disciplinary and multi-country team of Indian, Swiss and Chinese experts. This was followed by projects in Nepal and Vietnam and very recently in Afghanistan and Pakistan. During all these projects, hundreds of team members have worked hand-in-hand with brick makers in small villages and towns across Asia, working not only on introduction of VSBK technology but also on social, institutional and policy issues related with brick sector.

A large potential exists for energy savings and CO^2 reduction in brick making and construction. Apart from energy efficiency increases in brick manufacturing by using efficient kilns like VSBK, more savings are possible, literally, by adding holes to the bricks. One of mankind's strokes of genius has been the simple innovation of making holes in a brick: a good hollow brick does the same work as a solid one. Since only the mass – and not the holes – needs to be fired, energy consumption is further reduced: a brick with "20 %" holes will use almost 20 % less coal. Even more interesting – especially for the fast-growing urban middle-classes in the mega-cities of Asia – is the better insulation property of a hollow brick, which can save significant amounts of energy in air-conditioning. And this is just the beginning: many more savings could be made through buildings complying with optimal energy consumption standards.

I am delighted that SDC and the associated partners[1] in this regional brick project – in India, Nepal, Vietnam, Afghanistan, Pakistan and, soon, Cuba – have been at the forefront of a true innovation. This is a Win-Win strategy that combines development and environmental objectives. I appeal to the national governments and international institutions to come forward and commit resources and work together to assist the brick industry in Asia towards a sustainable future. We need to spread many more innovations such as the stroke of genius of making holes in bricks.

Walter Fust
Director General, SDC – Swiss Agency for Development and Cooperation

EXECUTIVE SUMMARY

The Vertical Shaft Brick Kiln is the focus of this publication; it is the most energy-efficient kiln, originally developed in China. The photo below shows a 6-shaft VSBK in Kathmandu, Nepal.

BACKGROUND

SDC, the Swiss Agency for Development and Cooperation, started a global environment programme in India in 1992 [2] and focused on improving energy efficiency in small and medium industries. It was felt that environmental issues would become an increasing problem in fast-growing emerging markets. The large and diverse sector of brick production was selected as an intervention area after the promising results shown by the Vertical Shaft Brick Kiln (VSBK) in China. However, earlier attempts to transfer the technology to Nepal, Pakistan and Bangladesh had failed, mainly because the technology was not adapted to local conditions and due to lack of support when operating problems occurred. For this reason, in 1996, SDC started not directly with dissemination but with an Action-Research Programme in India. This publication tells the story of the VSBK saga with its successes and shortcomings over the past decade and more. During the same period, SDC-supported brick programmes have spread to Nepal, Vietnam and Afghanistan and are also under consideration in Pakistan.

THE BUILDING VOLUME: 100,000 EMPIRE STATE BUILDINGS PER YEAR

Brick production is a very large and very traditional industry in many parts of Asia. It is a booming industry as the demand for bricks is increasing almost universally due to fast economic growth, urbanisation and prosperity. Statistically, every Asian citizen consumes some 250 bricks per year, though the usage patterns vary: consumption

The Vertical Shaft Brick Kiln stands in the centre of this publication; it is the most energy-efficient kiln, originally developed in China.

is higher in fast-developing urban areas, and there is also a strong trend towards using bricks for improving rural houses. The most common dream of poor people is to replace their mud houses with solid building materials, and as they may not have the money to build their house in one go, they do it 'brick by brick'. In Bangladesh and the river plains of North India, where no stone is found, large amounts of bricks are used to make gravel for the substructure of roads or as an aggregate in concrete.

Over 1,000 billion bricks are produced and consumed in Asia per year, an almost unimaginable figure. It is the equivalent size of 100,000 New York Empire State Buildings, and the corresponding surface area would be 10 times the present area of Manhattan. This unbelievable amount of built-up area is being created in Asia year upon year.

THE CO_2 SAVINGS POTENTIAL: EQUIVALENT TO THAT OF THE GLOBAL AIRLINE INDUSTRY

To produce these 1,000 billion bricks, the Asian brick industry consumes 110 million tons of coal per annum, another figure that is hard to imagine. If this coal was loaded on trucks carrying ten tons each, it would create the equivalent of a three-lane traffic jam of trucks around the globe. One hundred and ten million tons of coal – without counting the electricity used in brick production, the diesel for transporting the bricks – alone produce some 180 million tons of CO_2, roughly one-third of the total CO_2 emissions of the global airline industry (550 million tons of CO_2). While some may argue that this is less than 1% of the total world CO_2 emissions, it is still a lot of energy and the potential for savings in the brick industry is enormous.

Up to 40% of the 180 million tons of CO_2 emitted by the Asian brick industry could be saved just by switching to more efficient kilns such as the VSBK, but further energy savings could be made from introducing hollow bricks. This could reduce directly the energy used for firing (a lower mass of clay to be fired) but also through better insulation of walls made of hollow bricks, thus reducing the energy required for heating and cooling of buildings. This aspect is especially relevant, as in urban areas of Asia the share of air-conditioned buildings is increasing very quickly. Even if we calculate very conservatively that only 25% of these CO_2 emissions can be saved, some 44 million tons of potential CO_2 savings are possible by introducing more efficient brick kilns and resource efficiency measures in the Asian brick industry. If we consider, higher energy savings of 60% in brick production, it can result in CO_2 savings of 108 million tons/year, this is equivalent to the potential savings predicted in the airline industry through the introduction of the new Boeing 787 Dreamliner (if all airlines switched to the 787 aircraft which is claimed to have a 20% better energy efficiency).

ON BRICKS AND KILNS

Firing of clay bricks has been practised for more than 4,000 years. The brick firing process consists essentially of increasing the temperature of bricks progressively over a period of time, holding it at a peak temperature (at about 800-1100°C), and then cooling back to the ambient temperature. Over the years brick kilns have basically evolved from rudimentary "intermittent" kilns to more complex energy-efficient "continuous" kilns. In intermittent kilns, bricks are fired in batches. Generally, bricks and fuel are stacked in layers and the entire batch is fired at once; the fire is allowed to die out and the bricks allowed to cool after they have been fired. In a continuous kiln, on the other hand, the fire is always burning and bricks are being warmed, fired and cooled simultaneously in different parts of the kiln. The heat in the flue gases is utilised for heating and drying of green bricks and the heat in the fired bricks is used for preheating air for combustion. Thanks to the incorporation of heat recovery features, continuous kilns are more energy-efficient.

ENERGY EFFICIENCY OF DIFFERENT KILNS

The energy consumption varies significantly between different types of kilns as is shown in the following table. Overall, one can say that between 11 and 70 tons of coal is needed to fire 100,000 bricks, or that every brick (of 3 kg weight) consumes between 110 to 700 grams of coal.

Most brick kilns in Asia are still operating as traditional industries with very limited investments. Batch-fired clamp kilns are the most widespread kilns in rural areas and in South Asia the continuous "Bull's Trench Kiln" (BTK) is very popular. It has either a moveable or a fixed chimney and is a moving fire kiln whereby the fire moves through the brick stacked in an oval-shaped trench.

Tunnel kilns are the most common kilns in industrialised countries and are also found in some Asian countries such as China and Vietnam. They are usually highly mechanised and require substantial investments. In tunnel kilns, the bricks move through a "tunnel" on a cart.

VSBK – THE MOST EFFICIENT KILN

In a Vertical Shaft Brick Kiln the green bricks are loaded on the top platform and move slowly down to the central

Table 1. Comparison of Kilns: Energy Use

Type of kiln	Specific Energy Consumption (MJ/kg of fired brick)	Specific coal consumption* (tons/100,000 bricks)
Continuous Kilns		
VSBK (India, Nepal, Vietnam)	0.7-1.0	11-16
Fixed chimney BTK ** (India)	1.1-1.5	17.5-24
Moveable chimney BTK ** (India)	1.2-1.75	19-28
Tunnel kiln (Nam Dinh, Vietnam)	1.4-1.6	22-25
Modern tunnel kiln (Germany)	1.1-2.5	17.5-40
Intermittent kilns		
Clamp and other batch kilns (Asia)	2.0-4.5	32-71

* Specific coal consumption corresponds to gross calorific value of coal as 18.8 MJ/kg (4500 kcal/kg) and for a fired brick weight of 3 kg
** discussed later in detail, the BTK is the continuous Bull's Trench Kiln

firing zone (see picture in Chapter 2): the fresh air coming from below cools the fired bricks before unloading. The kiln works as a counter-current heat exchanger, with heat transfer taking place between the upward moving air (continuous flow) and downward moving bricks (intermittent movement). The maximum temperature is achieved in the middle of the shaft where fire is maintained. At intervals of 2 to 3 hours, a batch of fired bricks is unloaded at the bottom. A batch of bricks chas four to six layers.

To understand why the VSBK is the most efficient kiln, we will have to understand that in a brick kiln only a small part of the heat is utilised for the firing and drying operations and most of the heat is lost. Efficient heat transfer process and lower heat losses makes VSBK more efficient.

There are thus excellent reasons to promote such an energy-efficient kiln. However, the VSBK also has its limitations and it may not be the best solution for all situations. Its relatively short firing period of around 24 hours means that the green brick must be suitable to withstand quick heating and cooling to produce high quality bricks and the firing process requires skilled personnel. BTK and intermittent kilns are much less sensitive to green brick quality as the bricks take several days to be fired.

WHY START WITH AN ACTION RESEARCH PROGRAMME?

The VSBK originated in rural China. – A Danish engineer, Henrik Norsker, came across the VSBK in China and found that it was much more energy-efficient. After the economic reform process of Deng Xiaoping in 1979, over 50,000 VSBKs had been built by private brick producers all over rural China, attracted by the relatively low investment – compared to the industrial kilns promoted by the Chinese Government. However, most of these kilns were owned by farmers and few produced very good quality bricks. The working conditions – especially on the firing platforms – were appalling, with workers directly exposed to flue gases.

In 1996, an action research programme was initiated by SDC in India with the aim of transferring and mastering the entire set of VSBK knowledge. Serious adaptations were needed, however, to transfer the technology to the Indian conditions. For example, the air quality and occupational health conditions on the kiln platform needed to be significantly improved through introducing chimneys and ventilation systems. Detailed energy audits were performed in order to assess the energy efficiency – not only in the laboratory, but under effective operating conditions.

Before engaging in a dissemination programme, it was also decided to carefully study the reasons for the failed transfers. An Indian-Swiss team visited kilns in China and in Pakistan, Nepal and Bangladesh.

BEFORE DISSEMINATION: WHAT ABOUT THE SOCIAL DIMENSION?

The main motivation for initiating an intervention in the Indian brick industry was to find a solution to a global environmental problem (it was financed from a special global environmental fund). It would not, of course, have been acceptable to an agency such as SDC if the intervention would not – at the same time – improve the social conditions of the workers. This was not an easy task as

the brick industry is well-known for its very harsh working conditions. Millions of people from the poverty pockets of India and Bangladesh migrate every year during the dry season – when there is no work as farm labourers – to the more than 50,000 brick kilns in northern India, desperately seeking jobs as firemen or as brick-moulders. As long as this poverty remains, this "industrial reserve army" will flock out to these kilns. There are truly few incentives for brick kiln owners to invest in better working conditions or in selective mechanisation: as long as it is cheaper to pug clay by foot and mould bricks by hand, there will be no machines.
Despite these difficulties, the different brick teams in India, Nepal and Vietnam took up the challenge and tried to find different ways of techno-social integration. Many promising social innovations have been tried, a good number of them successfully:

a) Technical improvements: some innovations require technical improvements such as better air quality through chimneys and ventilation; and mechanical pugmills and mechanised brick-moulding machines instead of treating the clay by foot and moulding the bricks by hand.
b) Better working conditions for workers: significant improvements are possible with a practical approach such as introducing Child-care-centres on brick kilns rather than leaving the children to play in the mud; a dialogue with brick workers (firemen, moulders and kiln owners) can bring small but crucial improvements: for example, a simple mobile phone on a kiln makes communication between firemen and their families possible.
c) New forms of ownership: different models of new ownership have been tried out. For example, six community-owned kilns are operating in Orissa. In South India, 11 women Self-Help Groups are operating a VSBK. They are still struggling with management problems but with the right support they could well succeed. In East Uttar Pradesh, two brick firemen families are now owners of VSBK enterprises.
d) Organising small brick-makers and workers: More than 20,000 brick firemen and their families have been organised in North India. Similarly, capacity-building and organised dialogue has been undertaken with hundreds of small brick-makers in Nam Dinh province of Vietnam.

RESISTANCE TO CHANGE IN AN INDUSTRY WHERE NOTHING HAS CHANGED FOR 50 YEARS

In South Asia, in particular, there is a strong resistance to change as the conventional way of firing bricks is quite profitable and does not require high initial investments. Although more modern kilns and especially the VSBK provide significant savings in energy, they also require higher initial investments. The situation is quite similar to an energy-saving lamp where the initial cost is higher but savings are possible through lower energy bills and a longer lifespan. Yet even in industrialised countries, people shy away from these upfront investments.
However, the situation is even more complex. Operating modern kilns demands a revolution in management compared to the traditional brick kilns: these are well-known technologies and the kiln owner does not have to know anything about firing. He can just hire migrant firemen and labourers for the dry season and he has basically to overlook the kiln once a day; his most important job is to look after the cash-box. VSBKs, on the other hand, require a raft of commitments: 24-hour operation in several shifts and fixed investments, for example owning the land. With a drying shed for green bricks the kiln can be operated the whole year round. "But why should I bother to work the whole year round when I can make all my money within 6 months", commented one brick kiln owner in Nepal.

Moreover, what the market demands – especially in South Asia and probably due in part to British influence – are solid red brick with a good "ring" sound. Such bricks are best produced in traditional Bull's Trench Kilns. It is not easy to change this demand pattern as house-owners, architects, contractors and masons all have the same perception. Even if VSBK bricks, when tested, show a higher compressive strength, the traditional perception has great, if misplaced, staying power. It will require continued market education over time to change this. Have heart, however: it is not impossible to change traditional perceptions and stakeholder behaviour. In Vietnam, different types of hollow bricks have now gained 40-50% market share thanks to the efforts made by the government over the last 30 years.

IF POLICIES AND CONDITIONS ARE RIGHT, THINGS CHANGE FAST: VIETNAM

The history of the brick industry in Vietnam is quite different from that of South Asia. Since the 1960s and 1970s, the Government of Vietnam has been taking steps to "industrialise" the brick industry through the introduction of machines and new technologies such as the tunnel kiln. Several brick-making processes have been mechanised and it is unthinkable to find hand-moulded bricks in Vietnam. This has created very strong incentives for improved brick technologies and has also paved the way for hollow bricks. Thus, conditions were more favourable to the adoption of a technology such as the VSBK. Despite the fact that the Government has still not approved the VSBK officially, it has had a fast uptake: more than 600 shafts have been installed in only 3 years. This had been assisted by a strong regulation: the Vietnamese Government has plans to ban all traditional kilns by the year 2010 and so far only tunnel kilns have received the official stamp of approval. Several new technical innovations have been added to VSBKs in Vietnam and the SDC project is facilitating the development of a sustainable brick industry in Vietnam which includes a model enterprise based on VSBK technology.

STICK AND CARROT: REGULATION AND CARBON FINANCE

The only way to transform this traditional industry is through a combination of astute policies and incentives. Classical policies for environmental regulation in India and Nepal have not really worked in the brick sector. When, for example, the Government of Nepal banned the moveable chimney BTKs in the Kathmandu valley because of their unbearable pollution, the kiln owners immediately switched to fixed chimney BTKs: these kilns have higher chimneys and spread the pollution over a larger area. A similar phenomenon had occurred in the early days of environmental protection in Europe and America, when the policy of tall chimneys was introduced and acid rains no longer fell in the immediate vicinity but in far-away places.

For its transformation, the industry would require a comprehensive set of regulations which addresses environmental pollution; occupational health; resource efficiency; abolition of drudgery; decent working conditions; and – most importantly – new brick quality standards to take into account the resource efficiency and insulation properties of bricks.

This stick needs a carrot, and has to be supported by financial incentives. It has proved possible, in practice as well as in theory, to include the VSBK under the Clean Development Mechanism (CDM). In association with the World Bank, Development Alternatives has successfully handed over the first carbon finance cheques to VSBK owners in India. However, this carbon finance would be more effective if it could be made available upfront in form of soft loans. One especially attractive option seems to be the mobilisation of Voluntary Emission Reduction (VER) credits – their use would also shed more light on this forgotten but so important industry. The saving by one VSBK kiln of 500 tons of CO_2 can make a full Airbus flight from Europe to Kathmandu carbon-neutral; if all brick kilns in Nepal switched to VSBKs, the savings would compensate the entire air traffic tourism of this country.

AIR CONDITIONERS AND HOLLOW BRICKS: HOW CRUCIAL IT IS TO IMPROVE INSULATION

Many more savings are possible, in insulation properties of bricks. Hollow bricks not only need much less energy in the firing process – bricks with 20% holes have an accordingly lower mass than solid bricks – but their insulation property is considerably better. It is estimated that up to 5% of air-conditioning energy could be saved if a room is made of hollow instead of solid bricks. A small detail, perhaps, but it can make a lot of difference: more and more urban middle-class families in the Asian mega-cities aspire to install air-conditioners in their apartments. This market is growing at 25% per year and the coverage is still very low, as only some 2% of the population have air-conditioners. Each family will consume some 7200 KWh of electricity and produce some 6 tons of CO_2 per year. If 5% of this electricity can be saved, it will not only reduce the stress on energy scarcity but also save some 12 tons of CO_2 over the lifespan of the building.
It is very important, therefore, to look at better bricks from this angle and introduce better insulation standards and minimum-energy building technologies, mainly in view of the rapid growth of this sector in Asia.

TOWARDS A LONG-TERM REGIONAL INITIATIVE

What has been achieved so far in India, Nepal, Vietnam and Afghanistan may not yet seem very impressive in terms of numbers. It is, though, certainly a major achievement for a small agency like SDC. It has paved the way for some 500 brick kilns, adapted an environment-friendly and economically-viable brick-firing technology and created a team that has mastered all of the technical, social and economical knowledge required.

To transform this initial experience into a broad innovation and to bring it into the mainstream will require many more years of efforts to facilitate regulatory changes, to provide brick-makers with easy access to carbon finance and building their capacity. It may require a regional long-term initiative and involve many more donors, governments, civil society organisations, climate change agencies and the private sector.

This package of tasks may seem daunting indeed, but it is their results that must carry most weight. It is more than possible to dramatically reduce the amount of coal burnt in traditional brick kilns; it can provide millions of decent jobs to that industrial reserve army of poor people who find no work in agriculture. It may also prevent power shortages, and surely improve energy security, by saving on air-conditioning with the introduction of better insulated bricks. If all experiences gained so far can come to bear abundant fruit in Asia and elsewhere, then one can indeed say that, far from being half-empty, the glass is half-full.

PART ONE: THE LION THAT SLEEPS: THE ASIAN BRICK INDUSTRY AS A HIDDEN ECONOMIC POWERHOUSE

The Asian brick industry is a huge economic sector employing many millions of people and consuming sizeable amounts of energy, mostly in the form of coal and firewood. It is a very conservative and change-resistant industry, especially in South Asia, but has a very interesting potential for change. If it does change, energy savings and a reduction of CO_2 emissions similar to the entire airline industry would be possible.

INTRODUCTION: BRINGING CHANGE TO A VAST TRADITIONAL INDUSTRY

1

1.1. 1,000 BILLION BRICKS PER YEAR – GOOD FOR 100,000 EMPIRE STATE BUILDINGS

Growing economies, population growth and rapid urbanisation have caused a boom in construction activities in developing countries. There is a very strong correlation between these three factors and demand for building materials. Almost every economic activity has an impact on building materials: not only is the growth of infrastructure and urban buildings stimulating this demand, higher incomes are also leading to a higher demand for housing as people aspire for more comfort and built-up space. This is the case for the richer segments, but it also applies for the poorer segments of society who will invest most of their economic prosperity in housing improvements. Many houses of the 4 billion people living in Asia are being constantly upgraded, but this almost invisible process tends to be underestimated: most poor people tend to improve their houses 'brick by brick' whenever their financial situation allows – a process called 'incremental housing'.

A consequence of all these factors is a rapidly growing demand for building materials such as cement and bricks. One can estimate that about 1,000 billion fired clay bricks are made every year in the developing countries of Asia. This figure is scarcely imaginable, and we have thus tried to make some imaginative comparisons and conclude that this number of bricks would be sufficient to build some 100,000 buildings of the size of the Empire State Building in New York (see boxes).

Most of these bricks are still today produced in traditional industries with relatively simple technologies and low investments: in many countries it is still a seasonal activity, starting after the rice harvest and the rainy season is over. The topsoil of the fallow fields will then be converted into green bricks and fired in traditional clamp or Bull's Trench Kilns (BTKs). These kilns have low investment costs

The volume of all the bricks used in Asia each year is enough to construct 100,000 Empire State Buildings.

but are not very energy-efficient and the low level of mechanisation of the clay preparation and brick forming process usually does not allow for making of hollow or perforated bricks. The quality norms for bricks vary from region to region: in South Asia, a good brick should be solid and of red colour and have a metallic ring – certainly a colonial heritage from British times – whereas in Vietnam, hollow bricks are as common as they are in Continental Europe.

Empire State Building

It is said that the masons who built the Empire State Building in 1930 used 10 million bricks. Although the structure also used some 60,000 tons of steel frames, the figures may somehow tally: the total volume is 37 million cubic feet or about one million m^3; it seems plausible to use 10 million bricks for such a volume. The present annual building volume in Asia of 1,000 billion bricks would thus be good for building 100,000 Empire State Buildings. According to the official website (www.esbnyc.com) the surface of the building is 7,240 m^2. Thus 100,000 such buildings would cover a surface of 724 km^2, almost the entire surface of the five boroughs of New York City, or more than 10 times the surface of the single borough of Manhattan (61 km^2). Therefore: every year, Asia covers a surface of 10 times Manhattan with buildings of 86 storeys. Quite impressive.

1.2. WORK FOR PLENTY – SEASONAL MIGRATION ESCAPING POVERTY

The brick-making is a labour-intensive industry. Hard work is needed to transform clay from the soil into green bricks, transport them onto the kiln, fire them and unload them. In South Asia most of these tasks are still done by hand, while in South-East Asia more and more steps are becoming mechanised. But even then, brick-making is a source of sweat and equally a source of income for many people who would barely survive without it. Especially in South Asia, brick-making is in symbiosis with large-scale seasonal rural unemployment: during the dry season, when the soils of the plains in northern India provide no work, millions of small farmers and landless agricultural workers migrate to the brick kilns in North India and Nepal for six months to work as moulders and firemen in brick kilns. Some of them, such as the moulders migrate with their families, others like the firemen migrate alone. In both cases, this seasonal migration has a negative impact on their families and social life, particularly on the education of their children. On brick kilns, working conditions are tough and exploitative, and wages sometimes well below the minimum specified by the government. Labourers live in temporary housing without access to basic sanitation, water and electricity. However, this supplementary income is absolutely crucial for their survival. A study in Vietnam[3] analysed that the supplementary income from brick-making in rural Vietnam is essential to cross the poverty line: without this income, people would face starvation and misery.

1.3. ALMOST AS MUCH CO_2 SAVING POTENTIAL AS THE GLOBAL AIRLINE INDUSTRY

The production and transport of these bricks has severe environmental consequences: firing these bricks requires burning around 110 million tons of coal, and several million tons of firewood.

This brick production results in 180 million tons of CO_2, roughly one-third of the total CO_2 emissions of the global airline industry (550 million tons of CO_2) and, incidentally, more than four times the annual CO_2 emissions of Switzerland.

The airline industry is struggling very hard to reduce emissions, and an enormous potential for similar savings exists in brick-making.

Sir Richard Branson, of Virgin Atlantic Airlines, has announced his intention to provide finance of US$ 3 billion to cut CO_2 emissions and has made the point that the airline industry could cut its CO_2 emissions by 25% or 150 million tons, if strong measures were taken. He said such a cut is possible in 2 years but it is difficult to imagine that this would happen. The two recently presented new aeroplanes, the Airbus 380 and the Boeing 787 'Dreamliner' claim to save 8 % and 20 % of fuel respectively. This would amount to a saving potential of 44 million tons of CO_2, if the entire airline fleet is replaced by A380 aircrafts, and around 110 million tons of CO_2 if the entire fleet is replaced by Boeing 787. It has taken huge investments in developing these new models. The development of the A380 may have had a price tag of more than US$ 10 billion and design work started in 1990. With a single A380 aircraft costing around US$ 300 million, it will require hundreds of billions of dollars to replace the entire fleet with these new aircrafts and one should remember that these savings are still theoretical and would apply only if the planes travel full.

Comparable cuts in energy consumption are possible in the Asian brick industry: 30 % to 60 % savings of 180 million tons of CO_2 emissions would result in saving of 54 million tons or 108 million tons respectively, pretty much the same figures as for the airline industry and this is

Hundreds of thousands of migrant workers from the poverty pockets of northern India and Bangladesh find work on brick kilns amidst harsh working conditions; most operations remain manual as long as wages are cheap and drudgery is a common phenomenon.

possible with known technologies, at much lower investments, and with much larger co-benefits.

How would such savings be possible? The following measures could achieve such savings:

1. More energy-efficient kilns as the VSBK (see below) can save anywhere between 30 to 60% energy per kilogram of fired bricks;
2. If hollow bricks could be introduced – instead of solid bricks – this would lead to another dramatic reduction in energy: the energy consumption of baking a brick is proportional to its mass. A hollow brick, having up to 20% less mass, thus requires less energy for baking compared to a solid brick.
3. Improved building techniques and practices such as using rat-trap bond in place of traditional English bond masonry for constructing walls would further reduce the number of bricks and mortar required per m^2 of wall construction. This would reduce the embodied energy in building construction.
4. Finally, solid brick walls offer poor thermal insulation and thus a building constructed with solid bricks consumes considerably higher lifetime energy for heating or cooling of the building. In comparison, walls made up of hollow bricks and rat-trap bond have better insulation. As will be shown in Chapter 9, the potential energy savings in air-conditioning are much higher than those from brick firing. One single apartment can save from 12 to 24 tons of CO_2 over its lifetime, if only it is better insulated by using hollow bricks instead of solid bricks.

There is thus an enormous potential for energy conservation without reduction in comfort and safety that could be realised. With all measures together, the savings potential is much higher than only 30 to 60%. With best practices along the entire building materials value chain, the same volume of wall elements could be produced with only 20-40% of today's energy consumption. However, this would require major changes along the many links in the building value chain and not only the introduction of one measure such as the introduction of an efficient brick kiln. The same is true for the airlines as well: it is useless to have a more fuel-efficient airplane, if air traffic

The Asian brick industry emits roughly one third of the total emissions of the global airline industry. The savings potential through better brick kilns is similar to the case if all airlines were to introduce the new Boeing 787 "Dreamliner" with a higher 20% fuel efficiency.

110 million tons of coal are used in firing bricks in Asia; this corresponds to a three-lane traffic jam of 10 ton trucks loaded with coal, all the way around the world.

control remains as inefficient as it is now in Europe where many planes have to cruise in waiting loops for hours.

1.4. IT IS A HERCULEAN TASK TO BRING CHANGE TO THIS INDUSTRY

The brick industry in South Asia has not changed significantly in the last 50 years. There are several key reasons for its lethargy and resistance to change:

1. Low fixed investment costs of traditional kilns: Traditional kilns such as clamp kilns or Bull's Trench Kilns require very low fixed investments, not even ownership of the land. These kilns can even be placed on rented land and it is a common practice amongst brick-makers to shift every few years from one place to another. Vertical Shaft Brick Kilns or tunnel kilns require substantial fixed investments and thus long term lease or ownership of the land is essential. Investments in fixed assets for clamp kilns are almost negligible while a Bull's Trench kiln with a capacity of 6 to 8 million bricks per year may need a fixed investment of some US$ 3,000 to 20,000. A VSBK needs an upfront fixed investment of at least US$ 25,000 for a capacity of 2 to 3 million bricks per year and tunnel kiln based brick plant may cost around US$ 450,000 in the cheapest Vietnamese versions. Similarly the returns on investment (ROI) for traditional kilns are much higher: for example, in Kathmandu Valley in Nepal, a moveable chimney BTK yields a ROI of 135%, a fixed chimney BTK 80% and a VSBK 40% per annum.

2. Traditional attitudes of brick-makers: Brick making is more a kind of extended agricultural activity than industrial in South Asia. In several regions of South Asia, particularly the northern plains, brick kiln owners are typically politically/socially influential landlords or businessmen having some cash. They are reluctant to make long-term investment in fixed assets. They have their own land or prefer to rent land for a few years, hire migrant labourers and firemen, erect a kiln and produce as many bricks as they can during the dry season. They visit their kilns only for a few hours each day and leave the production to their workers and supervisors. Most of them have poor knowledge of the brick-making process and their limited technical and managerial capability is a major hurdle in introducing new technology. Past failures make them paranoid about any major technology change. As Anand Damle points out, Indian brick entrepreneurs have psychological blockages towards change and mechanisation: "The present psyche of the Indian brick fraternity can be best described by the term, mechanisation phobia'. The phobia is due to the techno-commercial failures of a large number of semi-mechanised or mechanised brick plants set up so far."[4] Without proper financial records and collateral security, they find it difficult to gain access to institutional finance and shift to efficient technologies which may require higher investments.

3. Availability of low-cost seasonal labour force: One of the main reasons for low levels of mechanisation has been the easy availability of low-cost workforce. In South Asia, every dry season there is an army of seasonal labour available. They pug the clay by foot, mould bricks by hand and transport bricks on their heads and shoulders. All of these tasks can be mechanised easily, but due to the availability of cheap labour they are performed by humans, with no option but to work under appalling working conditions in brick kilns without any social security and to live under unhygienic conditions in temporary housing. The owners find manual labour cheaper than machines and local governments are reluctant to take any steps to enforce existing labour laws or formulate new regulations to improve working conditions.

4. Conservative building materials market: The building materials market is a conservative market and people who build houses – unless they have a lot of money to spend – build only once in a lifetime. What they build should be a long-term investment and should last. In South Asia, the perception of quality of a good brick is that a brick should be of red colour, be solid and produce a ringing sound when clapped against another brick. The perceptions of house builders are reinforced by the masons, most of whom are not formally trained. However, colour and ring sound are not always a true measure of the compressive strength of bricks (the main scientific criterion for classifying brick quality). With most construction shifting to reinforced cement concrete column and beam structures, bricks are used more as filling material than as a load-bearing element. In most such cases, since solid bricks have very high compressive strength, they may not be required. Any change, for example from solid to hollow bricks, requires huge amount of market education. Market education is a time-consuming and costly affair which is beyond the capacity of individual brick-makers. This explains the hesitation by brick-makers in introducing new products such as hollow bricks.

5. Sector needs regulation and planning: Governments in South Asia have long neglected this sector. They have failed to implement labour laws, environmental regulations and quality standards in it. On the development front, the sector has been overlooked by government-funded R&D institutions and technical support organisations, and the brick industry has generally remained outside the ambit of government planning. There have been no incentives to modernise the production process and to make it more efficient. It is interesting to note here how a Communist government in Vietnam (see Chapter 7), with a greater commitment for better working conditions for workers, has actively intervened to transform the sector.

6. Lack of R&D efforts: There is a serious lack of R&D for developing or adapting technologies for the brick sector. Lack of interest from the government on one hand and the limited financial capability of brick kiln owners on the other has resulted in a neglect of the sector by R&D institutions.

1.5. MAKING A HUGE INDUSTRY MORE SUSTAINABLE: SOCIALLY, ECONOMICALLY AND ENVIRONMENTALLY

Is the brick industry likely to change in the future? The indications are that it would be under increased pressure to change. The reasons are many. The most important is the rapid economic growth being witnessed in several of the countries concerned. India, which was once famous for its slow 'Hindu' rate of annual growth (1-3%) is witnessing annual economic growth rates of the order of 7-9% for the first time in its history. This rapid growth has started to have an impact on the availability to the brick industry of a low-cost workforce. Brick enterprises in several regions in the country, particularly in the west and south, are experiencing a labour shortage which has started to affect their production. In this scenario, the prospects of mechanising some of the labour-intensive operations such as brick-moulding are now much more favourable. Another consequence of economic growth is the emergence of a new consumer class in society which is ready to pay more for newer varieties and a better quality of bricks; this opens a niche market for value-added products for brick-makers. In addition,

While modern brick industries have been heavily mechanised, the process is still based on cheap labour, especially in South Asia where migrant workers from the poverty pockets are desperately seeking jobs during the dry season.

there are more growing concerns about negative environmental impacts, particularly regarding air pollution and unplanned usage of good-quality agriculture soil for brick-making in large brick-making clusters. These concerns have already led courts to intervene to ban brick-making in some areas in India. If the industry takes no remedial measures, these concerns could intensify in future and could force the government to take a strong stand on implementation of environment norms and regulations. On the incentives side, the availability of carbon credits for energy efficiency measures has the potential to drive change in the industry.

The traditional brick industry has to change with time. However, a rapid transformation to fully mechanised production is not desirable. A modern tunnel kiln-based enterprise in Europe requires only one person to produce one million bricks per year and the entire brick production of 8 billion bricks in the US is produced by 83 firms in 200 brick plants, while India has over 100,000 brick kilns. A fully-mechanised brick plant has thus a labour productivity 25 times higher than at present in the South Asian brick industry. This would destroy 24 out of 25 jobs in the brick industry. It would be more desirable to implement a smoother step-by-step transformation to an industrial, small/medium scale, less polluting and semi-mechanised brick production using intermediate technologies. There is much scope and many arguments for supporting this transformation process through a comprehensive set of measures, such as:

1. Technology modernisation: Semi-mechanisation of the brick forming process along with introduction of efficient kilns, such as VSBK, can improve the quality of bricks, reduce energy consumption and reduce drudgery for the workers.

While solid red bricks are common in South Asia (influenced by British traditions), hollow bricks are fully accepted in Vietnam, most likely due to French cultural influence and adoption of modern brick manufacturing technologies.

2. Social changes and win-win situations: Working conditions on brick kilns are often appalling, and significant improvements are possible through technical and social interventions. Technical improvements aimed at mechanising tasks such as clay preparation, moulding of bricks and brick transportation through the use of mechanical pugmills, soft-moulding machines, de-airing extruders and conveyors, not only eliminate drudgery but also produce much better bricks. Similarly, measures to improve amenities for workers can also bring significant changes: for instance, easy access to communication facilities can assist migrant workers in staying in touch with their families, and access to safe water and latrines can have a positive impact on the health of workers. Some of these measures cost money but can provide win-win situations: for example, to introduce a child care centre on a kiln can not only make the life of the workers and children much easier, it can also increase the productivity of the workers. Developing workers' skills and organising them to help each other could have long-term positive impact on the sector.

3. Changes in regulations and policies: Unfortunately, most technical improvements require investment, and the return on investment is highest for the most polluting temporary kiln structures such as the moveable chimney Bull's Trench Kiln (BTK). Seasonal production brings the highest returns with the lowest investments, and all-year-round production is not at all seen as an advantage: "Why should I work all year round if I can make the same amount of money in 6 months?" asked the owner of a moveable chimney BTK. As long as pollution and drudgery are allowed, there are very few incentives to change towards better technologies. Comprehensive regulations and policies are thus needed to steer the transformation towards a more sustainable brick industry.

4. Creating a market for better quality and resource-efficient bricks: Creating a market for better quality and resource-efficient bricks such as hollow bricks would be an essential requirement for this transformation and would require changes in building regulations (for example, regulations requiring better insulation properties for walls) as well as creating awareness for better buildings, training architects, house builders, contractors and masons in better building practices. Only when a market for better quality bricks is created will it pay off for brickmakers to invest in new technologies with a long-term perspective.

5. Environmental changes: We have shown the enormous potential in improving the environmental performance in the brick industry through better kilns, selective mechanisation, hollow bricks, better building practices and buildings with minimum energy design. A set of such interventions all along the chain can reduce energy consumption by a range of factors from four to ten. Minimising the use of agriculture topsoil for brick-making through the use of deep clay deposits, use of clay from de-silting of tanks, ponds and dredging of rivers, would also improve the environmental sustainability of the industry.

1.6. THE CONTRIBUTION OF SDC: MORE THAN A DROP IN THE OCEAN?

Since 1995, SDC, the Swiss Agency for Development and Cooperation, has initiated several brick projects oriented towards techno-socio-economic improvements in the brick industry. It has proven to be quite a challenging task to bring improvements into an industry that is so patently lethargic and reluctant to change, yet it is of paramount importance for sustainable development, particularly in providing livelihoods to the poor and for the environment. As we shall see in this book, the programme started first in India and has now spread to Nepal, Vietnam and Afghanistan and, recently, to Pakistan.

The SDC programme has focused a great deal on the introduction of VSBK technology. The key hurdle to faster dissemination of VSBK is that less polluting technologies are cheaper in the long run but require higher initial investment. Even though substantial energy savings are possible, they do not compensate for the higher initial investment, and the returns on investment for traditional kilns are very high. The situation is quite similar to energy saving lightbulbs: while they use only 10% of a conventional bulb and last many years longer, the initial investment is several times higher.

In terms of the entire industry, SDC's intervention is little more than a drop in the ocean. But this drop has become bigger: already, some 500 VSBK kilns have entered operation, new human and institutional capacities to work in the brick sector have been built, new knowledge has been added, and innovative social actions have been tried on a pilot scale and are becoming a mainstream activity. Perhaps something between 1,500 and 2,000 million bricks are already produced in an environmentally friendly way using VSBK technologies: 2 billion out of 1,000 billion. For many, this seems a small number. But for a small agency like SDC, we think it is an impressive start, something to build upon and worth scaling up in the near future.

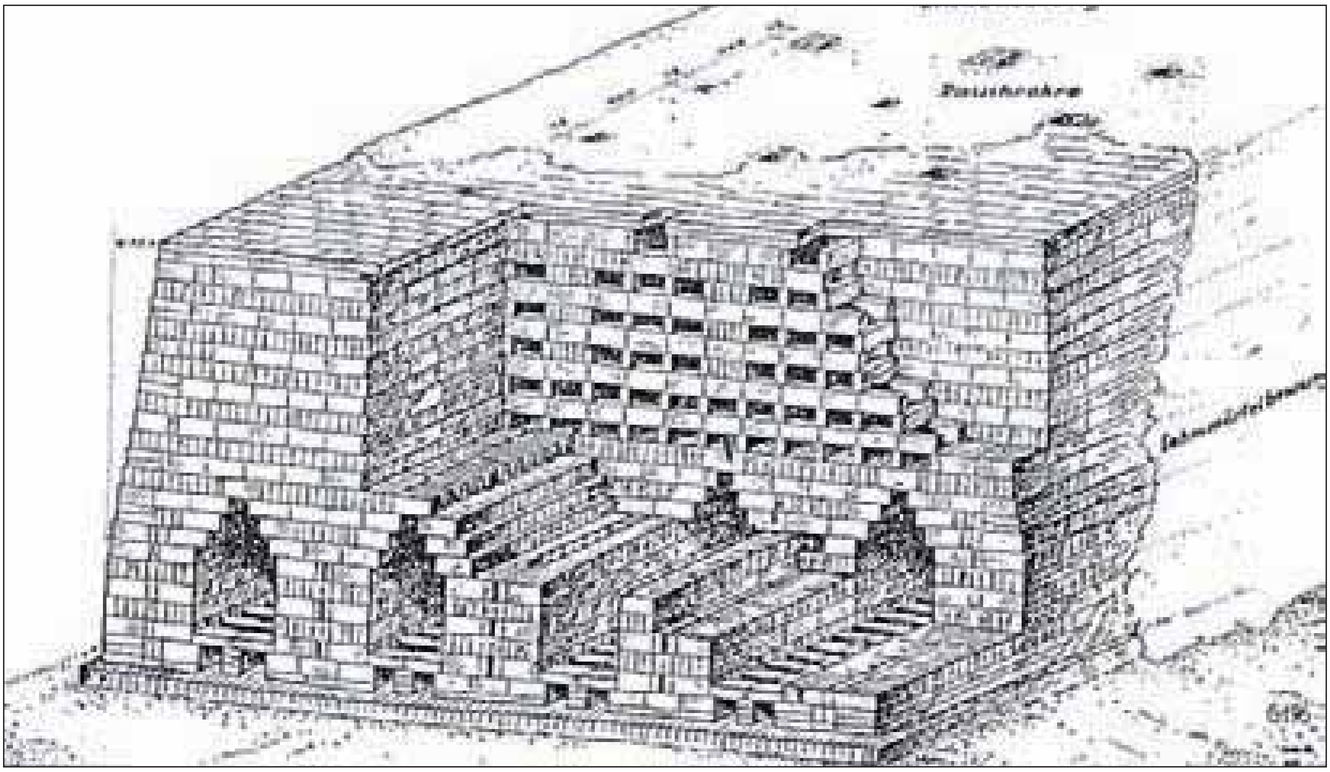
ABOUT BRICK-MAKING AND BRICK KILNS

2

2.1. A BRIEF HISTORY OF BRICK-MAKING

Since time immemorial, fired clay bricks have been the preferred building material of mankind. Fired bricks were in use in 4000 BC and were extensively used in the river valley civilisations of Egypt, Mesopotamia and Harappa. In the Western world, Romans, through their conquests, propagated brick and tile production and introduced brick-making in Spain, France, England, Holland, and Germany[5]. For several thousands of years, until the 19th century, the technology for brick-making changed very little. Bricks were made by hand, dried under the sun and then fired in clamps or scove kiln using firewood or coal.

The 19th century saw the development of several new technologies in Europe and the USA, including machines for shaping of bricks (extruder – 1854, press – 1827), efficient continuous kilns for firing bricks (Hoffmann kiln – 1858, tunnel kiln – 1877) and artificial dryers (chamber dryer – 1895). All these inventions opened the path for modern mass production of bricks. After the Second World War, a variety of factors resulted in radical changes in the European brick industry[6]: these factors were a shortage of coal and consequently the need to shift to oil and gas, the pressure on brickworks to improve working conditions, shortage of labour and environmental regulations to control air pollution. The changes include the shift from annular continuous kilns such as the Hoffmann kiln to the tunnel kiln. During the last fifty years, the brick industry in Europe has consolidated and thousands of small brickworks that existed at the beginning of the 20th century have been replaced by a few hundred large-scale, capital-intensive, highly mechanised brick works. The need to improve the insulation properties of walling materials has created a demand for new building materials, and hence a gradual shift from solid bricks to hollow and perforated blocks.
In contrast, the situation in rural areas of developing countries, in terms of both brick-making technology and the organisation of work, has not seen major changes in recent decades. In villages across Asia, Africa and Latin America, small-scale brick-making, is organised in family-owned micro and cottage enterprises serving local rural markets. In general, the traditional technology of hand-moulding, sun drying and firing in clamps[7,8], is still used, except in countries such as China and Vietnam, where manual moulding processes have been replaced by mechanised methods such as small-scale extruders.



A typical batch kiln where the green bricks are piled up and the fire must reach all parts of the kiln. Unlike continuous kilns, batch kilns are less energy-efficient as a lot of heat is lost through the kiln surface (sketch taken from Willi Bender: The Development of Brick Kilns…, Entec 2003).

Sometimes even minor technical innovations can bring substantial improvements in this change-resistant industry: this clay cutting tool with a simple steel wire used in Nepal produces much better-quality bricks.

Clamp kilns in rural India are still widely used: they require little investment and use large amounts of labour, but their energy efficiency is very low. While still an appropriate solution for local small-scale brick-making, clamp kilns can be a threat to the environment if they are used to produce large amounts of bricks.

A modern Western tunnel kiln is a capital intensive and highly automated structure where the green bricks move on carts through the tunnel. The firing zone is seen at the left of the picture where oil is sprayed to fuel the fire.

Development Alternatives, one of the partners in the Indian brick project, has used soft-moulding machines for green brick forming.

Brick making in the peri-urban and urban areas of developing countries – incidentally now the largest markets for bricks in the world – is characterised by different development paths in different regions. It is interesting to compare the development of the industry in China and Vietnam, with the countries of South Asia (India, Nepal, Bangladesh, Pakistan, and so on). In the case of China, most urban demand is met by town and village enterprises (TVEs), while in Vietnam it is state owned enterprises (SOEs) and joint stock companies that are the predominant suppliers of bricks to urban areas. These enterprises are relatively large in size (producing 10-20 million bricks per year) and are semi-mechanised, using extruders for shaping and employing tunnel or Hoffmann kilns for firing of bricks. The extrusion and tunnel kiln technologies that were imported from Eastern Europe during the 1960s and 1970s have now become fully indigenous in these countries. They produce solid as well as perforated and hollow bricks.

However, the situation in the peri-urban and rural areas of South Asia is markedly different. The bricks are made in privately owned, small-scale enterprises, generally clustered together on the periphery of urban areas. These enterprises (almost 50,000 in South Asia) operate only during dry months and have annual production capacities ranging from 2 to 10 million bricks. Bricks are moulded by hand and most of the material handling is also carried out manually. The bricks are dried under the sun

Bricks in Kathmandu valley

The city of Kathmandu has grown from 400,000 inhabitants in 1990 to over 1.5 million and the civil war has even increased this rapid urban growth. Altogether more than 5 million people live in the Kathmandu valley. It is estimated that Kathmandu consumes about 1.7 billion bricks per annum with a growth rate of 11% per annum or doubling in less than 7 years.
The already crowded Kathmandu valley counted some 140 brick kilns and they were responsible for one-third of ambient air pollution. When the Government banned moveable chimney Bull's Trench Kilns in 2003, many owners switched to fixed chimney Bull's Trench Kilns.

Brick Industry in China

The brick history in China can be traced back to 2,000 years ago in the Qin Dynasty, when the world famous Great Wall was built using a large quantity of burnt clay bricks. Traditionally, solid clay burnt bricks were the main wall materials. China consumes the largest amount of wall materials in the world. The annual output of wall materials in China during 2004 was around 900 billion in terms of standard brick. Of this, about 600 billion is solid burnt clay brick, accounting for 65 per cent of the total; new wall materials (hollow clay brick, coal spoil brick, fly ash brick, shale brick, and burnt clay lath brick; and non-burnt brick, including brick, block and slab made from cement, limestone, gypsum or other organic plastering agent) account for about 35 per cent of the total.

Chinese brick production is characterised by use of extruders for brick forming and the use of Hoffmann and tunnel kilns for firing of bricks for medium- and large-scale production. Several types of traditional kilns are used for firing bricks in rural areas on a smaller scale. It is in this segment that VSBK gained popularity and reached its peak during the 1990s. In 1992, concerned with the destruction of farm land due to brick-making, the State Council issued policies to strictly limit the use of solid burnt clay brick. The State Tax Bureau issued favourable tax policies to promote the development of new wall materials, which contribute to energy conservation and waste utilisation. The policy to limit use of solid clay fired bricks has led to a decline in VSBK kilns.

The Chinese Government has set a basic national policy of developing new energy-saving wall materials and reducing the production of traditional solid burnt clay bricks. Burnt clay brick is allowed when there is easy access to clay resources without destroying farmland. However, the output of hollow clay brick should be increased.
At the same time, new wall materials, including all kinds of masonry materials and slabs which use less or no clay, should be developed. According to the development strategy set by the former State Bureau of Building Materials Industries, the proportion of new wall materials should reach 40 per cent, and 60 per cent in the years 2010, and 2030 respectively.

(Based on an article posted on the website of China Building Materials Information: http://english. cbminfo. com)

and fired in a continuous kiln called Bull's Trench Kiln. All the operations are labour-intensive and typically, each enterprise employs 100 to 200 labourers. The industry provides seasonal employment to more than 5 million workers. These traditional enterprises have shown tough resistance to any change in technology and work organisation.

2.2. DIFFERENT TYPES OF BRICK KILNS

The brick firing process consists essentially of increasing the temperature of the bricks progressively over a period of time, holding it at a peak temperature (at about 800-1100°C), and then cooling back to the ambient temperature. Several chemical and physical changes take place in a brick during this process. They include removal of mechanical moisture or drying of bricks; combustion of inherent carbonaceous matter; decomposition of the clay molecules and evaporating of chemically combined water; and finally vitrification, a process of forming new mineral phases including liquid phases, which on cooling set as glass phases and provide strength to the fired brick. During its 6,500 years of history of firing bricks, humankind has used a large variety of kilns. Over the years, brick kilns have basically evolved from rudimentary 'intermittent' kilns to more complex, energy-efficient 'continuous' kilns.

In intermittent kilns, bricks are fired in batches. Generally, bricks and fuel are stacked in layers and the entire batch is fired at once; the fire is allowed to die down and the bricks allowed to cool after they have been fired. The kiln must be emptied, refilled and a new fire started for each load of bricks. In intermittent kilns, most of the heat contained in the hot flue gases, in the fired bricks and in the kiln structure is thus lost. Clamp, scove, scotch and downdraught kilns are examples of intermittent kilns. Such kilns are still widely used in several countries in Asia, Africa, and South and Central America as well as in some parts of England and Belgium.

In a continuous kiln, on the other hand, the fire is always burning and bricks are being warmed, fired and cooled simultaneously in different parts of the kiln. The heat in the flue gases is utilised for heating and drying green bricks, and the heat in the fired bricks is used for preheating air for combustion. Due to the incorporation of heat recovery features, continuous kilns are more energy-efficient. Such kilns can be further sub-divided into two categories: moving-fire kilns and moving-ware kilns.

In a moving-fire kiln, the fire moves progressively around a closed kiln circuit (**figure 1**) while the bricks remain stationary. The kiln circuit can be oval, rectangular or circular. Brick firing takes place over a narrow zone, as shown in the figure. Because of the counter flow arrangement, the incoming air encounters hot bricks exiting from the combustion zone. As such, air is preheated (and bricks are cooled) before entering the combustion zone. The combustion products (flue gases) from the combustion zone pass over the green bricks, resulting in the preheating of bricks (and cooling of flue gases). The fire travels in the direction of airflow. A chimney stack and/or a fan provide the necessary draught. Bull's Trench Kilns (the main kiln type for firing bricks in South Asia) are an example of a moving fire kiln (figure 2).

In a moving-ware kiln, the fire remains stationary, while the bricks and air move in counter-current paths. In a tunnel kiln, a horizontal moving-ware kiln, goods to be fired are passed on cars through a long horizontal tunnel (figure 3). The firing zone is located at the centre part of its length. Cold air is drawn from the car exit end of the kiln and is cooling the fired bricks. The combustion gases travel towards the car entrance losing a part of their heat to the entering green bricks. The cars can be pushed either continuously or intermittently at fixed time intervals. The tunnel kilns have provision for air extraction and supply, at several points along the length of the kiln.

The vertical shaft brick kiln (VSKB) is another example of a moving-ware kiln. In this kiln the movement of bricks is in a vertical downward direction, and upward air movement is brought about by natural convection (see photo next page and figure 4, page 38).

Figure 1: Moving Fire Kiln Circuit

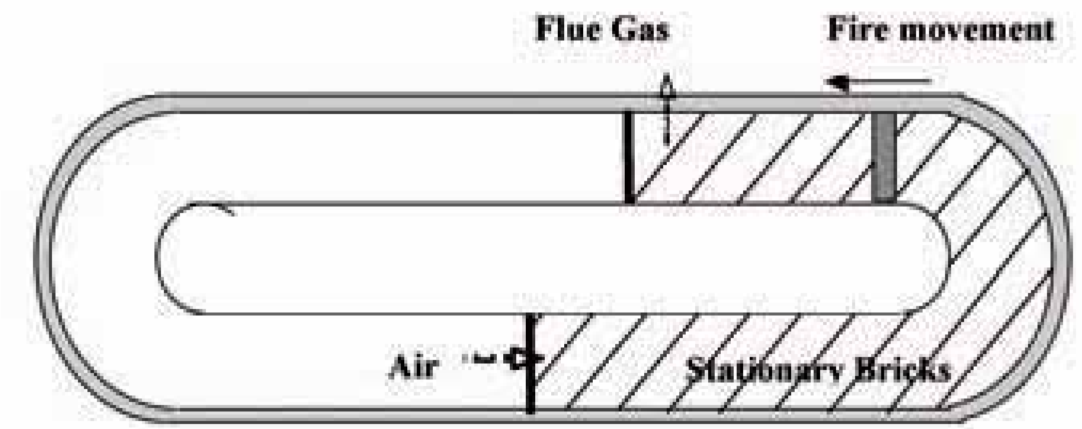


Figure 2

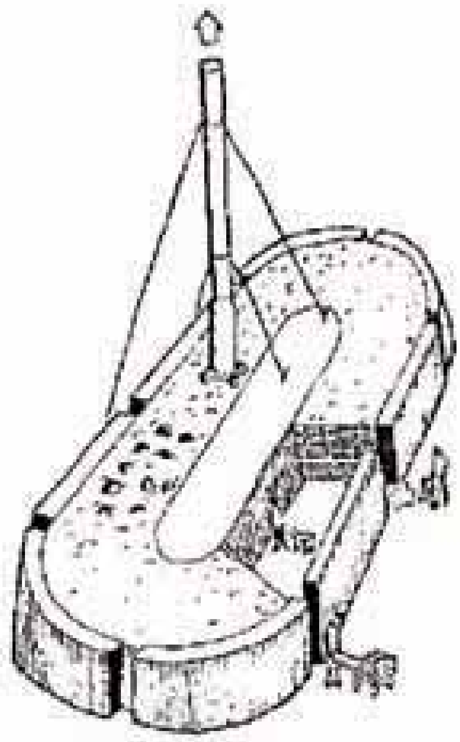
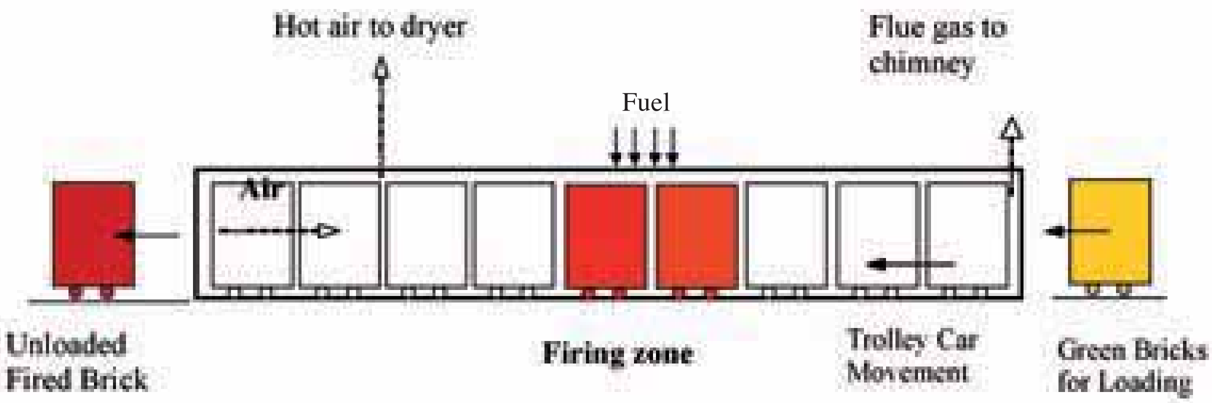


Figure 2: Bull's Trench Kilns are continuous kilns with either a moveable or a fixed chimney. They require only small investments and can operate even on leased lands. The fire moves through the bricks stacked in the oval trench.

A VSBK in Orissa, India with two shafts. The green bricks are loaded from the platform above and then move downwards through the shaft and cross the firing zone. Bricks remain in the kiln for 20-30 hours.

Figure 3: Tunnel Kiln



A moveable chimney BTK in Nepal: a highly polluting technology. The two chimneys are moved by the firemen at regular intervals to bring forward the firing zone of the oval kiln.

A fixed chimney kiln is usually larger than a moveable chimney BTK and can produce up to 8 million bricks per year. The chimney is higher and fixed and the firing zone moves around by opening and closing dampers.

2.3. VSBK – THE MOST ENERGY-EFFICIENT KILN

2.3.1. THE SPECIFIC ENERGY CONSUMPTION (SEC)

Table 1 presents a comparison of the specific energy consumption (SEC). The SEC is expressed in terms of energy required in MJ for firing 1 kg of bricks. Observing that VSBK has the lowest specific energy consumption, it is the most efficient kiln for firing common bricks. It saves 30-40% energy compared to BTKs and more than 60% compared to intermittent kilns. It is even more energy-efficient than the tunnel kiln.

Notes (regarding figures of table 1):

1. Specific coal consumption corresponds to gross calorific value of coal as 18.8 MJ/kg (4,500 kcal/kg) and for a fired brick weight of 3 kg.

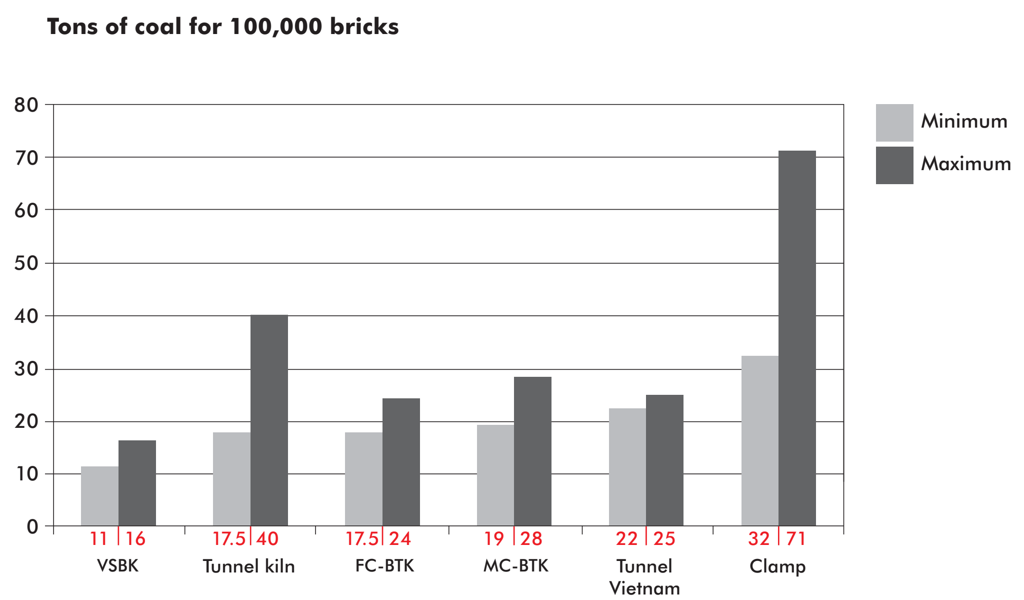
2. In the case of tunnel kilns, hot air from the kiln is supplied to the tunnel dryer. Hence the specific energy consumption also includes the energy supplied to the dryer.

3. The SEC values for kilns except tunnel kilns in Germany are taken from energy monitoring reports of the VSBK projects in India and Vietnam.

4. The SEC value for German tunnel kilns have been taken from the report of E. Rimple based on monitoring of 65 kilns by IZF, Essen, Germany (Rimple E. Good Housekeeping in Vietnamese Brick Factories, VSBP report, 2004)

Table 1. Comparison of Kilns: Energy Use

Type of kiln	Specific Energy Consumption (MJ/kg of fired brick)	Specific coal consumption (tons/100,000 bricks)
VSBK (India, Nepal, Vietnam)	0.7-1.0	11-16
Fixed chimney BTK (India)	1.1-1.5	17.5-24
Moveable chimney BTK (India)	1.2-1.75	19-28
Tunnel kiln (Nam Dinh, Vietnam)	1.4-1.6	22-25
Modern tunnel kiln (Germany)	1.1-2.5	17.5-40
Clamp and other batch kilns (Asia)	2.0-4.5	32-71



The basic relations between bricks and coal consumption for different kilns in tons of coal used to produce 100,000 bricks (of 3 kg each)

2.3.2. FUNCTIONING OF THE VSBK

The Vertical Shaft Brick Kiln technology has evolved from the traditional updraught kilns in rural China. The history of VSBK can be traced back to 1958. However, the wide-spread dissemination of the technology took place in the wake of economic reforms initiated in 1979 by Deng Xiaoping. The technology was adopted by thousands of farmers, who went into brick-making when this activity was allowed to be performed by the small private sector and the State monopoly fell. At its peak during the mid-1990s, there were more than 50,000 VSBKs operating in China.

The main element of the VSBK is the vertical shaft (of rectangular or square cross-section) in which the brick firing takes place. From the ground level, the green bricks are transported up the earthen ramp, a mechanical lift or a belt conveyor to the top-working platform. The green bricks are loaded, along with coal, into the shaft from the top and the fired bricks are unloaded from the bottom. At the bottom, a screw jack and trolley system is used for unloading bricks from the shaft. The unloaded fired bricks come out of the kiln through the unloading tunnel at the ground level.

The kiln works as a counter-current heat exchanger, with heat transfer taking place between the upward moving air (continuous flow) and downward moving bricks (intermittent movement). The maximum temperature is achieved in the middle of the shaft where fire is maintained. At an interval of 2 to 3 hours, a batch of fired bricks is unloaded at the bottom. A batch of bricks consists of four or six layers of bricks.

One of the larger VSBKs in China. With Deng's reforms allowing private sector initiative, these small- and medium-sized vertical shaft bricks kilns had sprouted up across in China.

2.3.3. WHY IS THE VSBK THE MOST ENERGY-EFFICIENT KILN?

To understand why the VSBK is the most efficient kiln, we have to understand that in a brick kiln only a small part of the heat is utilised for the firing and drying operations and most of the heat is lost. Energy balance for a tunnel kiln[9] is shown in Figure 5 indicating that almost 58% of the energy supplied to the kiln is lost in in flue gases, fired bricks and from the kiln surface. Compared to other kilns, the VSBK has lower heat losses, which make it more efficient. To illustrate this statement, let us look at the two main heat losses in Figure 5:

1. Energy loss in fired brick and flue gases: The fired bricks coming out of the kiln are at a temperature higher than the ambient temperature and thus a part of the heat contained in fired bricks is lost. Similarly, the hot flue gases leaving the chimney also contain heat. The higher the temperature of the fired brick at the kiln exit, the higher the measurable heat loss in fired bricks would be. The flue gas loss depends both on the temperature and on the flow rate of flue gases. Thus the fired bricks and the flue gases coming out of the kiln should be at the lowest possible temperatures. Further, fired brick and flue gas temperatures depends on the efficiency and completion of heat transfer process between air and bricks inside the kiln.

VSBK has a very efficient counter-flow heat transfer arrangement. The key to this is the brick setting arrangement. Figure 6 shows a typical brick arrangement in a layer in a VSBK. Here, bricks do not touch each other and every brick has air passages on all the four sides. All the four sides of a brick thus come into contact with air, which results in a high heat transfer area per brick. In contrast, in BTKs the bricks are arranged in the form of solid columns and bricks set inside the column do not directly come into contact with air, resulting in lower heat transfer area per brick. The heat transfer process in a VSBK is so efficient that the flue gases coming out of the shaft are cooled down to around 100°C , while the fired bricks at the bottom have temperatures in the range of 100-150°C.

2. Heat loss through kiln walls: In a brick kiln, the inside temperature in the firing zone is around 1,000°C. Kiln walls separate this high temperature region from the ambient which is at a much lower temperature (0-50°C). Due to this huge temperature difference between the inside and the outside, heat is conducted from inside to the outside through the wall and is lost from the outside surface of the wall. Kilns such as BTKs and tunnel kilns are very long and have large exposed surfaces and considerable amounts of heat is lost through kiln walls and

Figure 4: Vertical Shaft Brick Kiln

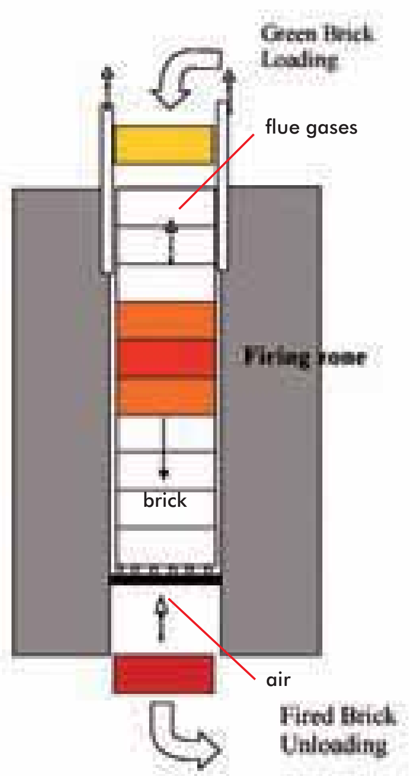
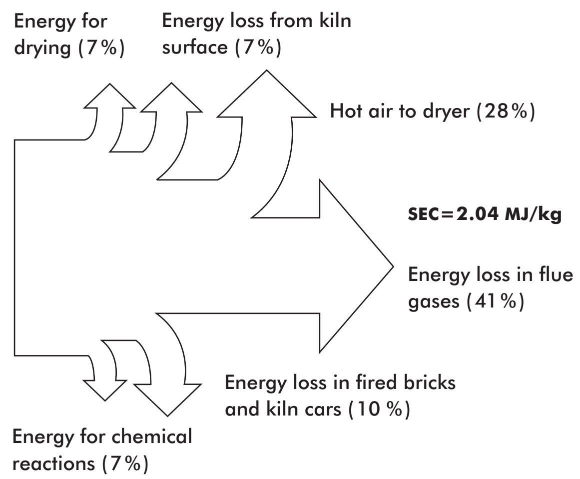
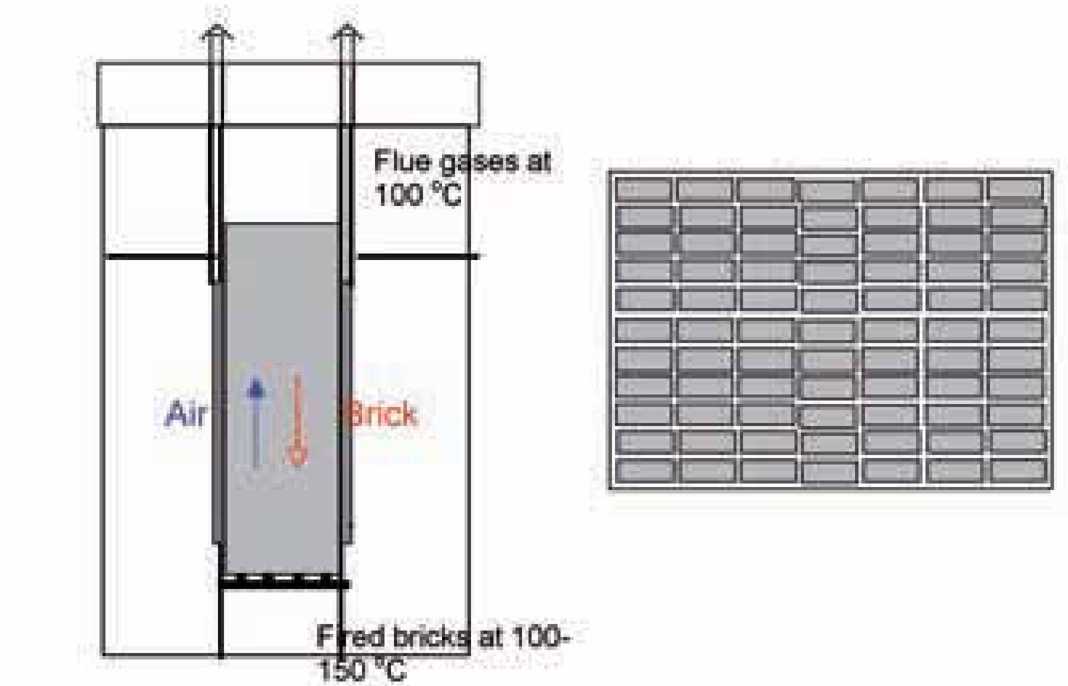


Figure 5: Heat balance for a tunnel kiln



Reasons for the high efficiency of VSBKs: The figure shows how the bricks move through the firing zone from the loading platform on the top to the unloading place at the bottom.

Figure 6: Stacking of Bricks in a VSBK



This figure shows the stacking of bricks allowing the heat access to large surface area of bricks. The fired bricks (bottom) pre-heat the air towards the firing zone and the exhaust flue gases (top) will pre-heat the green bricks.

to the ground. In comparison, a VSBK has a short shaft, insulated by a 1.5 m thick wall on all the sides. Moreover, the VSBK is the only kiln in which the firing zone is not in contact with the ground. Thus better insulation results in lower heat loss from the kiln surface.

2.4. VSBK IN COMPARISON WITH OTHER KILNS

We have seen in the last section that in terms of specific energy consumption, VSBK emerges as the most efficient kiln. However, energy efficiency is not the only criterion for selecting a technology. Other criteria are equally important and the final decision depends on the weights or the importance assigned to various criteria. Here we compare VSBK with other kiln technologies with respect to criteria related to:

a) Environmental performance
b) Social performance
c) Brick quality
d) Capital requirement and profitability

2.4.1. ENVIRONMENTAL PERFORMANCE

The overall environmental performance of a brick kiln depends on such factors as energy efficiency which is linked to CO_2 emissions; air pollution in the form of CO, SPM, SO_2, HF emissions; ambient air quality in the vicinity of the kiln and its impact on humans and vegetation.

VSBK: On all the environmental performance criteria, VSBK scores are high. It is most energy-efficient and has lowest CO_2 emissions. It also has low specific emissions of SPM and HF [10,11]. Initial Chinese VSBK designs had problems related with poor ambient air quality at the loading platform. This problem has been solved through the incorporation of properly designed chimneys and well-ventilated loading platforms.

Tunnel kiln: Tunnel kilns, if designed and operated properly, also have high environmental performance. Experience in Vietnam has shown that by avoiding air leakages in the kiln, operating kilns at their designed capacities and reducing the mass of kiln cars, tunnel kilns can be made more efficient and their environmental performance improved.

Bull's Trench Kilns: BTKs have poor environmental performance, particularly due to heavy air pollution and fugitive dust emissions.

Clamps and intermittent kilns: Clamps also have poor environmental performance, particularly in view of their very high energy consumption, as well as heavy air pollution during firing. For rural units and small-scale production – self supply of rural population – it may still be the most suitable solution.

A relative comparison of environment performance of brick kilns is shown in Table 2, where it can be seen that VSBK and tunnel kiln have a better environmental performance compared to BTKs and clamps.

Table 2. Comparison of Kilns: Environmental Performance

Kiln	Environmental Performance
VSBK	High
Moveable and fixed chimney BTK	Low
Tunnel kiln	High
Clamp and intermittent kilns	Low

2.4.2. SOCIAL PERFORMANCE

There are a variety of social indicators that can be used to define social performance of a kiln. From the view of working conditions, indicators such as occupational health risks for workers and drudgery are important. In the context of developing countries, decentralised production is desirable, and thus suitability of the kiln technology for small-scale production would be considered an important social indicator.

VSBK: On social performance indicators, a properly designed VSBK scores highly. Through incorporation of chimneys, mechanisation of green brick lifting and brick loading process, it is possible to minimise occupational health risk and drudgery for workers. VSBK has been found to be a suitable technology for small- and medium-scale production (500,000 to 4 million bricks per year).

Tunnel kiln: Tunnel kiln operations are generally safe for workers and drudgery is minimised through mechanisation. However, the tunnel kiln is not suitable for small- and medium-scale production and is generally used for production of excess of 10 million bricks per year. A highly mechanised tunnel kiln can reduce employment opportunities drastically.

BTK: the BTK poses several occupational health risks for workers, particularly firemen, who are exposed to excessive heat, dust and gases. As the entire kiln operations including fuel feeding, loading and unloading of bricks are manual, drudgery is high in BTK operations. In terms of production capacity, BTKs are quite suitable for medium scale production (2 to 8 million bricks per year).

A few minutes after the firemen have fed coal, the chimneys of this (moveable) BTK emit thick, black fumes of soot due to incomplete combustion of coal is blown out with flue gases. A serious source of air pollution.

These firemen from northern India working on a BTK in Nepal are exposed to many occupational health hazards: the temperature on top of the kiln is in excess of 80-90°C and their footwear (chappals) would melt unless they are made of wood. Coal dust, ash and other flue gases are omnipresent.

Clamps and intermittent kilns: arranging green bricks and fuel as well as unloading of fired bricks are all manual operations and involve a lot of drudgery. However, clamps and intermittent kilns generally do not pose the severe occupational health risks of BTKs. Clamps and intermittent kilns are suitable for small-scale, decentralised production.

Table 3 gives a comparison of kilns in terms of their overall social performance. VSBK scores over other kilns on most of the social performance indicators.

Table 3. Comparison of Kilns: Social performance

Kiln	Social Performance
VSBK	High
BTK	Low
Tunnel kiln	Medium
Clamp	Medium

2.4.3. BRICK QUALITY

It is desirable that a brick kiln provides a high percentage of high-quality bricks and the number of rejects and breakages is as low a percentage as possible. The ability of a kiln to produce good-quality bricks from a variety of raw materials (clays) generally depends on the rate of heating and cooling, as well as the operator's control over the firing process; generally, a slow firing kiln or a kiln with better control is able to handle much wider variety of clays. Another important property is the kiln's ability to fire a variety of products (solid bricks, hollow bricks, tiles and so on). A kiln's suitability to fire hollow bricks is an important parameter because hollow brick production requires both less energy and less clay, and walls made up of hollow bricks have better insulation properties.

VSBK: The quality of fired brick depends to a very large extent on the quality of green bricks. The VSBK produces better quality and has lower breakage rates when the green bricks are of good quality (adequate strength, regular shape and size and so on) for example when they are produced using machines such as extruders and soft-mud moulding machines. In China and Vietnam, where all the bricks are extruded, VSBK fired brick quality is better compared to the quality of bricks fired in traditional kilns. In India and Nepal, VSBK has given good results with hand-moulded bricks also. VSBK can have quality problems at places where the green brick quality is poor, as well as with clays that are not able to withstand thermal stresses developed due to fast heating and cooling of bricks in a VSBK (e.g. some places in northern Indian plains).

VSBKs have generally been used to fire solid bricks in South Asia. Nevertheless, VSBK has been used extensively to fire hollow bricks in Vietnam. However, VSBKs can fire bricks with 15-20% hollows only; for larger hollows the breakage rates are observed to be high. Thus, VSBK has some limitations in its ability to fire a large variety of clays as well as its suitability to fire a wide range of clay products.

Tunnel kiln: Tunnel kiln is the best option on all parameters, be it quality of fired bricks, control over the firing process, ability to fire a variety of clays as well as to fire diversified products, including a variety of hollow bricks.

BTK: Due to large temperature differences within the kiln, a large variation is observed in the quality of fired bricks in a BTK: generally only 70% of the bricks are of the highest quality. The firing process in a BTK is very slow (typical heating and cooling rates of less than 25°C/hr) and thus the kiln is able to handle a variety of clays. BTK is not as versatile as a tunnel kiln in its ability to fire a variety of hollow bricks.

Clamps and intermittent kiln: There is generally very little control over the firing process in clamps and intermittent kilns, so a large variation in brick quality is observed within a batch as well as from one batch to another. Generally, the quality of the fired product as well as the percentage of saleable bricks is low compared to other technologies.

In terms of comparison in brick quality the tunnel kiln emerges as the best option (table 4).

Table 4. Comparison of Kilns: Brick quality

Kiln	Brick Quality
VSBK	Medium
BTK	Medium
Tunnel kiln	High
Clamp and traditional kilns	Low

2.4.4. CAPITAL REQUIREMENT AND PROFITABILITY

Capital required for a technology is perhaps the most important financial criterion which influences the decision of a brick-maker or any entrepreneur. In Table 5, a comparison is presented on the capital requirement for setting up a kiln along with capital required per million bricks of annual production capacity. Here we see that the capital cost as well as capital required per million bricks produced annually is higher for VSBK compared to traditional kilns. As we shall see in later chapters, in certain regions this is an important barrier in the wide-scale dissemination of the technology.

Return on investment (ROI): What counts for an investor is the return on investment, especially in an entrepreneurial environment which hesitates over long-term investments. The ROI for different kilns in Nepal shows very clearly that it pays to pollute and that it is costly to be energy-efficient and environmentally friendly. As shown in Table 6, moveable chimney BTKs (MC-BTKs) have ROIs of 135% per year, FCBTKs a ROI of 80% and VSBKs a ROI of 40%.

The conclusion from this table (presented in more detail in Chapter 6.2.5.) is not that VSBK is not profitable: a 40% ROI is indeed an excellent investment. However, if the polluting alternatives have so much higher ROIs, nobody is interested in any change as long as there are no financial incentives (carbon finance) or strong regulatory disincentives.

2.5. THE BEGINNING OF THE SAGA: SDC DECIDES "TO GO"

We have seen that VSBK is the most efficient brick kiln; it also scores highly on environment and social criteria (Table 7). But in the early 1990s the question facing SDC and other development cooperation agencies was: how could this knowhow be transferred to other countries in Asia? There were – of course – no blueprints available, and by far not all of these 50,000 kilns in China were

Table 5: Capital requirements for brick enterprises based on different types of kilns, including land and equipment cost

	Product	Typical total fixed investment requirement for setting up the enterprise (US$)	Typical production capacity (million bricks/year)	Capital requirement per million bricks annual production capacity (US$)
Moveable chimney BTK enterprise (Nepal)	Hand-moulded solid bricks	35,000	4	8,750
Fixed Chimney BTK enterprise (Nepal)	Hand-moulded solid bricks	70,000	8	8,750
VSBK (4-shaft) enterprise (Nepal)	Hand-moulded solid bricks	100,000	4.5	22,222
Mechanised VSBK (2-shaft model Vietnam)	Extruded hollow bricks	160,000	4 (equals 3 million of brick size in South Asia)	53,000
Tunnel kiln (Vietnam)	Extruded hollow bricks	600,000	15	40,000

Table 6: Return on Investment (ROI) of BTKs and VSBKs in Nepal (in Nepalese Rupees NPR)

Investments and returns	MC-BTK	FC-BTK	VSBK (4-shafts)
Production capacity p.a.	4 million bricks	8.1 million bricks	4.5 million bricks
Total Fixed Investment	NPR 2,238,000	NPR 4,505,750	NPR 6,330,000
Returns (profits) first year	NPR 3,018,480	NPR 3,591,518	NPR 2,523,640
Returns (profits) three years	~ NPR 9,000,000	~ NPR 10,000,000	~ NPR 7,500,000
Return on investment (ROI) in %	135%	80%	40%

Table 7: Relative performance comparison of brick kilns

	Energy efficiency	Environmental performance	Social performance	Brick quality	Capital requirement and profitability
VSBK	Strong	Strong	Strong	Medium	Medium
Tunnel kiln	Medium	Strong	Medium	Strong	Medium
BTK	Medium	Weak	Weak	Medium	Strong
Clamp and intermittent kiln	Weak	Weak	Medium	Weak	Strong

so energy-efficient, as most of them had been built by former farmers and very little technical inputs had been available. So, many of these kilns were just informal sector undertakings, some working at near optimal performance, but many were just operating 'somehow' and produced mediocre quality of bricks. Moreover, most kilns did not apply any environmental norms and the local pollution for the firing men was astounding.

With SDC initiating a new programme in India to tackle global environmental problems, it focused on interventions in the small-scale industry sector. The glass industry, foundries, biomass gasifiers and the brick industry were selected as main areas for intervention, and the entire programme was conceived as an action-research programme. For the VSBK it meant a technology transfer programme from China to India, but it was leading much beyond technology. The following Part Two tells the story of this transfer of expertise to other countries in Asia: the VSBK saga.

PART TWO: THE VSBK SAGA – SDC'S ATTEMPT TO INITIATE CHANGE IN INDIA, NEPAL AND VIETNAM

This is the story of the VSBK interventions initiated by SDC in Asia in 1996. It is a story of many successes but also failures. The lessons learned during this technology transfer process have been many. An extremely valuable 'competence group' has been created spanning India, Nepal and Vietnam, Its players mastering not only the hardware of technology but also the software of social interventions and institutional innovations including access to carbon finance.

THE VSBK SAGA – HOW IT ALL BEGAN

3

The Swiss Agency for Development and Cooperation (SDC) initiated its first VSBK project in India in 1996. It was followed by brick sector projects in Nepal and Vietnam in 2003. During 2006 and 2007, the activities grew to Afghanistan and Pakistan, and – end 2007– a project in Cuba is in the planning pipeline. Over a decade full of SDC-funded VSBK technology transfer projects, they have made significant impacts on small-scale brick-making in each of the countries. Today a total of 500 VSBKs are operating in them.

Looking back, it was quite a bold decision to want to get into the brick sector. While the VSBK was indeed very promising, several attempts to transfer its technology had failed previously. At the outset, it was important to learn the lessons of these failures, and when SDC decided to opt for the VSBK and, as it were, give it a chance, it was after due and careful evaluation of these reasons for failure.

Despite this emphasis on failures, the VSBK saga narrated here is the story as much of struggle and success as it is of failures and lessons learned. The saga is set against the backdrop of the complex socio-economic realities of small-scale brick-making in developing countries and throws light on the sustainability challenges faced by the small-scale brick industry. It leads to calls for joint efforts and ploughing additional resources to assist the industry in its struggle to move from its 19th century moorings and find a place for itself in the 21st century.

The VSBKs in China were not always constructed with professional technical support and most of them had appalling working conditions, for example the workers were exposed to atrocious amounts of smoke while loading the bricks. Occupational health of workers did not rank high on the Chinese agenda of priorities.

3.1. A CHINESE TECHNOLOGY

The Vertical Shaft Brick Kiln (VSBK) technology evolved in China and was closely associated to the economic reforms initiated in 1979 that allowed private initiative in rural industries. Compared to the industrial Hoffman kilns, VSBKs required only a small amount of fixed investment and working capital. At the same time, the demand for bricks was steadily growing, in line with the overall economic growth of the Chinese economy. VSBKs gained popularity, mostly in rural areas, and by the year 2000 it is estimated that between 50,000 and 60,000 VSBK units were operating in China. Most of these kilns were used for small-scale brick-making and were operated by small informal sector entrepreneurs, mostly farmers.

While most of these small VSBKs spread in a 'wild', uncoordinated way, some were supported technically by the Energy Research Institute of the Henan Academy of Sciences at Zhengzhou. This support structure was also involved in the transfer process. Studies had showed a very good degree of technical performance and high energy efficiency. Yet as most kilns were self-constructed and did not follow any standard technical norms, it is unlikely that many operated at optimum efficiency. Moreover, many of these kilns were without chimneys and created appalling environmental conditions, with pollution levels at the working platform exceeding any decent workplace air quality norm.

Henrik Norsker, a Danish engineer, encountered the VSBK in China and played an important role in informing the outside world about the technology. From 1990 onwards, several attempts were made by bilateral and multilateral development agencies to transfer this technology to other developing countries, as the VSBK promised significantly higher energy efficiency than other traditional brick kilns used in Asian countries.

3.2. FAILED ATTEMPTS TO TRANSFER THE TECHNOLOGY

At the beginning, the road map of replication in other countries was paved with failures:

1. Nepal: In 1991, a twin shaft VSBK was constructed at the Kathmandu Brick Factory under a GTZ-GATE project. Later another VSBK was built in Biratnagar. "With an energy consumption of around 1 MJ per kg of fired brick, the energy saving potential of the VSBK technology was unquestioned. However, both kilns ran into early technical problems that the operators could not solve unaided"[12] and initial enthusiasm was eventually replaced by disappointment.

2. Bangladesh: With the assistance of SDC, a brick kiln owner from Dhaka visited a VSBK unit in Nepal and the entrepreneur subsequently built a kiln. The need for specialised technical assistance was again overlooked, and this pilot plant could never become operational. The entrepreneur made fundamental mistakes in kiln construction and failed miserably.

3. Pakistan: Several VSBKs were constructed, again under a GTZ-GATE project. Once operational, they were positioned as alternatives to the predominant BTKs (Bull's Trench Kilns). However, a BTK can produce between 15,000 to 50,000 bricks per day, while the VSBK with two shafts could only produce 3,000 bricks per day. This led to disappointment for the kiln owners, as their expectations were not met. As a consequence, the VSBKs did not make a significant breakthrough in Pakistan.

With these experiences, it became clear that rapid dissemination was not possible and to have attempted it would have been very risky. A more cautious approach was adopted: having learned from these failures SDC sent a team to Pakistan. Their observations visit significantly influenced the formulation of the Indian project.

3.3. ENTER SDC WITH AN ACTION-RESEARCH PROGRAMME

All these lessons learned made it abundantly clear that the transfer to a better brick kiln technology was very challenging. The only chance of success would be with a long-term action-research programme that would give continuous feedback about the precise needs of the brick industry. Two partners of SDC, SKAT and Development Alternatives, already had good experiences with such an action-research approach in the dissemination of micro-concrete roofing tiles (MCR) in India.

The key lessons from observation trips to China were:

1. "VSBK technology is not sufficiently developed as an alternative to large-scale brick production.
2. Basic technology development and further adaptation are required to optimise operating parameters and economics of operation.
3. The VSBK probably operates most successfully in a decentralised setup, where owner and family are fully and continuously involved.
4. The building up of local know-how as well as basic acceptance, is vital for the dissemination and sustainability of VSBK technology. For this, the crews from transferee organisations must have hands-on work experience in all phases of operation.
5. The technology providers, in this case the Chinese expert team, should be associated with the project on a long-term basis.
6. The first kiln should be under the control of the project till major improvements are implemented."[13]

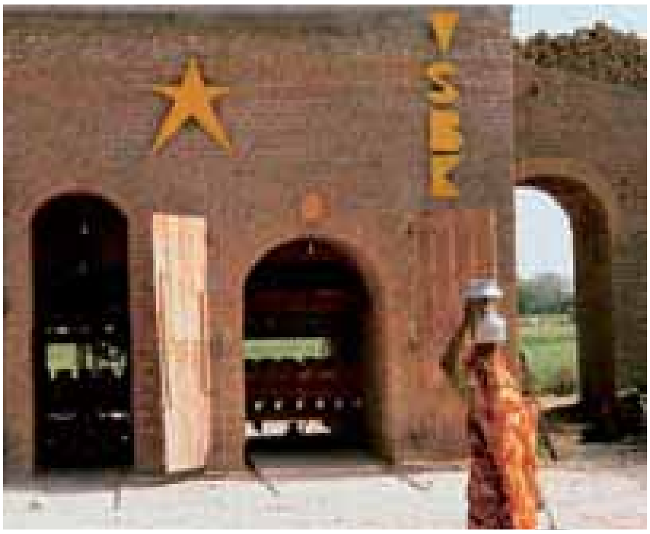
This kiln in Bangladesh was a bad copy of a kiln in Nepal; the entrepreneur tried to build a kiln without technical assistance and failed.

A delegation from India went on a study tour to China in order to grasp the intricacies of Chinese expertise. While the kilns were often quite rudimentary, many steps in clay preparation were already mechanised in China.

Energy saving alone was not a sufficient argument to the brick industry: if successful, an improved kiln needed to provide financial benefits and improved performance. An action-research programme may be seen by some as a waste of time but is indispensable to gather feedback and to fine-tune the technology to the needs of the industry. Even if the brick industry in India looks quite homogeneous at first glance, there are indeed fundamental differences between different regions: the soils, the traditions, the markets, the type and size of kilns, the fuel, the workers, the skills and the building habits vary considerably.

These lessons were then translated into an Action Research Programme with the following main characteristics:

The success of the action-research programme is mainly due to good cooperation between the Chinese and the Indian team: Mr. Yin Fuyin and Mr. Lakhsmikantan were the key persons for the technology transfer.



The first VSBK in India was erected in Datia in Madya Pradesh. The Chinese team assisted the operation and consisted of technical experts and practitioners such as firemen.

1. Positioning: Rather than promoting it as an alternative to the much larger Bull's Trench Kilns (BTKs), the VSBK was positioned against existing clamp kilns with similar capacities. Thus the first pilot kiln in Datia was erected next to a clamp kiln with a capacity of up to 5,000 bricks per day.

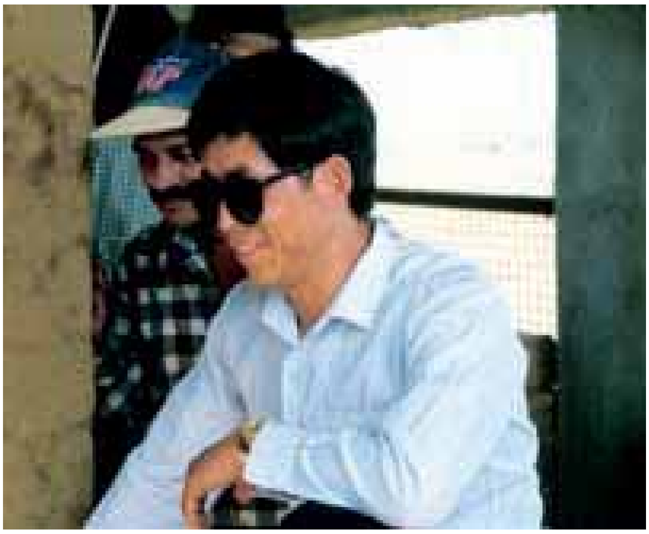
2. Technology inputs: A Chinese team consisting of two technology experts, Mr. Yin Fuyin and Ms. Yang Hongxiu, firemen and an interpreter, was engaged on a long-term basis to set up and test fire the kiln in Datia and to provide continuous technical assistance – not only as technology experts but also to train local firemen and the construction team.

3. Multi-disciplinary team: Rather than straight away transferring the technology to an entrepreneur, a multi-disciplinary team was created to receive, master, adapt and further develop the technology from China. This team consisted of Development Alternatives (DA) as a leading actor in building materials and the then-Tata Energy Research Institute (TERI) as a leading energy research organisation in India. They were supported by SKAT in a backstopping role. The Brick Action-Research project was further integrated into the overall small-scale energy efficiency work of SDC coordinated by SORANE, which targeted interventions in the glass, foundry and sericulture industries.

4. Multi-stakeholders: It was envisaged from the outset to disseminate the technology in partnership with a variety of stakeholders: private entrepreneurs, brick-makers and new entrepreneurs, commercial organisations and NGOs. SDC played the role of an actively involved donor organisation in order to ensure the cooperation of all participating institutions. This was by no means an easy task: many different organisations were willing to participate in the action-research programme on an eye-to-eye basis; they accepted a coordinating role of SDC but would not have accepted such a role by one of the peer organisations.

3.4. THE FIRST PILOT KILN IN DATIA, MADHYA PRADESH

After careful examination of ten potential sites, the first VSBK was erected on the outskirts of Datia in Madya Pradesh, mainly for pragmatic reasons: Development Alternatives already had a strong base in the Bundelkand region and was working intensively on alternative building materials.
The brick entrepreneur, Mr. Aslam, was owner of a clamp kiln, and he and Development Alternatives agreed to construct and operate the VSBK on the basis of shared



Chinese firemen assisted the Indian team from kiln construction to firing. They worked very hard under extreme conditions, rarely with such a clean white shirt.

Technical experts from TERI and DA, along with Swiss experts, worked on improving energy efficiency and environmental conditions for the workers: chimneys and damper systems were introduced in order to reduce the exposure of workers to flue gases on the platform.

responsibilities. With the assistance of the Chinese team, construction of the first VSBK started in March 1996 and was completed within 45 days.

By end of April the first shaft was fired, and the second shaft on 10 May. The Chinese team assisted the Indian firemen from initial firing to stabilising the fire, to troubleshooting and improving firing methods to achieve high energy efficiency and good quality bricks. "They lived and worked with their Indian counterparts at the kiln site and transferred their knowledge and experience effectively"[14]. This was no easy task in the Bundelkhand region during the hottest months of April, May and June, when the temperature rises to nearly 50° C even without a fire in the brick kiln.

The first VSBK had two shafts and could process some 4,500 bricks per day, roughly one-third of the smallest BTK and one-tenth of a large BTK. During the 'normal' firing season of six months, a VSBK could thus produce some 800,000 bricks, a very small number for the conventional brick industry. The fact that it could produce twice that number as an all-year-round operation was not such a striking argument: brick-makers were accustomed to seasonal operations, the moulders were usually agricultural labourers without a job in the dry season, and if bricks were to be fired during the monsoon they had to be dried and stored in a safe place. All this was new to the industry. And even for a clamp owner with a batch firing operation – it takes normally up to 20 days from the start of making a clamp, firing and unloading the bricks – to switch to a VSBK operation with a 24-hour continuous firing operation was a big step. Every three to four hours, the firemen have to unload a batch of fired bricks from the shafts, day and night. If the crew falls asleep, the fire moves up the kiln and might even get extinguished. A VSBK needed constant operation and presence 24 hours a day.

Two key steps were taken, namely to introduce a thorough energy audit (by TERI) and environmental monitoring (by DA). They revealed very promising results, much better even than anticipated. While the energy consumption per kg of fired brick is 2.0 MJ in a clamp and 1.1 MJ in a (moveable chimney) BTK, it was only 0.79 MJ in the VSBK of Datia. To visualise this difference better: firing one brick of 2.5 kg consumes thus roughly 235 grams of coal in a clamp, 130 grams in a BTK and 93 grams in a VSBK – a saving of 60% compared to the clamp.

Also in terms of environmental pollution, the VSBK showed very interesting results: measurements showed Solid Particle Emissions of 600 to 2,127 mg/m^3 in three fixed-chimney BTKs while the SPM emission in Datia were only 53 mg/m^3, ten times less than the emission limits specified for Fixed Chimney BTKs by the government (750 mg/ m^3).

3.5. PILOT KILN WITH GRAM VIKAS IN KANKIA, ORISSA

These encouraging results of the first pilot kiln motivated SDC and the whole team to go ahead and initiate a second kiln. Rather than going with a private entrepreneur, this second kiln would also be operated in a protected environment. A cooperation agreement between Development Alternatives and Gram Vikas, a large NGO in Orissa, was signed. One of the main purposes of involving an NGO with a high social competence was to integrate the social dimension of the brick industry from the outset.

The first kiln in Kankia, Orissa, was meant to produce bricks for the building projects of Gram Vikas. At a later stage, Gram Vikas will see if the ownership of a brick kiln can be handed over to an entire community.

The second VSBK would be designed for a higher production of at least 7,000 bricks per day in two shafts. The original shaft dimension of 1x1 m was extended to 1x1.75 m, after the team in Datia were confident that such larger shafts could be unloaded. There had been some doubts – even on the part of the Chinese experts – whether the single screw mechanism for unloading could be manufactured in India.

The second VSBK unit was set up in Kankia in Orissa and was first fired in May 1997 after a construction period of 45 days. However, brick quality remained a matter of concern, due primarily to the poor soil quality for brick-making on the site. The safe storage of green bricks was another matter of concern since the site was often affected by rain and stormy conditions. While this second kiln indeed proved that construction in other areas was possible, it also showed that the VSBK is quite sensitive to local conditions such as green brick quality, humidity and staff handling. Equally important was the constant adaptation of the technology, not only of the centrepiece of brick-making, the kiln, but also the clay selection and preparation and the proper drying of bricks.

3.6. BUILDING LOCAL AND INTERNATIONAL CAPACITIES

Unlike several technology transfer projects that continue to rely on foreign technology expertise over a long period, SDC was determined to develop a strong local Indian team and at the same time to increase backstopping capacities. To this end, a multi-organisational and multi-disciplinary Indian team was assembled to anchor the technology. Very few members of this team had much prior experience of working in the brick sector, so a significant amount of resources were spent in enabling this team to acquire the necessary skills and expertise. SDC made sure that the Chinese team, along with the Swiss backstoppers, SKAT and SORANE, were available for an extended period of time in the field to give sufficient time to the local team to interact and learn from them. The project was constantly seeking Indian experts with different skills whose expertise could be utilised: technical, environmental, social and economic skills were in great demand.

Often, brick quality was not satisfactory for many different reasons: the clay was not optimal or not optimally treated and the VSBK was a much more delicate kiln than the robust BTKs or clamps. Even though many under- or over-fired bricks are produced in those kilns, the firing time is higher whereas a VSBK is not 'forgiving' if the clay is not well prepared. For this reason Swiss and Indian brick specialists were involved: one backstopper who played a crucial role was Hans Brauchli, an experienced ceramic engineer and successful brick entrepreneur who owns and operates two state-of-the-art tunnel kilns in Switzerland. Mr. Brauchli is manager of a family brick business established in 1863 and can count on brick production expertise over four generations. He was able to provide critical but highly professional expertise in all fields related to brick production and was without a doubt an excellent balance to the generally theoretical project experts.

His very basic practical and entrepreneurial inputs – in the form of green brick production, operation (firing schedule development) training, as well as the introduction of simple soil and brick quality testing tools – all established vital links to the fundamental requirements of the VSBK design and technology development. Mr. Brauchli's famous saying: "Rubbish in; rubbish out" is still the basic guiding principle that underlines the importance of considering the entire brick production process rather than focusing on the VSBK development only.

A similar role was played by Anand Damle from Pune, who was supporting many VSBK installations mainly in the South of India. He now assists the Brick programme in Vietnam. The emphasis on building local capacities yielded handsome results. By the end of the pre-dissemination phase the local and international teams had developed expertise in design, construction and operation of VSBKs; energy and environment monitoring; clay testing and project management, and was ready to take over all the responsibility of running the project.

3.7. ADAPTING THE TECHNOLOGY TO THE LOCAL CONDITIONS

Building up local capacities also proved to be crucial in adapting VSBK technology to the Indian conditions. The project team realised that technology adaptation is a constant requirement in the brick sector, as each new region has different characteristics in terms of quality of the soil, the firing temperatures, the fuel used, the moisture content and the size of the bricks, brick quality benchmark, workers' skills and management practices. In the initial years, the adaptation work resulted in:

a) Standardising the height of the shaft: In China most VSBKs are relatively low, and hence, the first VSBK at Datia had a shaft height equivalent to 8 batches of bricks (approximately 3.5 m). This height was less for the Indian bricks which, due to their large size required more time for heating and cooling. The low kiln height also resulted in higher heat losses. The shaft height was gradually increased and was later standardised at a height equivalent to 10 to 12 batches (4.5 to 5.4 m).

b) Introducing chimneys and flue systems to improve environmental performance: a major criticism of the VSBK in China was its poor ventilation at the top of the kiln. A large number of VSBKs in China were not equipped with chimneys, and as a result all the flue gases came out of the shaft. As the working platform at the top of the kiln was enclosed on all sides it was usually full of smoke and workers were exposed to flue gases while loading bricks in the kiln. The Indian project was aware of this problem, and the first VSBK constructed at Datia was equipped with chimneys. However, the team found that the chimneys did not have sufficient draught to remove all the flue gases and this led to the height and cross-section of the chimneys being increased. One important decision they took was to construct flue gas openings in the shaft at two levels. During the loading operation, the lower opening was connected with the chimney by opening a damper, resulting in better evacuation of flue gases. Another crucial innovation – potentially – was the concept of a lid to cover the shaft opening. However, this measure proved to be cumbersome and was never fully adopted by the firemen.

c) Introducing a ramp for loading of green bricks: it is very common to use donkeys for transporting material in the central region of India. The absence of electricity at most of the kiln sites meant that electrical hoist could not be used for lifting green bricks to the loading platform. The local brick-makers preferred to use donkeys

Better working conditions on the platform have been achieved with the introduction of chimneys and dampers so that all flue gases escape through the chimney while loading green bricks.

Suitable conveyer belts and lifts have been developed that can ease the drudgery of transporting green bricks as headloads onto the platform

to transport bricks to the top of the kiln. This led to the design of different types of ramps suitable for transporting bricks on donkeys to the top of the kiln.

d) Firing of bricks with internal fuel: in China, it is common practice to mix powdered coal along with clay for making bricks. The bricks thus have a considerable amount of internal fuel, making it possible to fire the bricks by adding only a small amount of external fuel. The addition of internal fuel is not very common in India, particularly in the northern plains. As a result, the use of large quantities of internal fuel required modifications in the brick setting as well as in the firing process.

3.8. THE FIRST COMMERCIAL KILNS

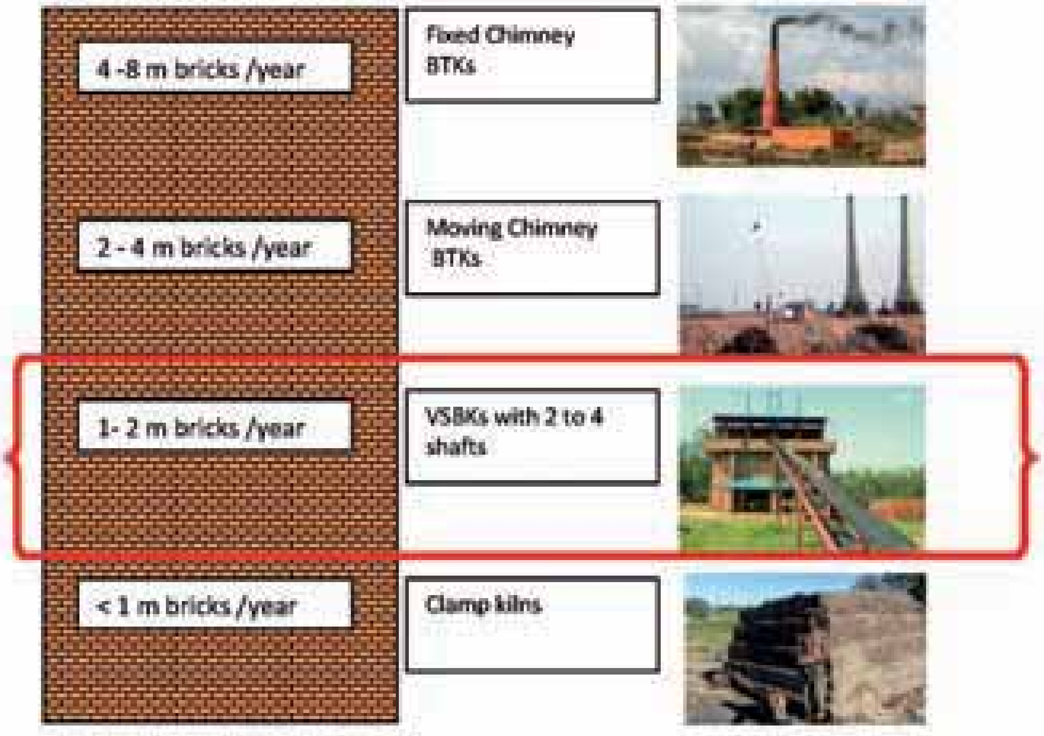
With over 100,000 existing brick kilns there was a huge theoretical potential for dissemination. Yet complex issues arose: where to start and how to position the VSBK, given the Indian brick industry's lack of homogeneity? There are considerable differences in soil conditions, social factors, types of kilns and operation and also market preferences. It has already been mentioned that VSBKs have a typical production capacity of 5,000 to 10,000 bricks per day, or roughly 1 million to 2 million bricks per year (in a seasonal production of 180 days).

The VSBK was thus positioned as an alternative to clamp kilns or smaller moveable chimney kilns with a production range of 1 to 2 million bricks per year. There was little chance to promote a VSBK as an alternative to a fixed chimney BTK.

In order to test the dissemination patterns, the India Brick Project tried to enter into commercial ventures with different partners:

1. Partnership with Comtrust in Kerala: The 'Commonwealth Trust India, Ltd' – also known as Comtrust – was a charitable corporate organisation which had been working in brick and textile production for over 150 years. It was originally created by the Basle Mission and aimed at combining the entrepreneurial spirit of industrialists from Basle, Switzerland, with missionary work in southern India. The Basle Mission had sent brick – and tile makers – from Switzerland and southern Germany to Kerala and was running large brick and tile factories. Comtrust decided to try out VSBK at its plant at Palghat, with a plan to close the existing Hoffmann kiln and shift to VSBK for firing bricks.

The cooperation with Comtrust raised hopes, given the company's outstanding experience in brick – and tile – making. Despite some problems encountered during the



construction of the kiln, the Palghat kiln produced excellent quality bricks: a good ring sound and a compressive strength of 180 kg/cm² were characteristics of the Palghat bricks. This was mainly due to the excellent clay quality but also a refined treatment of the soil and the use of a mechanised extruder.

Non-availability of dry bricks during monsoons emerged as a technical challenge for the year-round operation of the kiln. Palghat has a long monsoon season and experiences very high humidity levels for several months of the year. The drying of bricks took a long time (sometimes up to 45 days), and the final moisture content in the dried bricks was still high. In the case of the Hoffmann kiln, due to the slow firing process, it was possible to fire bricks having a high moisture content, but in a VSBK, firing of bricks with a moisture content of more than 6-7 % proved to be a problem. The project helped Comtrust in improving the drying process and also provided a biomass gasifier-based brick dryer.
Unfortunately, by then Comtrust was struggling with overall management problems and decided to close brick and tile production at Palghat. This promising experiment thus came to an end. The Palghat experience was important for the project as it showed that if the green bricks are of good quality then it is possible to get good quality fired bricks from VSBK.

2. Partnership with MITCON – Damle in Pune: The fourth kiln was constructed in Pune, Maharashtra, in partnership with MITCON, a consulting company and Damle Clay Structurals (P) Ltd, a technical consulting firm providing turnkey consulting services for the brick industry. The main objective of this partnership was the search for

A VSBK operated by Comtrust in Palghat, Kerala, unfortunately did not continue as the company decided to stop brick and tile production after more than a century in brick-making. Comtrust was the successor company of the brick works brought to India by the famous Basle Mission.

commercial partners and private entrepreneurs. In the surroundings of Pune the demand for burnt clay bricks is huge, but the quality of the soil and hence the product is poor. Customers are prepared to pay a higher price for good-quality bricks produced and transported from far away. A VSBK kiln owned by a private company was constructed in 1998. Poor brick quality and high breakage rates were major areas of concern in the first year of operation and it was difficult to get good-quality green bricks. The problem was subsequently overcome, through the installation of a de-airing extruder and a semi-automatic cutting table. This experience showed also the importance of looking beyond the kiln: soil selection, clay preparation and drying of green bricks is as important as having an efficient kiln if good-quality bricks are to be produced.

3. Commercial kiln in Gwalior: VSBK 5 was setup by Narayan Das Prajapati, a traditional brick-maker in Gwalior, Madhya Pradesh, who operates BTKs and large clamp kilns with a capacity to produce up to 800,000 bricks per month. He decided in 1999 to set up a VSBK to replace a moveable chimney BTK, first with two shafts and adding two more shafts by the end of 1999. He had produced over 3 million bricks in the year 2000 and up to 6.5 million bricks in the consecutive years. However, he ran into a problem of water scarcity from 2004 onwards and had to buy water from tankers for moulding the bricks – a costly exercise. At the same time the city of Gwalior expanded fast, and his land became so valuable that he sold the kiln in 2006.

As Narayan Das is a respected brick-maker, the VSBK-5 has virtually become a place of pilgrimage for brick-makers and many visitors have seen his kiln. Whether or not he has been successful in disseminating VSBKs will be dealt with in a later chapter on dissemination.

What were the prospects for a rapid dissemination of VSBKs? What were the main conclusions to be drawn from this pre-dissemination phase? Was investing in a VSBK a good business? Who should be targeted: primarily traditional brick-makers who know the business for many years? Clamp owners who wanted to rise socially and climb on a next step of sophistication? Or owners of moveable chimney kilns who wanted to have better social and environmental performance?

All these questions are more easily asked than answered. We shall first look at the economics of different kilns.

3.9. ECONOMICS OF THE VSBK: IS IT A GOOD INVESTMENT?

As the table below shows, the investment cost in a Fixed Chimney BTK enterprise is 2.3 million Rupees (US$ 50,000) compared to 1.5 million Rupees (US$ 37,000) for a VSBK enterprise. However, an FC BTK enterprise can produce 5.4 million bricks per year while a VSBK will only produce 2.4 million bricks. This number can be increased to 3 million bricks with an additional investment of 200,000 Rupees (US$ 5,000) in a drying shed that would allow all-year round production for 300 days per year.

At a first glance, the economic parameters of the VSBK [15] look quite favourable and there is a considerable savings potential on different aspects. These figures are very superficial and we shall look more closely at the economics of kilns in the chapter on Nepal. However, we can already say that, in practice, FC BTK owners look at their economics quite differently:

1. Whereas a VSBK needs to be built as a fixed structure, BTKs are temporary structures and can use rented or leased land;

Items	**Fixed Chimney BTKs**		**VSBK**	
Capital Investment	**Rupees INR**	**US$**	**Rupees**	**INRUS$**
Land	10 acres		5 acres	
Chimney/kiln	6 lacs	15,000	9 lacs	22,500
Other cost	2 lacs	5,000	2 lacs	5,000
Working capital	12 lacs	30,000	4 lacs	10,000
Total	23 lacs	50,000	15 lacs	37,500
Production capacity				
Daily production Number of firing days/year	30,000 bricks day 180 days per year		10,000 bricks/day 240 days (up to 300)	
Coal consumption Tons per 100,000 bricks	14 ton or more		8 ton or less	

2. While the working capital requirement is much higher, brick-makers are usually carrying lots of working capital and are much more reluctant to invest in fixed assets.

3. While savings in coal consumption translate into monetary savings, energy costs represent only 40% of the production costs. A saving of 6 tons of coal, or 40% of 14 tons is thus considerable, but in monetary terms it is not as significant as the higher investment.

4. It is a fact that, for the same production capacity of 30,000 bricks per day, a VSBK would require a twice as high investment – 45 lac Rupees instead of 23 lacs – in case the land can be leased.

This explains why, despite the very favourable environmental benefits of the VSBK, entrepreneurs are hesitant to jump on a new technology. As long as they can use their old technologies, especially if they have a 'licence to pollute', the VSBK cannot compete on the basis of ROI. For broad dissemination the VSBK will either need to get financial incentives for less pollution or the BTKs and clamp kilns need to be banned or restricted through environmental regulation.

However, before we look at the large-scale dissemination strategies we shall look at other strategic issues of sustainability, namely techno-social integration.

INDIA: FROM TECHNOLOGY TRANSFER TO TECHNO-SOCIAL INTEGRATION

4

While the VSBK programme in India had started as a CO_2 reduction project financed under the Global Environment Programme of SDC, it could not end by only looking at the environmental performance. If the brick-making industry were to become truly sustainable, it should also address the other key dimensions of sustainability, the economic and social dimensions.

This was, put simply, easier said than done: how was one to bring a social dimension into such an archaic industry where an entire industrial reserve army of migrant labour was desperately seeking any kind of job they could get? In the many thousands of villages in the poorest areas of India, in Uttar Pradesh, Bihar, West Bengal and Orissa there was no work for most landless people during the dry season, and even those who had some land could not grow anything on it. Thus, the working conditions on most brick kilns had no incentive to be anything but appalling and there was little scope for any change.

Or was there still a possibility that a new technology could also serve as an entry point to discussion on, and ultimately change, in working conditions? These questions raised by SDC led to an intensive debate about integrating social action along with technological intervention or techno-social integration.

Making the Asian brick industry sustainable should not end with the environmental dimension. Social aspects are as important: an 'industrial reserve army' of migrant workers are exposed to drudgery, misery and occupational hazards in this huge industry employing millions of people.

4.1. THE BROADER SCOPE: INTEGRATING THE SOCIAL DIMENSION

What could be done, what room was there, to improve the social conditions of the workers? First of all, this question in itself was quite challenging for the implementing partners of the India Brick Project, as most of them were technology organisations. It took considerable effort to get it understood, and some conceptual guidelines were provided by Sunil Sahsrabudey, a resource person for the social action component. The brick sector in India employs millions of workers and most of them live for 7-8 months with their families on the work sites. "Both the conditions of work and the habitat are extremely hazardous and unsanitary: Absence of any form of security, low wages, no healthcare facilities, no education for children, unsafe and hard conditions for women and all this far away from their parent village characterises the life of the workmen and their families... About half of the brick sector consists of small-scale enterprises. These are the clamps. Apart from the northern region stretching east to Kolkata, the entire country uses bricks from the clamps. The small-scale sector has a strange capacity to survive against heavy odds." [16] Through discussions over several months, a framework for social intervention emerged. It consisted of actions to improve the social conditions of the workers along with ideas for empowering them and initiating a social change process in which their knowledge, strengths and initiatives provided the active context for devising and strategising the social intervention. In practice this is a difficult task but interesting and even amazing results have come out of a creative phase of techno-social integration.

These main approaches emerged:

1. Organising the workers and their families: one strategy emphasised especially by TERI and its partner NGOs focuses on empowering firemen by organising them: defending their human rights and initiating a social change process based on the knowledge, strength and initiatives of the firemen community.
2. Technical improvements to reduce drudgery: Many of the hazardous working conditions are due to environmental pollution, lack of mechanisation and poor occupational safety.
3. Changing ownership and community kilns: Can ownership be changed and kilns handed over to entire communities or Self-Help Groups?
4. Downscaling kilns and artisan ownership: Would it be possible to downscale a kiln to the size of a family unit so that a fireman can run his own kiln rather than migrating to work in a large kiln?
5. Social win-wins: Can social improvements and better working conditions bring benefits for the entrepreneur too, for instance in higher productivity or better quality? Is a better work atmosphere also a win-win in terms of higher profits?
Many of these approaches have been tried out and the results are presented in the following sections.

In an annual migration, over 100,000 firemen migrate for more than six months to work on the many thousands of brick kilns in Northern India and Nepal. Most are from a region near Allahabad in Uttar Pradesh. They have followed this pattern for decades.

4.2. ORGANISING FIREMEN AND THEIR HOUSEHOLDS

Every year, 100,000 firemen from 4 or 5 districts of eastern Uttar Pradesh seek a seasonal job on one of the over 30,000 brick kilns spread over the entire northern plains of India and Nepal. They usually go in groups of six to eight firemen under the guidance of a master fireman. The kiln owners usually pay an advance to the master fireman a only few months before departure. A fireman is paid some 2,000 to 3,000 Rupees per month or US$ 50 to US$ 75.

With the help of Lokmitra and Pepus, two local NGOs, TERI, initiated a programme to organise and empower these firemen and their households. In the first phase, extensive dialogues were conducted with the firemen and their families. This not only covered the problems they faced at the worksite, and their families at home, but also delved into their traditional knowledge of firing and the strengths and initiatives of the firemen community. These dialogues led to the initiative of organising the firemen and their households into a mass body, not as a trade union and not as a community but as an organisation based on knowledge.
The organisation of the firemen and their household is called Bhatta Parivar Vikas Sangathan (BPVS), and now reaches out to more than 20,000 firemen.

Firemen leave their families behind and the wives have to cope with daily life alone. Their demands are straightforward: the advance should be paid when the husbands leave so that the family can buy food and access to mobile phones so that they can communicate. These simple measures would change their lives dramatically.

The working conditions for firemen on most kilns are quite appalling. The heat on the kilns is such that common *chappals* would melt very quickly, and the firemen need to wear wooden *chappals*. Indeed, it is so hot on the surface that a pot of water will reach boiling point after half an hour and the firemen often cook their meals directly on the surface of the kilns.

Sometimes, very simple measures – such as installing a hand pump to provide water, a simple bed so that the workers do not have to sleep on the floor or better communication between workers and kiln owner – can bring substantial improvements. As many owners only appear at the kiln from time to time, there is little or no dialogue between workers and owners. The workers' wives complain that they have no cash to feed the family after their husbands have left, and they suggest that the advances are paid just before the workers leave. Making a telephone available on the kiln site would change their lives dramatically as well: the women would be happy if at least they could speak to their husbands on the phone periodically.

Of course, the key issue is a higher wage, as is improving occupational safety on the kiln, as the risks of accidents are quite high. Lokmitra and Pepus regularly hold meetings of firemen and their wives to reach an agreement on a common code of minimal standards. They also aim to arrive at a written standard contract between the firemen and kiln owners. Although this 'contract' would have little legal basis, it would still clarify many hitherto unclear working conditions and increase the overall transparency of labour conditions in the industry. Such improvements could also result in win-win situations as better working conditions could also lead to higher productivity, savings of coal and better brick quality.

Apart from developing a standard contract between the firemen and the kiln owner, the firemen's organisation also issues identity cards to its member firemen and organises training programmes of two to three days to improve their technical and social organisation skills. Several of the women of the firemen's families have taken leadership positions in the firemen's organisation, which now also helps firemen families in accessing benefits from the government-run development programme, sets up local micro-finance groups (called self help groups) and provides a safety net to families.
(For more information, see the respective film clips on the companion CD.)

4.3. TECHNICAL MEASURES TO IMPROVE WORKING CONDITIONS

Many improvements relate to technical measures, but with the hitherto almost unlimited proliferation of cheap seasonal labour, many processes remain archaic. Selective mechanisation such as mechanical excavators and pugmills to dig out and treat the clay, moulding machines and extruders to replace hand-moulding of bricks seem to be only slowly introduced into the Indian brick industry.

Kiln owners seem to be very hesitant to invest in any kind of mechanisation as manual processes still seem to be cheaper. That pugmill and mechanical moulding technologies would not only replace the most striking drudgery for the workers but also increase the quality of the

A simple elevator would reduce the drudgery of the workers considerably, but even where lifts have been installed they are often not used, sometimes because of electricity outages or because lifting the bricks manually is cheaper.

bricks considerably, is also not seen as a strong argument, as the market is very conservative and does not demand better quality bricks. Perforated or hollow bricks have only a very limited market in India, unlike in Vietnam (see Chapter 7) where hand-moulding is unthinkable both from a quality point of view as well as in terms of working conditions.

Working conditions for workers, particularly firemen working on BTKs, can be improved considerably by technical measures. Use of a 'shunt' or 'valves' eliminates the need for the firemen to enter the flue duct, full of smoke and flue gases at around 100°C, for opening and closing flue duct connections. These simple measures are now being used in several brick kilns, but can be made mandatory. Similarly, provision of goggles, face masks, gloves and safety shoes to firemen can reduce their exposure to heat and flue gases. Better insulation of the roof of the firing zone can reduce heat exposure. The project has tried to increase awareness of these possible technical improvements, both among the brick kilns owners as well as firemen, and some of the brick kiln owners have adopted some of the measures voluntarily. Still a lot more needs to be done to improve working conditions, however, and things may not change without government intervention and conducive regulation.

Gram Vikas, an NGO working with poor people in Orissa has successfully handed over the ownership of six VSBKs to entire communities. They employ a professional manager to run the kiln.

An impressive social impact of the community kiln is the fact that people now find work in their village. Earlier most villagers worked as migrant moulders in brick kilns in the northern plains of India.

4.4. CHANGING OWNERSHIP: GRAM VIKAS AND COMMUNITY KILNS

Gram Vikas (GV) is an Orissa-based NGO led by Joe Madiath. It was registered as an NGO back in 1979 and is focusing on tribal and poor areas of Orissa. The idea of building a VSBK run by an entire community was born at Asurmunda, a poor village with a long tradition of seasonal migration: the majority of the villagers had experience in working as brick-moulders. Why not then build moulders their own kiln so that they can produce bricks in their village instead of migrating?

It is indeed an amazing experiment that has worked well so far: the kiln is well managed, produces good-quality bricks, is profitable and can sell all the bricks on the local markets. Even in rural Orissa there is growing construction activity and bricks are in high demand. However, it must be said that Gram Vikas itself was an important client for bricks as GV is involved in many house-building and infrastructure projects.

The kiln was built in 2001 and faced some difficulties, as one shaft collapsed during the construction period due to heavy rains; this shaft was later rebuilt. Initially, they had many production and organisational problems. The total investment of 622,000 Rupees (US$ 15,000), not including land, was intended as a loan to be paid back. Moreover, the villagers were supposed to buy shares of 1,000 Rupees each in order to raise a capital of 50,000 Rupees. However, up to 2002 the villagers had only paid 6,000 Rupees, and it is not yet known how far the loan for the investment has been paid back to GV.

In 2006 these problems seemed to have been overcome: the kiln is now planning to produce 2 million bricks per year and make a profit of 800,000 Rupees (US$ 20,000). This experience – certainly with a great deal of input from Gram Vikas – has proven that an entire community can manage such a complicated instrument as a big kiln. However, whether this institutional setup can be considered as a model and can be replicated is still an open question. Even if the investment in terms of capacity-building is high, it has created local jobs and has improved the poverty situation in the village quite radically: 45 out of 50 families lived below the poverty line and had to migrate before the kiln started its operation, but the practice of migration has reduced substantially after the commissioning the kiln. After Asurmunda, Gram Vikas has successfully constructed five more VSBK-based enterprises with other village communities. (For more information see the film clip on the Companion CD.)

4.5. RUNNING A VSBK AS A WOMEN'S SELF-HELP GROUP

Another interesting social experiment is taking place in Thogur, a small town in Tamil Nadu, South India, where 11 women's Self-Help Groups (SHG) together operate a two-shaft VSBK. This is a huge task and the groups count over 200 members, of whom only some 25 to 35 are very active.

For a women's Self Help Group to operate a VSBK is a bold experiment: 11 SHGs with over 200 members have joined together with lots of enthusiasm. They still face severe organisational, management and financial problems but are still optimistic.

The kiln construction was completed in August 2005 but the first firing could only take place in May 2006 due to heavy floods that caused considerable damage. However, that did not dampen the enthusiasm of the women's group – quite self-confident and entrepreneurial. They had invested before in an enterprise as tax collection agents from tourist buses at the bus stop in their town, and when the municipality invited bids for tax collection – as it did every year – they were awarded this bus stop to the astonishment of everybody – probably the most surprised were the women themselves. They had run the bus stand for two consecutive years profitably, and this gave them the confidence to invest in a VSBK as well. In setting up a VSBK-based enterprise they received partial financial support from the government, a loan from a bank and technical support from the project.

These three women were the leaders and managers of the VSBK in Thogur in 2006; optimistic to overcome their management problems, they would not give up. A big problem is organising the work as the women have family obligations and cannot work 8 hours a day.

When asked how they managed a VSBK they immediately pointed to some weak points in the manual handling processes, especially those activities most associated with drudgery: bringing the bricks on the platform or hand-moulding. They asked for an elevator and, through a bank loan, invested in a soft mud moulding machine to produce green bricks. They even acquired a tractor for transporting clay and bricks.
However, the SHG is struggling to reach profitability, not because of the kiln or the technology, but because of management problems. Unfortunately, the women's group had no sound business plan and production is much lower than full capacity: in 2006 the kiln was operating for 70 days and produced 285,000 bricks, roughly 25 % of total capacity. In 2007, the kiln was only working for 30 days as the SHG did not have the working capital to buy coal.

The SHG basically faces three key management problems:

1. They sold bricks to the Gram Panchayat and to one influential contractor. Neither paid on time, meaning they ran out of working capital and could not buy coal in time. This will not happen anymore, as they have decided to only sell for cash;

2. The soft-moulding machine should operate for at least 8 hours a day, but the women have other obligations at home (cooking, bringing the children to school and so on) and can only start working at 10 am. The same problem occurs in the evening where they stop working at 4 pm. This leads to a low production of green bricks and thus to low profitability. To overcome this, the groups would need to jointly agree on a division of labour so that some women can work in the morning while others take care of their home duties. This is, nonetheless, a demanding organisational task that also requires a lot of trust;

3. The SHGs are not really equipped for the financial management of such a complex operation. Their standard management practices of SHGs and their rules and regulations are not appropriate: so far, the groups are sharing responsibilities in rotation and each SHG has a secretary and a treasurer. However, this is not adequate for running a kiln, and they should consider if they should not get the support of an administrator or hire a kiln manager.

It is very disheartening that such promising ventures are facing so many problems in the daily reality and it is sad that – for the moment – it is still not proven whether a VSBK run by a women's group is viable. This group should receive long-term organisational support in order to develop a viable business and management model, and it should only be replicated with other SHGs if this is consolidated. (For more information see the film clip interview with two SHG members.)

4.6. DOWNSCALING VSBK KILNS TO FAMILY SIZE

Another attempt of techno-social integration was focused on scaling down the technology so that it could be owned by an artisan family and become a family investment. Scaling down should allow for a fireman or a family of moulders to exploit their own kiln instead of migrating to a big brick kiln.

Indrajit Verma is a former fireman from a village in Uttar Pradesh and is operating a one-shaft VSBK. However, he faces a shortage of working capital and has not been able yet to really exploit the downsized kiln profitably. More work is needed to make these downsized versions viable.

There was considerable debate among the Indian brick team whether such a downscaling was feasible. The idea of making VSBK entrepreneurs out of firemen or moulders is both tempting and challenging: can families hovering close to the poverty line invest in an asset that is worth several lac Rupees? The downscaling exercise aimed at reducing the capital investment to 1-2 lac Rupees (US$ 2,500 to US$ 5,000), but this was not very realistic.

Together with PEPUS and Lokmitra, TERI constructed two VSBKs with firemen families. A part of the capital expenditure on the kiln was provided as loan, while another part, along with the land, was contributed by the firemen families. One of these kilns is owned by Indrajit Verma, a former fireman from the village of Pure Kalander in Uttar Pradesh has set up a one-shaft kiln in February 2005. He reported a total investment of 4.2 lac Rupees (US$ 10,000) not counting the land he was already owned. While he produced only 55,000 bricks in 2005 and 180,000 bricks in 2006 he expected to produce 500,000 bricks in 2007. However, due to lack of working capital – for green bricks and for coal – he could only produce 200,000 bricks in 2007, and it is still not conclusive to determine whether a downscaled kiln run by a fireman family is viable or not. Theoretically, it should be viable, as he would achieve a net income of some 200,000 Rupees (US$ 5,000) if he manages to produce 500,000 bricks. This would certainly be a much better income than what he can earn as a fireman.

It is a pity that the downscaling efforts have not yet been pursued further and have received much less attention: one-shaft kilns would make VSBKs very similar to the over 60,000 clamp kilns in India. Clamp kilns do have a capacity of 500,000 lac bricks per year and could be replaced by one shaft VSBK kilns if they can be made profitable. This could be a major upgrading exercise for small-scale informal sector industries, despite the higher fixed investment compared to the clamp kilns.

4.7. DO BETTER WORKING CONDITIONS LEAD TO WIN-WINS?

As long as brick kiln owners perceive investments in the social dimension as a nuisance, improvements are not very likely in the South Asian brick industry. Unfortunately, many kiln owners have a feudalistic mindset. Many have political influence and are not 'sensitive' to the social hardships of their workers. Owners and workers are accustomed to tough working conditions and find them somehow 'normal', as they have been used to them for many decades.

However, there are real win-win situations and it is absolutely conceivable that kiln owners will perceive a better working climate one day as an investment in order to achieve higher returns. How can this change of mindset be achieved? How can improved working conditions become part of better management?

Three factors have influenced the working climate in Western economies: **a)** the relative scarcity of finding skilled labour and **b)** the demand for high-quality products, **c)** government regulations on working conditions and health and safety of workers. So far, astonishingly, by these standards, though not by the prevailing values, the reserve army of migrating job-seekers seem to be inexhaustible. As long as this trend continues there seem to be few incentives for the brick industry to invest in any kind of mechanisation. But will this trend continue for ever? Will the reserve army dry up soon if the rural economies provide better work opportunities? Economic growth in India will certainly lead – sooner or later – to a shortage of migrant labour, but nobody dares to say when this will be the case. On the other hand, as long as the market does not demand higher quality bricks, hand-moulding of bricks may go on for another few years. A government intervention also has the potential to initiate change as has happened in Vietnam. The present period of rapid growth in the Indian economy is perhaps also the right time to improve working conditions and improve productivity of the workforce.

4.8. LESSONS LEARNED FROM TECHNO-SOCIAL INTEGRATION

What conclusions can be drawn from this new thrust? What lessons can be learned from integrating the social dimension into an intervention programme that was originally based on technology?
On the one hand, it is quite challenging to bring social change into an industry that has not changed in the last 50 years. It was hoped that improved technology could

Market forces alone will not lead to better working conditions in the brick industry, at least as long as the supply of cheap migrant labour continues. The case of Vietnam has shown that regulation plays a key role in eliminating drudgery and health hazards for workers.

serve as an entry point for a debate on social issues. However, it would be an illusion to think that hard-core brickmakers who have worked in a certain way for many years would suddenly change their perceptions. Moreover, the VSBK technology is too small to be an alternative to large fixed-chimney BTKs in northern India. As long as the brick industry is not forced to move towards higher investments and higher-quality bricks, and do feel a need to improve the work climate, there is little scope for social action in the mainstream brick industry.

However, techno-social integration has shown some amazing innovative avenues:

1. Organising firemen can improve their working conditions with even modest measures, and initiating a dialogue between workers and owners seems to be highly necessary. A standard contract for the entire brick industry would be desirable, but it is still questionable whether it can be realised and implemented.

2. Focus on Knowledge for Social Intervention: The project tried a new approach for social intervention, in which new knowledge of VSBK and the workers' knowledge constituted the two focal resources for innovative thought in social intervention. Whereas the worker's knowledge was a source of strength, the VSBK knowledge has helped to break the stranglehold of formulas derived from BTK operations. This led to training which attempted to synthesise knowledge to produce inclusive knowledge packages.

3. Many **technical measures** such as selective mechanisation, especially in clay preparation and transportation of bricks, could bring major improvements, but so far manual operations seem still to be cheaper than any mechanisation. Most of the kilns do not have electricity. Major improvements in ambient air conditions have been achieved in VSBKs and there are technical options available to improve the environmental performance of BTKs and reduce pollution and heat exposure to workers.

4. It seems to be feasible to **change the classical ownership pattern** and empower communities, Self-Help Groups of women and artisans to run and manage kilns. However, all of them require substantial assistance in management skills and support, not only with technology but also with financial resources such as working capital.

5. Downscaling activities have begun but it would need further R&D to bring one-shaft VSBKs to the technical and financial maturity required for large-scale dissemination as an alternative to clamp kilns. The dissemination will only be successful if accompanied by a coherent business support package and working capital loans.

However, win-win situations are, possible: there is no reason why a mother must carry a child on her back while she is moulding bricks. Child care centres in Nepal have proven to be a profitable solution for the kiln owners as well: productivity increases and the children are much better looked after. Workers are even prepared to pay a fee.

6. Finally, many brick kiln owners in India have not yet realised that **win-win situations** are possible and that suitable improvements in working conditions can also result in higher productivity, quality and thus better returns.

In summary: The Swiss Agency for Development and Cooperation, SDC, has initiated pioneering and innovative work in one of the most sizeable rural industries in India. There is still much to do, but many promising approaches have been tested and seeds of change sown for the future.

DISSEMINATION IN INDIA: FINDING THE RIGHT STRATEGY

5

It was, in retrospect, somewhat premature, but having built the first five kilns it seemed easy to scale up, and many people were already dreaming of VSBKs everywhere. In reality, scaling up was much more challenging: it meant introducing a new technology in an industry that had not witnessed any major technological changes in the last one hundred years. Even the large-scale adoption of the relatively simpler upgrading from moveable-chimney BTKs to fixed-chimney BTKs has taken almost forty years in India. Despite the VSBK being the most energy-efficient brick kiln, its dissemination would turn out to be a slow process for the following reasons.

Rapid dissemination of the VSBK has to face five major realities:

1. The VSBK, is a **new technology,** requires more precision, skills and supervision. As bricks are fired within 24 hours – compared to 7 days or more for other kilns – the operation needs much stricter control than a clamp or BTK kiln.

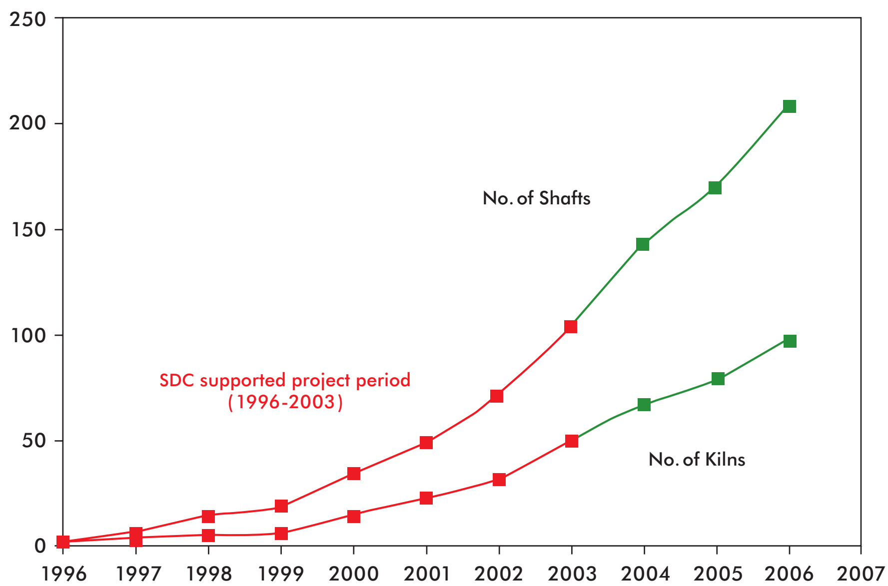
2. The VSBK requires a **higher capital investment** than clamps or BTKs. This hurdle is very typical for many environmentally-friendly technologies: energy saving lamps cost more initially and offset this investment with lower operating costs. But in a poor country, particularly for small entrepreneurs, capital is usually costly and future savings have little value. For the same reason a taxi owner would rather continue to drive a fuel-inefficient Ambassador car than invest in a fuel-saving new car.

3. The **brick market is extremely conservative** and price sensitive. It does not provide any incentive for new or better quality products: the bricks are as good as they are and nobody asks for anything better. The market wants bricks that fulfil the traditional criteria of 'ring' and colour, and if an entrepreneur invests in a VSBK or an extruder and produces a brick which is different from the traditional brick, he faces a lot of market resistance in selling his bricks at a profitable price.

4. The VSBK is **positioned in the middle:** it has higher production volumes than clamp kilns and lower production than large BTKs. As an alternative to clamps, a VSBK is a costly investment for small entrepreneurs not used to handling lots of cash and without access to bank loans. For the larger brick-manufacturers, the capacity of a VSBK was seen as too small: they were used to producing eight million bricks per year, not the one million of a VSBK.

5. Strategy of SDC: it was quite challenging to find the right role as a donor in the dissemination process. Should SDC actively promote a technology or let it be driven by

Figure 1: Annual growth in installed kilns and shafts 1996-2006



the market? Should VSBKs disseminate through (non-commercial) technology providers or through so-called 'lead entrepreneurs'?

SDC was not always sure about the right strategy, especially given its internal debates about whether VSBK dissemination contributed to poverty reduction or only to a better environmental performance.

5.1. THE DISSEMINATION PROCESS SO FAR

From the first kiln in 1996 to early 2007, India has around 100 VSBKs (more than 210 shafts) and the technology has been demonstrated in approximately 15 Indian states. During recent years, most VSBK replications have taken place in 5 states: Orissa, Jharkhand, Chhattisgarh, Madhya Pradesh and Tamil Nadu (See Figure 1).

5.2. TECHNOLOGY PROVIDER, OR LEAD ENTREPRENEURS AS DIFFUSION AGENTS?

The India Brick Project was not clear about the best strategy to follow for dissemination. One consideration was whether the dissemination agents should be 'technology providers' such as DA, Damle or MITCON, consulting and supporting agencies that would bring the technology to the new entrepreneurs and provide them support and 'hand-holding' until they succeeded?

Alternatively, should some of the pioneering lead entrepreneurs bring the technology to their peers? For a high-tech technology dissemination such as Western tunnel-kilns, there are private sector technology providers that will support a brick industry with turnkey technology transfers and do everything necessary to make it work. As we talk here of investments of several million dollars, this technology provision is a good business. Nobody would even think of investing in such a complicated kiln without buying the technology transfer package associated with it.

However, in the traditional brick industry, where every Rupee is turned several times and then turned again before it is spent, technology fees are a foreign language for most entrepreneurs. The project proposed charging new kiln owners a fee of 40,000 Rupees (around US$ 1,000) for a two-shaft kiln, a small amount compared to the investment of around US$ 20,000. As a matter of fact, this fee already created substantial confusion and it was not easy to levy. Moreover, a new entrepreneur had to have access to an entire technology package including training of firemen, soil analysis and, above all, new skills – and machinery such as pugmills and mechanical soft-moulding machines – to produce green bricks and to dry them properly. It emerged that most of the entrepreneurs were not really used to such kind of technology transfers.

The other concept of lead entrepreneurs was not straightforward either: the idea was that once an entrepreneur had become successful with a VSBK he could convert his 'fraternity' to switch over as well. Other existing or prospective brick kiln owners would trust a "fellow entrepreneur" more than a technology provider. But why should a successful VSBK entrepreneur share his know-how with his potential competitors? He would not be able to levy a

Gwalior, 'Mecca' of VSBK: When Narayan Das built the first commercial VSKB, Nr. 5, in Gwalior, he became the 'Mecca' of clamp owners and he was considered as a 'lead entrepreneur'. He was indeed successful and produced with his six shafts up to 4.5 million bricks per year. However, Narayan had his own ideas on how to disseminate VSBKs and those did not tally with the concept of

DA TARA. He stopped the VSBK in 2005 because he had insufficient water to produce enough green bricks.

Nevertheless, he influenced his peers and eight clamp kiln owners established VSBK. Apparently, even in places as far away as Indore (300 km away), a VSBK spread under his influence fee either. So, sometimes "the entrepreneurial position vis-à-vis the brick fraternity was influenced by personal anxiety and context. He would praise the VSBK more than deservedly, if he wanted to keep up a public image of a wise or smart man. He would exaggerate holes in it (shortcomings) to discourage others from entering the VSBK-community." [17]

In 2007, out of the four main project partners, DA-TARA and DAMLE were operating as private technology providers. DA-TARA is the most active and the largest agency, in terms of number of kilns constructed as well as trained manpower. However, the consultancy fee from the prospective VSBK owners only partially covers its cost of operation. It has successfully attracted additional funding from ICEF and carbon trading, to finance the dissemination effort. DAMLE, along with an associate (a trained engineer in VSBK technology), is involved in construction of some VSBKs. TERI is not directly involved in commercial dissemination; with SDC support it has tried to seed the technology in some new regions and has trained local manpower in construction and operation, in the hope that some of these trained persons will undertake the task of commercial dissemination in future. Gram Vikas is concentrating only on constructing VSBK in collaboration with communities in the villages where it is operating. It does not work directly with commercial brick-makers.

5.3. WHY DISSEMINATION IS SLOW: ON EARLY AND LATE ADOPTERS

Why does an innovation not disseminate like wildfire, especially in such a conservative industry such as bricks? Everett Rogers [18] explained the process of adoption of innovations many years ago with the graph below, distinguishing between innovators, early adopters, early and late majority and finally laggards.

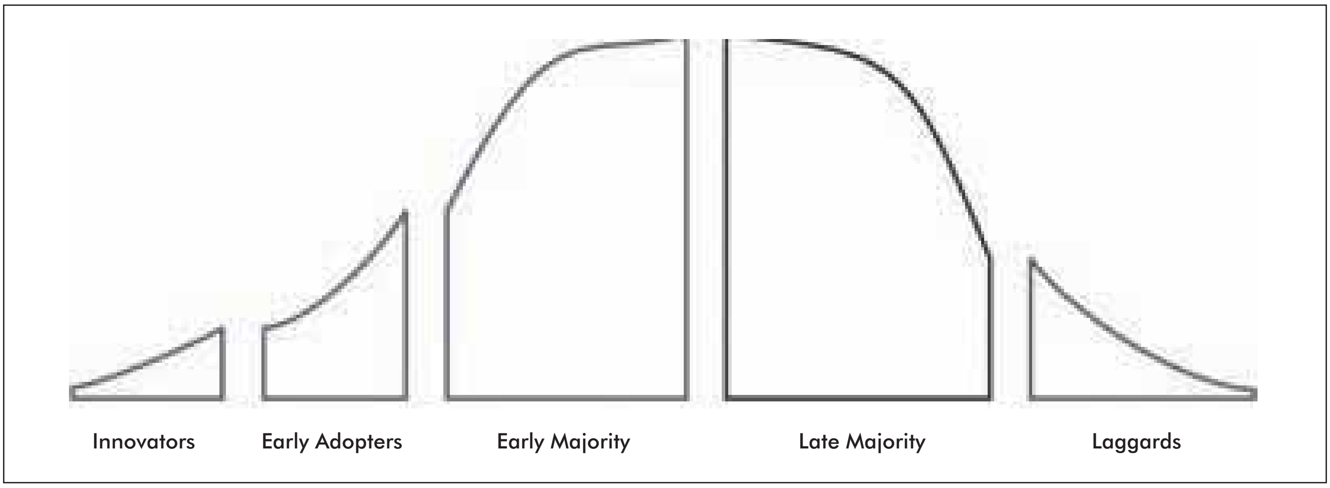
Moreover, Geoffrey Moore has pointed out that there is a 'chasm' [19] between each group of innovation adopters, especially for discontinuous innovations. While, for instance, the transition from black and white TV to colour TV is a continuous innovation, it is the same button on the TV set and the only difference is that the picture can now be seen in colour. Many innovations, however, require a change of attitudes. The introduction of VSBKs demands a very significant change of attitudes and practice: bricks are now fired continuously in a 24-hour operation – as compared to a batch firing of 2-3 weeks for a clamp kiln – or a 1-2 week cycle in a Bull's Trench Kiln.

The main reason for this chasm-in-discontinuity is that decision making is not a linear process but is influenced by social factors: different groups of people listen to different peer groups. Some want to be the first ones to adopt an innovation no matter if there are still technical teething problems, whereas a representative of the early or late majority will only be influenced in his/her decision by other representatives of the early majority. To illustrate the difference, one can refer to the computer world: everybody knows that an Apple computer system performs better than other systems of similar scales, and most innovators or early adopters have adopted Apple systems. For a large organisation, however, compatibility is much more important than performance and this is the reason why most mainstream companies have adopted Microsoft Windows computer systems.

The key question for a dissemination strategy for the VSBK is thus: which targeted entrepreneurs would most likely adopt the innovation: mainstream brick-makers who owned either a clamp kiln or a BTK before? Or new entrepreneurs who had never operated brick kilns before?

One VSBK adopter in Orissa, Mr. Bana Bihari Bastia, is a typical **innovator**. He ran a moveable BTK until the year

Figure 2: Who adopts when?



Mr. Bana Bastia is a typical innovator, highly interested in scientific aspects. He reads science magazines and tries out new technologies, also in agriculture. He can also afford to take some risks.

2000 and became interested in a VSBK after a massive cyclone hit Orissa in 1999 and demand for building materials soared. Mr. Bastia is very interested in science and became convinced that this kiln is much better than the BTKs because of its technical performance, especially its low coal consumption. Unfortunately, innovators such as Mr. Bastia are rare, and it would be unrealistic to assume that many other entrepreneurs would copy a typical innovator. (See the interview on the Companion CD.)

Early adopters are those new entrepreneurs who are curious and open for innovations but are not necessarily 'techno-freaks'. Such an early adopter is Sudhir Mishra, a young entrepreneur whose father is a teacher and whose brothers and sisters have all entered government service. Sudhir Mishra has never operated a brick kiln and would have preferred to become a government official but was not selected. He thus became an entrepreneur and brick-plant owner as a second choice, and he made the investment with the help of his family. He has still not settled his kiln, not because he is struggling with technical issues but because he has still to master the management of a brick kiln enterprise, mainly how to deal with labour problems. It is difficult to get trained firemen and they often leave once they have received their advance. TARA, the commercial arm of DA, is therefore training firemen and this input is essential for these new entrepreneurs. They would never be able to train such firemen themselves. (See interview with Sudhir Mishra on the Companion CD.)

One example of a first member of the **early majority** is Mr. Manjalam, a mason and building contractor with a clamp kiln in Orissa. He wanted originally to set up a BTK but the bank refused to give him a loan, as moveable chimney BTKs were banned by the Government of Orissa. He attended a seminar by TARA and was persuaded

Mr. Sudhir Misra (left), a young entrepreneur in Orissa, listens studiously to Mr. Manjulam, an experienced brick-maker and former mason. While Mr. Manjulam has already solved his technical problems, Sudhir Misra is still struggling.

to build a VSBK. He has mastered most of the technical problems but still faces labour problems, the same endemic issue as Sudhir Mishra. Mr. Manjalam is also a kind of technical mentor and more advanced entrepreneur for Sudhir Mishra, the young 'rookie' entrepreneur.

Strong environmental regulation is thus helping to speed up the dissemination process considerably and has allowed entrance into one early segment of the mainstream market. (See interview with Mr. Manjalam on the companion CD.)
The dissemination process for VSBKs in India is just starting to reach the mainstream brick-market, involving some segments of the early majority in some pockets. This is not surprising in such a large country with over 100,000 brick kilns and in view of the conservative nature of this industry. As the diffusion process is not linear but takes on one segment after the other, it is of necessity a very slow and long process to make a major dent into the brick industry of India. The brick industry in South Asia is especially resistant to change, as we will explain in the next section.

5.4. WHY SO MUCH RESISTANCE TO CHANGE IN SOUTH ASIA?

The brick industry in South Asia is much more resistant to change than its peer industry in Vietnam. To understand this, it is necessary to examine how the industry is organised socially and as a business and how the regulatory environment influences decision making.
One key feature distinguishing the brick industry in South Asia is easy access to a huge number of cheap migrant workers. This is in fact rather similar to the 'industrial reserve army' as described by Karl Marx. South Asia is home to a very large population of absolutely or virtually landless farmers. In 1992, about 43 % of the rural population in India was absolutely or near landless [20]. During the dry season, lack of farm work forces these landless peasants into migration, desperately seeking any kind of work. It is a coincidence that just at that time, tens of thousands of brick kilns need these workers as moulders to transform soil into green bricks and as firemen to convert them into red bricks. It is a perfect push-and-pull symbiosis: when the dry season prevents the land from being used for growing crops, the conditions are optimal for drying bricks under the sun. These workers would not find work at home and are thus prepared to accept work far away from their home. The work is physically very hard, the living conditions are bad, they work in the open under the scorching heat of the summer sun, there is hardly any social security and the wages are low. There are, though, no better alternatives available for earning a livelihood.

The management of brick kilns is feudalistic in nature. Typically, an owner of a brick kiln has land of his own or he acquires agricultural land on lease for brick-making. He then hires masons to construct the kiln for him. The next task is to organise workers. A brick kiln requires several different categories of workers: firemen (to feed coal and tend the fire), moulders (to mould bricks), loaders and unloaders (to load and unload bricks in the kiln). The owner signs contracts with several labour contractors who act as middle men for supplying the different categories of workers. These middle men travel to the villages of the brick workers, pay them an advance and bring the workers to the brick kilns. The workers at the brick kilns are directed by supervisors (munshi), who also supervise the entire day-to-day operations. Most of the owners generally do not take much interest in the operations and in the day-to-day management of the enterprise. Their knowledge of the brick-making process is generally poor. They would like to maintain the status quo. Thus, operating a brick kiln in South Asia is like investing in a truck and hiring a driver; it is not necessary for the owner to know how to drive a truck.

Another distinguishing feature is the low demand from the market for superior quality of bricks and for new (hollow) bricks. In this scenario, there is no incentive for the brick works to upgrade the technology. Some of the technologies, such as extruder based semi-mechanised brick plant or the zigzag fired kiln, were introduced by the Central Building Research Institute of Roorkee, India, but they found it very difficult to penetrate the Indian brick industry. As long as there were people who did the job with their own hands or feet, there was no need to invest in a machine. What in other countries would have

Managing a brick production is a feudal undertaking. An industrial reserve army of cheap migrant labourers often accepts exploitative working conditions, simply for lack of alternatives and out of desperation. In Vietnam, the situation has improved mainly through government commitment to remove drudgery.

been regarded as drudgery was socially accepted in South Asia because 'it was always done like this', and doing it by hand was even cheaper.

Regulations and incentives also play an important role in moulding the response of an industry. As we will see later, government policy and regulations have played an important role in facilitating long-term changes in the Vietnamese brick industry. However, in the case of the South Asian brick industry, until very recently, there was a total lack of regulations on environmental issues, labour and quality. Today, even if the regulations exist, their implementation is generally very poor. Most brick kilns remain outside the formal small industry sector and continue to be treated as informal enterprises.

5.5. COPING WITH TECHNOLOGY: HANDLING A VSBK IS MORE DEMANDING

A VSBK needs more skills to operate and a better clay preparation and green moulding process than its slower siblings. It is obvious that a more efficient kiln that can fire bricks in less than 24 hours is more delicate to run than a clamp kiln with a firing cycle of several weeks. This demands not only more skills but also much better green brick quality. If poor quality soil – having several impurities – is only treated by foot and hand-moulded, it will not result in high-quality bricks, especially if the green bricks are dried without protection in the open on an uneven ground surface. Under these conditions, breakages and other quality problems are frequent.
These technical problems are sometimes aggravated by mainstream brick-makers and traditional moulders who

are opposed to changing old habits. Problems are even more widespread if a kiln owner is running several kilns in parallel. In order to overcome such problems it is often necessary to train new firemen and moulders, to accompany a new kiln for several months and to correct all teething problems. A common mistake made by new kiln owners is to sell their first bricks despite having quality problems. This can damage the reputation of a VSBK for quite a long time: if a new product is associated with problems from the outset, it is very difficult to overcome.

It is thus important to ensure the smooth running of new kilns: just as good examples can finally have a positive dissemination impact and attract new entrepreneurs, bad examples can hamper the dissemination for many years. One entrepreneur's problems can thus become contagious and prevent others from adopting a new technology.

5.6. FINALLY SOME GOOD NEWS: THE WIND IS CHANGING

Slowly, the situation is changing and becoming more favourable for change. Brick makers in several regions in India are facing labour shortages for the first time. The reasons for labour shortages are twofold. First, the booming economy is offering more job opportunities for unskilled workers, particularly in the construction sector, and secondly, the implementation of a government scheme[21] in 150 backward districts guarantees that rural poor get at least 100 days of paid work in their home district and this is reducing the supply of migrant workers to brick kilns. Several brick-makers are thus interested in mechanisation of green brick production. Also from the demand side, the wind seems to be changing. As Venugopal Krishna from Malur district (Karnataka) says (see the interview on the companion CD), the demand for quality bricks from the cities of Bangalore, Mysore and several towns in Kerala is constantly growing and perforated bricks also seem to have an emerging market. Slowly, brick-makers are showing some interest in investing in higher technologies such as mechanised de-airing extrusion.

Mr. Venugopal from Malur district is operating several large kilns and sees the wind changing: close to mega-cities like Bangalore the demand for high quality hollow bricks is growing fast. He is still trying out his VSBK.

These changes are expected to open up new opportunities for new technologies including VSBKs. However, the new VSBK entrepreneurs need considerable assistance to overcome their technical problems not only with the kiln but with the clay preparation and handling. Making machine moulded bricks – and especially making perforated bricks – is a new process in most regions of India. The changeover from traditional brick-making to modern brick-making is thus comparable to a revolution that involves much more than just changing the kiln.

On the other hand, when the demand for bricks is booming as much as it is in India, there is also an inherent

Regulation so far has not yet brought the incentives to induce change: enforcement of environmental laws is very weak and many kiln owners are influential people.

danger that almost all bricks can be sold and this provides few incentives to produce quality. The wind is, apparently, changing now and – for the first time – newer varieties of bricks may have a chance in the Indian markets.

5.7. TAIL WINDS FOR DISSEMINATION: REGULATION AND CARBON FINANCE

Of course, the resistance to change could also be overcome if the right incentives were in place: negative incentives through environmental regulation and positive incentives through carbon finance.

5.7.1. THE IMPACT OF REGULATION: MIXED RESULTS, SO FAR

There is a great role to be played by stronger regulation banning the more polluting kilns or imposing a pollution tax. In 1994, the Indian Government announced new emission standards for brick kilns, proposing a complete ban on the moveable -chimney BTK, which was the main firing technology at that time. The brick industry tried to resist these standards but finally had to yield to the government, resulting in a changeover to the marginally more efficient and less polluting fixed-chimney BTK.

The higher chimney provides the kiln with a higher draught and this leads to a better combustion and some reduction in generation of pollutants. The higher chimney also 'dilutes' the pollution and spreads it over a larger area. This is not a new phenomenon in environmental policy: when air pollution – mostly SO^2 and Suspended Particle Matters (SPM) – in European cities became an issue, many large coal-fired power plants increased the height of their chimneys with the effect that acid rain travelled over larger distances, for example affecting the forests in Sweden and Norway. Unfortunately, the new environmental regulation is not enforced uniformly everywhere in India, and the changeover to fixed chimneys has brought only cosmetic changes in brick-making. It has not had any significant impact on the organisation of the industry. A real change would only occur if the standards demanded better quality bricks, with better insulating properties **and** a better environmental performance during production. We shall present and discuss such environmental strategies in the third part of this study.

5.7.2. CARBON FINANCE: ONE VSBK OFFSETS UP TO 500 TONS OF CO_2

The other factor that will help the dissemination is the introduction of carbon finance. It is not always easy to calculate the CO_2 savings of a VSBK due to the comparison baseline. If the baseline is a clamp kiln – as it is in central India – a VSBK with two shafts and an estimated production of 1.8 million bricks will save around 500 tons of CO_2 per annum [22]. This corresponds to the equivalent of some 160 round trips from London to Delhi by air in economy class. But can this saving be converted into a monetary incentive?

DA-TARA recently managed to develop a Clean Development Mechanism (CDM) project and has a contract with the Community Development Carbon Fund (CDCF) programme of the World Bank [23] to sell CERs*. Based on the 14 VSBKs in operation, it calculated that these 14 VSBKS are saving some 71,000 tons of CO_2 over a ten-year period. This project will ultimately cover more than 100 VSBKS in India. The application procedure for the CDM mechanism is quite cumbersome and as the CO_2 savings from individual brick kilns are small and as the brick kilns are geographically dispersed, it requires a bundling agent; this role is played by DA-TARA in this project.

* Carbon Emissions Reduction Certificates

Development Alternatives Director, Arun Kumar (with hat) handing over the first carbon finance cheque to Mr. Prajpath for his VSBK near Indore, Madhya Pradesh.

The price per ton of CO_2 is highly volatile and ranges from US$ 5 up to US$ 25 per ton. With CO_2 savings of 500 tons, this would amount from US$ 2,500 to US$ 12,500. However, the sales value of 1.8 million bricks is close to US$ 80,000 (@ 2,000 Rupees per 1,000 bricks) and carbon finance can thus not influence the economics very significantly, especially if the carbon finance is paid *ex-post*. However, the situation would change if carbon finance could be used upfront to bring the fixed investment down. If an anticipated ten-year saving of 10 x 500 tons of CO_2 could be convert into an upfront investment loan, then the VSBK could operate on a much more level playing field with low-investment technologies such as clamps and BTKs.

5.8. ACHIEVEMENTS: IS THE GLASS HALF-FULL OR HALF-EMPTY?

So, how should we assess the progress so far? Is it a beginning to making a huge industry more sustainable, or is it a flop? Is the glass half full or half empty?

5.8.1. STRUGGLING WITH NUMBERS AND OVERCOMING RESISTANCE

The actual number of kilns in operation may cause disappointment: while 100 VSBKs would be a great achievement in a small country, it is a drop in the ocean in a country such as India with over 100,000 brick kilns. But are numbers the only yardstick?

Transforming such a large and complex industry is a huge task and overcoming the resistance to change as described in the previous chapter is a Herculean task – or an assignment for Sisyphus, depending on one's point of view. This industry has not changed for the last 100 years and it has no internal reason to change as long as the market does not demand better bricks nor the regulators insist on resource efficiency.

The Indian brick project has laid the foundation for technical change: it has at least developed a technical alternative for the more than 60,000 clamp kilns. The VSBK – in its present form – may not yet be a substitute for the large Bull's Trench Kilns with a production capacity of 8 million bricks per year, despite the fact that a six-shaft kiln can produce up to 10 million bricks in an all-year-round production. However, shifting from a seasonal low investment and low mechanisation production towards an all-year-round high investment and high mechanisation production requires drastic changes, mostly in the mindset of the brick kiln owners. So far, there are almost no financial incentives available that would support such a change.

A modernised brick industry in India could look like this: a VSBK with conveyer belt, soft moulding machine and a drying shed in order to produce bricks the whole year round.

5.8.2. WHERE WILL THE BRICK INDUSTRY GO AND WHEN?

This change may also go a step further and introduce tunnel kilns, but the change would be a similar one: instead of a process driven by low – mostly working capital – investments, seasonal utilisation of cheap labour and producing large amounts of low-quality solid bricks, it would require a significant investment of several hundred thousand dollars into a fixed kiln. To repay such an investment, one would need to assure a long-term supply of good clay for at least 30 years, and this alone would make it necessary to own a piece of land with such a – deep set, not only superficial – clay deposit. An investment of this nature will only pay off if high-quality bricks can be made and find a market; it is – *ceteris paribus*, or all other things being equal – impossible to compete with the cheap bricks of low-investment processes. This is only possible if the market demands such higher-quality bricks. All of these changes depend on a set of assumptions and the trigger should come from market demand: as long as solid bricks are the mainstream demand nothing will change, no matter how many SDCs and TERIs and DAs and Damles are trying. Changes in the brick industry will only occur if the structure of the brick-market and/or the production environment will change, either through market forces and/or through regulation.

5.8.3. CAN BUSINESS AS USUAL CONTINUE, AS USUAL?

How likely is it that such structural change will occur? Without being able to predict a schedule of change, one thing is sure: **business as usual cannot continue for ever**, even in South Asia. There are four most likely reasons for changes ahead:

1. Rapid urbanisation: at present a strong trend of urbanisation prevails in South Asia and entire satellite towns with a million inhabitants or more are mushrooming. This trend is not compatible with solid brick houses with poor insulation property. The demand for better quality and hollow bricks will increase sooner or later.

2. Regulation and building standards: The new suburbs occupied by the fast-growing middle class will be increasingly equipped with air conditioning in summer and heating in winter. In consequence, the demand for electricity will grow at a pace that no country can ever satisfy without imposing energy consumption standards. Stricter regulation on energy consumption in buildings is thus essential and would increase demand for high quality bricks.

3. Supply constraints of labour: Overall economic growth may increase employment opportunities agricultural products and thus lead to a shortage of seasonal labour. This may create incentives for selective mechanisation in the brick industry.

4. Regulation and carbon finance: Any change of this order can be induced not only by voluntary action but by policy measures such as subsidies, taxation and regulation. Environmental standards have – as in the West – only been enforced by financial incentives or disincentives and with parallel support through strong social pressure. Major changes in the brick industry will only occur through strict regulation – and its enforcement – in combination with financial incentives from carbon finance.

5.8.4. ONE MAJOR ACHIEVEMENT: INDIA IS PREPARED FOR CHANGE

It is clear that the Indian Brick Project has made considerable progress:

1. Capacity-building: The project has been successful in creating new capacity (individuals as well as institutions) to work in the brick sector. The project has helped large NGOs such as DA, TERI and GV to develop capacities to work in the brick sector. The project has brought several top professionals (including engineers, social scientists, management and policy experts and environment experts) into the sector. Thousands of brick-makers have been exposed to this new concept of firing through the outreach activities of the project partners, and more than 1,000 fire masters and several dozen masons have been trained in this technology.

2. Policy advocacy: Through the work carried out in the project and outreach efforts by the project and partner institutions today there is much greater awareness amongst policy makers (for example, Central Pollution Control Board, Ministry of MSME) of the brick sector at a national level. Awareness about VSBK technology is now quite high in several state governments such as Jharkhand, Orissa and Chhatisgarh.

3. Mutual learning and International cooperation: The VSBK project teams from India regularly exchange experience with several international projects in Nepal, Vietnam and Afghanistan, and the project partners receive regular requests for information and assistance from other developing countries.

4. Leveraging carbon finance and environment funds: Indian partners have been able to build on SDC support and have been able to attract co-financing. DA has successfully developed a CDM project to sell CERs to the CDCF programme of the World Bank. It has also been able to attract ICEF funds, while TERI has submitted a project proposal along with UNDP to access funds from Global Environment Facility (GEF) for energy efficiency improvements to brick kilns in India.

5. Adding new knowledge: New methodologies have been developed for energy and environment monitoring of brick kilns in developing countries. New concepts on techno-social integration have been experimented with, and new literature in the form of manuals, training materials, books, papers, Web sites and PhD theses, have been added.

6. Social impact: The project has been able to reach out and bring some positive change into the lives of more than 20,000 firemen in eastern UP, several hundred moulders in Orissa and women members of several self-help groups in Tamil Nadu. Better sanitation facilities are being provided to hundreds of workers working on VSBKs that are accessing carbon funds.

As things are now changing in the sector in India and several other developing countries, all these capacities/ experiences will play an important role in the future change process. The VSBK technology is an important tool as a radically different and very efficient medium-scale kiln for firing bricks. Its introduction brought a totally new way of looking at brick firing in India. Before the VSBK, nobody believed that bricks could be fired in 24 hours and with so little fuel.
Nobody can say with any certainty what will be the future of this technology in India. If we regard the entire programme as being an agent for change which has been able to prepare India for far-reaching transformation in this important industry, then SDC should be proud of this programme. In this sense it is correct to say, with sincere optimism, that the glass is at least half-full.

VSBK DISSEMINATION IN NEPAL

6

6.1. THE VSBK SAGA IN NEPAL: IN THE BEGINNING

Brick making in Nepal is an important economic sector, highly polluting and with appalling working conditions and social cruelties. But there is a ray of hope for this child: child care centres are becoming popular even on traditional brick kilns.

In 2003, the Government of Nepal and SDC signed an agreement for a VSBK Technology Transfer Programme implemented by SKAT Switzerland with the Department of Cottage and Small Industry (DCSI). The Government of Nepal was to provide a favourable and enabling environment, in particular through appropriate rules, regulations and incentives for an efficient and effective technology transfer process.

SDC was to promote the Programme through its Natural Resources and Environment (NRE) Division at headquarters and through its country programme in Nepal. The implementation of the Programme was to be through a partnership with SKAT responsible for operational issues and DCSI taking a facilitation role.

So far, six VSBKs with a total of 20 shafts have been implemented, some with traditional brick makers in the Kathmandu valley and some with mostly new entrepreneurs in the Terai. The dissemination patterns are similar to India and the adoption process is rather slow. The socio-economic conditions are pretty similar in Nepal and northern India and therefore there are similar resistances to change.

6.2. CHANGE DEFICIENCY SYNDROME – A SOUTH ASIAN DISEASE?

The brick industry in Nepal is – as in India – an extremely change-resistant and conservative industry influenced by similar traditional socio-economic patterns. And – as in India – the persistent massive resistance to change is rendering the dissemination of the VSBK a slow process.

Nevertheless, even in a small country, the construction industry is an important and dynamic economic sector, very often underestimated in its paramount importance for development and poverty reduction.

6.2.1. SIZE AND SOCIO-ECONOMIC ROLE OF THE CONSTRUCTION SECTOR

Construction activities in most developing countries play a crucial role in economic development and form a quite sizeable economic sector. In Nepal, the construction sector accounts for more than 10% of GDP and is thus the second largest economic sector after agriculture, ahead of tourism and manufacturing. Brick-making is not even included in these figures.

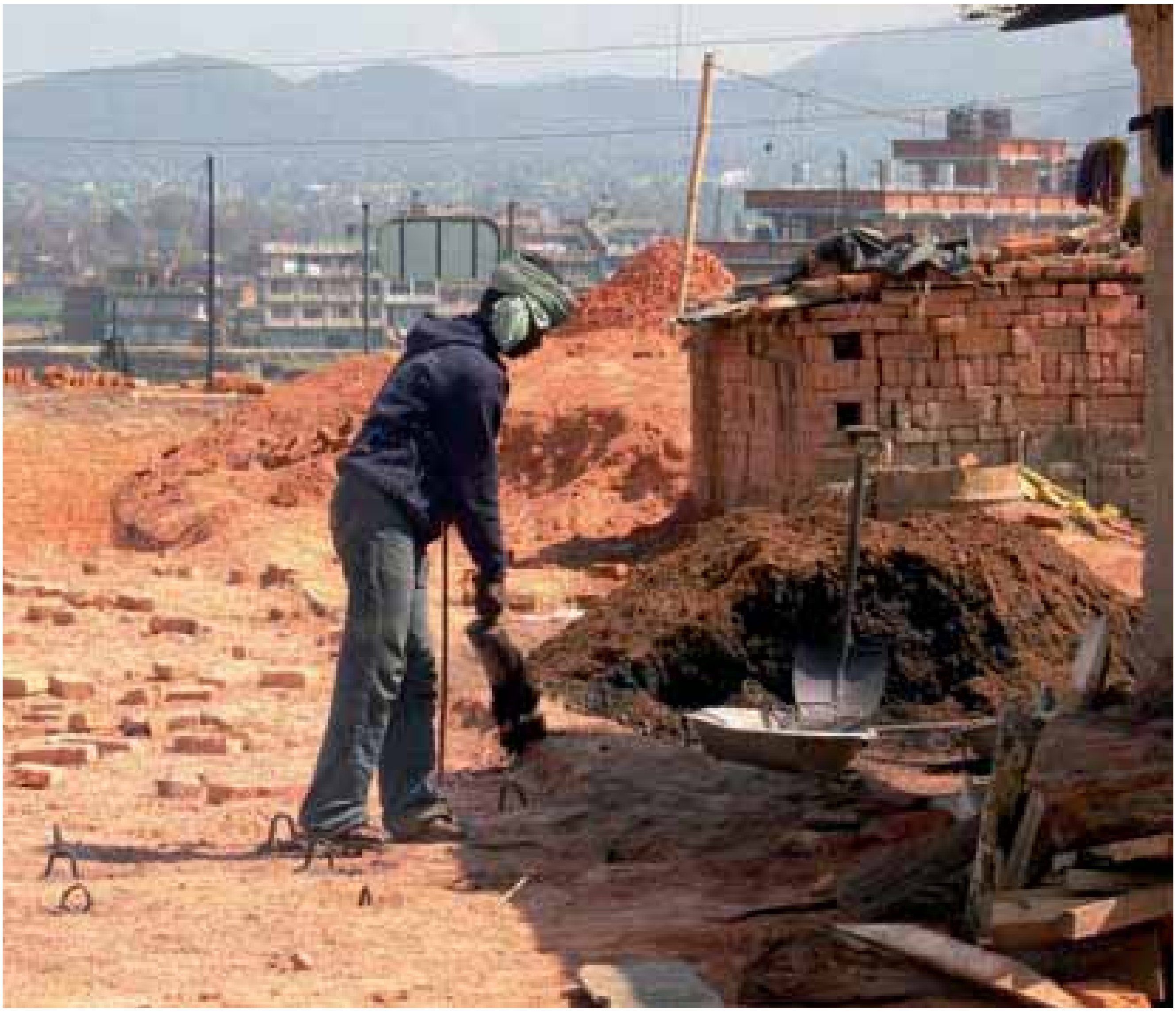
The construction sector is important, for two reasons. Firstly, on the demand side, a significant part of savings is invested in house improvements and is thus quite 'immune' to economic shocks. Under conditions of economic insecurity people tend to invest even more in housing improvements. This explains the extremely high growth rate of 11% per annum in brick demand in Kathmandu valley.[24]
Further, construction is the most important absorption sector for all kinds of skilled and unskilled labourers, from the moulders and firemen on brick kilns, to stone and brick cutters, workers operating concrete mixers, masons, helpers and, above all, transporters of bricks and building materials.

The sector is not held in high esteem, nor does it enjoy high social status. It is, nonetheless, by far the most democratic sector when it comes to job creation: whoever is willing to bear the hardship of transporting bricks up and down a ladder, or to sweat with merely a shovel as tool, may find a job, sometimes well-paid and sometimes just enough to survive.

6.2.2. THE SYMBIOSIS OF POVERTY AND BRICK KILNS: MIGRATION PATTERNS IN THE DRY SEASON

For many decades, little has changed in the brick industry in Nepal: making bricks is still basically a manual operation done by hand-moulding families who migrate from the villages of the Indian poverty pockets where there is no work available during the dry season. These migrants are in desperate need of any kind of job between November and May, when the soil becomes totally dry in their homelands. Usually the entire family migrates to the brick kilns, and the children cannot go to school during these months. These migrants are used to hard work, harsh living conditions and are not very demanding, as long as they get a decent salary. On the other hand, the wages are comparatively good: a moulder's family (man and woman together) can make some 1,500 green bricks per day and is paid 330 Nepalese Rupees (NPR) per 1,000 bricks. This translates into an income of almost 500 NPR or US$ 7.50 per day and per family but it is highly seasonal.

Similarly, a whole army of firemen from Bihar and Uttar Pradesh in India swarms out to the brick kilns of Nepal every year. These firemen usually travel in groups of six to eight and stay on the kilns for some six months without their families. They have acquired the knowledge of kiln firing from their fathers and forefathers and they know intuitively when coal is to be added to the firing holes. The firemen receive an advance before leaving their homes and are paid monthly. Theirs is a skilled worker's job with equally harsh working conditions, and they are often exposed to occupational hazards such as air pollution, extreme temperatures and rough living conditions. However, the salaries are usually quite good: a fireman may get around 7,000 NPR per month or a little more than US$ 100.



Most firemen come from India during the dry season and a traditional brick kiln owner can rely on them to operate a kiln. A VSBK would create jobs for local firemen throughout the year.

6.2.3. GOVERNMENT-INDUCED CHANGES: THE BAN ON MC-BTKS IN KATHMANDU VALLEY

When the Nepal Government banned the Moveable Chimney Bull's Trench Kilns in the Kathmandu Valley by a decree in 2003 (very similar with the Indian environmental regulations for BTKs), it came rather as a surprise to the industry. Studies had shown that brick kilns produced around one-third of the ambient air pollution in the crowded Kathmandu valley. For its more than 5 million inhabitants, air quality had become more and more unbearable. The owners of brick kilns were thus forced to change over to Fixed Chimney Bull's Trench Kilns (FC-BTKs). Out of 140 kilns, 86 had already switched to FC-BTKs by 2004 – the remainder did so the following year. This changeover was extremely fast, taking into account that it took more than 20 years to disseminate the FC-BTK in India without the pressure of regulation.

Fixed-chimney BTKs are said to pollute less and to use coal more efficiently than moveable-chimney BTKs. The coal savings are in the order of 10%, as the combustion is better in a higher chimney with a stronger draught [25]. However, the pollution reduction is also the result of a higher chimney (which spreads the pollution more thinly in the form of small particles). It is, nonetheless, certainly no clean technology and it remains to be seen if FC-BTKs will comply with the standards set by the government (SPM concentration of 900 mg/Nm^3 in flue gases in chimney), provided there is strict government monitoring and enforcement.[26]

6.2.4. BARRIERS TO VSBK ADOPTION: IT NEEDS A MANAGEMENT REVOLUTION

In 2003, when the ban on MC BTKs was imposed, the VSBK technology was not ready for a large-scale dissemination,

The pollution of the Kathmandu valley by over 130 Bull's Trench Kilns was especially severe and in 2003 the Government banned Moveable Chimney BTKs. Most kiln owners switched to Fixed Chimney BTKs: these kilns pollute slightly less and the higher chimney disperses the pollutants over a larger area.

as it had only recently been introduced in Nepal. Compared to a FC-BTK with a production capacity of 8 million bricks per annum, the VSBK has a production capacity of only 4.5 million bricks (with 4-shafts) and is thus – in the perception of FC-BTK owners – considered as a small kiln, too small to be viable. Moreover, the change from MC-BTKs to FC-BTKs was supported by a DANIDA project through the Institute of Environmental Management (IEM), with technical assistance and some financial incentives.

However, the main barrier for the adoption of the VSBK as opposed to FC-BTKs is not the size of the kiln. This could even be compensated by adding more shafts and a longer production season.

The most important hurdle is the entirely different management requirement: while an investment into an FC-BTK can be compared, as mentioned before, with the 'purchase of a truck and hiring a driver', operating a VSBK requires that the owner sits himself in the driver's seat. A VSBK can be operated the whole year round and requires specially trained staff. It cannot rely on the migrant firemen from India; it imperatively needs trained firemen from nearby or elsewhere in Nepal, as they have to be available the whole year round.

While a BTK owner can basically operate like a 'landlord', a VSBK owner needs to become a dedicated entrepreneur, a kind of 'industrialist', overseeing and supervising the operation very regularly. It is not enough simply to appear at the kiln once a day after dusk. The term 'industrialist', on the other hand, is associated with a much higher social status than that of brick kiln owners, whose prestige has been severely damaged, and it is seen as a polluting and exploiting activity.

6.2.5. WITH 'BUSINESS-AS-USUAL' SO PROFITABLE, WHY CHANGE?

Brick-making is a very profitable economic activity: even MC-BTKs are extremely profitable compared to the fixed investment needed. As most of the land for any BTK can be leased, the initial capital investment remains modest for both the conventional technologies.

In contrast, the VSBK needs a fixed, built structure, and it is necessary to own the land. The fixed investment is thus considerably higher. The table below shows that all kilns produce similar scales of profits per year, but based on considerably different investments. The return on investment (ROI) is therefore much higher for MC-BTKs and FC-BTKs. This is not to say that VSBKs are not viable: a ROI of 40% is excellent, but it is less attractive compared to BTKs with the sensational profitability of 80% or 135% respectively. This ROI, and the much higher personal involvement in managing a VSBK, explains the rather slow adoption rate for VSBKs – without further incentives.

6.2.6. RING THOSE SOLID, RED BRICKS: MARKET PERCEPTIONS

As discussed in section 1.4 and in Chapter 5: a good brick in South Asia must be a solid brick, of red colour and have a special 'ring' sound. The market for hollow bricks is extremely limited in South Asia, and the perception is that hollow bricks are not strong enough. It is remarkable that these cultural differences should still underscore the distinction between the 'British' cultural and colonial heritage prevailing in South Asia and the 'French' influence prevailing in Vietnam, where hollow bricks are the common standard.

Investments and returns	**MC-BTK**	**FC–BTK**	**VSBK (4 shafts)**
Production capacity p.a.	4 million bricks	8.1 million bricks	4.5 million bricks
Land – own (Nepal Rupees)	---	625,000	2,225,000
Land-development (Nepal Rupees)	280,000	145,000	150,000
Cost of kiln (Nepal Rupees)	200,000	1,200,000	2,600,000
Sheds, wells, office buildings (Nepal Rupees)	275,000	885,000	170,000
Preliminary expenses (Nepal Rupees)	183,000	310,750	185,000
Advances paid (Nepal Rupees)	1,300,000	1,340,000	1,000,000
Total Fixed Investment (Nepal Rupees)	2,238,000	4,505,750	6,330,000
Returns (profits) first year (Nepal Rupees)	3,018,480	3,591,518	2,523,640
Returns (profits) three years (Nepal Rupees)	~..9,000,000	~..10,000,000	~ 7,500,000
Return on investment (ROI) in %	135%	80%	40%

A good brick is perceived as red, solid and having a good 'ring' sound. Bricks from VSBKs need to prove that they are as good or better. This new housing colony in Kathmandu built with VSBK bricks is a good demonstration.

These perceptions are quite important market factors and are more easily met with FC-BTK bricks than with VSBK bricks. The quality of VSBK bricks can be excellent provided that the clay is well-selected and especially if it is treated in a mechanical pugmill. As discussed in detail in section 2.4, bricks fired in a FC-BTK are less sensitive to soil conditions and green brick quality, mainly because of the longer firing time. Whereas bricks are fired in a few hours in a VSBK, they remain for several days in the firing zone of a FC-BTK.

However, neither the colour nor the 'ring sound' are guarantees of quality in a scientific sense: the compressive strength of good VSBK bricks has been proven higher than that of BTK bricks. The following table shows the compressive strength of several bricks tested in the Central Material Testing Laboratory of Tribhuvan University, Kathmandu.

However, it will not be easy to convince the market on the basis of such scientific facts and overcome the traditional perception of brick qualities. Unfortunately, some

Brick Strength

Technology	**Brick Strength (Kg/cm²)**		
	Min.	**Max.**	**Average**
Fixed Chimney Natural Draught Kiln *	79.2	132	105.6
VSBK Kathmandu **	138.6	297.00	217.8
VSBK Jhapa**	205.26	229.09	217.13

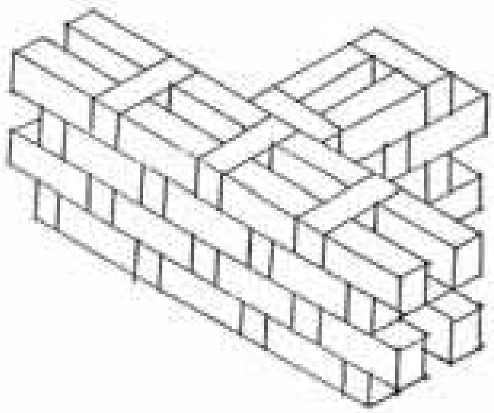
Source: Central Material Testing Laboratory, Institute of Engineering, Tribhuvan University, December 2005

low-quality bricks made in VSBKs – due to lack of care or initial teething problems – have already created a bad image of VSBK bricks that need to be corrected urgently.

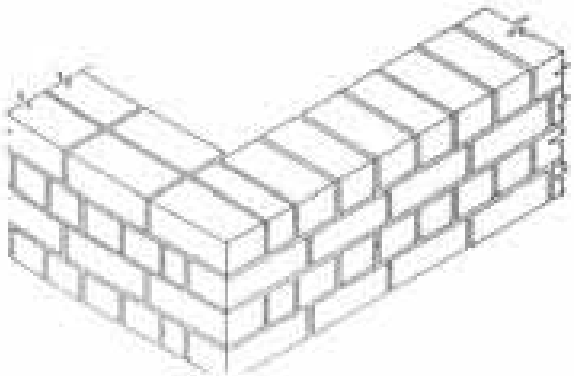
Moreover, the British building tradition seems to be quite deep-rooted and the masonry techniques are also extremely conservative. The majority of masons, contractors, builders, architects and engineers are used to red bricks and the 'English bond' masonry technique. The 'rat-trap bond' method of wall-building is unknown, despite the

Rat trap walls use more than 20% fewer bricks per m^2 and have a better insulation

Rat-trap Bond



English Bond



fact that it saves some 20% bricks per m^2 (and consequently the same amount of energy).

The introduction of more advanced building techniques can thus be an important supporting element to the introduction of VSBK bricks as well. Similarly, it would be very desirable to introduce hollow (perforated) bricks. The traditional 'English bond' method of bricklaying solid bricks not only uses more bricks but it also leads to a very low insulation performance. Hollow blocks and rat-trap bond would not only save costs and energy in terms of 'embodied' energy in buildings; it would also save energy for cooling and heating during the lifetime of a building.

However, such changes would need changes in deep-rooted perceptions: the first reaction of builders in South Asia when it comes to hollow bricks is a widespread scepticism about whether hollow bricks can have enough compressive strength compared to solid blocks – a strange perception for a Swiss observer, to whom hollow blocks are common standards. A Swiss construction textbook [27] considers the hollow brick as the 'normal brick' and the 'full brick' rather as an exception. This all shows just how deeply-ingrained are the differences between culture, even in everyday matters.

6.3. DISSEMINATION STRATEGIES: MAINSTREAM BRICK-MAKERS OR NEW ENTREPRENEURS?

The project has applied a two-pronged strategy of working both with existing brick-makers in the Kathmandu valley and with new entrepreneurs in the Terai.

6.3.1. THE PIONEER ENTREPRENEUR: "VSBK IS A JOY FOR ME"

One existing enterprise, Satya Narayan Brick Industry, owned by Mr. Chandra Maharjan and his son Laxmi, is strongly supportive of VSBK technology. Chandra Maharjan is now 53 years old and had a hard time as a child. He became a mason when he migrated to the Kathmandu valley and started a moveable-chimney brick kiln in the late 1970s. Although he was not always lucky with his kiln, he nevertheless became quite wealthy and entered politics and was elected as mayor of Lalitpur, a neighbourhood of Kathmandu. During the recent People's Movement against the King in Nepal in 2006 he was sent to jail for 50 days.

He heard about the VSBK through the newspapers and joined a meeting for new entrepreneurs organised by the VSBK project. He became interested and was given the

Mr. Satya Narayan's six-shaft VSBK is a very environment-friendly solution and can produce the whole year round in close vicinity to Kathmandu town.

opportunity to go to India to see a kiln in operation. Afterwards, he started a VSBK in Kathmandu in 2003 and is now a really successful pioneer entrepreneur.

He and his son now run a six shaft VSBK and they have solved – on their own initiative and with support from the project – most of the teething problems that go naturally with a new technology. Their enterprise, Satya Narayan Bricks, is not only a flourishing enterprise but enjoys many advantages of being the innovation leader in Nepal. Their operation is now fully converted to all-year-round production, with a large covered deposit of green bricks that allows them to operate also in the monsoon season. They have introduced a number of technical innovations and significant mechanisation steps such as six mechanical pugmills, an extruder to make perforated bricks and a mechanical excavator for clay. (See the interviews on the companion CD.)

6.3.2. IN THE WAITING ROOM: SCEPTICAL MAINSTREAM BRICK-MAKERS

Unlike Chandra Maharjan, many existing brick-makers appear to see difficulties in VSBKs, especially if running a kiln on the same site as a FC-BTK. The management requirements for a VSBK are so totally different from the conventional operation that it seems incompatible to run a VSBK alongside a FC-BTK. These difficulties have led to low-quality bricks in their VSBK, and the owners claim that technical problems inherent to the VSBK are responsible for their quality problems. On the other hand, the VSBK project team claims that bad practices (bad soil selection, bad firing practices and the lack of mechanical pugmill treatment) are responsible for the sometimes bad performance.

R.K. Awale is Chairperson of the association of Kathmandu valley brick kiln factories. He has been associated with the brick kiln industry for over three decades and has a respectable position among the brick kiln owners. He is member of the VSBK Steering Committee in his capacity as Chairperson of the association and has been

R. K. Awale is still sceptical whether VSBKs can produce good-quality bricks profitably. He also runs a Fixed-Chimney BTK side by side as long as he can: the BTK is much more profitable but he knows that he will soon have to close it. The BTK is polluting too much and needs too much precious land in the vicinity of the city.

Mr. Mariku is an experienced brick-maker from Bhaktapur and is operating six BTKs. He has installed a VSBK as a solution "in the future"; as long as he can continue with the more profitable BTKs he will not switch over, but he knows that the day will come when pollution will not be possible any more.

running a VSBK and a fixed chimney next to each other at Imadol in Lalitpur district.

In the past he ran a moveable chimney until some 14 years ago. He has been running a fixed-chimney BTK and a VSBK together for the last four years. He became interested in VSBK as voices began to be raised against the polluting industries in Kathmandu such as the moveable and fixed brick kilns. "The brick industry is in my blood. My forefathers used to make bricks without chimney. But I do the same with chimney. This is the only difference between what I do and my forefathers did," he tells.

He has, however, no good experience with VSBK, though he introduced pugmills and other suitable technologies for the success of this industry. He says, "The initial investment in VSBK is about Rs. 1,700,000 (US$ 27,000), but it is only Rs. 1,200,000 (US$ 19,000) to set up a fixed chimney. The quality of bricks prepared through VSBK technology is inferior to that produced from fixed chimney. Only the engineers say that fuel consumption in VSBK is less than fixed chimney, but it is not significantly lower. Also, the production of bricks in VSBK is low. As a result, the cost of production of bricks in VSBK is higher compared to those from the fixed chimney. It is even difficult for me to sell the bricks produced from VSBK because of their inferior quality. I have to keep the price of such bricks lower. However, I am running this industry because I have a feeling that I will not be able to get the required land for the fixed chimney after two or three years from now."

It is certain that the VSBK requires a higher investment, better soil selection, preferably mechanical treatment for better clay preparation, the use of internal fuels and a more active management presence at the kiln sites. It appears also that existing mainstream brick-makers are not really interested in running a VSBK as long as 'business-as-usual' is possible. The low-quality bricks produced by these experienced brick-makers could also be a defence strategy in order to gain more time. There are no grounds for such a statement but it appears unlikely that these most experienced brick-makers could not achieve good bricks, while Satya Narayan and the new entrepreneurs in the Terai do produce good bricks.

Bishnu Bhakta Marikhu has been in the brick industry for nearly two-and-a-half decades. He is the owner of six fixed chimney BTKs in Bhaktapur. In 2006, he started a VSBK. However, the factory had to be stopped shortly after it started production as the bricks were of inferior quality. The bricks had virtually no ring sound. They had no proper colour. The breakage percentage of bricks was also quite high.

He continued, "So this year we put pugmills as a precautionary measure and we have been selective about the soil." He concluded, "I have a feeling that VSBK is not a successful technology. I am still involved in this business as I get certain technical support from the VSBK project. I think that there is still a need for an improvement in VSBK technology to make it adaptable to the local situation. No entrepreneur will make an investment in VSBK in the existing situation. If at all anyone is interested in VSBK, it will be out of compulsion only. So long as the licence of all the polluting brick industries is not cancelled, nobody will go for VSBK."

It looks as if the mainstream brick-makers in Nepal are sitting in the waiting room until they are forced to change to a less polluting technology. We have seen that there are some good financial reasons to wait as BTKs are extremely profitable and do yield very high returns on a low investment.

6.3.3. PROMISING EXPERIENCES WITH NEW ENTREPRENEURS IN THE TERAI

Interestingly, the experiences with new entrepreneurs in the Terai are more promising. There is a pronounced interest expressed by a different group of entrepreneurs to invest in VSBKs and they are more open towards a new technology than traditional brick-makers.

These two tea growers from Jhapa are interested in diversification; they feel that brick-making has a good market and a VSBK has a better image than BTKs with their bad reputation as polluters. They have built a drying shed to produce bricks the whole year round. By this, they consider themselves more as industrialists' rather than brick-makers.

Some of these entrepreneurs in the Terai are tea growers who are interested in diversification. They see brick-making as a steadily growing business: the market for bricks is quite dynamic in view of the many ongoing housing projects. This market is mainly fuelled through remittances of migrant workers abroad who regularly send money home to be invested in improved housing. It is estimated that one person from almost every family works abroad. Building a 'pukka' house is the dream of every Nepali.

The new entrepreneurs in the Terai had to face some technical and other difficulties at the outset: one serious technical problem was due to a bulging shaft that needed to be corrected and another serious problem was that many bricks were just split in the middle after firing. This was mainly due to a high degree of moisture in bricks which, when evaporated suddenly, was causing a kind of 'explosion' when the bricks entered the firing zone. Similar experiences in BTKs are not common, as the firing time is much longer and slower.

Many problems were also caused by political instability, social unrest and frequent strikes. The opposition movement even wanted to stop brick production completely in February and March 2007, but the workers finally managed to persuade the leaders that it was detrimental to their interests if all the work stopped.

It is obvious that the initial experience needs to be consolidated first before other entrepreneurs will be tempted to enter production. It is also unlikely – and could even be counter-productive and potentially dangerous – if more entrepreneurs start before the first movers have proven their success. One issue to be resolved is brick quality: while initial technical problems occurred (such as moisture and consequent splitting of bricks) and have now been mastered, low-quality bricks of the test firing during the first three months have entered the market and spoilt the image of VSBK bricks. This is very unfortunate and needs to be corrected through better promotion and especially the demonstration of the scientifically-proven higher compressive strengths of the VSBK bricks.

There are also some doubts about the entrepreneurial 'maturity' of the new entrants: in Jhapa, it was observed that the owners had covered the VSBK platform with bamboo walls which resulted in a deterioration of the ambient air quality on the platform, as there was no draught left. It is somehow difficult to understand why the entrepreneurs did not correct this mistake – during our visit, we started coughing immediately upon entering the platform – by simply removing one or two bamboo elements on their own initiative. Moreover, six trained firemen had run away from this kiln already in the past year and this had caused considerable damage to the enterprise.

While we were in Jhapa, word of mouth spread, and three new entrepreneurs wanted to talk to us and showed considerable interest for setting up a VSBK. One of them was a Marwari family living in the Terai for many decades and operating a very successful tea business. Although the family is guided by very conservative values and beliefs – the father had never eaten or drunk any water that was not from his own house – the family was extremely open and interested in new technologies: the father had set up the first FC-BTK in the Terai a few years ago and is also running a large biogas plant from the dung of his 12 cows.

Conservative values can go with enterprising spirit

Shyam Sunder Agarwal's family came to Nepal 150 years ago when the British Raj passed a regulation that Marwaris could come to Nepal and settle. It is a family with very strong conservative beliefs. His own father had sent him to the Goethel's boarding school in Darjeeling and he was an outstanding student who had qualified for a scholarship in the UK. When his father came to visit him, he needed to go to the toilet and asked for the water bowl. When the son told him: "We use toilet paper here", the father took him from the school saying: "I don't want you to follow habits that are against our culture and religion".

Shyam Sunder also told us that the introduction of the VSBK would need some incentives: "When the British wanted to introduce tea in India, the perception was that 'tea is poison'. British tea companies thus introduced the habit that two biscuits were served with the tea... Indians were very interested in getting the biscuits and finally also adopted the tea."

Mr. Shyam Sunder with his mother in his prayer room is from an old Marwari family: they came from Rajasthan to Nepal many years ago and are traditionally very famous for being smart business people.

6.4. THE SOCIAL DIMENSION: A REAL WIN-WIN SITUATION?

6.4.1. BRICK KILNS: THE PLACE TO GO FOR THE INDUSTRIAL RESERVE ARMY

It is, as stated earlier, in the brick industry that the industrial reserve armies of Nepal and India find a place to gather. The brick industry can absorb people from all walks of life who have been expelled from another industry or from the agricultural sector. Most moulders are unskilled, many are illiterate and to a large degree are even composed of single-headed households. It quite often occurs that a whole family works on a kiln while both husband and wife are working.

I have no other choice

Rolpa carries bricks at the Satya Narajan Brick factory in Kathmandu.
"This is the only option I have. My husband has been missing for the last four years in India. I have no idea where he is and what he is doing. I work for six months in brick factory and go back to my home village.
Every season, I come to work in the brick factory here in Kathmandu with my daughter who is four-and-a-half years old. Now the factory has arranged Child Care Centre (CCC) for younger children like my daughter. I am here to take my daughter for lunch then after the lunch, I will be bringing her again. It is good that the factory has arranged this facility so that we could concentrate on our work. She also could learn reading and writing. I do not need to worry about sun and rain. I am working so hard for my daughter's future and wanted to earn as much as possible. I hope I can educate her for a better future than I had. She is the only strength I have".

This social situation features labour and living conditions among the hardest in the world; a degree of hardship often difficult for middle-class people to imagine. Many people work in this industry because they have no other choice – and even express this in our interviews we held.

It is thus remarkable that the project has achieved much progress and has been able to introduce significant social innovations. This is remarkable in such a conservative industry, driven for decades by the symbiosis between job-seekers facing the desperation of not finding any suitable work and income during the dry season and the brick-owners needing plenty of seasonal workers. It is almost miraculous that social improvements are even possible in such a conservative, competitive industry that demands little more than hard physical work from its moulders and those who carry green or burnt bricks from one place to another.

6.4.2. TECHNOLOGY AND SOCIAL CHANGE – CHILD CARE CENTRES AS A RUNNER

While introducing the VSBK as a better and more environment-friendly technology in India, the question soon arose: 'does it also help to improve the lot of the workers?' This question is not easy to answer and has led to a whole array of different approaches and answers in the different VSBK programmes.

The underlying hypothesis for the strategy of 'techno-social integration' is that 'if technological change is needed, social change may come along', or, in a more refined way: 'entrepreneurs who are ready for technical innovations may also be open for social innovations'.

The social action component of the VSBK project is described more closely in a well-written Strategy Paper [28]

Children are better taken care of in a Child Care Centre (CCC): they can play, learn and the parents can dedicate themselves to their work without fear that something may happen to their children.

and focuses on improving working conditions in water supply, shelter, health and especially child care through the introduction of Child Care Centres. It is also aimed at introducing more health awareness among workers and empowering them to speak out more openly. In many cases, the VSBK project has been able to facilitate a dialogue between workers and kiln owners and improve it considerably: usually, there is very little communication between workers and owners.

The experience in Nepal seems indeed to confirm that some small and precise improvements are possible. Whether these improvements go along with technical change, or if social improvements are even possible without technical change, cannot be said with certainty. The fact is that all six VSBK operators have introduced social action programmes; interestingly, a good number of FC-BTK operators have likewise introduced such programmes: the Child Care Centres (CCC) are the most attractive option, with more than 20 CCCs operating and substantially supported by the owners themselves.

Social Action in FC-BTKs

We met the owner of a fixed brick kiln of Bhaktapur at a hotel in that town. He was very interested in social action and was also positive about the problems of the workers. He wanted to have a CCC at his brick kiln site so that it could take care of the children of the workers. In addition, he also wanted to provide health care to the workers at the brick kiln site.

We asked the gentleman if there was any financial benefit of social action. He replied: "We are interested in the CCC so that it can take care of the children of the workers; they can work better if not disturbed by the children.

We also have to take the workers to hospital far away as and when they fall ill. But if we have a health unit at our brick kiln site, we will not have to take them out. Again, this will save our time and energy, apart from adding to the productivity of the workers."

The entrepreneur was interested to have all such social activities at his brick kiln site that are now available at VSBK. However, he did not have much information on VSBK, other than having seen the activities of Satya Narayan Brick Factory. He will wait and see and is not yet inclined to go for a VSBK .

It cannot be concluded with any certainty whether technological change is the entry point for social action (as the hypothesis claims); social action can also serve as an entry point alone and may then later on lead to a dialogue on technical changes. It is, however, not so important to know the exact sequence of actions: what is important is that the brick industry is not totally closed but open to a certain change, and it may well be that some social actions are in a way preventive actions for survival: many brick owners know that their industry is considered a 'dirty' industry with a bad image and a low social status. The 'dirt' refers not only to pollution but also to exploitation, bad working conditions, and creating some social tension with the neighbours when suddenly 300 to 1,000 seasonal workers arrive in a neighbourhood.

6.4.3. VSBK PROVIDES A SOCIAL LADDER FOR LOCAL WORKERS

The nature of the VSBK provides both a challenge as well as interesting opportunities: firemen now need to be available all year round and the firemen from India will not do the job for more than six months. A VSBK thus needs local firemen and needs a certain level of staffing during the whole year. For this, most VSBKs are producing more green bricks during the dry season and stockpile them under a roof during the monsoon.

The fact that unskilled workers can climb the ladder and become firemen is a considerable social improvement and the possibility to rise socially is very much appreciated by the firemen:

Raj Kumar Lama (30) has been working as fire master at Satya Narayan VSBK, Imadol, since 2003. He comes from

Raj Kumar Lama has found year-round employment on Mr. Satya Narayan's 6-shaft VSBK. He received training as fireman and can work in his own country – no need to migrate.

Makwanpur district and is associated with this VSBK since its inception. Before joining this kiln he used to work as moulder and as a truck-driver there. He was trained as a fireman and also learned this skill from the Indian firemen who had come to Satya Narayan VSBK as trainers. Though illiterate, he has been drawing a monthly salary of 7,000 Rupees (US$ 110), quite a good salary. He maintains his family comprising his wife and a minor son of five years with this amount. He even sends his son to a boarding school. Since he is employed round the year and insured against injury, he looks satisfied and wishes to stick to this occupation.

6.4.4. WIN-WIN AND UNREALISTIC SOCIAL ACTIONS

Child Care Centres are a true win-win-win for the children, the workers and the owners. Not only are the children taken care of, the productivity and quality of brick work can increase significantly. Moreover, it gives to the kiln owner prestige and satisfaction.

There seems to be a clear win-win for certain social actions, the most evident one being the Child Care Centre. It is obvious that the productivity of the workers will go up if the children are looked after, but as the kiln owner pays them by the piece, the owner does not directly gain from higher productivity; it is the workers that will make more income in a day. On the other hand, there are also tangible benefits Child Care Centres: it seems that in the past, almost every year one child had a severe accident or fell in a clay pit and died.

It would be unrealistic to expect that all people are happy with the Child Care Centre: some complain about the food, others complain that their language (Bengali) is not sufficiently spoken by the caretakers, and others still complain that it is too expensive to pay 5 Rupees per child per day. Although the productivity gain for a family may easily exceed these 5 Rupees, this cost may present a barrier for some people. If a family (of two people) makes 1,500 bricks a day and is paid 330 Rs per 1,000 bricks, with only 15 bricks more it has gained these 5 Rupees.

Cost to establish and operate child care centre	**NRs**
Up-front Investment	**220,000**
Construction (permanent structure)	100,000
Kitchen utensils and furnishing	15,000
Training (except resource person)	90,000
Educational materials	15,000
Operating cost/month (for 25 children)	**13,200**
Salary for two caretakers	5,000
Utilities and fuel (25 days/month)	700
Food for children @ 8 per child per day	5,000
Stationery (25x100)	2,500
Cost per Day child/day	**21**

However, if a family has three children or more, it may become a burden that counts and it would be necessary to introduce a lower fee for families with many children. The Child Care Centre is thus a great innovation, but it should not be seen as the answer to all the questions. The project has tried to express the win-win in specific figures and facts (see table).

It is thus obvious that the installation of a CCC requires an up-front investment of some 220,000 Rupees (US$ 3,500) and the operational costs per day per child are in the order of 21 Rupees (33 US cents). If the contributions by the families are lowered, even more subsidies would be required from the owners. On the other hand, according to the calculations of the project, a transporter woman (single woman) can make up to 70 Rupees more per day and a moulder's family up to 130 Rupees more per day if the children are taken care of.

Other planned social activities seem somewhat unrealistic: The project can of course – with external support – enhance awareness on certain issues but to convert this 'preaching' into practice is another story. While social action has been able to increase awareness on reproductive health practices, nutrition and HIV/AIDS prevention and been able to ensure that 30% of the women are aware of the need for sanitation and hand-washing, only 10% are practising them. This difference can also be explained by the lack of facilities, lack of water supply and lack of a clean environment in general: a brick kiln is by definition not the most hygienic place. One should keep in mind that any progress in social terms among these marginalised migrant populations is a big step.

6.5. OUTLOOK FOR DISSEMINATION IN NEPAL

Will there be a rapid dissemination of brick kilns in Nepal? As long as basic conditions do not change, a fast take-up is not very likely. Traditional mainstream brick-makers will continue with BTKs as long as they are allowed to do so.

As in India, as long as the government does not enforce stricter regulations markets do not demand better quality hollow bricks, and migration goes on there is little incentive for any change. However, in the long run, similar constraints will force change in the Nepali brick industry as in India. We shall discuss these prospects in a later chapter in Part Three.

THE VSBK AND THE BRICK INDUSTRY IN VIETNAM

7

7.1. BRICKS: A DIVERSE AND VIBRANT ECONOMIC SECTOR [29]

A country of two great river deltas, the Mekong in the south and the Red river in the north, with abundant good quality clay resources, Vietnam has a rich history of pottery and brick-making. In fact, Vietnam has one of the most diverse and vibrant structural clay industries in the developing world today. In the year 2000, Vietnam produced 8.79 billion bricks, a volume which was projected to rise to 13.07 billion by the year 2010. However, half-way estimates by the Institute of Building Material Science and Technology (IBMST) of the Ministry of Construction indicate that demand for bricks has been increasing at a much faster pace than expected, and production had already reached 18 billion bricks in the year 2006.

Vietnam has developed relatively low-cost tunnel kilns with an investment cost of only US$ 450,000 for producing 15 million bricks per year. This may be a good intermediate solution for many countries in Asia; modern Western tunnel kilns cost much more.

Box 1: Government policy on brick industry

The Prime Minister's decree, issued in 2001, on the overall planning of the Vietnam building material industry calls for a tighter focus on production of non-fired bricks and the elimination of traditional kilns for firing bricks in suburban areas by 2005, and in the entire country by 2010. It also proposes further development of tunnel kiln technology as well as the need to invest in more production lines of bricks fired in small-scale tunnel kilns with a capacity of 7 to 10 million per year. The introduction of the VSBK has yet to get formal support from the Government. However, it has emerged as a feasible option for replacing traditional kilns for small- and medium-scale production of bricks in this transition phase of the industry.

The diversity in the sector is not only limited to ownership patterns, markets and products: it also extends to brick-making technology. One can distinguish between a modern, industrial and a traditional production line:

1. Modern industrial brick-making: At one end of the spectrum is a small number of modern tile and brick-making enterprises – having state-of-the-art imported machinery from Europe – producing a wide variety of structural clay products [30] for the upper-end local market and for exports to countries as far as Australia, New Zealand, Japan and Korea.

2. Industrial tunnel kiln enterprises: There are several hundred (around 400) tunnel kiln enterprises producing hollow bricks, blocks, roofing and flooring tiles, catering to the demand of large, publicly-funded construction projects and urban markets. They typically have production capacities of 10-20 million bricks per year.

3. Traditional brick-making: At the other end of the spectrum is a large number (more than 10,000) of small-scale traditional brick-making enterprises owned by farmers and small entrepreneurs, making common solid and perforated bricks for local consumption in villages and small towns. They use traditional batch kilns for firing.

4. VSBK enterprises: a new and fast growing sector, comprising VSBKs, has emerged only in the last few years and has already captured a 10-15% market share. VSBK enterprises have production capacities of 2-6 million bricks per year and may now become an accepted alternative for traditional brick-making.

The contribution of different types of brick firing technologies in Vietnam is presented in Table 1.

The brick industry has been heavily influenced by the political philosophy and policies of the government. Moreover, a certain colonial influence is also visible: for example, the introduction of extrusion machinery for roof tile making can be traced back to French rule in the first half of the twentieth century; the French influence is also reflected in the preference for hollow bricks, having hollows parallel to the length of the brick [29] (box 2).

Table 1: Brick Firing Technologies in Vietnam

Brick firing technology	Estimated number of enterprises	Annual production capacity per enterprise (million bricks/year)	Percentage of total production *	Fuel
Tunnel kilns	400	10-20	35%	Coal
Traditional kilns	>10000	< 2	50-55%	Coal, rice husk
VSBKs	300	2-6	10-15%	Coal

* Total brick production is estimated at 18 billion bricks for the year 2006

During the period, 1958 to 1986, the government followed a socialist central planning framework. Industrialisation was an important pillar of government policy and this period saw the import of heavy brick extrusion machinery (around 1965) and coal-fired tunnel kiln technology (1973) from friendly Socialist countries of Eastern Europe. Initially, these technologies encountered several teething problems and had to be re-engineered locally to suit local requirements. They were later indigenised and locally produced and were instrumental in the development of state owned enterprises (SOEs) for brick-making in North Vietnam. During this period most brick production (as was the case with most manufacturing industry) was carried out in SOEs and, apart from small-scale production of bricks for self-consumption in rural areas, private enterprises for commercial production of bricks were not allowed.

1986 saw the end of the Soviet financial assistance and the beginning of the country's 'Doi moi' renovation policy with radical reforms in all sectors of the economy. The important step was the proclamation of 'market socialism', which implied the legalisation of private enterprises in almost all sectors, self-financing of state enterprises and provision for joint public-private ventures, so-called "joint stock companies". This new economic policy also had an immediate impact on the brick industry. Small-scale brick-making enterprises, mostly owned by farmers, mushroomed all over the country. Several SOEs were merged to form a large corporation called Viglacera and others were sold to private investors or were converted into joint stock companies.

Box 2: Colonial influence on brick-making

In Europe, centuries ago, different countries opted for different types of bricks. These preferences also influenced brick industry in their colonies. For example, the English preference for solid bricks is reflected in the preference for solid bricks in the Indian sub-continent; similarly, the French preference for hollow bricks (with hollows parallel to the length of the brick) is evident in Vietnam, which was a French colony.

7.2. DISTINGUISHING FEATURES OF VIETNAM'S BRICK INDUSTRY

The Vietnamese brick industry has several distinguishing features which make it very different to the brick industry in South Asia.

a) Use of extruders instead of manual moulding

The most important distinguishing feature is the complete absence of the practice of manual brick-moulding and the use of simple brick-making machinery. Even the smallest brick-making plant uses a simple extruder for brick-moulding. These extruders are generally driven by a small diesel engine. Manual moulding practices were prevalent

Extrusion machines for making hollow blocks are common. It would be unthinkable to make hand-moulded bricks in Vietnam.

Hollow bricks are gaining more and more acceptance in Vietnam.

in Vietnam until the end of the 1960s, but the introduction of mechanisation to reduce drudgery for workers was one of the main pillars of the Communist philosophy in Vietnam. This led to the government's support for mechanisation in brick industry. As mentioned earlier, the first extruders were imported from Eastern Europe towards the end of the 1960s. Since then, extrusion has become prevalent in Vietnam and the country has now a well-established manufacturing base for extruders and other brick-making machinery suitable for large enterprises producing more than 10 million bricks per year.

After 1986, with the emerging small-scale brick-making enterprises, there was a tangible demand for small extruders and they are now manufactured locally by the private sector. The widespread use of small-scale extruders has also been possible with large parts of the country being blessed with the best-quality clay available. This clay is amenable to extrusion without requiring extensive pre-processing. There is, however, still a considerable scope for improving the quality of small extruders.

b) Hollow bricks are gaining acceptance

More than half the bricks produced in Vietnam are hollow or perforated with hollows ranging from 10-40% of the brick volume. The hollow bricks became popular with the introduction of the tunnel kiln technology in 1973. During this time the government took the decision to discourage the use of Hoffmann kilns. This decision was taken primarily in view of the poor working conditions for kiln operators – mainly the exposure of workers to heat and dust during loading and unloading operations. Tunnel kilns were considered better in terms of working conditions. During the introduction of tunnel kiln, it was found that the air flow and ventilation in the kiln, as well as the firing rate, is better with hollow bricks and thus hollow bricks were preferred in tunnel kilns. As the tunnel kiln enterprises had de-airing extrusion technology, production of high-quality hollow bricks was possible. However, it is not possible to produce bricks with bigger hollows using rudimentary extruders which are used for brick forming in small traditional kilns; hence most production in traditional kilns is either solid bricks or bricks with smaller hollows.

c) Pro-active government policy on building materials

The other distinguishing feature in Vietnam, compared to South Asian countries, is the pro-active – or even interventionist – role played by the government in shaping the policy for the sector. This has primarily to do with the Socialist form of government with its strong focus on central planning. Vietnam has a separate Department of Building Materials in the Ministry of Construction at the national level and Departments of Construction at the provincial level. Besides, there is a significant public sector presence in brick-manufacturing through SOEs and Viglacera. The presence of the government in the brick industry is thus much larger than in South Asia. The government decree issued by the Prime Minister on 1 August 2001 describes the vision and steps for the development of the buildings material sector until the year 2010. For brick-manufacturing, it calls for modernisation of technology, focus on tunnel kiln-based brick enterprises, elimination of traditional small-scale brick-manufacturing and increasing production of non-fired and non-clay bricks.

7.3. FAST TRACK VSBK DISSEMINATION

VSBK made its debut in Vietnam in 2001 in a project under the UNDP-GEF Small Grants Programme (SGP). The SGP provided financial assistance of US$ 32,415 to a local NGO, the Vietnam Thermal Technology and Science Association (VTTSA). This NGO received technical assistance from Professor Yin FuYin of the Energy Research Institute of Henan, China [31] in constructing the first single-shaft VSBK in Hung Yen province. The project worked with the traditional brick-makers of Xuan Quan commune, located on the outskirts of Hanoi, under pressure from local authorities to close traditional brick kilns due to concerns over air pollution they caused. The project successfully demonstrated a reduction in air pollution levels and fuel savings of around 50% compared to traditional kilns, and about 30% compared to tunnel kilns. By mid-2003, six more kilns had been built in Hung Yen province and 15 more were constructed in Hai Duong province with support from the government [32].

A VSBK technology evaluation mission, conducted under the SDC project by Indian experts in November 2003, mentions that Vietnam then had around 100 VSBKs, including some very large VSBKs with six shafts. Several were self-replicated; while others built with technical help from VTTSA and the IBMST institute of the Ministry of Construction. There are now around 300 VSBK enterprises in Vietnam, accounting for 10-15% of total brick production (Table 2).

The initial years of VSBK introduction also saw a lot of experimentation and innovations in the technology. A document prepared by visiting Indian experts in 2004 [33] documented these experiments and innovations.

VSBKs have not been allowed by Government policy as it wanted to phase out traditional kilns by 2010. Given significant improvements in environmental pollution and the introduction of mechanisation, the Government has tolerated VSBKs for small industries. It is likely that it will soon accept VSBK as a clean and modern technology.

Table 2: Dissemination of VSBK technology in Vietnam

Year	
2001	First VSBK constructed under UNDP project
2003	Around 64 VSBKs in operation in 16 provinces #
2005	Around 200 VSBKs in operation in 22 provinces*
2007	Around 300 VSBKs in operation*

Entec: Diagnostic Report on Brick Making in Nam Dinh Province, Entec AG. June 2003; * Estimates provided by IBMST

The two major innovations were:

1. Mechanisation, which included:
a) Mechanisation of the green brick lifting system.
b) Mechanisation of the fired brick unloading system with a hydraulic and electric-motor driven system.
2. Firing of hollow and perforated bricks: for the first time a variety of hollow and perforated bricks were fired in VSBKs.

Despite its better performance in terms of economics, energy and environment, VSBK dissemination in Vietnam hit a roadblock because of opposition from the Central Government. It should be remembered that before the VSBK was introduced, the government had already decided to ban small-scale brick-making by 2010 (see box 1) and had decided to promote medium- and-large scale tunnel kiln enterprises. Thus in 2002, the Ministry of Construction, while accepting the better energy performance of VSBK technology, opposed its actual introduction.

The opposition was based on following factors [34]:

- Labour intensity: kiln operation being manual labour intensive and not mechanised.
- Health and safety of workers: exposure of workers to flue gases containing such emissions as CO and SO_2, during loading of bricks in the shaft.
- Traditional nature of VSBK enterprises: since most initial VSBKs replaced traditional kilns, there was no change in the organisation of the enterprise. In the eyes of government it still remained 'disorderly', not complying with planning and wasting natural resources in violation of land and mineral laws. Furthermore, in its perspective, there was no change in the brick production process, which remains 'primitive'.
- Limitations in producing a variety of structural clay products: VSBK can only produce solid bricks or bricks with small hollows and cannot produce other high-quality products which are possible in a tunnel kiln.

The Government of Vietnam also took note of the fact that China was considering a ban on VSBK technology [35].

Bricks are made by mechanical extruders and making hollow bricks is possible. Most brick kilns in Vietnam are equipped with electricity

It was reluctant to adopt a technology which looked like an obsolete technology, about to be banned in a neighbouring country.

Overall, lack of support from the Ministry of Construction (MoC) had a negative impact on the dissemination process, as refusal by several of the provincial governments to register VSBK enterprises made it difficult for the entrepreneurs to raise loans from banks and created uncertainty about the future of the technology. Despite this, the dissemination of the technology has progressed. The economics of VSBK enterprises are favourable and this has attracted the attention of brick-makers. Some provincial governments such as those of Dak Lak and Hai Duong have supported the introduction of the technology.

Government institutions such as IBMST have been actively (though not openly) involved in the dissemination process. Since 2003, the SDC-supported VSBP project has facilitated an objective assessment of the technology, worked for demonstration of a sustainable VSBK enterprise model and engaged both the national and some of the provincial governments on the issue of policy towards VSBK, as we will see in the next section.

7.4. VIETNAM SUSTAINABLE BRICK PROJECT: AN EFFECTIVE FACILITATOR

Having seen above the different policy context and structure of the brick industry in Vietnam compared with South Asian countries, it comes as no surprise that the SDC intervention programme in the brick sector in Vietnam has unfolded in a very different manner compared to India and Nepal. The SDC brick programme in Vietnam, now called the 'Vietnam Sustainable Brick Project' (VSBP), is jointly implemented by ENTEC SA (a Swiss consulting company) in partnership with the Department of Construction (DOC) and the Department of Natural Resources and Environment (DONRE) of Nam Dinh province. Nam Dinh province is located about 90 km south-east of Hanoi in the Red River delta. The project focuses on small-scale brick-makers in the province and aims at developing and implementing a model programme of technical solutions, policy instruments and management tools, to assist the brick-makers in making a transition to environmentally sound and economically viable forms of brick production. One project component deals with VSBKs.

In the diagnostic phase of the project the VSBK was identified as one of the technical alternatives to the traditional kilns. Since then, through various interventions, the project has played an important facilitative role in the development and dissemination of VSBK technology in Vietnam.

Energy and environment performance assessments of brick kilns

When the project started in 2002, the MoC had already taken a position opposing the introduction of VSBK technology in Vietnam. In contrast, the technology enjoyed strong support from the brick-makers and by mid-2003, Nam Dinh already had seven VSBK-based enterprises. One of the project's first tasks was to carry out an objective assessment of the performance of the VSBK technology. Thus, the project initiated the task of comprehensive energy, environmental and economic monitoring of existing VSBK enterprises and comparing their performance with the performance of tunnel and traditional kilns.

The project spent significantly large resources on monitoring the environmental performance, because, in the context of Vietnam, issues such as the damage caused to crops and vegetation by air pollution from brick kilns, as well as exposure of workers to air pollutants and its impact on their health and safety, were much more prominent than in India and Nepal. In Vietnam, high sulphur content in coal and high fluorine content in clay results in higher concentration of SO_2 (sulphur dioxide) and HF (Hydrogen Fluoride) in flue gases. Both of these gases are harmful to crops, plantations, animals and human beings. The project assembled a team of experts from Vietnam, India, Germany and Switzerland to monitor the performance of kilns. The monitoring results, published in 2005 [36] confirmed the superiority of VSBK in terms of energy performance. The emission factors (emission of pollutants in g/kg of fired brick production) for VSBK were found to be much less compared to traditional kilns and tunnel kilns.

Improving environment performance of VSBK

At the same time, the project also started working on improving the VSBK design, particularly to reduce concentration of pollutants in the ambient air on the loading platform. On the basis of the advice of the Indian experts involved in the project, the chimney diameter and height were increased and flue inlets were provided at two levels in the shaft to ensure easy evacuation of flue gases through the chimney, thus reducing air pollution at the loading platform. With assistance from a technical expert from the Brick and Tile Research Institute (IZF) of Essen in Germany, the project developed a technique to mix limestone powder (2-4% by weight) into the clay, helping to fixing fluorine and sulphur as solid compounds (CaF_2 and $CaSO_4$) within the brick body. This resulted in a reduction in emissions of the two harmful gases, HF and SO_2. Further, the practice of internal fuel mixing [37] (mixing coal in powder form with clay) also helped to reduce particulate emissions.

VSBK technology in public domain

The project worked on developing a close rapport with the small brick-makers in the province. As a part of this exercise it made available the design and drawings of standard VSBKs free of charge to all the brick-makers who approached the project for technical help. This was an important step because, previously, the design and drawings of VSBK were not available. The brick-makers sometimes (mis-) copied these designs and this led to mistakes in construction. The project also made available (on request) the technical expertise of VSBK experts from IBMST to the existing VSBKs to help them in improving their operations.

Setting up a Model VSBK enterprise:

Through discussions with the Provincial Government, the project learnt that their main concerns regarding the VSBK technology were its poor track record with respect to occupational health and product quality as well as its 'traditional' nature – that is, its small-scale and seasonal production. To address these concerns adequately and to help the Provincial Authorities in the process of grant approval to the technology, VSBP decided to support setting up a 'Model VSBK Enterprise' in Nam Dinh.

The main features of the model VSBK enterprise were as follows:

1. Technical:

- Improved VSBK design incorporating modifications in the flue gas system and chimneys, and use of a hydraulically operated unloading system

• A good quality de-airing extruder to mould hollow bricks
• Adequately sized drying shed to ensure uninterrupted supply of dried green bricks to the kiln even in the rainy season.

2. Business:
• Long-term availability of clay at source
• Accessing credit from commercial banks

3. Regulatory:
• Compliance with all necessary Government clearances and approvals.

The layout of the model enterprise was designed in such a manner that if the enterprise decides in future to increase production it can change over to tunnel kiln technology. The model VSBK tried to fulfil all the government criteria for being considered as an industrial enterprise.

The model VSBK enterprise was planned and implemented by a private entrepreneur. The enterprise became the first VSBK enterprise in the province to get all necessary clearance and registration with the Provincial government as well as from a commercial bank. VSBP provided technical support and a partial financial support to incorporate new features (such as a hydraulic jack). In May 2007, the model VSBK started operations and by August 2007 the firing of the kiln was stabilised. The project was assisting the brick-maker in clay preparation and brick forming to reduce the breakage of fired bricks and further improve their quality.

Policy advocacy

The project is in continuous dialogue with policy makers at the provincial and the national governments on the issue of policy on VSBK technology. As a part of this strategy, a 'status paper on VSBK technology' and a detailed report on 'energy and environment assessment of brick kilns' has been shared with policy makers. The design of the model VSBK enterprise has been developed in close cooperation with the provincial authorities, who have now granted a license to the model VSBK enterprise. Study tours for government officials to visit VSBK kilns in Nam Dinh and other provinces, such as Dak Lak as well as to India, have been organised. In addition, information on government policies on VSBK technology in other countries has been made available through policy workshops.

The three-pronged strategy has comprised the provision of technical support for VSBK improvements directly to entrepreneurs; generating performance data through comprehensive monitoring of VSBK enterprises for an objective assessment of VSBK technology; and continuous

Table 3: Highlights of Model VSBK Enterprise Recommended For Nam Dinh Province

No.	Item	Details
1.	Constitution	Private Limited/Joint Stock
2.	Product size	220 x 105 x 60 mm with 2 cores (each ≤ 30 mm dia.)
3.	Installed Capacity	4 million bricks/year
4.	Project Cost (Comprising Land, Site Development, Buildings, Machinery, Miscellaneous Assets, Preliminary Expenses, Pre-operative Expenses, Contingencies and Working Capital Margin)	US$ 160,000
5.	Means of Finance, Term Loan from Bank Equity	US$ 32,000 US$ 128,000
6.	Annual Turnover	US$ 87,000
7.	Annual Profit Before Tax	US$ 9,400
8.	Return on Investment (Earnings Before Term Loan Interest and Tax / Project Cost)	13.47%
9.	Fuel Cost as % of Selling Price	13.2%
10.	Break-Even Point (% of Installed Capacity)	75%
11.	Employment Potential	38 (30 Workers + 8 Staff)
12.	Implementation Period	6 Months
13.	Total Electrical Load (3 Phase)	91.7 kW

Note: US$ 1 = 15,700 VND

policy dialogue with provincial and national government. In all, it has been quite successful and government policies have become much more tolerant and favourable towards VSBK technology.

7.5. FUTURE OF VSBK IN VIETNAM

During the past six years of its existence in Vietnam, the VSBK has been found to be highly energy-efficient and less polluting. Equally important, VSBK enterprises have proven to be profitable businesses and the technology has received great support from brick-makers. The VSBK enterprises have been progressively mechanised and the trend has been to position them as medium-scale industrial enterprises for making bricks (2-6 million bricks per year). The country has developed local technical expertise and competence for its construction and operation. The technology has spread to 45 provinces in the country and has already garnered 10-15% of the country's brick production (the highest-ever percentage share in any country for VSBK). Thus, the stage seems to be set for large scale dissemination. However, the future of VSBK technology in Vietnam is very dependent on government policy. At this point in time, the Government seems determined to impose its ban on traditional kilns, at least in urban areas. The only technology option that has the full support of the Government is the tunnel kiln technology. The Government was hoping that some of the smaller brick-makers would shift to small capacity tunnel kilns (7-10 million bricks per year). However, instead of having smaller tunnel kilns, the recent trend has been to operate tunnel kilns to maximise production (mini-mum of 20 million bricks per year). The investment required for a tunnel kiln enterprises is of the order of 7.5 billion VND (US$ 487,000), which is beyond the reach of small brick-makers. In this scenario, an industrial VSBK enterprise requiring an investment of 2-2.5 billion VND (US$ 130,000 to US$ 150,000) and a production capacity of around 4 million bricks per year, emerges as a promising option for many of the traditional brick-makers. The Government has realised this and some provincial governments have softened their position on VSBK technology.

The Government is keenly watching the development and performance of the model VSBK enterprise, and there are positive indications that VSBK will get Government approval soon.

Many types of bricks and tiles are used in modern buildings and brick quality is an important criteria in the market.

PART THREE: PLEA FOR A FUTURE REGIONAL STRATEGY – WHAT COULD AND SHOULD BE DONE

This outline looks at the strategies that might be able to influence the entire brick industry in Asia and make it more sustainable economically, socially and environmentally. It is a huge task but the stage is set to make it happen. This is, of course, a task that goes far beyond the scope of a small donor such as SDC but with perseverance, the right strategy, long-term funding, leverage and the right alliances, it can be done.

LESSONS LEARNED: SEARCHING FOR THE RIGHT STRATEGY

8

The experiences from the VSBK projects are rich and many lessons can be drawn, from successes as well as from failures. We will first draw some common conclusions and then briefly look, one by one, at different countries.

8.1. TEN LESSONS LEARNED FROM THE VSBK SAGA

It is quite challenging to summarise even some of the many lessons learned over the last eleven years by hundreds of project staff working closely with brick-makers, in setting up kilns, solving problems and through experiences, both bad and good. We will nevertheless try to draw ten lessons, as listed below, not necessarily in the order of importance. Some are perhaps also applicable to several other clean technology transfer projects in micro, small and medium enterprises:

1. Technology transfer – adaptation is needed: As the project had identified from the outset, a technology cannot simply be transferred with a cut-and-paste method from one country to another. It needs substantial adaptation to make it suitable to different conditions and also to make it acceptable to other constituencies. When in China VSBKs spread rapidly like wildfire, it did not solve many urgent problems, among them environmental pollution for workers on the platform. Many of these issues have since been resolved and substantial innovations have been made though shared learning processes. Better ventilation and chimneys, a mechanised screw system, firing of hollow bricks, mechanical pugmills, transportation systems for bricks with lifts and conveyer belts have all been amply tested, and a great deal of knowledge about firing, clay selection and materials handling has been acquired. At an inter-regional level, the SDC intervention has probably brought together the most valuable and unique knowledge base for the intermediate – semi-mechanised, low investment – brick industry.

2. Drivers of change – role of regulations: When the brick industry adapts, it is above all to the prevailing regulatory and policy environment. As the example from Vietnam has shown, fundamental transformations such as the abolition of hand-moulding and the introduction of hollow bricks are not possible without a policy intervention from government. The experience from India also shows that even a relatively simple change-over from moveable-chimney to fixed-chimney BTK became possible primarily through an environment regulation. For large-scale changes to occur, a suitable regulatory and policy framework are important.

3. The change process is slow and needs long-term, sustained interventions: All the experience gained in the project has shown that in a traditional industry like the brick industry, transformations take several years, generally decades. Large-scale change from moving to fixed chimney systems took 40 years. In Vietnam, although hollow bricks were introduced almost 35 years ago, their penetration is still limited to around 50% of the total market. Similarly, the dissemination of VSBKs has been slower than originally anticipated in almost all the countries concerned. This calls for designing long-term interventions and programmes with a heavy emphasis on developing local capacities and empowering local teams to take through the intervention process to its logical end.

In India, changes in the overall orientation of SDC policy have shed new light on the social dimension but have also changed the focus of the project and hampered the dissemination process. Successful dissemination would have required a longer-term, uninterrupted support following a clear dissemination strategy.

4. Environmental regulations need to be comprehensive: The introduction of environmental regulation in the brick industry – and even more its enforcement – can be beneficial, but simple SPM[38] pollution standards (specifying SPM concentration in flue gases coming out of the chimney in mg per m^3) or chimney height regulations, as prescribed for BTK in India and Nepal, have resulted in only marginal reductions in air pollution and have brought only cosmetic changes in the technology. In the case of BTK, standards should also take into account the fugitive dust emissions caused by ash covering the kiln, as well as provisions for firemen safety and health. Thus there is a case for comprehensive environmental regulation to promote clean technologies. A comprehensive set of environment standards should promote overall resource efficiency and, apart from air pollution norms, should include norms prescribing maximum energy consumption per kg of production of bricks, and building codes specifying thermal insulation of walls. Such an approach will bring large environment benefits and would give impetus to less resource-incentive brick-making.

5. Economics and scale needs to be right – the case for intermediate technologies: Entrepreneurs will always optimise investments and returns and the economics of the technology should be affordable. The experience in Vietnam shows that entrepreneurs prefer intermediate technologies – semi-mechanised VSBKs and low investment tunnel kilns – over highly automated, high-investment and very high production kilns and technologies. Intermediate technologies have the right scale and are affordable for developing economies.

6. Financial incentives and carbon finance: Fiscal incentives have been tried in Nepal but are quite marginal compared to the investment; the exemption of excise duty amounts to only about 100,000 Nepal Rupees per year. An exemption of VAT on hollow bricks, for example, would be a much more effective incentive.
There is, however, considerable scope for carbon finance. A two shaft VSBK can save 500 tons of CO_2 per annum compared to a clamp kiln in India, while in Nepal a four-shaft kiln can save around 385 tons of CO_2 compared to a fixed-chimney BTK. However, these large differences in CO_2 savings show one difficulty as well: the coal consumption both of the VSBKs and of the baseline kilns (clamps or BTK) are relevant and must be measured regularly. Making carbon finance available involves a cumbersome procedure and a bundling agent, as each single kiln is a relatively small emitter – compared, for example, to a power plant. The incentive of carbon finance would become attractive by simplifying the provisions for small producers and also by making it available up-front and reducing the investment.

7. Reducing drudgery and protecting employment – the relevance of semi-mechanisation: The drudgery involved in manual brick-moulding in South Asia and the harsh working conditions in brick kilns make a strong case for introducing machines. However, it is crucial to smooth the transformation process through selective mechanisation: while a labour-intensive BTK is using 20 to 25 workers to produce one million bricks, a semi-mechanised VSBK or tunnel kiln in Vietnam can do this with 12 to 14 people. If implemented, this change would reduce the number of workers by 2-3 million in South Asia. In a fully mechanised Western tunnel kiln, less than one person is required for a million bricks. A change from traditional to the most modern technology would thus eliminate more than 90% of the jobs – a strong case for selective mechanisation and a smooth transition process.

8. Know the limitations of a technology as much as its strengths: All of the projects have clearly demonstrated the superior energy and environmental performance of VSBK technology. However, some failures also highlight certain technical limitations of the technology. The experience of operating two VSBKs in North India has shown that the kiln is not suitable for firing solid bricks made from clays sensitive to fast firing (heating/cooling rates of the order of 100°C/hour). Increasing firing time beyond 30-32 hours to slow down firing is difficult to achieve, and even if it is implemented it brings down the productivity of the kiln, making it commercially non-viable. Experience also shows that, amongst solid bricks, the kiln gives better techno-commercial results with thinner bricks and bricks with internal fuel. Experience in wet climates in Vietnam and South India indicates that for VSBK's stable operation, the green bricks fed into a VSBK needs to be properly dried. Their moisture content should not exceed 5-6%, which calls for the integration of a drying system. Knowing the limitations of a technology is as important as knowing its strengths – and one size does not fit all. This understanding helps a project to carry out an objective evaluation of the technology, to finding its right niche as well as to guide the technical teams in working towards developing different technology packages for different requirements.

9. Social improvements are possible – integrate social action component in technology projects: Small traditional industries are an inseparable part of society and culture. Thus, technology and social change processes go hand in hand. A technology project with a well-integrated and properly thought-through social action component could increase the effectiveness of the intervention. VSBK projects have shown that it is possible to use the technology for positive social impacts: for reducing pollution, for reducing drudgery and for providing all-year-round employment. The Indian experience of 'community ownership' and 'firemen ownership' has shown how VSBK technology can be used for poverty reduction and empowerment of brick workers and women's self-help groups. There are also win-win situations possible by creating awareness of social and technical issues amongst workers, promoting functional literacy, improving technical skills, providing vocational training and setting up Child Care Centres (CCC), as demonstrated in Nepal. All these measures improve the work climate and productivity in addition to providing new employment opportunities to the workers.

10. Better building methods – a triple win: The most promising win-win situation, however, is that better-quality bricks, especially hollow bricks and – as we shall see – better building practices can provide incentives to change the brick industry in the right direction. The most important savings can be realised through better insulation properties of the bricks and the walls with, for example, rat-trap bond masonry. This is the good news: but the even better news is that these will make the buildings much cheaper, as we shall see in Chapter 9.

THE ENERGY AND RESOURCES INSTITUTE (TERI): LESSONS LEARNED

The VSBK is the most efficient brick kiln: detailed scientific energy monitoring exercises by TERI have shown that VSBK is the most energy efficient kiln for firing bricks.

The VSBK has good environment performance: TERI undertook a study to formulate national emission standards for the VSBK on behalf of the Central Pollution Control Board. The stack emissions in VSBKs were found to be significantly lower compared to those of fixed chimney BTKs, confirming better environment performance of VSBK.

The VSBK is a better solution in South India than in eastern Uttar Pradesh: TERI introduced technology in two regions – eastern Uttar Pradesh and southern India (Karnataka and Tamil Nadu). A variety of local factors determines whether the VSBK is an appropriate solution for a certain region: quality of clay and green bricks and their suitability to undergo fast-firing in a VSBK; economics; production capacities; and the quality of bricks produced by competing technologies. Work done so far indicates better conditions for VSBK dissemination in Tamil Nadu than in eastern Uttar Pradesh.

Alternate ownership models show promise, but require significant work before replication TERI endeavours to integrate social interventions with technical interventions (the "techno-social integration approach"). With partner NGOs, TERI has experimented with alternate ownership models for providing livelihoods and empowering the rural poor and brick workers. A VSBK brick enterprise owned by women's Self-Help Groups has been established in Tamil Nadu, while two small (downscaled) VSBKs owned by firemen families have been established in eastern Uttar Pradesh. These models show promise but require a significant amount of work to make them robust and ready for replication.

KEY CHALLENGES

Integrating VSBK into government development programmes: TERI's VSBK dissemination strategy focuses on leveraging financial assistance and other benefits available under the various government-run rural development programmes, such as the Prime Minister Rojgar Yojana (PMRY), the National Rural Employment Guarantee Act (NREGA) and others. This can improve dissemination and overcome initial investment hurdles. The integration of VSBK dissemination in these programmes remains a key challenge.

To institutionalise the knowledge organisation of the firemen community: TERI has been involved in organising firemen working on brick kilns and their families in eastern Uttar Pradesh. With its partners, TERI has been able to reach out to more than 20,000 firemen and their families. In this process, the key challenge is to develop a self-sustainable 'Knowledge Organisation' of the firemen community for integrating their traditional knowledge and skills with scientific and technical knowledge. To institutionalise this knowledge organisation would lead to upgraded skills; social upliftment; greater capacity in organisational and institutional aspects; and their enhanced status in society. To translate this concept of the firemen's knowledge organisation into a reality remains a key challenge.

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This is the first of seven texts from seven project partners on their perception of the "Lessons learned" and "Key challenges", presented during this chapter. Each separate text, and the seven texts together, demonstrates the dynamic and participatory nature of the Bricks programme. Because each such text has been prepared and submitted by each project partner, and is thus "in their own words", the texts have not been subjected to the same editing protocols applied to the rest of this publication. They have only been edited for clarity, and the original vocabulary and values have been fully respected.

DEVELOPMENT ALTERNATIVES:
LESSONS LEARNED

1. Small-scale brick enterprises are well aware of the threats to their business and are willing to invest in new technology: Small-scale brick entrepreneurs face multiple threats from regulatory agencies in their current business of brick production. The rising cost of coal and the uncertainty of its supply, the irregular nature of the monsoon season and restrictions in the movement of organised labour are all major threats to their business.

2. VSBK is a very effective brick firing technology: The technology has proven advantages: energy efficiency (40% savings in coal consumption); a short firing cycle (firing completed within 24-30 hours); better environmental performance (significantly lower SPM); and flexibility in operations (number of shafts can be operated independently). This results in better product quality and higher profitability.

3. Investments in brick-moulding machines improve brick quality: The success of the VSBK technology is contingent upon consistent quality of green bricks. VSBK entrepreneurs willingly invest in brick-moulding machinery which provides them with multiple advantages; uniform mixing of internal fuel, uniform product and the ability to use local manpower.

4. A network of commercial service providers, operating regionally, who can achieve business growth and profitability is essential: The dissemination of VSBK technology is managed by a network of regional service providers; channel partners for contracting new businesses; construction contractors; equipment manufacturers; and firing crews for kiln commissioning. The technology provider, TARA, provides such assorted services as soil testing, kiln design and troubleshooting.

5. Financial incentives, based on performance, accelerate growth of VSBK Enterprises: The growth of VSBK enterprises has benefited from the realisation of revenues from carbon finance. Through the Community Development Carbon Fund, up to 2015, VSBK enterprises will get assured returns, in US$ 3,000 for an annual production of 2 million bricks.

6. Brick workers are able to acquire new sfiring skills: Existing fire masters are able, with 15 to 20 days of training and supervised on-the-job training, to pick up nuances of controlling the fire zone within a VSBK and regulating other parts of the kiln operation.

7. Policy support at the State level is crucial for ensuring wide acceptance of new technology in the SME Sector: The rate at which VSBK technology is adopted by brick manufacturers is critically dependent upon the policy support of State Governments. Endorsement by the Department of Industries has accelerated technology promotion and growth.

OUR MAIN CHALLENGES

1. Availability of bank finance for industrialisation of brick manufacturing in India: Financial institutions continue to perceive the brick sector as largely unorganised and thus assign low credit worthiness. A stronger "clean technology" positioning with endorsement by Apex level financial institutions is required to create innovative channels for credit availability.

2. Large-scale capacity-building across all levels of personnel engaged in VSBK technology: Demand from VSBK entrepreneurs for trained personnel is greater than anticipated. It is expected that trained persons will be provided by the technology promoter, such as TARA. An institutional network will have to be activated to create a large pool of moulders, machine operators, fire masters, supervisors and quality control professionals.

3. Quality assurance in VSBK operations: VSBK technology will thrive only if promoted on a platform of quality and cutting-edge expertise. Resources are needed for continuous technology monitoring which will lead to further market-driven research and development work are required. New product development is required in such areas as perforated bricks for raw material savings and enhanced energy efficiency.

4. Use of industrial by-products and other substitute materials: There is an immense potential in materials being generated in such large-scale industrial processes as sponge iron residue in brick-making; this practice needs to be widely adopted.

5. Major improvements in brick-making need to be mainstreamed across "scales" and "geographies": It will be important to facilitate knowledge networking amongst VSBK entrepreneurs and other stakeholders. This development will also strengthen the case for policy support and fiscal incentives for VSBK technology.

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GRAM VIKAS
LESSONS LEARNED: UNLESS THE POOR COME FIRST, THEY COME LAST

Gram Vikas looked at VSBK as a technology which could be directed to address the issue of poverty. Orissa is home to millions of brick workers who migrate every year to brick kilns in other states. We wanted the technology to be used as tool by the brick-moulders of Orissa to set up their own community-owned brick kilns, so that their desperate migration in search of employment could be reduced. With this objective, Gram Vikas assisted in the setting up of two community VSBK brick kilns in two villages, where there were a large number of brick-moulder families.

During the setting up of the two community kilns, the Gram Vikas VSBK construction team found that the task of motivating green brick-moulders, constructing the kilns with them and accompanying the communities till they were on their feet is a slow and arduous one. So the construction team argued that to keep abreast of the construction technology, they should build some kilns for private entrepreneurs. Permission was granted and the construction team built six kilns for private entrepreneurs in a very short time. However, we soon realized that the entire energy of the construction team was now focussed on the easier task of building private VSBKs for entrepreneurs and no attention was being given to our prime goal, and more difficult task, of building VSBKs for brick-moulding communities. We had to take a drastic decision that we would not build VSBK kilns for private individuals and that our entire energies would go into promoting community kilns for brick-moulders, who are one of the most marginalised sections in Orissa society. We learnt our lesson that unless the poor come first they come last.

KEY CHALLENGES:
GRADUATING FROM LABOURERS TO OWNERS AND MANAGERS OF CAPITAL

The section of people Gram Vikas has chosen to work with – the asset-less, green brick-moulders – are not the easiest people to set up an enterprise and run it successfully. They are 'comfortable' in the 'discomfort' of their present state of affairs and have developed survival mechanisms in their present form of existence.

Gram Vikas efforts to set up community VSBK brick kilns with bank loans with the moulders, where they are the shareholders as well as the labourers, may be accepted initially by moulder communities as a good idea. To put this idea into practice, however, needs a lot of handholding, accompaniment, persistence and perseverance. We have managed in two instances to graduate moulders from mere labourers to owners and managers of brick kilns. The challenge is not only in going through this process, but also replicating it more often and learning from each venture.

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DAMLE CLAY STRUCTURALS PVT. LTD.
LESSONS LEARNT:

Attention to human and institutional development (HID) issues is essential for the sustainability of bilateral cooperation projects: a focus on HID is highly critical for ensuring the sustainability of such projects beyond the project period

Having a diversity of partners and pilot project locations helps in adaptation: the diversity of partners, and a diverse set of pilot project locations, helps in a faster, and better, adaptation of a technology

There is a basket of conditions which favour adoption of VSBK technology: VSBK stands maximum chance of commercial success in regions where:

- existing green brick quality is high and fired brick quality is low to medium
- demand for bricks exceeds supply
- coal is traditionally used in brick firing
- brick-maturing temperature is less than 950°C
- firing labour is plentiful and cheaply available; and
- environmental awareness is high

KEY CHALLENGES

Need for scaling-up and down-scaling of the VSBK technology: scaling-up and down-scaling of the technology is necessary for creating a broader end-user base and for meeting changing demands of the brick industry

Need for a critical mass of successful VSBK enterprises, for dissemination: the creation of a critical mass of techno-commercially successful VSBK-based enterprises in a region, and thus in different regions altogether, is a necessary pre-condition for dissemination

It is necessary to arouse and sustain the interest of commercial banks and other traditional financial institutions to fund VSBK-centered enterprises

Ensuring and maintaining healthy relationships beetween existing India Brick Project partners is essential for the further development of VSBK technology, its high quality and its low-cost delivery

It is essential to develop a critical mass of VSBK technology providers and firemen teams which can take up firing contracts on piece-rate basis

Mechanised pugmills and other means to improve the quality of green bricks is an important pre-condition for disseminating VSBKs.

DAMLE

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SORANE SA
LESSONS LEARNED:

The need for complex multi-cultural cooperation, and to pool competence in developing VSBK technology

The introduction of the Vertical Shaft Brick Kiln in India has been a very interesting and challenging experience.

The first aspect is that one could rarely work in such a multi-cultural environment. Working together to develop and adapt a technology from China, "discovered" there first by Danish experts, imported to India with support from the Swiss Agency for Development and Cooperation (SDC), and working with Swiss and Indian institutions with very different backgrounds – all this has really been a challenging and exciting experience.

The second dimension is that working on the VSBK was definitely the most complex component of all the different energy-efficient technologies for small and medium enterprises (SMEs) that were developed in India with SDC support. In the other domains, such as energy and environmentally-efficient cast iron foundries all over India, and glass furnaces in the town of Firozabad, work concentrated on improving the energy efficiency of existing furnaces, and demonstrated this on existing units. Their energy and environmental performance, as well as product quality, were improved (with reductions of 30-50% of CO_2 emissions), but the process in itself – the working pattern – was not modified. In a similar approach, in the field of thermal gasifiers, even if the technology was a new firing technology, it was simply producing heat in a more efficient manner than in traditional "chulhas" (traditional wood-fired ovens and furnaces) for various processes in SMEs. Once the energy-efficient technology had been demonstrated and credibility won in the sector, then its adoption was a question of conviction and time. The energy-efficient technologies developed with TERI for foundries, glass and thermal gasifiers have now reached a level where dissemination is rapidly gaining momentum. In the field of the brick kiln technology, on the other hand, the challenge was not only to introduce a new firing technology (VSBK), which was more energy-efficient, but also to introduce a new brick production system with all the related quality issues and the initial disbelief of the brick makers to be surmounted.

The main lesson learned out of the VSBK component is that the complexity of the project set-up was a very difficult process to handle – with many different institutions having different backgrounds and competencies, being either more technical or more socially-focused) – but it could not have succeeded without all the actors involved. The competence network, developed under the India Brick Project, has helped in getting different institutions to work together, using each other's expertise and taking into account many dimensions. Different actors in India and abroad have now appropriated this technology, and further developed it for various market segments and geographical areas.

KEY CHALLENGES

Developing the VSBK technology package for different niche markets

The main challenge ahead lies in developing further VSBK socio-techno-economic packages which cater to the different niche markets where the VSBK technology has a comparative advantage. One example is of energy performance in a coming energy crisis. However, the rapidly-changing scene of the building industry in India (quality consciousness, larger players) may lead to the introduction of more capital intensive technologies such as tunnel kilns, especially nearby big cities. These technologies will most likely be less efficient than the VSBK (using continuous artificial brick-drying techniques). The VSBK technology also has specific niche markets in other areas; for example, it can help in developing community-owned enterprises.

Achieving improved energy-efficiency in foundry and glass industry was easier than in the brick industry as the process needed no changes.

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8.2. THE VSBK IN INDIA: TAKING STOCK

In terms of numbers alone, the VSBK has not yet been so successful. It is not that 100 kilns is nothing, far from it; it would in fact be a great achievement were India not such a big country. While the dissemination process has started and while the implementing agencies, DA, TERI, Gram Vikas, Damle and, previously, MITCON made great efforts and acquired a remarkable expertise, the conditions for a fast take-up are not yet right. Neither is the regulation system conducive to truly environmentally-friendly technologies, nor are the financial incentives in place. As long as clamps and BTKs are allowed, cheap seasonal labour is abundant and the market is happy with red solid bricks, resistance to change will continue.

However, a very rich technical and financial knowledge base has been developed in India and very promising social innovations have been undertaken: the creation of awareness in firemen and moulders, community kiln ownership, kilns run by a women's self-help group and down-scaling have all been tried, not yet always fully successfully, but in many promising ways.

All signs show that the wind may now be changing, and probably fast. The fast-growing economy, particularly the building construction industry, is sucking in cheap labour from rural areas; on the other hand, the government-sponsored rural employment guarantee scheme in the poorest districts is providing new employment opportunities for the poor. The combined effect has been that the flow of labour to the brick industry has lessened, and for the first time the industry is considering reducing its dependence on manual labour through selective mechanisation. Simultaneously, after many years of resistance, a niche market – at least in and around fast-growing cities – is demanding new varieties of bricks, and a small breed of forward-looking entrepreneurs and some of the largest European brick-manufacturers are investing in modern brick plants. A new Energy Conservation Building Code (ECBC), which demands better insulation property of walls, is in the making; this is likely to open up market for hollow bricks in the near future.

The multi-disciplinary technical capabilities developed amongst several organisations and individuals during the Indian project have already resulted in several new initiatives in the Indian brick industry. Beyond India they have played an important role in the Nepalese and the Vietnamese project. The Indian team is well-poised to play an important role in the entire Asian region.

8.3. THE VSBK IN NEPAL: WHAT WORKS AND WHAT NOT

At the outset in Nepal, the VSBK was accepted very enthusiastically by one pioneer in Kathmandu and by some new entrepreneurs in the Terai. When the Government imposed a total ban on moveable-chimney BTKs in the Kathmandu valley in 2003, the VSBK technology had not yet been tested sufficiently to provide the more than 140 mainstream brick-makers with a viable alternative: they switched over to fixed-chimney BTKs with a larger capacity than a normal VSBK. It seems that the mainstream brick-makers in the Kathmandu valley are reluctant to change and want to gain, or play for, time as long as they can, especially as BTKs provide very high returns on investment. Those brick-makers running a BTK and a VSBK in parallel have mixed results due to such different practices such as the need for more stringent clay selection and preparation for VSBK. Overall conditions in Nepal are quite similar to India, and the same migratory firemen and moulders are flocking in during the dry season from the poverty pockets of Bihar and northern India. New entrepreneurs in the Terai region are more receptive – despite frequent strikes and other political disturbances, but they will need more time to gain experience and master the new technologies.

Major achievements have been made on the social front: over 20 Child Care Centres have been established at different kilns. Many BTK owners refuse to invest in a VSBK but gladly adopt the CCC concept on their kilns. This has proven to be a real win-win situation, providing benefits also to the kiln owners.

The VSBK team in Nepal – with the support of SKAT – has also acquired many skills and developed a knowledge base that can be used for technology transfers in other Asian countries.

8.4. THE VSBK IN VIETNAM: A TAIL WIND BRINGS ENCOURAGING RESULTS

The contrasting nature of the Vietnamese brick industry offers a lot of hope to the brick industry in South Asia. For quite a number of years, it has been unthinkable to produce bricks by hand or to prepare clay by foot in Vietnam; clay preparatory machinery and extrusion machines have been a standard for many years. Along with solid bricks, hollow bricks are used in large quantities.

The VSBK has had an eventful beginning in Vietnam. The dissemination rates have been much faster compared to India and Nepal and already 300 VSBKs contribute to more than 10% of total brick production. Vietnam also leads in terms of innovations in the technology. The main issue in Vietnam has been government policy, which did not approve the technology due to concerns regarding high air pollution on the loading platform and the unorganised nature of some of the earlier VSBK enterprises. Actions have been taken to solve both of these issues – the air pollution through improved chimney systems and through mechanisation of some of the processes and building of model VSBK industrial enterprises. The Sustainable Brick Project in Vietnam has also looked at other technologies such as the Channel Kiln – a section of the Hoffmann kiln – and a relatively low-investment tunnel kiln. The latter, with an investment of around US$ 450,000 (in the kiln) is an interesting option for many other countries even in South Asia. By positioning a modernised version of the VSBK, not as a simple alternative to traditional kilns but as a smaller version of an all-year round industrial brick-making technology, it may have created a low-cost alternative to the tunnel kiln as well.

The main lesson from Vietnam, however, is that a technology can progress or stagnate depending mostly on government policies and the socio-economic environment. Vietnam is in the process of regulating small traditional kilns and VSBKs, as well as tunnel kilns, have been taken up very quickly. The acceptance of hollow bricks is high, fuelled by rapid economic growth and demand from government projects and urban centres.

8.5. NEW PROJECTS: AFGHANISTAN, PAKISTAN AND CUBA

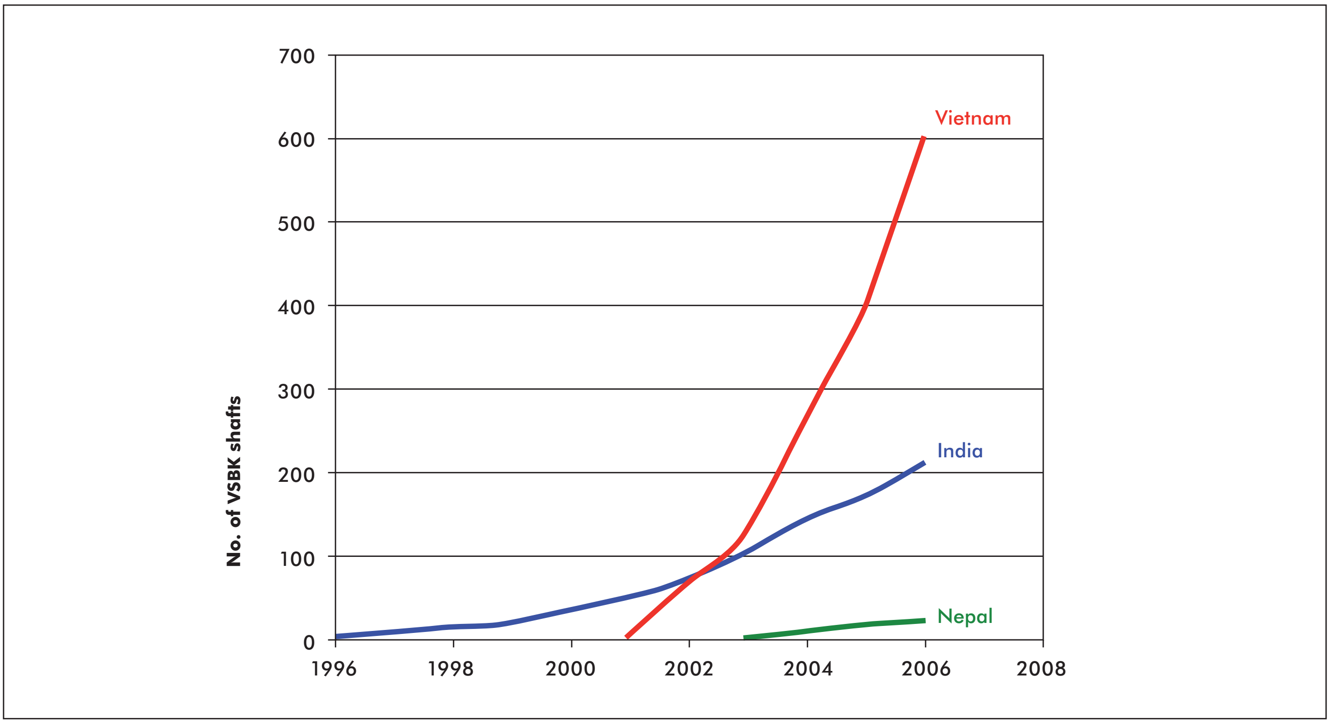
Recently, some new initiatives have begun in Afghanistan and Pakistan. While the experiences in Pakistan are just beginning, in Afghanistan already three VSKBs are under construction. The entrepreneurs are very enthusiastic and there is a good market for bricks.

The transfer of knowledge to these projects is managed by the VSBK project in Nepal, with the support of SKAT in Switzerland and engineers from Nepal. Supplies are either from Pakistan or, for specialised items such as the screws for unloading, will be imported from Nepal. Firemen from Afghanistan have been trained in Nepal and local workshops will be used for producing the metal parts.

This transfer is an excellent example of the rich network of knowledge and experience that has been created, and a true South-South exchange will be possible throughout the entire region. A similar project is now starting in Pakistan and one is under negotiation in Cuba.

8.6. SYNOPSIS: A DYNAMIC, SURGING TREND

The initial process of change may appear to be slow, but trends have nevertheless become dynamic of late. The following graph shows the uptake in numbers of VSBK shafts in India, Nepal and Vietnam.



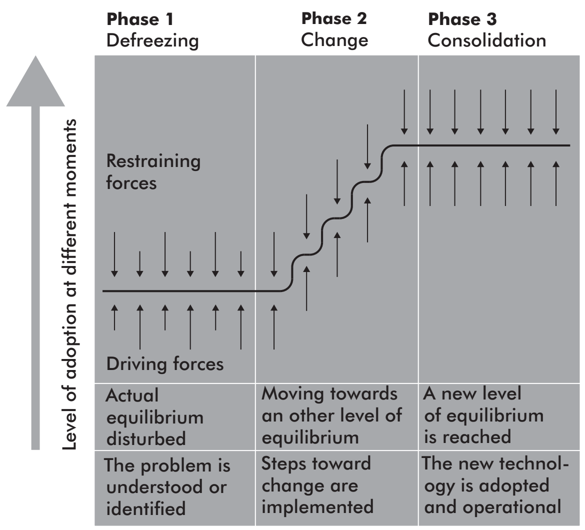
One of the first VSBKs under construction in Afghanistan. Technology transfer has been supported by the VSBK project in Nepal and firemen have been trained there.

SKAT NEPAL, AFGHANISTAN
LESSONS LEARNED:

Holistic approaches and solutions, with the right partners, are needed

A scientific process of kiln technology development is not enough. Brick-making is not only an environmental process but also an economic and social one. The intervention must therefore be complemented with the following three components:
a) the need for balance with practical and market-oriented working experience, leading to a clear win-win situation between environment and economics;
b) the importance of adjusting the entire brick production system and business management to meet the specific characteristics of technical kiln improvements (e.g. VSBK firing system);
c) making available interdisciplinary expertise including technical, social, institutional and legal competencies embedded in local and current top international experience.

The identification of, and cooperation with, innovative and experienced entrepreneurs is fundamental to implement and anchor these key lessons in the local context, successfully and sustainably. In addition, the entrepreneurs must aim at a sustainable business which includes a caring attitude towards workers and the environment, is financially sound and is recognised as an influential stakeholder.



KEY CHALLENGES

Scaling-up changes in technology requires powerful and concerted driving forces

The main challenges in scaling-up the clean production system are found at the following three levels:

- Establishment and institutional anchorage of effective supply chains, regarding both hardware (such as refractory bricks or metal parts) and software (such as capacity and competence building, or training capacity)

- Mobilisation (through alliances) and implementation of "push" forces (through a regulatory framework, emission standards, and an informed and alert civil society) and "pull forces" (incentives, CDM mechanism)

- Assurances of external support to the process of technology change (see diagram) for defreezing and change periods are required. They are needed even more for the consolidation phase, up to the point of achieving a critical mass of self-sustaining enterprises. This requires persistence over an extended period, an element which is often underestimated in the technol ogy transfer process. Such support might consist of access to quality assurance, trouble-shooting and technology development know-how, all demand based. This external support can only be substituted with a local support service mechanism after achieving the point of critical mass of VSBK industries.

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ENTEC SA
LESSONS LEARNED:

VSBK technology needs adaptation and improvements to suit local needs: realising this, the VSBK technology has been adapted and improved through inputs from local and international engineering and consulting entities. Major improvements include:

- Standardising the construction of VSBK through the use of pre-moulded refractory bricks
- Reducing air pollution at the loading platform by introducing double air ducts for flue gas collection and evacuation
- Reducing HF and SO_2 emissions through addition of lime stone powder to clay or coal mixed with clay
- Reducing drudgery through a winch system for lifting green bricks and a motorised/hydraulic unloading system
- Accelerating green brick-drying by constructing a natural drying shed with transparent roofing
- Reducing external coal-feeding and improving energy efficiency by optimising the mixing of coal dust into green bricks
- Appropriate green brick stacking to allow firing of hollow bricks in VSBK
- Proper sizing of green brick forming equipment to enable VSBK enterprises to improve green brick quality and to make them more competitive with hollow tunnel bricks.

VSBK is an affordable, alternative technology for small and medium scale brick-making enterprises: after five years of development, about 300 VSBKs have been self-developed in about 45 out of 64 provinces of Vietnam and have proven that VSBK is an affordable alternative technology for small and medium scale brick-making entities. This means a transformation from polluted intermittent brick firing to a much more energy-efficient, cleaner and continuous process.

For dissemination, a techno-commercially viable VSBK Enterprise Model is needed: under the project, a VSBK Enterprise Model with long-term business investment and development plan has been developed at a total investment range of 60-70,000 USD. This has been demonstrated and proven as an enterprise development step which enables small-medium scale brick-making entities to transform into a regularised and more sustainable brick-making business.

KEY CHALLENGES

Access to clay resource reserves for long-term business for new VSBK enterprises

In the Vietnamese policy context, the start-up steps of getting land-use certification, clay resource extraction permits, enterprise registration, access to project financing and other requirements is a challenge for new VSBK enterprises. For these steps, VSBK investors need to have proper investment and long-term business plans.

Three investment thrusts: in appropriate green brick forming process, green brick-drying facilities and in implementing environmental mitigation measures

Assured and continuous availability of good quality dry green bricks is necessary for assuring good quality fired bricks and acceptable environmental performance in a VSBK. VSBK enterprises would require investments in appropriate green brick forming process as well as green brick-drying facilities.
Emissions of HF and SO_2 have an adverse impact on workers' occupational health and also causes crop damage, leading to payment of crop damage compensation by brick enterprises to farmers. The project has demonstrated that emissions can be reduced through the addition of limestone powder during the brick forming process. Further, mechanisation of the loading system can minimise the working time for workers at the top of the kiln, thus reducing their exposure to polluting gases. At several sites, VSBK enterprises would have to make investments in these environmental mitigation measures.

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TRANSFORMING THE BRICK SECTOR IN ASIA: A CHALLENGING BUT NECESSARY TASK

9

The story of the introduction of the VSBK in the Asian brick industry has shown the great potential for making the industry less resource-intensive and more sustainable.

9.1. OVERCOMING THE HURDLES – WHY IS IT SO CHALLENGING?

With major forces in place that strongly resist any change, it is evident that market forces alone will not solve the problem. What is needed is a comprehensive, strategic intervention based on four pillars:

1. Comprehensive environmental and social regulations: Without regulations there will be no need to change: as long as pollution is free of cost it will continue. Regulatory interventions should not simply focus on the most visible air pollution and 'dilute' the fumes through building higher chimneys: the regulation should also deal comprehensively with issues of soil depletion, air and CO_2 emissions, resource-efficient bricks and insulation properties of bricks. It is also essential to implement social standards and norms to improve working conditions, reduce drudgery, enforce minimal safety standards, reduce migration and provide better housing facilities, child care centres and schooling facilities for workers.

2. Financial incentives through carbon finance: No entrepreneur will invest in more capital-intensive technologies for environmental reasons alone, especially as long as his competitors are allowed to continue polluting. While environmental regulations will be the stick, carbon finance can be the carrot to initiate changes. It will be especially important to make carbon finance available as upfront investments in the form of soft loans to be repaid with CO_2 savings over time.

3. Demand-side interventions: The demand pattern must change in order to create incentives for delivering high-quality hollow bricks instead of solid red bricks. This will require marketing interventions to change perceptions but, even more, it will need evidence that better construction methods are also cheaper and more durable. This requires a lot of training, from masons to house-builders and architects, and is a process which must be supported by energy standards for modern buildings when it comes to insulation properties.

4. Insulation properties and minimum energy standards: A badly-insulated building produces substantial additional CO_2 emissions if it is air-conditioned, and the trend towards air-conditioned housing is growing extremely fast. Allowing the use of solid bricks without insulation in the fast-growing housing colonies of Asia's middle-classes will accentuate already significant electricity shortages and produce additional CO_2 emissions. The following sections analyse these measures one by one.

9.2. URBAN GROWTH AND RURAL POVERTY – WHY IS CHANGE NECESSARY?

Two alarming trends can be observed in Asia, to some extent two sides of the same coin:

9.2.1. EXPLODING DEMAND FROM URBAN MIDDLE-CLASSES

Economic growth and prosperity in Asia are resulting in rapid growth of urban middle-classes in small, medium and even mega-cities of Asia. They are, at the same time, a driving force for further growth. These middle-classes will consume more and more bricks and building materials, not only for their direct housing needs but also for their schools, offices, train stations, bus stops, parking spaces for their cars and shopping malls. Soaring economic growth and associated rapid urbanisation and middle-class lifestyles will be an important stimulus for prosperity. At the same time, this phenomenon carries a potentially serious threat to the environment, not only in terms of CO_2 emissions but also in terms of air pollution and soil degradation. This economic growth and associated growth in the construction sector is most welcome, especially as a high growth rate in the construction sector provides more jobs than any other sector, especially for poor people. The construction sector is the most democratic absorption vessel for unskilled labourers: even illiterate people, men and women, unfortunately even children, will always find a job carrying a bag of cement, a pile of bricks or similar tasks.

It is, then, absolutely essential to move the Asian brick industry towards greater sustainability. It cannot continue with its present energy inefficiencies. If the demand for bricks indeed doubles – and in the Kathmandu valley the growth rate is 11 % per annum, which leads to a doubling after 7 years – then the same traffic jam of coal trucks around the world that we spoke of earlier will, by 2015, have grown from three to six lanes. This is one major reason why the brick industry in Asia must change: we shall, we already do, need a more efficient way to use natural resources.

9.2.2. THOSE WHO ARE LEFT BEHIND: THE RURAL POOR

This reality of fast urban growth and prosperity is but one side of the coin. There is another: still many hundreds of millions of people in rural areas will not have an air-conditioned house in the near future. What they need is a decent roof over their head. Millions of these poor people have found a way to survive by seeking work as migrant firemen and moulders. With selective mechanisation of the brick industry, some jobs – not all, as was the case in the rapid Western modernisation of the brick industry – will disappear. If some of the most drudgerous jobs are replaced by machines, this should be welcomed. There is no place anymore to justify pugging clay by foot, where workers have to get up at 3 o'clock in the morning to first pug the clay by foot; with a mechanical pugmill they can start at 8 am.

If jobs indeed disappear for migrant labourers, it is even more important to bring other jobs to rural areas. Hence the importance of continuing with social experimentation in the brick industry. Consolidating the community ownership models, the Self-help Group-run kilns and the down-sized brick kilns for family enterprises as a replacement for clamp kilns – all this is of primary importance. What Gram Vikas, TERI and Development Alternatives have started in India are valuable experiences to build on: these alternative models can bring prosperity to the rural areas, to those who would be left behind if their only source of livelihood were to disappear. Moreover, Gram Vikas has shown the imperative of local employment, housing and sanitation in rural areas as a basis for development and for a decent life.

9.3. A COMPREHENSIVE VIEW ON SUSTAINABILITY

Before designing a programme for the transformation of the brick sector, one must take a comprehensive view on its sustainability. It is important to look into the sustainability concerns along the entire value chain of brick production and utilisation and the options available to address these concerns (Table 9.1).

In the following sections, some of the major strategies that should be pursued for transformation of the brick industry in Asia are examined.

9.4. COMPREHENSIVE ENVIRONMENTAL REGULATIONS FOR BRICK PRODUCTION

Environmental regulations are an important tool for bringing change into the brick industry. However, they must be well-focused and comprehensive to have any significant impact. The simple SPM pollution standards (specifying SPM concentration in flue gases coming out of the chimney in mg per m^3) or chimney height regulations, as prescribed for BTKs in India and Nepal have resulted in only marginal reduction in air pollution and have brought only cosmetic changes in the technology. In the case of the BTK, the current standards do not take into account the fugitive dust emission caused by ash covering the kiln as well as the issues related to firemen's health and safety.

There is, thus, a strong case for comprehensive environmental regulation to promote clean technologies for brick production, and a comprehensive set of standards. They should promote overall resource efficiency and should include – apart from air pollution norms – norms prescribing maximum energy consumption per kg of production of bricks. Equally, they should have provisions to address workers' health and safety issues. The record of implementation of environmental regulations has remained patchy so far. Therefore, in addition to developing a comprehensive environmental standard, it is also necessary to strengthen the implementation apparatus.

9.5. SOCIAL REGULATION AND ELIMINATION OF DRUDGERY

As shown in the case of Vietnam, the industry has changed over to semi-mechanisation as a consequence of social regulations. Similar regulations are desperately needed in South Asia as well: as long as the 'industrial reserve army' in the form of migrant moulders continues to be cheaper than investing in machinery, the drudgery of pugging clay by foot, hand-moulding of green bricks and transporting bricks on shoulders and heads will not cease. This leads not only to unacceptable social working conditions but also to low quality and low resource efficiency of bricks.

Social innovations such as standard contracts, child care centres and even compulsory schooling should be introduced by regulation and enforced in an industry that has remained totally archaic in the middle of fast-changing and fast-growing emerging economies. One can, of course, argue whether or not the enforcement of these social norms in Vietnam is compatible with a democratic society and with free enterprise. Yet, one can equally argue that the amount of drudgery prevailing in the South Asian brick industry is simply a disgrace, and that such

Table 9.1 Sustainability concerns in the value chain of brick production and use

Brick value chain	Sustainability concern	Options for actions
A) Brick production	Use of agriculture top soil for making bricks	**a)** Modifying the production process to produce hollow bricks **b)** Modifying the production process to use alternate materials such as fly-ash **c)** Deep mining of clay **d)** Use of hollow cement blocks and stabilised soil blocks
	High energy use, combustion-related air pollution and CO_2 emissions	**a)** Efficient kilns such as VSBK **b)** Improving the operating practices and use of fuel additives **c)** Hollow bricks **d)** Increased use of renewable energy to replace fossil fuels
	Fugitive dust emission due to ash covering in BTKs	**a)** Covering/replacing ash layer **b)** Banning BTKs
	Drudgery	**a)** Semi-mechanisation of the brick-making process
	Poor and exploitative working conditions	**a)** Implementation of regulations related with working conditions and labour welfare **b)** Reducing seasonal migration by shifting to year-round industrial production **c)** Empowering workforce **d)** Dialogue with workers and entrepreneurs
	Loss in employment due to mechanisation	**a)** Opting for decentralised semi-mechanised brick-making instead of centralised, large-scale, fully-mechanised process
B) Transportation of coal, clay and fired bricks	Fossil fuel use in raw-material and brick transportation	**a)** Decentralised production of bricks, efficient use of coal and use of local raw materials **b)** Lighter material such as hollow products
C) Wall construction	High resources intensity of construction of per unit area/volume of wall construction	**a)** Use of bricks that are less resource-intensive **b)** Regular brick size and finish (such as machine moulded bricks) reduces cement requirement for mortar and plastering **c)** Use of rat-trap bond to reduce material intensity
D) Building operation	High energy requirement for building operation, particularly for air-conditioning	**a)** Use of bricks having better insulating properties such as hollow bricks, **b)** Use of construction techniques to improve the insulation of the wall element such as cavity walls, walls having rat-trap bond

exploitative labour practices are not compatible with a modernising economy in the 21st century.

9.6. USING CARBON FINANCE: ONE VSBK CAN OFFSET UP TO 500 TONS OF CO_2 PER YEAR

A primary hurdle to the adoption of VSBKs is in the level of investment required. Here, the concept of carbon finance has a primordial role to play.

The following graph compares the fixed capital required per million bricks of production capacity for brick-making enterprises based on different types of brick kiln technology. The first three bars compare investments in enterprises for hand-moulded bricks; it can be observed that for an efficient option such as VSBK, the investments are 2-2.5 times higher compared to moving and fixed-chimney BTKs. However, if one opts for the most energy-efficient option, production of hollow bricks in efficient kilns – VSBK and tunnel kiln [39] – than the investments are still higher, 5-7 times that required for BTKs.

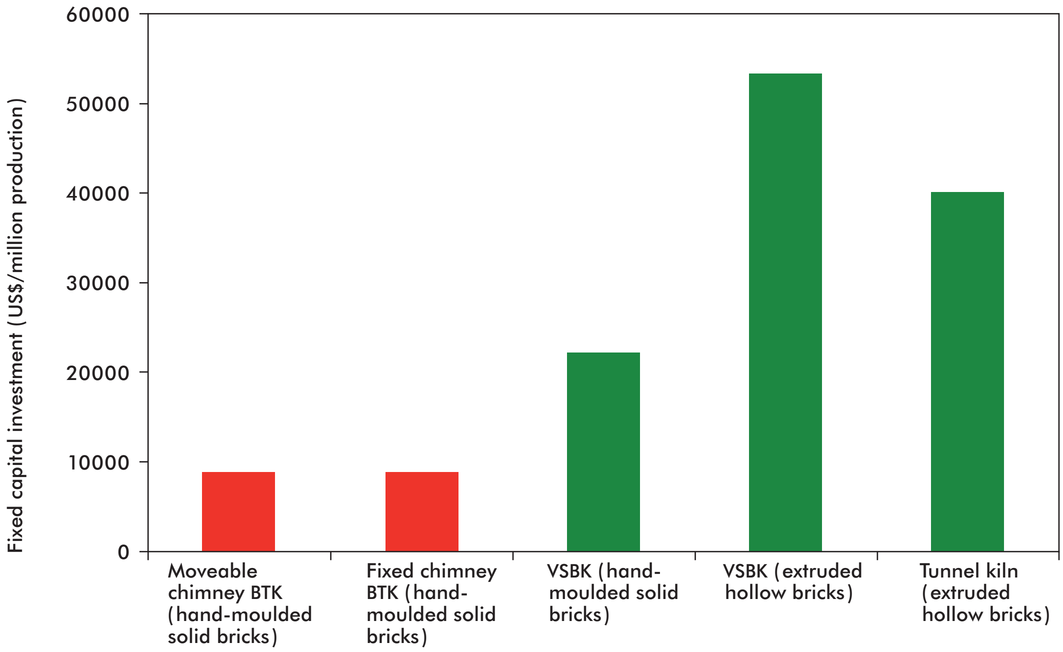
We have further seen (sections 3.9 and 6.2.5) that, although a VSBK-based brick enterprise is a profitable venture under most conditions, the return on investment (ROI) is much lower than with traditional kilns. This means that an investment in a traditional kiln is much more profitable for a brick-maker than an investment in a VSBK. In this scenario, some financial incentives are essential to promote efficient brick-making technologies. Carbon finance is one such option: it could compensate lower ROIs and a driver for change. The situation is quite comparable to energy-saving lightbulbs: while normal bulbs cost less but consume more electricity, energy-saving lightbulbs cost 5 to 10 times more but save over the life-cycle. Even in rich countries, many consumers hesitate to invest upfront in expectation of future savings.

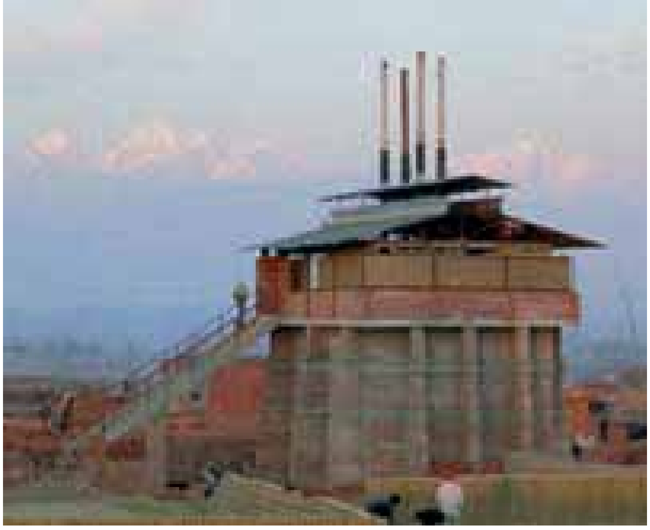
9.6.1. THE CONVENTIONAL WAY: THE CDM MECHANISM

We have shown in Chapter 1 that the overall potential for CO_2 savings in the Asian brick industry is of the order of 54-108 million tons of CO_2 per year. Even if we consider the lower figure of 54 million tons of CO_2 per year, this has the potential to bring in additional revenue of US$ 1.2 billion annually, at the current price of US$ 24 per Carbon Emissions Reduction (CER) certificate. The real challenge is in accessing this carbon finance. Unlike a large power plant, each brick kiln is a relatively small emitter. In the conventional CDM mechanism, making carbon finance available for them needs an extensive and often cumbersome procedure and requires a bundling agent to deal with a number of kilns.

Development Alternatives has proven that VSBKs are eligible for carbon finance under the Clean Development

Capital investments for different types of brick kilns





One VSBK can save some 500 tons of CO_2 in one year – the equivalent of making one Airbus Europe – Kathmandu or Delhi with 250 passengers carbon neutral (one way)

Mechanism CDM), but so far the carbon finance is paid *ex-post*, every year, after the CO_2 savings have been properly assessed.

9.6.2. NEW WAYS: UPFRONT PAYMENTS AND VOLUNTARY EMISSION REDUCTIONS (VER)

This good news above is not enough. To become really effective, carbon finance should be made available upfront as a means to reduce the fixed investment. If the carbon finance for the prospective 10 years of operation could become available in the form of a loan which can be serviced with the yearly carbon credits, then the higher initial investment for a VSBK would not be a bigger hurdle. It could become a profitable investment, with most interest charges being paid by energy savings.

Many investments in the brick industry would qualify as programmes with a strong developmental impact and thus qualify for the 'gold standard' of Voluntary Emission Reduction (VER) programmes: for example, 20% of the carbon finance in a VSBK is targeted towards improvement of social conditions, such as investment in Child Care Centres or building latrines for the workers.
The opportunity for tapping the voluntary emission reduction (VER) market for VSBK investments is very promising and makes the CO_2 advantages much more visible, in a marketing sense. The average emission for a one-way flight from Europe to Kathmandu or Delhi is 1.5 tons of CO_2 for a passenger in economy class and 2.3 tons of CO_2 for a passenger in business class. In other words, one four-shaft VSBK[40] can neutralise some 250 long-haul single trips, or the equivalent of one Airbus with 250 passengers[41], one way.

In Nepal, for example, virtually the entire tourism industry could be made carbon neutral if all bricks were made in VSBK instead of FC-BTKs: the potential savings of 315,000 tons of CO_2 correspond more or less to the CO_2 emissions of all air traffic from and to Nepal in one year.

There are now voluntary emission reduction schemes available and in high demand: for instance, My Climate[42], an agency operating in Switzerland, is successfully marketing voluntary contributions on air tickets and these contributions are then invested in CO_2 reduction projects. The VSBK would not only qualify for such VER certificates, it would most likely even qualify for the 'Gold Standard' of emission reductions, a label for greenhouse gas reduction projects with a sustainable development component.

Moreover, entire companies, conferences and government agencies – including SDC and the complete Swiss Government – are currently considering making all their air travel carbon neutral by purchasing VER certificates. For a return trip from Zürich to Kathmandu, the add-on price is CHF 125 (US$ 103).

9.7. INFLUENCING THE DEMAND SIDE – BETTER BRICKS AND CONSTRUCTION METHODS

The best way to overcome the resistance to change in South Asia's brick industry would be market signals and a clear preference for high-quality bricks and hollow bricks. This trend is slowly happening in the mega-cities as modern construction methods require better bricks and better insulation. However, the change in the market is slow because many house builders, architects, contractors and masons are used to building with traditional bricks and traditional methods.

9.7.1. SIGNIFICANT WIN-WINS ARE POSSIBLE: BETTER CONSTRUCTION IS ALSO CHEAPER

Better construction methods will come to some extent through market forces and there is a considerable win-win potential in applying them. The VSBK project staff in Nepal have made innovative calculations on this savings potential.

Their five scenarios, summarised below, are all based on the same two-storey house with a total floor area of 1,471.5 sq ft:

1. Scenario 1: the house is constructed with 15 RCC[43] pillars and built with local bricks and English Bond masonry;
2. Scenario 2: the same house but all bricks are VSBK bricks, all other parameters being unchanged;
3. Scenario 3: the same house but all bricks are VSBK bricks built with rat-trap bond walls;
4. Scenario 4: the same house but only 4 RCC pillars are included, 11 'quetta bond pillars' (rat-trap brick bond wall filled with concrete and one reinforcement bar), RCC doors and window frames used instead of wooden frames;
5. Scenario 5: basically the same structure as scenario 4 but all brickwork is made with six-inch hollow cement blocks.

Embodied energy of a m² of wall

Hollow cement blocks are energy-efficient alternatives to bricks. This may be a surprising fact for the layman. The Nepal VSBK team has made calculations on the embodied energy of a m² of wall made with different building blocks:

a) Ordinary BTK bricks 427 MJ/m²
b) VSBK bricks 300 MJ/m²
c) Hollow cement blocks 154 MJ/m²

The results are striking. Here is a summary table of the cost and energy consumption (embodied energy) of the five scenarios:

Cost and Energy comparison

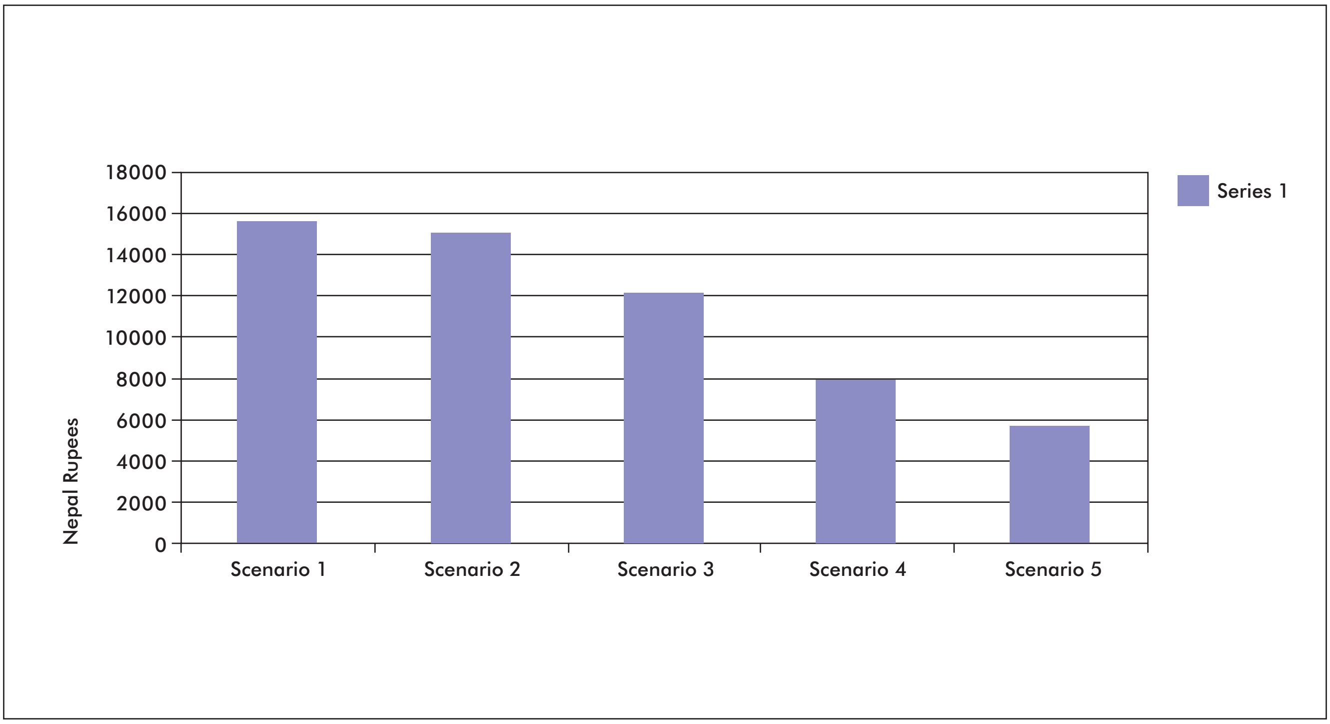
	Cost in US$	**Cost in %**
Scenario 1	15,589.18	100.00%
Scenario 2	15,039.98	96.48%
Scenario 3	12,146.65	77.92%
Scenario 4	7,944.00	50.96%
Scenario 5	5,612.00	36.00%
	Coal used (in tons)	
Scenario 1	21.35	100.00%
Scenario 2	18.98	88.90%
Scenario 3	17.86	83.65%
Scenario 4	10.02	46.93%
Scenario 5	7.59	35.55%

These comparisons show a savings potential in terms of cost and energy of 50% between scenarios 1 and 4 and 65% saving with scenario 5. Cement-based products are thus also a very interesting and attractive alternative. The following graphs will visualise these differences.

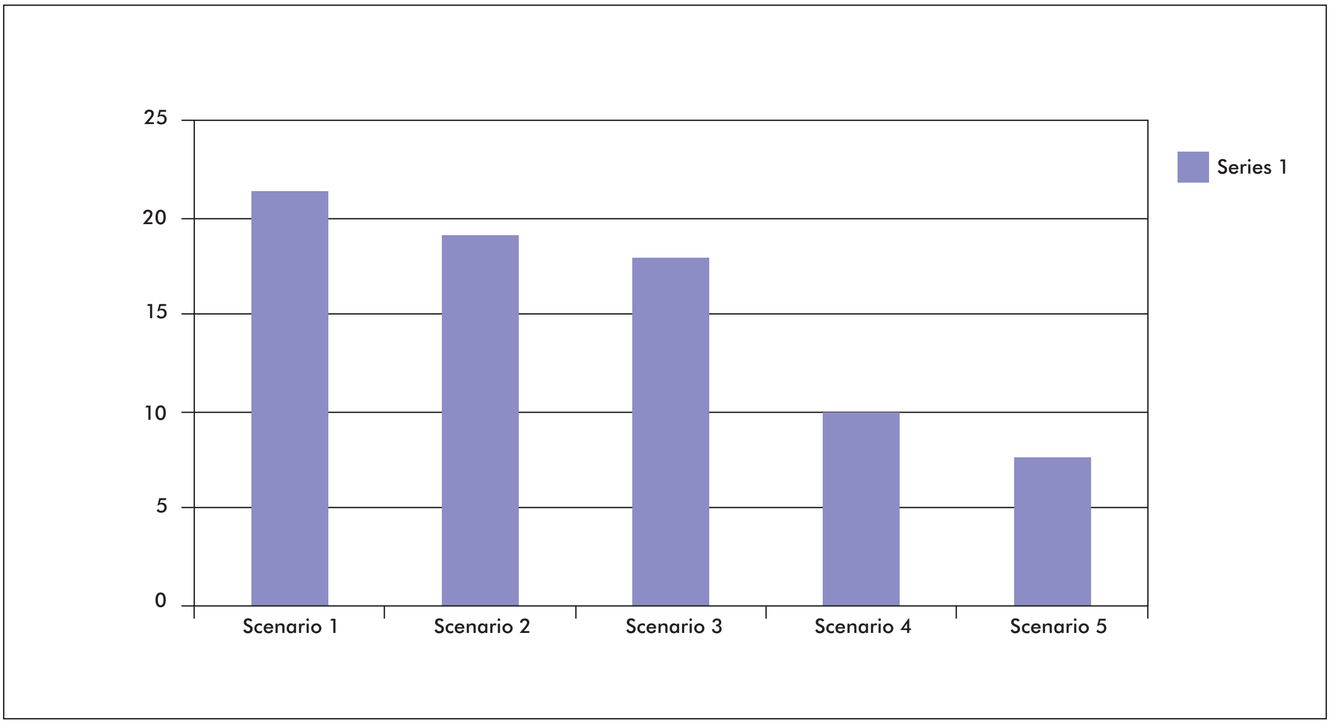
The main reason for the relatively little difference between scenarios 1 and 3 is due to the RCC pillar work: a considerable amount of energy is used for the steel bars (almost 7 tons of coal equivalent), and it is indeed a wasteful practice to use bricks only as a filler. This makes the resistance to hollow bricks even more irrational: if in Europe and Vietnam hollow bricks can have a carrying function, why can hollow bricks in South Asia not even be used as filler materials?

Based on these calculations it seems to be highly promising to look at the entire building technologies in more detail and to achieve the win-win potential in full: what is very attractive in these scenarios is the fact that not only energy savings are realised but also substantial cost savings. If it is possible to prove that scenarios 4 and 5 offer similar building qualities, comfort and safety, then the way should be open for a much faster uptake. It will not be easy to change habits and perceptions that have prevailed for half a century and more, but if these innovations cost only one-third of the conventional buildings, then there should be space for change: cost savings are, in the long run, a currency that ought to be accepted anywhere in the world.

Cost comparison



Energy in Tons of coal



9.7.2. REGULATIONS TO IMPOSE MINIMAL ENERGY STANDARDS WOULD HELP THE CHANGE PROCESS

Sustainable changes would require that governments develop a comprehensive framework for resource-efficient construction methods and thus create the right incentives for the brick industry to produce better bricks with low embodied energy or which use less clay. To do this, on the demand side, the construction sector should be forced to meet certain standards of resource-efficiency, namely less embodied energy and better insulation.

As the construction sector is such a huge and labour-intensive industry, regulation must be accompanied by massive capacity-building measures: millions of masons, plumbers and electricians need to be trained but, before that, first of all house-builders, architects, contractors and even bankers need to be informed as well, and change their attitudes accordingly.

Some examples of specific measures that can be taken are:

- The prevailing codes and regulations for products and building methods need to be modified to specify embodied energy as well as thermal properties of construction elements (such as walls, roofs, and so on).
- Incentives in the form of tax-benefits for the use of resource-efficient bricks – for example, exemption from VAT or availability of carbon finance – would be required to promote the production of resource-efficient bricks.

A market transformation would require a large-scale awareness and capacity-building campaigns to educate end-users and to train the major stakeholders in the construction industry. Masons, house-builders, contractors, architects and designers should be exposed to and trained in resource-efficient construction techniques.

9.8. POTENTIAL SAVINGS ON AIR-CONDITIONING THROUGH USE OF HOLLOW BRICKS

So far we have only considered the CO_2 savings that are possible in the production of bricks. Additional, often much larger, savings are possible if we also consider the CO_2 savings due to reduction in energy requirements for air-conditioning by using bricks with better insulating properties, such as hollow bricks or use of cavity walls and walls constructed using rat-trap bond masonry methods. Although these calculations will require further study and verification, we have tried to get a first estimate of these savings, knowing that it is a bold attempt to quantify these savings. But these calculations are highly necessary as the prospects are quite frightening:

9.8.1. AIR CONDITIONING IS BOOMING: IT GROWS AT 25% PER ANNUM

Fuelled by rapid economic growth, the air conditioning market in India is growing at the rate of around 25%, annually [44]. This is expected to continue for several years as the penetration level of air conditioners is still very low: only 2% of the households own an air conditioner in India today.

A partly or fully air-conditioned house typically consumes 2 to 4 times the electricity consumed in a non-air-conditioned house. The fast growth in air conditioning of buildings has thus a significant impact on the demand for electricity and hence on CO_2 emissions. In most developed countries, the residential and commercial buildings already account for 40-50% of electricity and their total CO_2 emissions. If the trend continues, in the near future, air-conditioned buildings in developing countries will become one of the largest global sources of CO_2 emissions.

It is possible to reduce the cooling load of a building significantly by making appropriate choices for building material and by a careful design of the building envelope – comprising such elements as external walls, windows and roof. Some of the recent work in India has shown that building envelope optimisation can result in up to 12% reduction in energy consumption in a building [45]. Better insulation of walls is an important strategy for building envelope optimisation. It is here that hollow bricks can play an important role, as walls made up of hollow bricks have U-values up to 25% lower compared to the U-values for walls made up of common solid bricks [46].

To get an accurate estimate of the reduction in electricity consumption (and CO_2 savings) for air-conditioning by replacing solid bricks with hollow brick as walling material, a detailed computer simulation of the thermal performance for a building is necessary. The results would vary from building to building and also for similar buildings located in different climatic regions.

9.8.2. ONE SINGLE APARTMENT WITH HOLLOW BRICKS CAN SAVE 18 TONS OF CO_2

In the following simple analysis, extrapolating the results presented by the simulation results for a residential house (bungalow) located in the composite climate of Delhi by Nayak and Prajapati [2006] [47], one can assume that around 5% savings in air-conditioning load is possible by opting for hollow bricks in place of solid bricks. One can thus show that, for a typical two-bedroom residential

Table 9.2: CO_2 savings by reduction in air-conditioning energy through use of hollow bricks in a residential house in Delhi

	3 room air-conditioners of 1.5 ton, each operating for 6hrs/day for 200 days in a year	3 room air-conditioners of 1.5 ton, each operating for 12 hrs/day for 200 days in a year
Annual electricity consumption	7200 kWh/year	14,400 kWh/year
5% savings due if the house is constructed by hollow bricks	360 kWh/year	720 kWh/year
Annual CO_2 savings (emission factor 0.84 kg of CO_2/kWh)	302 kg of CO_2/year	604 kg of CO_2/year
Cumulative CO_2 savings over 40 years	12.2 tons of CO_2	24,4 tons of CO_2

house, an annual CO_2 reduction of around 302 kg or almost 12.2 tons of CO_2 savings over a 40 years period is possible (see table 9.2.).

9.8.3. POTENTIAL IMPACT OF HOLLOW BRICKS FROM ONE VSBK

The choice between hollow or solid bricks can make a huge difference. If one calculates the potential impact of one VSBK producing hollow bricks on CO_2 savings through better insulation, one arrives at amazing figures, with the bulk of the impact being through reduced energy consumption in the use of the finished building: [48]

1. For a VSBK making 1.84 million solid bricks the annual savings are 481 tons of CO_2/year.
2. If now this VSBK produces hollow bricks (20% hollow) and we assume that it would result in 15% additional savings in coal, the annual CO_2 savings would increase to 537 tons of CO_2/year.
3. a) If all the 1.84 million hollow bricks are sold for making houses that would be air-conditioned and if each house requires 25,000 bricks, the total number of houses that can be constructed is: 1.84 million/25,000 = 74 houses.
b) The CO_2 savings due to 5% electricity savings in each house is 12-24 tons/year and if we take an average of 18 tons/year/house. Total additional savings for 74 houses would be 74 x 18 = 1332 tons of CO_2/year.
Thus the total CO_2 savings of a VSBK due to production of hollow bricks would be = 537 + 1332 = 1869 tons of CO_2/year/kiln, if all the hollow bricks are being used for the construction of air-conditioned houses.

In other words, the most important impact of modernising the brick industry will be felt in substantial savings through better insulation.

= 481 tons of CO_2

= 56 tons of CO_2

= 1332 tons of CO_2

Total savings of one VSBK = 1869 tons of CO_2/year
If it produces hollow bricks and all used for air-conditioned apartments (including lifetime savings on air conditioning over 40 years). A VSBK producing hollow bricks would result in savings of 37380 tons of CO_2 over its 20 year lifetime.

9.9. CAPACITY-BUILDING: HOW TO TRAIN MILLIONS OF WORKERS?

9.9.1. SKILLS TO TRANSFORM THE BRICK INDUSTRY

The brick sector consists of millions of workers and entrepreneurs, many of them unskilled, some with traditional skills and many with obsolete ones. A transformation of the brick industry would affect the lives of a large population consisting of people directly involved in brick-making as well as their families. Thus, the transformation process would have to be supported by a huge human capacity-building effort.

The capacity-building effort for workers would focus on technical skills to handle new brick-making processes as well as training some of the workers who may lose their jobs due to semi-mechanisation for other professions. A programme to develop technical skills would need to be supplemented by a programme to build social organisational skills, as workers' organisations could play an important role in renegotiating owner-worker relations during the transformation process.

Capacity-building of brick kiln owners is necessary to make them ready for the transformation. The capacity-building effort would have a technical component dealing with new technology possibilities but should include a managerial and legal component which helps them in dealing with new technologies, regulations and new emerging market situations. Capacity-building should also emphasise on social skills in order to improve the relationship with workers and assist them in building stronger and better organised brick-makers' associations which can play an important role in this transformation.

9.9.2. BREATH OF FRESH AIR IN THE CONSTRUCTION SECTOR

However, the main task would be to train the brick users: the house-builders, the architects, the contractors, the supervisors, the masons and all the unskilled workers absorbed by the fast-growing construction sector.

It is a huge task, but there is no doubt that this transformation has to be done: the demand in small, medium and mega-cities will develop towards better and higher buildings, and building quality will become a much more important criterion than in the past.

This transformation, however essential, cannot take place if the construction sector remains as informal as in the past. It is crucial to institutionalise certain functions such as training, R&D and building standards. It will also be essential to work together with the private sector, for example with large cement companies. They have a large and decentralised supply chain and can use their networks to upgrade the skills of masons by giving them some fundamental training and recognition if they have been trained, for example by registering them as licensed masons.

9.10. R&D, TESTING AND KNOWLEDGE SHARING

The VSBK technology transfer experience has shown the importance of strong indigenous R&D capabilities to adapt technology solutions to local conditions. While a considerable amount of work was done on firing technologies during the SDC-supported projects, several other areas, such as artificial drying of bricks, shaping machines for green brick production as well as material handling require R&D inputs to develop new technology solutions.

Another important lesson of the VSBK saga, particularly regarding the innovations in Vietnam, is that R&D need not be confined to large R&D institutions alone; private industry, consultants and sector experts play a very important role in finding appropriate technical solutions. Thus, a new paradigm for R&D that promotes a strong collaboration between the private industry, sector experts and R&D institutions would be required, rather than the creation of one centralised and government-owned brick institute.

Implementation of product quality standards, new environmental regulations and building construction standards would also generate demand for various of testing and laboratory services. At present these services, apart from the regular product testing services, are not easily available. Thus developing these services would also be an important work element for the programme to transform the brick sector.

CONCLUSIONS: WHY IT IS WORTHWHILE TO CONTINUE 10

10.1. SOME MAJOR CONCLUSIONS: THE GLASS IS HALF FULL

The VSBK saga has shown the paramount importance of the brick industry as such and its part in the entire construction industry in Asia. The demand of four billion people for better housing, better work places, new offices, restaurants, schools, better infrastructure will fuel a steady growth in the construction sector. It will be the most important sector for absorbing the large numbers of job-seekers.

The brick industry is a traditional industry with a strong resistance to changes, but these changes are necessary and will come sooner or later. The environmental contradictions will increase and it will not be possible to use topsoil and coal excessively, even to produce low-quality bricks. Social conditions may continue to be as bad as they are, at least as long as there are no other employment opportunities for the migrant labourers who flock out to the brick kilns as moulders or firemen.

The wind is changing: even in South Asia the demand for better bricks is growing, and the industrialisation of the brick industry will happen sooner or later. SDC and the different brick teams in China, India, Nepal, Vietnam, Switzerland, Afghanistan and Pakistan have accumulated an expertise that is unique: together this team has all the knowledge and experience to make a 'soft revolution' in the brick industry.
With the 'soft' revolution, the process of transformation can be make smoother, socially harmonious and environmentally more sustainable.

Of course one can say: what has been achieved in more than 10 years? Only 2 out of every 1,000 bricks are made in a VSBK. But is this not a great achievement for such a small group? While critical people may say: "the glass is half empty, this industry is so resistant to change; we had better give up." There are also good reasons to say: technologies have been developed that work, that are promising and feasible, much progress has been made on the social front and new forms of ownership have been tested, not yet to full maturity, but with great hopes. In other words, the glass is also half full.

Not much is required, though the list seems long and demanding: simply to keep on going with relatively small pioneering efforts; supporting change in the industry with intelligence; capacity-building; suitable and targeted R&D efforts; new business models such as making carbon finance available; bundling all these; and advocacy efforts to make the public aware of the dangers and of the opportunities that are hidden in the brick sector. This awareness may be created by involving the existing partners of the brick project in Asia and by exchanging experiences, organising and participating in major conferences and putting the case of the brick industry on the international climate change and development agenda. For this reason, there is a case for a long-term regional support programme.

10.2. THE CASE FOR A LONG-TERM REGIONAL SUPPORT PROGRAMME

The VSBK experience shows the important role played by international development cooperation in sowing the seeds of change in the brick sector in South Asia. Apart from the bilateral initiative of SDC, new GEF supported brick sector programmes are well-advanced in the pipeline in India and Bangladesh.

Large-scale brick sector transformation processes have to be led by local governments and institutions. The ownership of the process should clearly lie in the hands of the key stakeholders: the brick industry and the construction sector as a whole supported and regulated by local and national governments.

However, international development cooperation can play a constructive role through facilitative actions, such as facilitating knowledge exchange and knowledge transfer through a regional initiative. The knowledge exchange could cover technical and social as well as policy and regulatory aspects. While many specific actions are required to be taken at the local level, there is a strong need for advocacy and information to ensure that it becomes known that the brick industry has relevance for the development of poor communities and for improving local and global environment. Such a regional initiative should thus monitor the progress in all the countries of South and South-East Asia and produce reports, provide assistance in accessing carbon finance; assisting individual countries in setting up capacity-building programmes; dissemination of best practices; and technical support for R&D and creation of testing infrastructure.

A regional initiative will not require a huge institution with a huge budget: with good facilitation, much can be achieved with relatively modest means. But all concerned stakeholders should be aware: transforming the Asian brick industry is a Herculean task, involving millions of stakeholders. It is a noble and absolutely necessary task. It will require an intelligent strategy and a deep breath: only with passion and patience will it be possible to make this huge industry more sustainable.

All the stakeholders involved in the VSBK saga so far have prepared a very fertile ground for this change. Even though the road is still long, they can be very proud of their achievements so far, and of the distance they have already travelled. There is no turning back.

FOOTNOTES

1 DA, TERI, SKAT, Sorane, Entec, Damle and Gram Vikas

2 The Swiss Parliament had sanctioned in 1991, on the occasion of the 700th anniversary of Switzerland, a special credit of 700 million Swiss Francs, of which 400 million were earmarked for debt relief and 300 million for global environmental programmes.

3 Rolf Jensen, Donald M. Peppard Jr.: *The Traditional Brickmaking Industry and the Rural Economy of Vietnam*, Journal of Asian and African Studies, SAGE Publications, 2004

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9 Ruppik, M., *Discovery of Defects in the Use of Primary Energy in Tunnel Kilns and Dryers, Ziegelindustrie International*, 37 (11), 584-588 (1984).

10 Hausammann B. *Report on environment performance of brick kilns in Nam Dinh. Vietnam Sustainable Brick Project*. Entec AG, Hanoi, March 2005, pp.45.

11 Maithel S., N. Vasudevan and R. Johri. *Status paper on VSBK*. TERI, New Delhi, February, 2003, pp.19

12 Development Alternatives, SDC: *Action Research in Technology Transfer – Vertical Shaft Brick Kiln a case study*, New Delhi 2006, page 3

13 Development Alternatives, SDC, op. cit. page 4

14 Development Alternatives, SDC: op. cit. page 13

15 These figures are taken from a leaflet of TARA, Development Alternatives's implementing company that is selling VSBKs; it is not a financial analysis of production costs.

16 Sunil Sahsrabudhey: *"India Brick Project – Social Action: Reflections"*, discussion paper, Varanasi, 2005

17 *Fourth Vision: India Brick Project 1999 – 2003 – a Report from Project Facilitation Unit*, SDC New Delhi, May 2005, page 113

18 Everett Rogers: *Diffusion of Innovations*, first published in 1962 and since then the classical reference for marketing

19 Geoffrey Moore: *Crossing the Chasm – How to win mainstream markets for technology products*, first published in 1991, Harper Business, New York 1999

20 The large population of landless peasants in South Asia can be traced back to the two centuries of British rule. The British introduced the *'zamindari'* system, in which large tracts of land were given to feudal landlords. The peasants became tenants and had to give rent to the zamindars. After independence, several legislations were brought for land reforms, but did not result into substantial progress.

21 National Rural Employment Guarantee (NREG) programme which strives to provide a minimum of 100 days employment, in a year, to each family. The scheme is now being extended to all the districts in the country.

22 *India – Vertical Shaft Brick Kiln Cluster Project, PDD Version 03*, 17. April 2006, CDM executive board and UNFCC

23 See: http://carbonfinance.org

24 G.B. Banjara et al: *"Economic Analysis of Brick Industry in Kathmandu Valley"*, Kathmandu, March 2004

25 See Sameer Maithel: *"Energy Utilisation in Brick Kilns"*, IIT Bombay, 2003, doctoral thesis, page 14 ff.

26 G.B. Banjara: op.cit. page 19

27 Brigitte Capaul: *"Materialbericht Backsteine"*, Technical College Rapperswil 2003

28 *VSBK Social Component – Strategy Paper 2005-2007*, Kathmandu 2005

29 This chapter has been written with inputs from Ms. Vu Thi Kim Thoa, VSBP Resident Project Manager.

30 Some of the examples are Viglacera brick and tile plant at Ha Long and Do Nai brick and Tile Company.

31 Readers may remember that Professor Yin Fu Yin is the same Chinese expert who provided assistance in the Indian project as well as in all earlier VSBK technology transfer projects in Nepal, Pakistan and Sudan.

32 Ebrahimian Esther. *Community action to address climate change: Case studies linking sustainable energy use with improved livelihoods*. GEF small grants programme. UNDP. November 2003. page 87-88.

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34 Entec AG: *Diagnostic Report on Brick Making in Nam Dinh Province*, June 2003.

35 Since the mid 1990s the building material policy in China has aimed at discouraging the use of clay for brick production. The proposed ban on VSBK is linked with the Government policy to conserve clay. The Chinese policy supports perforated and hollow bricks as well as bricks produced from wastes and non-clay raw materials.

36 Hausammann B. *Environment Report. Vietnam Sustainable Brick Making Project*. March 2005. Maithel S., Kumar S. and A. Damle. *Performance of Energy Monitoring of Brick Kilns*. The Energy and Resources Institute. Vietnam Sustainable Brick Making Project, February 2005

37 In Vietnam it is common to add 80-90% of the coal internally with clay

38 Suspended particulate matter

39 The investment here is calculated per million bricks produced. The VSBK figures are taken for a highly mechanised model VSBK kiln in Vietnam and may come down by 20% in the future. The graph suggest that tunnel kilns are less capital intensive than mechanised VSBKs, if one takes the figures again per million of bricks produced. In absolute figures, however, the initial investment for the mechanised VSBK is US$ 160,000 and US$ 600,000 for a tunnel kiln.

40 In Kathmandu the VSBK is compared with Fixed Chimney BTKs and saves 385 tons of CO_2 per year while in India it is compared with clamp kilns and thus offsets 500 tons of CO_2.

41 Assumed: 200 Economy and 50 Business class passengers

42 www.myclimate.org and www.cdmgoldstandard.org

43 RCC=Reinforced Cement Concrete

44 http://www.ficci.com/press/119/ua-as.doc accessed on August 9,2007

45 Bureau of Energy Efficiency (BEE): Energy Conservation Building Code Compliant Buildings, A booklet published in association with TERI, 2007.

46 U-value is the thermal transmittance of a building el-ement. It is defined as the heat flow in Watts through one sq. m of area of a building component, in one second, when there is 1°C temperature difference between the inside and the outside air, under steady state conditions.

47 J. K. Nayak and Prajapati J. (2006) *Handbook on energy conscious architecture*, IIT Bombay and MNRE, New Delhi.

48 The calculations are based on the PDD for the CDCF project prepared by Development Alternatives in India.

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This publication tells the story of the Herculean task of cleaning up the Asian brick industry, an important sector in the booming economies of Asia. The industry produces 1,000 billion bricks per year, equivalent to 100,000 Empire State Buildings. It consumes 110 million tons of coal, comparable to a 3-lane traffic jam around the Equator if loaded on 10 ton trucks.

Of tremendous relevance to climate change, the brick and construction industry holds an enormous energy-saving potential: more than 40 % could be saved with better brick kilns, producing hollow instead of solid bricks. The Vertical Shaft Brick Kiln (VSBK) is the most energy efficient kiln whereever and, with social improvements, it can also change the lot of the millions of poor workers in this sector. Introducing better technologies and social standards is a win-win situation for the workers, for the environment and for the society as a whole. But – like energy-saving lamps – more efficient brick kilns require higher investment and the transformation process would be much faster and smoother if carbon financing mechanisms can be made available.

110 million tons of coal are used in firing bricks in Asia; this corresponds to a three-lane traffic jam of 10 ton trucks loaded with coal, all the way around the world.

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POVERTY ALLEVIATION AS A BUSINESS SERIES