A Roadmap for Efficient Brick Production in Nepal

Submitted to

South Pole

Submitted by

MinErgy, Nepal

December 2012

List of Abbreviations

CBS	Central Bureau of Statistics
CDM	Clean Development Mechanism
CEN	Clean Energy Nepal
CO2	Carbon dioxide
DCSI	Department of Cottage and Small Industry
EEC	Energy Efficiency Centre
FCBTK	Fixed Chimney Bulls Trench Kiln
FNBI	Federation of Nepal Brick Industry
FNCCI	Federation of Nepalese Chambers of Commerce and Industry
GDP	Gross Domestic Product
GIZ	German Technical Cooperation
GoN	Government of Nepal
HHK	Hybrid Hoffman Kiln
IEE	Initial Environmental Examination
IEMP	Industrial Energy Management Project
IFC	International Finance Corporation
MCBTK	Movable Chimney Bulls Trench Kiln
MJ	Mega joule
MoE	Ministry of Environment
NEEP	Nepal Energy efficiency Program
NORAD	Norwegian Agency for Development Cooperation
NRs	Nepalese Rupees
RENP	Renewable Energy Nepal Program
RSPM	Respiratory Suspended Particulate Matter
SDC	Swiss Agency for Development and Cooperation
SEC	Specific Energy Consumption
TERI	Tara Energy Research Institute
TRDC	Technology Research and Development Committee
USD	United States Dollar
VDC	Village Development Committee
VSBK	Vertical Shaft Brick Kiln

1 Introduction

This road map outlines the possible ways forward for expediting the process of improved energy-efficiency and environmental performance in the brick sector of Nepal. This road map is prepared based on the assessment of the available secondary information on brick sector of Nepal as well as study of various national and international relevant reports on brick kilns.

2 Background of Brick Sector

The officially registered brick kilns in Nepal are recorded to be 429 while the Federation of Nepalese Brick Industries (FNBI) estimates more than 700 brick kilns in Nepal with 107 numbers being operated within the Kathmandu Valley. The variation in data shows that substantial numbers of brick kilns are operating under informal conditions without compiling to legal considerations. The contribution of the brick sector to Gross Domestic Product (GDP) of Nepal is estimated to be 1.41% in 2011. The bases for this estimation are 3.2 billion bricks per year with average brick selling price of NRs 7 per brick.

The brick sector is still in the rudimentary stage and there is lot of scope to improve the brick firing technology in terms of energy efficiency and environment performance. The brick industry is one of the major consumer of imported coal and major source of environment pollution. Brick kilns are 3rd largest source of pollution after Vehicular emission and Road Dust Re-suspension contributing 9.6% of TSP and 11.4% of PM10 *(Source: Shah and Nagpal, 1997; MOPE 2003; Gautam, 2006)*.

3 Prevalent Firing Technologies

There are four main brick firing technologies prevalent in Nepal viz. Clamp Kiln, Movable Chimney Bulls Trench Kiln (MCBTK), Straight-line Fixed Chimney Bulls Trench Kiln (FCBTK) with natural draft and force draft, zig-zag FCBTK with normal and forced draft and Vertical Shaft Brick Kiln (VSBK). Based on the report of CEN-2009 after incorporating VSBK and Hoffman kiln in the baseline report, MCBTK constitute 57% of the market share, followed by FCBTK with 33%, clamp kiln 6.7 VSBK 3.6 and Hoffman 0.3%.

Coal is a major fuel for brick firing in Nepal while other fuel such as agriculture residue, fire wood, rice husk, saw dust, etc are also used. The energy consumption of VSBK is the least, as demonstrated by specific energy consumption in terms of Mega Joule per kg of fire bricks in the following table, compare to other prevalent technologies. The SEC of VSBK is 28.5% and 33.6% less compare to FCBTK and MCBTK respectively. The improved FCBTK with Forced Draught Zigzag stacking pattern shows higher energy efficiency compare to other techniques within FCBTK and MCBTK.

The environmental performance of VSBK is superior to all other technologies. The Suspended Particulate Matter (SPM) of VSBK is 28.5 % less compare to FCBTK and 33.6% less compared to MCBTK respectively. Similarly, the toxic gas Sulphur Dioxide (SO_2) emission is 84.2 % less for VSBK compared to FCBTK. The environmental performance of Forced Draught Zigzag Stacking of FCBTK is better compare to other FCBTK technologies.

The energy and environment performance and status of different technologies are estimated as in the following table.

S. No.	Kiln Type	Total Brick Production [a]	SEC (MJ/kg of fired brick) [b]	Coal consumption (tons) [c]	CO_2 (tons)
1	Clamp Kiln	16,856,000	2.36	4,378	10791
2	MCBTK	1,652,000,000	1.50	272,699	672,202
3	FCBTK				
	FCBTK inside Kathmandu Valley	834,300,000	1.25	84,411	208,074
	FCBTK outside Kathmandu Valley	569,835,000	1.25	78,386	193,222
4	VSBK	75,000,000	0.72	5,943	14,648
5	Hoffman kiln	35,000,000	1.25 [d]	3,541	8,729
Total				**449,358**	**1,107,667**

a. *Estimation*
b. *External review of the VSBK and CESEF projects in Nepal, Heierli et al., (2007)*
c. *Calculated based on following assumptions*
   - ✓ *Brick weight in Kathmandu Valley is is 2.03 Kg (CEN,2009)*
   - ✓ *Brick weight outside Kathmandu is 2.76 kg (CEN, 2009)*
   - ✓ *CV of coal is 6000 kcal/kg*
d. *Based on assumption that SEC of FCBTK and Hoffman's Kilns are more or less same (information provided by Hoffman's Kiln entrepreneur)*

4 Stakeholders

The major stakeholders in the sector are brick consumers, brick entrepreneurs and their associations, government agencies, donor-funded projects and technology providers.

4.1 *Brick Consumers*

The major brick consumers are household and petty contractors constituting 80% of the market. This category of consumers are sensitive to price and less concerned with brick quality as well as the environmental damages. However, the consumers out of the Kathmandu Valley, especially in *terai* (the southern plain of Nepal) are conscious about the brick quality. There are some instances that larger contractors are concerned about brick quality and its impact on construction costs.

4.2 *Financial Institutions and Investors*

Brick kilns in Nepal are generally small scale operations and considered as informal sector. The financial institutions and banks in Nepal do not yet consider brick kiln as a formal industry that can access capital. The bank finances in the brick sector are usually accessed based on private collateral, equity and demonstrated track record of individuals. In this instance, brick entrepreneurs have limited access to bank financing or commercial loans to invest in new or cleaner technologies. There are cases that Clean Energy Development Bank (CEDP) has provided loan to VSBK entrepreneurs.

4.3 Technology Providers

The brick sector in Nepal is operating in informal conditions. There is no such formally established entity as technology provider in the sector. However, as a strategy of the SDC supported VSBK project to locally anchor the VSBK technology, MinErgy has been evolved with the initiatives of the ex-project staff as an organization to work in the sector. Some of the other donor-funded projects have also developed energy auditors and supply chain actors in order to provide services to brick entrepreneurs.

MCBTK and FCBTK entrepreneurs heavily rely on kiln supervisors, masons and firemasters (mainly coming from India) to construct and operate their kilns. These technology providers usually gain skills through experiences and skill transfer from the experienced ones than the formal training. Often the skill transfer and experiences are not copied correctly resulting into higher energy consumption and often a major contributor to a failure of establishment.

Innovative Machineries has manufactured green brick moulding machine for the first time in Nepal having a potential to produce hollow bricks as well as mix internal fuel, which have the proven results with regard to energy-efficiency. This company has a plan to carry out applied R&D on semi-mechanization for controlled coal feeding (fuel injection) to increase energy-efficiency and improve occupational health conditions.

Brick Clean Network (BCN) is an informal network of NGOs working in the brick sector, particularly within the brick kilns, in different disciplinary areas such as on child labour, living and working conditions, health and hygiene, work-place security, discrimination and violence, energy and environmental performance and animal welfare. BCN is particularly active in consumer awareness and policy advocacy aiming to make brick kilns more socially responsible.

4.4 Donor Supported Projects and Programmes

Within the framework of bilateral development cooperation between Nepal and the Federal Republic of Germany, "Nepal Energy Efficiency Programme" is being implemented. Under the industrial energy-efficiency improvement, one of its three components, NEEP supported the establishment of Energy Efficiency Centre (EEC) under the umbrella of the Federation of Nepalese Chambers of Commerce and Industry (FNCCI). The main areas of activities are awareness raising for Nepalese industries (including brick sector), facilitate energy-efficiency services through training of energy auditors and financing through financial institutions.

With support from the Renewable Energy Nepal Programme (RENP), managed by Kathmandu University and financed by NORAD, MinErgy is promoting coal substitution in brick kilns by charcoal produced from forest waste. Apart from the fuel substitution, MinErgy is planning to promote internal fuel in all the brick kilns.

European Union, under the Switch Asia Programme, launched "VSBK and Other Sustainable Construction Practices - SCP" in 2012 which will last for three years. This project has the strategy to work through service providers in order to provide technical assistance to achieve the outputs of additional 35 VSBK units. It also has the mandate to capacitate service providers in order to achieve the outputs.

International Finance Corporation (IFC) are carrying out energy efficiency study, training and certification to energy auditors, and training to financial intermediaries.

4.5 Government Agencies

Government agencies are primarily responsible for setting and implementing the policies. The government institutions for governing and regulating the brick kilns are the Department of Cottage and Small Industries (DCSI) under the Ministry of Industry, Commerce and Supplies (MoICS) and Ministry of Environment (MoE). DCSI is responsible to verify and make decision on license application after verification of Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA)[1] as per the requirement. A no objection letter from the village development committee (VDC), on the behalf of local community and local government administration, is required as a first step for license application. The monitoring of brick kilns in response to complaints of environmental impact is the responsibility of DCSI. DCSI also has a mandate to make recommendations to the Industrial Promotion Board (IPB), which is a decision making body to devise policy on investment and incentives for industries.

Ministry of Environment (MoE) is a regulatory body in relation to environment protection and pollution controls also for the brick sector. MoE is the authorizing agency to issue different pollution and emission standards and monitor accordingly to ensure the compliance of the standards.

Industrial Energy Management Project (IEMP) under Government of Nepal is carrying out energy audit training and awareness campaign for brick entrepreneurs to shift from MCBTKs to more environment friendly brick making technologies.

4.6 Brick Entrepreneurs' Associations

Entrepreneurs in the sector have organized themselves into associations. The VSBK entrepreneurs are organized under the VSBK Entrepreneurs' Association while the registered FCBTK and MCBTK entrepreneurs under the district level Brick Entrepreneurs Association. The district associations are then federated in the Federation of Nepal Brick Industries (FNBI).

The VSBK Entrepreneurs' Association is carrying out VSBK technology promotion activities. The Federation of Nepal Brick Industries (FNBI) has recently formed a sub-unit called Technology Research and Development Committee (TRDC) to carry out different activities related to technology development, improved energy efficiency, reduced pollution and other pertinent issues of the brick sector.

[1] *IEE required for brick industry with annual production capacity of 20 million units or less; EIA required for brick industry with annual production capacity above 20 million units*

5 Way Forward

Currently Government of Nepal (GoN) has enforced ban on the MCBTK technology all over the country by 2012 after the similar decision in 2003 for the Kathmandu Valley. The FCBTK, VSBK and Tunnel Kilns are provided as alternative options. The decision of GoN to ban MCBTK provides an opportunity to introduce more efficient technologies than the prevalent ones such as the tunnel and hybrid hoffman kilns. Almost all MCBTK operating in the Kathmandu Valley were converted to FCBTK when MCBTK was banned in 2003. The experiences from the technology changes that took place in 2003 in the Kathmandu Valley give an indication of the future trends. However the trend can also be influenced with strategic moves in order to introduce more efficient and cleaner technologies and other improvements in operating practices.

The way forward is discussed in the following chapters to achieve energy-efficiency and better environmental performance in the brick sector.

5.1 Technology Transfer of New Technologies

The new technologies for Nepal but prevalent in other countries, especially in South Asia, are tunnel and hybrid Hoffman kilns. The Hybrid Hoffmann Kiln (HHK) consists of highly insulated enclosed structure along with provision to trap the hot flue gas recycled to dry the green bricks stacked in a drying chamber. The HHK, like traditional technologies, does not require a tall chimney. Most bricks work as filters inside the drying tunnel and absorb un-burnt coal particles from the exhaust during the drying process. The Tunnel Kiln is long rectangular chamber lined with high quality refractory bricks. The bricks are loaded from one end in a trolley stacked with green bricks at a predetermined pattern. After a fixed interval of time, depending on the firing cycle, a trolley is pushed from one end, simultaneously taking one trolley with fired bricks out from the other end of the tunnel. There were no more hot and dusty chambers to deal with and workers were no longer exposed to the extreme changes of temperature when loading and unloading the kiln.

The enabling and disabling factors for introduction and dissemination of these more efficient technologies are discussed in this chapter. Investment for technology change is the primary factor that influences the decision of brick entrepreneurs and hence impacting the wider dissemination. The complexity in operation and requirement for totally different operational practice would hamper the speed of change in technology. Additionally, production capacity and easy access to technology services are other important factors that influence the adoption and speed of technology change. The confidence of entrepreneurs for investment on efficient technologies is also determined by success of demonstration kilns in the initial technology transfer phase. This is crucial when the new technology is sensitive as well as has different operational practices. The adaptation to the local context including the technical fine tuning is required while transferring the new technologies considering the existing skills, practices and capacities. The know-how and skill transfer, local anchoring together with successful technology demonstration is pre-requisite for further dissemination potential. The availability of and access to capable service providers by the entrepreneurs also plays an important role in investment on efficient technologies. Continuous supply of technical assistance and coaching along with capacity building in the production line enhance the confidence on technology for adoption by the entrepreneurs. The policy incentives for efficient technologies as well as disincentives for non-efficiency (including illegal operations) are effective instruments for wider technology dissemination.

The following analysis gives an overview on potential energy and environmental benefits against the investment with change in technology against the investment. Information on newer technologies such as Hybrid Hoffman Kiln (HHK) and Tunnel Kiln are taken from the reports of Bangladesh and India.

Table 13: Analysis of Investment and Impacts of Technology Change in Brick Kilns

Base Data	*Cost (NPR millions)*	*Energy Consumption (MJ/kg of fired brick)*	*CO2 (g/kg of fired brick)*
			CO_2
FC-BTK	2	1.22	115.00

Technology Transfer (assuming equivalent production)	*Cost (NPR millions)*	*Energy Saving (MJ/kg of fired brick)*	*CO2 (g/kg of fired brick)*
			CO_2
FC-BTK to VSBK[a]	9	22.1%	39.1%
FC-BTK to Zig-Zag	1	8.2%	10.4%
FC-BTK to IFC-BTK[b]	0.65	23.0%	20.0%
FC-BTK to Tunnel Kiln	80-160[c]	-20.5%	-44.3%
FC-BTK to HHK	40 -80[d]	45.1%	26.1%

- *Data from GreenTech (2012), UNDP (2012), BKEMP (2009) and World Bank (2011)*
- *a - assuming equivalent production*
- *b "IFC-BTK" refers to Fixed Chimney Bull's Trench Kiln with efficiency improvements*
- *c including kiln, dryer, drying shed, extruder*
- *d including kiln, mechanical extrusion system and dry tunnel The probability of negative figures for tunnel kiln is mainly due to use of energy for drying green bricks and mechanical extrusion which otherwise are done through natural solar energy and hand moulding in case of other technologies.*

5.2 *Improvements in Operational Practices*

The above analysis also shows the potentials in improvement of the prevalent technologies, which is discussed in this chapter.

The wider acceptance of FCBTKs is mainly due to the fact that this technology is similar to MCBTKs in infrastructure and in operation. Since this technology is widely popular in the neighbouring states of India as well, technical support can be brought in cheaply from Indian FCBTK kilns. The efficiency of FCBTK is only about 35-50% that is 50-65% of energy is wasted (TERI, Maithel et al, 2001). The energy and environmental improvement in FCBTK can be done through retrofitting interventions and adopting best operational practices such the zig-zag and natural/forced draught firing, usage of fuel as internal fuel, better insulation, controlled feeding, etc which have already been proven and is in practice in neighbouring India and Bangladesh. The zig-zag firing in FCBTK would result in better energy efficiency and lower emissions. The proper design and construction of kiln, chimney and other accessories such as fan for forced draught can contribute to higher efficiency. The heat loss from kiln structures like walls, ground and coal feeding holes are the most substantial in FCBTK. About 20-35% of heat loss is only from kiln ground and walls. Small improvements in kiln structures incorporating the insulation can save huge amount of energy. Control coal feeding through proper coal size, feeding spoon, feeding pattern and mechanized fuel feeding can save 5-10% energy losses minimizing the incomplete combustion. The internal fuel has demonstrated savings up to 16% coal consumption. It is estimated that about 52.5 % of energy lost can be minimized, i.e. 52.5 gram of coal can be saved per brick in FCBTK with these simple interventions. But the brick entrepreneurs are still not aware of possibility of achieving the energy efficiency with simple and less-costing measures. The technology is easily understandable and acceptable to entrepreneurs who had been previously operating MCBTKs, hence they can be convinced even by simple demonstrations and small technological supports.

5.3 Other Measures for Energy Efficiency

Taking an advantage of availability of huge forest waste resources in Nepal, charcoal produced from forest waste resources can replace coal in brick firing. The energy and environmental performance with the use of such renewable energy source has been proven in Nepal in an applied research done by MinErgy, a Nepali organization working in the brick sector. The energy consumption of baking a brick is proportional to its mass. A hollow brick having 20% hollow consumes 20% less coal. Hence, promotion of hollow bricks not only saves energy and environment but also reduce soil consumption and seismic weight of the structure. 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.

5.4 Investment Capacity and Financing

Normally higher investment is required for adoption of energy-efficient technology. Entrepreneurs are hesitant for higher investment and have concerns on favourable environment for investment security due to political instability. Due to unfavourable investment security environment, entrepreneurs are more inclined towards the investment where shorter pay back period is preferred compare to other financial and economic parameters. The higher initial investment and lower returns of VSBK compare to FCBTK has been one of the key factors for entrepreneurs in Nepal not to preferred VSBK despite of being energy-efficient, cleaner and economically profitable (Winrock, 2011). Similarly, the Hoffman Kiln, despite being introduced over forty years, could not be disseminated at larger scale due to high upfront investment. The financing constraint is likely to affect any efforts to introduce lower-emission, higher-efficiency kilns (e.g., Hybrid Hoffman Kiln-HHK and Tunnel Kilns) that cost 10 times or more than FCBTK (World Bank, 2011).

The financial institutions and banks do not consider brick kiln as an industry and hence do not provide commercial or industrial loan with competitive interest rate. Most of the entrepreneurs have ownership on limited areas of the land, mainly for the kiln structure, and they tend to lease land for other requirements such as for green brick moulding, stacking and storing. In the case of kilns established on rented land, entrepreneurs cannot use land as collateral to access commercial loans to invest in efficient technologies. Hence, most of the brick entrepreneurs have to access private lending and investment which do not encourage for higher investment on energy-efficient technologies.

5.5 Enabling Policy for Investment

Without stringent energy-efficiency and environmental emission policy and regulatory enforcement, it is obvious that the investment on efficient technology is less likely to happen when the ROI for MCBTK is 135%, 80% for FCBTK and 40% for VSBK (Heierli and Maithel, 2008). Most of the current policies on brick sector do not differentiate between energy-intensive and energy-efficient technologies. The policy incentives to encourage investment on energy-efficient technologies are often lacking. Even when there is such favourable policy, the access to such incentives are cumbersome and the mechanism to implement such policy is not yet in place. Similarly, the disincentives for higher intensity along with the illegal operations should be in effectively implemented for the promotion of efficient technologies and measures.

5.6 Marketing and Communication

The right marketing and communication strategy plays a vital role in promotion of any energy-efficient measures. Considering the exposure level and technical capacity of brick entrepreneurs, the version of "seeing is believing" absolutely fits into the context. Hence, demonstration of new technologies and other efficient measures along with site visits, exposure trips, training and skill impartation will contribute to the effective dissemination.

5.7 Monitoring

Monitoring on energy and environment performance is inevitable in order to promote efficient technologies and measures. The monitoring results should be the base for policy formulation, promotion and marketing. Similarly, the benefits of the adoption of efficient technologies can be demonstrated based on the monitoring results.

6 References

- Central Bureau of Statistics (CBS), 2008: Census of Manufacturing Establishments 2006/2007, Government of Nepal.
- Central Bureau of Statistics (CBS), 2008: Environment Statistics of Nepal, Government of Nepal.
- Clean Energy Nepal (CEN), 2009: Baseline Study of Brick Kilns in Nepal, Kathmandu.
- D.A, Practical Action, May 2009: Final Report of Brick Kiln Emission Management Project (BKEMP)
- Federation of Nepal Brick Industries (FNBI), March 2012: Personal Interview.
- Genentech, January 2012, Brick Kilns Performance Assessment and A roadmap for Cleaner Brick Production in India.
- Heierli U. and Maithel S., 2008: Brick by Brick: The Herculean Task of Cleaning up the Asian Brick Industry, Swiss Agency for Development and Cooperation (SDC), Natural Resources and Environment Division, Berne.
- Maithel S., Vasudevan N., Johri R. and Kumar A., 2001: Pollution Reduction and Waste Minimization in Brick Making, TERI.)
- Ministry of Environment, Science and Technology (MoEST), 2005: Ambient Air Quality of Kathmandu Valley, Kathmandu.
- MoEST, 2006, Action Program on Air Quality Management of Kathmandu Valley. Final Report, Ministry of Environment, Science and Technology, Government of Nepal.
- PACE Nepal, Feb 2012: Baseline study of selected sector industries to assess the potentials for more efficient use of energy , Nepal Energy Efficiency Programme (NEEP)/GIZ
- Premchander S., Bloesch U., Tuladhar B., and Raghunandan D. 2011: External Review of Clean Building Technologies for Nepal VSBK-CESEF Project 2008-2011.
- TERI, June 2002: The Energy and Resources Institute Project Report No. 200CR 45, New Delhi, India.
- Tuladhar B., Acharya J. and Raut A., 2006: Co-Benefits of Financing Vertical Shaft Brick Kilns in Nepal.
- UNDP, 2012: Fact sheet of Improving Kiln Efficiency in the Brick Making Industries (IKEFBMI) Project. http://www.undp.org.bd/projects/prodocs/IKEBMI/IKEBM%20-%20Project%20Fact%20Sheet.pdf
- VSBK Nepal, 2008: Financial Analysis of VSBK Plants in Kathmandu Valley and Jhapa (Terai), Kathmandu, Nepal
- VSBK Nepal, 2012: http://www.vsbknepal.com/technology/vsbk_history_01.htm
- Winrock International, January 31, 2011: Study on Economic Instruments for Promotion of VSBK Technology in Nepal. Submitted to VSBK Project Nepal.
- World Bank, 2007: Nepal Country Environment Analysis, Report No. 38984-NP, Washington DC. Available at http://siteresources.worldbank.org/INTRANETENVIRONMENT/3635842-1175696087492/21643874
- World Bank, June 2011: Introducing Energy- efficient Clean Technologies in the Brick Sector of Bangladesh.