Greentech Knowledge Solutions Pvt. Ltd.

SHAKTI SUSTAINABLE ENERGY FOUNDATION

Roadmap for Promoting Resource Efficient Bricks in India: A 2032 strategy

A win-win approach that promotes environment sustainability, quality housing, and sustainable livelihoods

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FOREWORD

For many years, an oft-repeated statement in policy circles has been that '70% of India of 2030 is yet to be built'. While this statement is accepted at face value by most, the underlying issues related to it are seldom addressed. For instance, what will be the social and environmental impacts of such a massive construction boom? How would we ameliorate those impacts? What kind of policy and practice changes would be required to address the issue of climate change in the building sector? We need to answer these questions simply because the building sector has one of the highest resource and environmental impacts. It is estimated that in India, the building sector uses up 30% of the energy, 40% of natural resources, and 12% of water consumed by the country; in addition, it generates more than 50% of the country's solid and liquid waste.

Though all materials used in building construction are resource- and pollution-intensive, the manufacturing of bricks contributes significantly to the environmental impacts. It is estimated that presently, about 860 million tonnes of materials is consumed per year to produce different kinds of bricks – largely clay bricks – in India. The brick sector is also one of the largest emitters of greenhouse gases. About 66–84 million tonnes of CO_2 and over 100,000 tonnes of black carbon is emitted every year from brick kilns.

In a business-as-usual scenario, resource consumption and emissions are projected to increase four-fold in the next 20 years as the annual demand for bricks is expected to quadruple during this period. This is completely unsustainable. It is, therefore, imperative to start deliberating about resource-efficient bricks both from the demand as well as supply side.

The report, 'Roadmap for promoting resource efficient bricks in India: A 2032 strategy' is an excellent trigger to start this deliberation. It presents a resource efficiency framework, compares different types of bricks available in the Indian market, and identifies different options for resource-efficient bricks in the Indian context. The report also presents a strategy and a roadmap for the next 15 years to transform the brick-making sector.

It is quite clear that a major transformation in the brick sector is required for social and environmental sustainability. This sector, especially the clay brick sector, is largely unorganised and informal. There is a huge scope to improve technology, resource efficiency and labour conditions. In a nutshell, a National Brick Mission is the need of the hour to leapfrog this sector into the 21st century.

Chandra Bhushan
Deputy Director General
Centre for Science and Environment
New Delhi

PREFACE

Construction of buildings require a variety of building materials such as sand, aggregates, brick, cement, steel, aluminum, timber, glass, ceramic tiles, etc. Building materials have a large environment footprint. Building materials manufacturing is already one of the largest contributors of greenhouse gas emissions, single largest user of mined raw materials, and an important source of air pollution in India. This publication focuses on a roadmap for bricks.

Masonry construction using bricks is the main type of building construction technology used in the country. Among various types of bricks, solid burnt clay bricks are the most widely used bricks. In recent years, several new walling construction technologies and materials have been introduced, but in the foreseeable future, bricks are expected to retain its dominant position. Given the large anticipated growth in the building construction, the annual demand for bricks in India is expected to peak to 750–1000 standard billion bricks (SBUs) a year during 2032–37 from about 250 SBUs a year during 2012–17.

It is against this background of rising demand for bricks and growing concerns about the environment sustainability that this study was conducted by Greentech Knowledge Solutions with funding support from Shakti Sustainable Energy Foundation. The study titled, 'Roadmap for Promoting Resource Efficient Bricks in India', covered a wide range of aspects.

a) It starts with presenting the current status of the brick sector in India, which includes an analysis of the market for bricks,manufacturing industry, and the environment policy landscape. It highlights the unique features of the brick sector in India, be it pre-dominance of the small unorganised sector enterprises in manufacturing, large number of persons employed, regional differences in raw materials availability, markets, etc.
b) It then presents a resource efficiency framework and compares different types of bricks available in the Indian market– solid burnt clay brick, perforated burnt clay brick, hollow burnt clay brick, burnt clay fly ash brick, compressed stabilised earth block (CSEB), fly ash lime brick, fly ash cement brick, hollow concrete block, solid concrete block, autoclaved aerated concrete (AAC) block, and cellular light-weight concrete (CLC) block. This analysis leads to identifying options for resource efficient bricks (REBs) in the Indian context.
c) The last section of the report deals with the estimation of the future demand for bricks and presents a strategy and a roadmap for next 15 years to transform the brick sector and make it resource efficient.

This publication is culled out of the larger study report and carries analysis, facts, figures, and constructive suggestions for the future. We anticipate and welcome debates and discussions on the numbers and the roadmap presented in this publication.

Targeting policy makers, decision makers, and other important stakeholders of the brick industry, we strongly believe that this audience can shape and give direction to the future of the brick industry in the country and help the country in its quest for *environment sustainability, providing quality housing and sustainable livelihoods to all its citizens.*

In the preparation and finalisation of the larger study report and this publication, we sought and received help from various quarters. Foremost, Shakti Sustainable Energy Foundation came forward with funding support to undertake this major study. Dr Veena Joshi reviewed the report and provided some invaluable suggestions. Several enterprises in the brick sector across the country that we interacted with during the course of this study not only provided substantial data but also gave us their perspectives of the whole scenario. My colleagues at Greentech Knowledge Solutions Pvt. Ltd. together as a team during the course of the study period to deliver what was expected of us. Mr K P Eashwar of Academic and Development Communication Services (ADCS) edited the report. We gratefully acknowledge the support given by each and every one.

Sameer Maithel

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ABBREVIATIONS/ACRONYMS

AAC	autoclaved aerated concrete
BIS	Bureau of Indian Standards
C&D	construction and demolition
CLC	cellular light-weight concrete
CPCB	Central Pollution Control Board
CPWD	Central Public Works Department
CSEB	compressed stabilised earth block
DEAC	District Level Expert Appraisal Committee
DEIAA	District Level Environment Impact Assessment Authority
DIC	District Industry Centre
DST	Department of Science and Technology
ESP	electrostatic precipitator
FCBTK	fixed chimney Bull's Trench Kiln
INR	Indian National Rupee
MCBTK	moving chimney Bull's Trench Kiln
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MoEFCC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
MoMSME	Ministry of Micro Small and Medium Enterprises
NCR	National Capital Region
NGT	National Green Tribunal
NSDC	National Skill Development Council
PM	particulate matter
PWD	Public Works Department

REB	resource efficient brick
SBU	standard brick units
SEIAA	state environment impact assessment authority
SLCP	short-lived climate pollutant
SPCB	state pollution control board
SPM	suspended particulate matter
ULB	urban local body
VSBK	vertical shaft brick kiln

1. INTRODUCTION

Masonry is the building of structures from individual units (bricks, stone, etc.). These individual units are often laid in and bound together by mortar. Masonry construction using bricks is the dominant form of house construction in India, accounting for 58.3% of the households as per 2011 census. Burnt clay brick is the most popular walling material, accounting for 48% of the households. Census data for 1991–2011 show that the use of burnt clay bricks as walling material has been growing steadily in both rural and urban areas.[1] The annual production of bricks has increased six times during the past 40 years.

"In a business-as-usual scenario, the annual demand for bricks will increase from 250 billion a year currently to around 1000 billion a year by 2032."

The application of alternative construction systems such as monolithic concrete construction and construction using pre-fabricated concrete panels as a replacement for masonry is being promoted by the Government of India, particularly for mass housing.[2] However, their penetration, though increasing, is still low and is confined to a section of organised construction industry only. It is expected that in the next 15 years, masonry construction will retain its dominant position and the average annual demand for bricks will increase from around 250 billion Standard Brick Units[3] (SBUs) a year during 2012–17, to a peak of around 750–1000 billion SBUs a year[4] during 2032–37.[5]

[1] The census collects data on material for wall construction. An analysis of census data for 1991 and 2011 shows that the percentage of households having burnt clay brick masonry construction has increased from about 34% to 48%. *censusindia.gov.in/2011census/hlo/Data_sheet/India/00_2011_Housing_India.ppt* (accessed on 22 January 2018).

[2] BMTPC. 2017. Compendium of prospective emerging technologies for mass housing. New Delhi: Building Material Technology Promotion Council.

[3] Standard brick unit (SBU) refers to the common size of burnt clay bricks produced in India which is 230 × 120 × 75.

[4] Assuming that all the new construction will be masonry construction using bricks, the demand will be about 1000 billion bricks a year in 2032. If a 25% market share is taken up by industrial construction technologies, the demand for bricks will be 750 billion bricks a year.

[5] Based on GKSPL analysis.

This study has been conducted amid growing concerns about negative impacts on the environment due to resource-intensive and polluting nature of the brick industry. The objective of the study is to:

- develop a deeper understanding of brick manufacturing and brick markets in the country;
- propose and apply a multi-parameter resource efficiency framework to various types of bricks available in the Indian market;
- identify resource efficient brick (REB) options; and
- suggest a policy roadmap for promoting REBs.

> *“Bricks are of many types ranging from burnt clay to cement–bonded products.”*

The study covers all major types of manufactured bricks available in the Indian market (Figure 1.1), which includes solid burnt clay brick, perforated burnt clay brick, hollow burnt clay brick, burnt clay fly ash brick, compressed stabilised earth block (CSEB), fly ash lime brick, fly ash cement brick, hollow concrete block, solid concrete block, autoclaved aerated concrete (AAC) block, and cellular light-weight concrete (CLC) block. Annexure 1 provides a brief description of different types of bricks covered in the study.

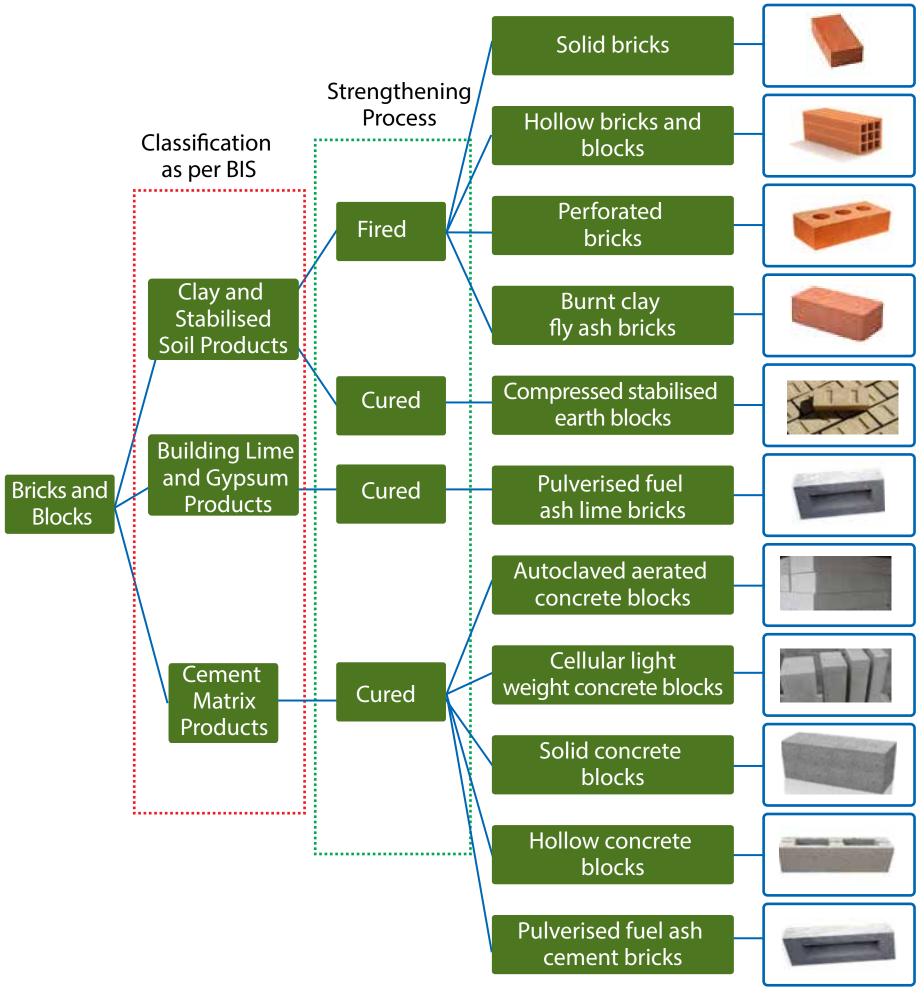

Figure 1.1. Types of bricks covered in the study

2 INDIAN BRICK SECTOR: CURRENT STATUS

2.1 Market

The total production for bricks is estimated to be 274 billion SBUs/year (2014/15).[6] The solid burnt clay bricks hold the largest production share of about 89%. Concrete blocks, AAC blocks, and fly ash lime/cement bricks are the other dominant brick types, accounting together for 10% of the production share. The production share of the remaining types of bricks is negligible.

At present, the market for bricks is equally divided between rural and urban areas, but with regional variations. The market is influenced by the availability of main raw materials (brick earth, fly ash, aggregates, etc.) used for the manufacturing of bricks and by the type of construction. The country can be divided into three distinct geographical regions:

1. Western Himalayan and north-eastern hilly states: Burnt clay bricks produced in nearby plains or valleys dominate the market in the western Himalayan region while concrete blocks produced locally have significant market share in the north-eastern states.
2. Indo-Gangetic plains: This region covers Punjab, North Rajasthan, Haryana, Delhi, Uttar Pradesh, Bihar, West Bengal, Assam, and Tripura. Burnt clay bricks are the pre-dominant brick type (>95% market share). The market for AAC blocks, fly ash bricks, and concrete blocks is small but is growing in large urban centres.
3. Peninsular, desert, coastal India: A variety of bricks are used in this region. Burnt clay bricks dominate the market (e.g., Tamil Nadu, Gujarat), while solid concrete blocks (e.g., Karnataka), AAC blocks (e.g., Pune, Surat, Mumbai) and fly ash bricks (e.g., parts of Maharashtra and Andhra Pradesh) have large market shares.

"Bricks are made using local raw–materials; this explains regional differences in the type and quality of bricks."

[6] GKSPL analysis

Within a geographical region, the market for bricks can be further segmented based on factors such as type of building (residential, commercial, etc.), scale, agency responsible for construction, and location (urban/rural) of the building. Some of the key trends in the market for bricks are as listed below.

- Trend of replacing the buildings constructed using traditional mud/unburnt brick/bamboo with buildings made of solid burnt clay bricks in rural areas.
- Strong and stable market for solid burnt clay bricks in low-rise housing construction in urban areas.
- Increasing market share of light-weight blocks like AAC blocks in high-rise housing and commercial building construction in urban areas.
- Increasing application of fly ash-based bricks and blocks in government construction because of fly ash regulations.

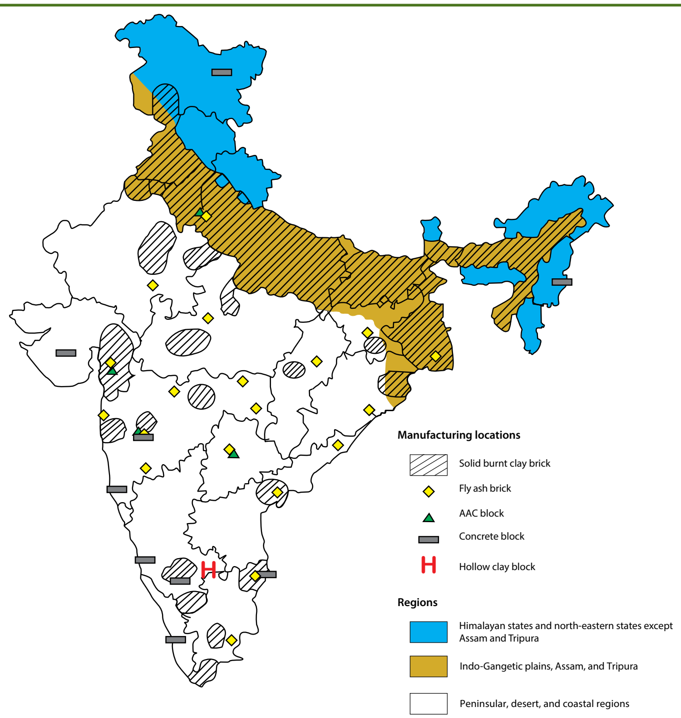

Figure 2.1. Key brick manufacturing regions in the country by brick type

2.2 Manufacturing industry

The manufacturing of bricks is decentralised, and the industry is spread across the country. While in rural areas bricks are typically consumed within 30–40 km radius, in urban areas, bricks are used within 100–200 km radius from the point of manufacturing. Bricks are produced in 250,000–300,000 enterprises, mostly small and informal enterprises. The combined annual turnover of the brick industry is estimated to be around INR 100,000 crore. These enterprises play an important role in the local and national economies in addition to providing employment to over 9–10 million workers,[7] especially in rural areas. Figure 2.1 shows the key brick manufacturing regions in the country by brick type.

Small-scale concrete block manufacturing[8]

Small-scale fly ash brick manufacturing

Burnt clay brick manufacturing: a cluster of brick kilns (North India)

Burnt clay brick manufacturing: Western India

Figure 2.2. Photographs of small unorganised sector enterprises

[7] J S Kamyotra. CPCB presentation titled 'Brick Kilns in India', Presentation made at the workshop on "Roadmap for Brick Kiln Sector Challenges and Opportunities", organised by Centre for Science and Environment at New Delhi on 8 February 2016.

[8] https://www.youtube.com/watch?v=S33akB4PQAg (accessed on 29 January 2018).

Majority of the enterprises manufacturing bricks (accounting for >90% of the production) belong to the small unorganised sector.[9] The main types of bricks produced in the small unorganised sector are solid burnt clay bricks, solid concrete blocks, and solid fly ash lime/cement bricks. Most of the operations in these manufacturing units are manual and seasonal migratory workers from rural areas are engaged in the production of bricks.

Mechanised hollow clay block manufacturing

Automated concrete block manufacturing

Automated autoclaved aerated concrete block manufacturing[10]

Figure 2.3. Photographs of organised sector enterprises

[9] Unorganised sector refers to partnership and proprietorship enterprises, which do not maintain any annual report presenting the profit and loss account and balance sheet. Enterprises in the organised sector are those that come under the purview of the Companies Act 2013 or Factories Act 1948 and maintain any annual report presenting the profit and loss account and balance sheet (Vaidyanathan, R. 2014. India Unincorporated. Westland and Tranquebar Press. 372 pp.).

[10] https://www.understanding-cement.com/autoclaved-aerated-concrete.html# (accessed on 29 January 2018).

Remaining 10% of the production takes place in the medium/large organised sector enterprises. These enterprises are semi-mechanised or mechanised and are engaged in the production of AAC blocks, perforated and hollow burnt clay blocks, hollow concrete blocks, and fly ash bricks.

Brick manufacturers, particularly those in the unorganised sector, face multiple challenges, such as problems with the procurement of raw materials like brick earth, fly ash, sand, etc.; limited ability to maintain consistent product quality; limited ability to adopt new technology and offer new products as per changing market demand; problems in complying with environment, mining, labour and tax regulations.

"The manufacturing of bricks is decentralised. Bricks are produced in 250,000–300,000 enterprises, employing close to 10 million workers."

3. ENVIRONMENT: IMPACTS AND EXISTING POLICY FRAMEWORK

3.1 Resource use

Production of bricks is resource-intensive, consuming large quantities of raw materials. The estimates[11] of the quantities of raw materials used for brick production are furnished below.

- ~750 million tonnes of brick earth a year to produce burnt clay bricks.
- ~30 million tonnes of coal a year and ~10 million tonnes of biomass annually for firing of burnt clay bricks making brick industry as one of the largest energy consuming industry in the country.
- ~60 million tonnes of stone aggregates and sand a year used to produce fly ash bricks and concrete blocks.
- ~12 million tonnes of fly ash used in a year in the production of fly ash bricks and AAC blocks.
- ~5–10 million tonnes of cement and lime is used annually to produce fly ash bricks and concrete blocks.

3.2 Environmental impacts

The key environment impacts of brick-making activities in India are as listed below.

- Brick sector is one of the largest industrial sources of emission of CO_2, a greenhouse gas responsible for global warming. About 66–84 million tonnes of CO_2 emissions[12] is generated from brick kilns annually. Over 100,000 tonnes of black carbon emissions[13] is generated in a year from brick kilns, which is a short-lived climate pollutant (SLCP), having a warming influence on climate.

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[11] GKSPL estimates

[12] TERI. 2016 Report on Resource Audit of Brick Kilns New Delhi: The Energy and Resources Institute [Project Report No. 2015IE22]

[13] Cheryl Weyant et al. 2014. Emissions from South Asian Brick Production, *Environ. Sci. Technol.* 48(11): 6477–6483.

- The main air pollutants from the brick sector are particulate matter and sulphur dioxide, which have adverse impact on human health and vegetation. Emissions from brick-kiln clusters due to burning of fuel are a significant source of $PM_{2.5}$ in several Indian cities. In Patna, the brick kilns are estimated to contribute to 9% and in Varanasi 30% of the annual $PM_{2.5}$ emissions.[14] Sulphur dioxide is generated due to combustion of high-sulphur containing coal and petroleum coke in brick kilns and adversely affects the vegetation and crops.[15] Apart from the air pollution generated due to burning of fuel, significant amount of fugitive emissions also takes place during the manufacturing of both burnt clay[16] as well as fly ash bricks,[17] which adversely impact the health of the workers.
- One of the main areas of concern is the damage to farmland due to mining of brick earth. In addition, environment damage associated with the mining of large quantities of other raw materials such as stone, sand, coal, and limestone is also an area of concern.

“Air pollution due to emissions of sulphur dioxide and particulate matter, global warming due to carbon dioxide emissions; and damage to farmlands due to mining of topsoil are major environmental concerns.”

3.3 Environment policy framework

Three key existing environment policies and regulations that are applicable to the brick sector are:

1. Emission standards/regulations for brick kilns to regulate air pollution from brick kilns;
2. Fly ash regulation to promote utilisation of fly ash in building materials including bricks;
3. Environment impact assessment for mining of minor minerals like brick earth and sand, which are important raw materials for brick production.

[14] http://www.urbanemissions.info/india-apna/varanasi-india/,http://www.urbanemissions.info/india-apna/patna-india/(accessed on 23 January 2018).

[15] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4708652/ (accessed on 15 January 2018).

[16] Chen Y. 2017. Stack and fugitive emissions of major air pollutants from typical brick kilns in China. *Environmental Pollution*. May 2017; 224: 421–429.

[17] Abt Associates. 2017. Considerations on the health impacts of coal fly ash use in brick making and building construction in India. Report prepared for The Climate and Health Research Network (CHeRN). 25 pp.

A brief description of these policies and their impacts is explained in the subsequent sections.

3.3.1 Emission standards for brick kilns

Emission standards for brick kilns setting the maximum permissible limit for suspended particulate matter (SPM) in brick-kiln stack were first introduced in 1996. These standards applicable to moving chimney Bull's Trench Kiln (MCBTK) technology, which accounted for about 70% of the brick production in the country. The emission standards led to a changeover from MCBTK to fixed chimney Bull's Trench Kiln (FCBTK) technology. The standards did not cover clamps, which account for about 25% of the brick production. No large-scale studies/surveys are available, which quantify the impacts of the emission standards. However, field monitoring of energy and environment performance of sample kilns[18] shows that the shift from MCBTK to FCBTK resulted in the reduction of energy consumption and SPM emission as well as improvement in the percentage of well-fired bricks and increase in production per kiln.

> *"The 1996 environment standards for brick kilns did not cover clamp kilns, which account for about 25% of the brick production."*

Since 2015, as a part of the strategy to reduce air pollution, environment regulations in some regions (e.g., National Capital Region [NCR][19] and Bihar) mandate replacement of FCBTKs with less polluting technologies like zigzag kiln technology. The mandate is based on field monitoring data[20] from a sample of zigzag kilns and FCBTKs, which had shown the possibility of reduction in fuel consumption by about 20% and SPM emissions in stack gases by up to 75% through a shift from FCBTK to zigzag kiln technology.

> *"Retrofitting or replacing existing FCBTK with zigzag kiln offers environment and economic benefits."*

[18] Maithel S. 2003. Energy Utilization in Brick Kilns, PhD Thesis, Indian Institute of Technology, Bombay.

[19] https://economictimes.indiatimes.com/news/politics-and-nation/centre-releases-draft-action-plan-to-tackle-air-pollution-in-capital/articleshow/62261423. cms (accessed on 28 December 2017).

[20] GKSPL. 2013. Towards Cleaner Brick Kilns in India: An Approach Based on Zig Zag Firing Technology, Discussion Paper published by Greentech Knowledge Solutions Pvt. Ltd, February 2013, 17 pp.

Regulations to combat air pollution in NCR and Bihar have relied mainly on technology mandates (specifying certain cleaner kiln technologies). The policy instrument of technology mandate is seen as easy to implement by regulators[21] as it does not entail emission monitoring of kilns, which is perceived as a difficult task for the regulators given the informal nature and large number of brick enterprises. Recent work carried around Patna[22] to track the implementation of technology mandate for brick kilns indicates that access to good quality technical support and training of owners and workers in new technology are important pre-requisites to achieving the desired environmental benefits of the technology mandates. Performance monitoring of sample kilns by state pollution control boards (SPCBs) both before and after the implementation of the technology mandates would help in gaining a better perspective on the effectiveness of such mandates and help in future policy formulation.

> *"Access to good quality technical support and training of owners and workers in new technology like zigzag kiln are important prerequisites to achieving the desired environmental benefits."*

The Ministry of Environment, Forest and Climate Change (MoEFCC) and the Central Pollution Control Board (CPCB) are in the process of revising emission standards for brick kilns. The process has been extremely slow. It was initiated in 2009, but the revised standards are yet to be notified. The new emission standards should be comprehensive, covering all types of brick kilns as well as specifying

[21] Haque N. 2017. Technology mandate for greening brick industry in Bangladesh: a policy evaluation. *Clean Technologies and Environmental Policy* 2017;19:319-26.

[22] In February 2016, Bihar State Pollution Control Board (BSPCB) directed all the brick kilns located in 5 blocks of Patna district, namely Patna Sadar, Fatuah, Danapur, Fulwarisharif and Maner; to shift to cleaner brick production technologies before the commencement of next brick making season. Around 100 kilns out of 192 shifted to zigzag kiln technologies for one year. A programme to create awareness, provide limited technical support and track the implementation was carried out by GKSPL with support from Bihar State Pollution Control Board and Shakti Sustainable Energy Foundation. A post-implementation survey of the enterprises that shifted to the cleaner brick production technology showed that around 70% of the kilns achieved some or all of the desired benefits in terms of reduction in energy consumption and improvement in brick quality. However, due to issues related with poor quality of technical design and construction, shortage of trained workers and lack of supervision by owners, resulted in around 30% of the kilns not achieving the desired benefits.

the methodology for the monitoring of brick kilns and guidelines on the implementation of regulations in the brick industry. The announcement of new emission standards should be accompanied by a programme to provide technical support to brick industry and monitoring of brick-kiln performance.

3.3.2 Fly ash regulation

The first regulation for fly ash utilisation was notified in 1999, which have subsequently been revised in 2003, 2009, and 2016. The revised 2016 notification states the following:

- All brick manufacturing units within 300-km radius of a thermal power plant are required to use fly ash for the manufacturing of bricks.
- All cities having a population of more than 1 million to amend building bye-laws to make the use of fly ash bricks mandatory.
- Further, the use of fly ash-based bricks and products is made mandatory in all Government schemes or programmes, e.g., Mahatma Gandhi National Rural Employment Guarantee Act, 2005 (MNREGA), Swach Bharat Abhiyan, Urban and Rural Housing Scheme, where built-up area is more than 1000 square feet and in infrastructure construction including buildings in designated industrial estates or parks or special economic zones.

“Issues of implementation and market demand limit the impact of fly ash regulation in brick production.”

Since the notification of the fly ash regulation in 1999, the utilisation of fly ash in the country has increased from 7 million tonnes in 1998/99 to 102 million tonnes in 2014/15.[23] However, utilisation of fly ash in brick production is still small, about 12 million tonnes in 2014/15 or 6.5% of the annual fly ash generated in the country. There are multiple reasons for the limited effectiveness of fly ash regulation concerning brick production. Some of these are related to issues of implementation and market, e.g., lack of awareness and

[23] Central Electricity Authority. 2015. Report on fly ash generation at coal/lignite based thermal power stations and its utilization in the country for the year 2014-15. New Delhi: Central Electricity Authority.

negative perception about fly ash bricks, distributed nature of the brick industry, lack of fiscal incentives for fly ash brick makers, and problems with fly ash sourcing.[24] There are multiple agencies such as MoEFCC, CPCB, SPCB, power plants, and municipal corporations, which must work together to implement the fly ash regulation. The limited effectiveness of the fly ash regulation indicates that either there is a lack of clarity on the roles, responsibilities, and coordinating mechanism in the fly ash regulation or the arrangements suggested in the fly ash regulations are not practical.

"As availability of fly ash is highly skewed among states, mandatory use of fly ash bricks in all the states of the country is not practically possible."

The fly ash availability is highly skewed among states (Figure 3.1).[25] There are several states having almost no or very little amount of fly ash available for brick making, hence, the provision of making use of fly ash bricks mandatory throughout the country is not practical. The fly ash regulation makes it mandatory for coal-based thermal power plants to supply at least 20% of dry electrostatic precipitator (ESP) fly ash free of charge to units manufacturing fly ash or clay-fly ash bricks, blocks, and tiles on a priority basis over other users. Most of the power plants at present are not meeting this requirement. Even if all thermal power plants can supply 20% dry ESP fly ash generated annually for brick production, the total quantity of fly ash available for brick production will be around 35 million tonnes a year.[26] This quantity will be sufficient for making 25–35 billion bricks a year or meet only 10% of the total current annual requirement for bricks. In addition to fly ash, about 140 million tonnes[27] of other inorganic wastes, e.g., coal mine, lime stone waste, and construction waste, is available in the country every year, which may be suitable for brick making. The sole focus on fly ash impedes utilisation of other types of wastes and other types of REBs.

"There are many inorganic wastes other than fly ash available in large quantities, which can be used for brick products."

[24] Development Alternatives, 2016. The fly ash brick industry in Bihar. New Delhi: Development Alternatives.

[25] Ahmed *et al.* 2016. Geographical spread of fly ash generation and residual potential for its utilization in India. *International Journal of Innovative Research and Review,* 4(1): 8–19.

[26] Pond ash, which is available in large quantities, is generally not suitable for fly ash brick making and, therefore, brick-making units generally use dry ESP fly ash.

[27] Venkatarama Reddy B V. 2009. Sustainable materials for low carbon buildings. *International Journal of Low-Carbon Technologies,* 4(3): 175–181.

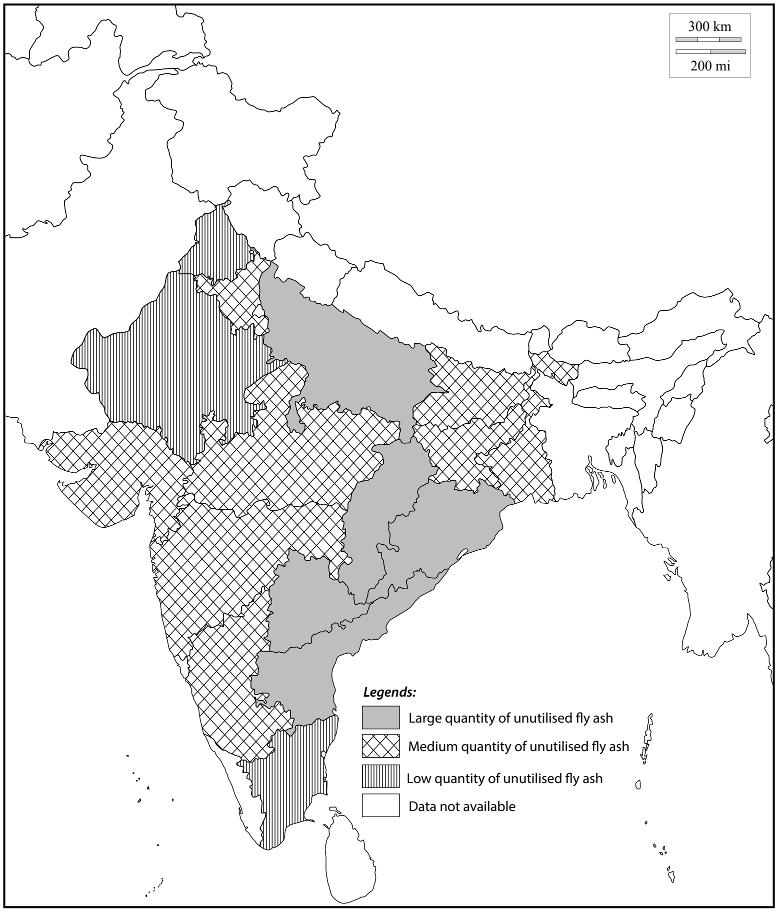


Figure 3.1. Fly ash availability in the country[28]

[28] Adapted from Ahmed, *et al.* 2016. Geographical spread of fly ash generation and residual potential for its utilization in India. *International Journal of Innovative Research and Review,* 4(1): 8–19.

There is a strong case to have a fresh look at the fly ash regulation as far as use of fly ash in brick production is concerned. As argued later, it may be better to have a single new regulation for bricks that promotes use of all types of wastes and all types of REBs.

3.3.3 Environment impact assessment for mining of minor minerals

> *"The environment policy framework for brick industry in India consists of disjointed individual policies with limited understanding of implementation issues."*

Through a notification issued in 2012 by the MoEFCC, the excavation of brick earth to produce burnt clay bricks is permissible only after prior environment clearance from the respective state environment impact assessment authorities (SEIAAs). Through a notification issued in January 2016, the MoEFCC has instructed the formation of District Level Environment Impact Assessment Authority (DEIAA), for grant of environmental clearance for Category 'B2' Projects for mining of minor minerals (applicable to brick earth). For the purposes of assisting DEIAA, the notification also instructs constitution of the District Level Expert Appraisal Committee for all the districts of the country (DEAC for the district). Before the January 2016 notification, several SEIAAs had started granting environment clearances for brick enterprises. However, the process of providing clearances has slowed since then, as the formation DEIAA and DEAC is still in progress. Several environmental experts have raised issues regarding the composition of the DEIAA and DEAC, particularly on the lack of environment expertise and hence their inadequacy to protect the environmental requirements of ecosystems in granting clearances for mining of minor minerals.[29]

The provisions of environment clearance limit the depth of clay mining to a maximum of 3 metres, and it does not allow two mining locations to be within a distance of 500 metres. It also puts the onus of rehabilitation of the mined land on the agency involved

[29] http://indianexpress.com/article/india/india-news-india/ngt-notice-to-moef-on-decentralisation-of-ec-for-sand-mining-3053156/ (accessed on 1 October 2017).

in mining. The environment clearances are being given based on an affidavit by the agency mining brick earth that it will follow the conditions mentioned in the environment clearance. Generally, no visits/physical checks are made to verify that these conditions are being met. Lack of institutional capacities at the district level and lack of oversight have raised a question mark on the effectiveness of the EIA for mining. Also, the complex paperwork for getting environment clearance means that brick kilns must hire the services of consultants for the paperwork and bear substantial additional expenditure. The number of cases in the National Green Tribunal (NGT) and in other courts regarding brick kilns and this regulation has gone up significantly. Ongoing litigations have increased the uncertainty regarding the availability of raw material (brick earth) and are impeding new investments in the modernisation of the burnt clay brick sector.

“Slow process of environmental clearances, uncertainty on the availability of brick earth, and fear of litigations hamper new investments coming in to the burnt clay brick sector towards modernisation.”

Overall, the environment policy framework for brick industry in India consists of disjointed individual policies developed through a top-down approach with limited understanding of the implementation issues. There is a complete lack of policies and programmes tailored to the requirement of brick industry on finance, technology transfer, training, skill development, etc. An analysis of the policy framework in China (Box 1) points out the need for a multi-pronged policy approach linking production of REBs (supply side) with energy-efficient building construction (demand side), and covering aspects such as finance, R&D, raw material supply, and energy and environment standards. It also indicates that the transformation in brick industry is a long-term process; in the case of China, the process started in 1992 and is still ongoing.

Box 1: Chinese policy framework for walling materials[30-31]

China is the largest producer of bricks in the world. In 2004, the Chinese brick production was estimated to be 900 billion bricks a year. Like in India, in China also the solid burnt clay brick is the main walling material. In 2004, it was estimated that solid burnt clay bricks made up for 65% of the brick production. China has been promoting new types of bricks such as hollow burnt clay bricks, fly ash bricks, and AAC blocks and is aiming to raise the contribution of these new bricks to 60% by 2030. The Chinese policy on bricks have several aspects and has developed over a period of time:

1992: First policy statement on the need to accelerate transition to new walling materials and promote energy efficient buildings. This was followed by several policy actions:

- Policy on restriction of solid burnt clay bricks in identified regions and urban areas
- Preferential tax policies for new walling materials
- Strengthening of institutions for R&D and for providing technical support to brick industry
- Emission standards for brick kilns.
- Policy on phasing out of kilns based on outdated technologies.
- Energy consumption standards for brick kilns

2007:11th Five-year plan on brick and tile industry in China

2010: Aim to have 40% of the total walling materials as new walling materials

Several ministries and departments have played a key role in policy formulation and implementation, which includes the Ministry of Construction, the Ministry of Agriculture, the National Development and Reform Commission, the State Economic and Trade Commission, the Ministry of Finance, the Ministry of Science and Technology, the State Administration of Taxation, the State Bureau of Quality and Technical Supervision, the Construction Material Bureau, etc. No recent updates are available in public domain on the status and effectiveness of the Chinese policies.

[30] ESMAP. 2011. Introducing Energy Efficient Clean Technologies in the Brick Sector of Bangladesh. https://openknowledge.worldbank.org/bitstream/handle/10986/2797/601550ESW0P1110e00201100Color0FINAL.pdf.

[31] Heierli and Maithel S. 2008. Brick By Brick: The Herculean Task of Cleaning Up The Asian Brick Industry. New Delhi: Greentech Knowledge Solutions Pvt. Ltd.

4. RESOURCE EFFICIENT BRICKS

4.1 Resource efficiency framework

Till now environment policy and regulation have been piecemeal, guided by a specific environment objective, be it air pollution or fly ash utilisation. To develop a comprehensive environment policy on bricks, a more integrated understanding of various environment issues is required. The resource efficiency framework developed in this study is an attempt to develop such an understanding.

Resource efficiency is defined as 'using the earth's limited resources in a sustainable manner while minimizing impacts on the environment'.[32] The resource efficiency framework for bricks in this study covers various stages of the life cycle of bricks and comprises four quantifiable parameters.

"The resource efficiency framework used in this study covers the primary material consumption along with energy used, CO_2 emissions, and air pollution during production."

1. Primary material consumption is the quantity of virgin material (kg/m^3 of bricks) used for the manufacturing of bricks.
2. Primary energy (MJ/m^3 of bricks) used in the manufacturing of bricks.
3. Carbon dioxide emission (tCO_2/m^3 of bricks) during the manufacturing of bricks.
4. Air pollution caused in the form of particulate material emissions (g/m^3 of bricks) during the manufacturing of bricks.

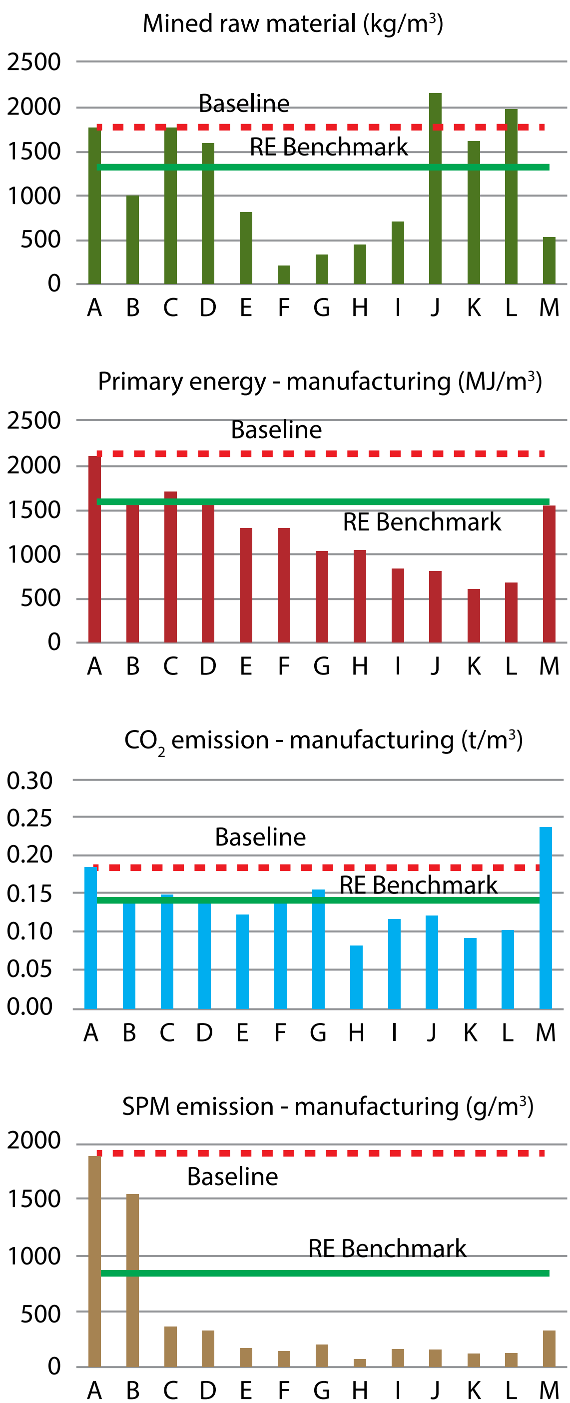
Resource efficiency parameters have been computed for different types of bricks. For burnt clay bricks, data have been collected by monitoring some of the manufacturing units, while for other types of bricks it is based on data reported in literature and provided by the industries. Figure 4.1 shows the performance of various types of bricks on these selected parameters. In each of these graphs, the red dotted line representing the baseline refers to the value

[32] http://ec.europa.eu/environment/resource_efficiency/index_en.htm (accessed on 16 March 2017).

corresponding to the predominant brick type, i.e., solid burnt clay brick. The green line represents the hypothetical resource efficiency target value. Table 4.1 gives the resource efficiency target values and their rationale. Further, it is proposed that *all bricks that meet the resource efficiency benchmark values can be defined as resource efficient bricks.*

Table 4.1. Resource efficiency target values

Parameter	Resource efficiency benchmark	Rationale
Mined raw material	1320 kg/m^3	25% reduction from baseline value
Primary energy (manufacturing)	1560 MJ/m^3	25% reduction from baseline value
CO_2 emission (manufacturing)	0.14 t CO_2/m^3	25% reduction from baseline value
Suspended particulate matter (SPM) emission (manufacturing)	828 g/m^3	Corresponding to the SPM concentration of 250 mg/Nm^3 in stack gases as proposed in the draft revised national emission standards for brick kilns



A: Solid burnt clay - FCBTK (Baseline)

B: Solid burnt clay fly ash - FCBTK

C: Solid burnt clay - Zigzag kiln

D: Perforated burnt clay - Zigzag kiln

E: Hollow clay blocks - Tunnel kiln

F: Autoclaved aerated concrete blocks

G: Cellular light-weight concrete

H: Pulverised fuel ash-lime bricks

I: Pulverised fuel ash-cement bricks

J: Solid concrete blocks

K: Hollow concrete blocks

L: Compressed stabilised earth blocks

M: Construction and demolition waste bricks

Figure 4.1. Comparison of various types of bricks on resource efficient parameters

Table 4.2 presents the values of the parameters for different types of bricks. The values that lie above (unfavourable) the resource efficiency benchmark value have been marked red and the values that lie below (favourable) the target value have been marked green.

“AAC block, fly ash brick, and hollow burnt clay block are good examples of resource efficient bricks.”

The following conclusions can be drawn from the analysis:

1. There are several types of bricks that can be classified as REBs. AAC block, fly ash brick, and hollow burnt clay block meet all four resource efficiency parameters and can be taken as examples of REBs.
2. Solid burnt clay fly ash brick, perforated burnt clay brick, cellular light-weight concrete (CLC) block, hollow concrete block, and compressed stablilised earth block (CSEB) meet several criteria and with improvements in the production process can become options of REBs.
3. Solid burnt clay bricks perform poorly on most of the resource efficiency parameters considered in this study. However, moving away from the production of solid burnt clay bricks in traditional kilns to hollow and perforated burnt clay bricks fired in efficient kilns results in significant improvements in resource efficiency parameters.

The proposed resource efficiency framework covers some of the major resource efficiency parameters. However, there is scope to further enlarge the resource efficiency framework by incorporating aspects such as the following:

- Thermal conductivity (W/m-K) of the brick, which has an influence on the heat gain or loss through the external walls of a building and hence on the energy uses for cooling or heating of the building.
- Reusability.
- Recyclability, etc.

Table 4.2. Comparison of various types of bricks on compulsory resource efficiency parameters

Resource Efficiency Parameters				
Parameters	**Mined raw material**	**Primary energy manufacturing**	**CO_2 emission manufacturing**	**PM emission manufacturing**
Units	kg/m^3	MJ/m^3	tCO_2/m^3	g/m^3
Solid burnt clay - FCBTK (Baseline)	1760	2080	0.19	1888
Solid burnt clay fly ash - FCBTK (30% by wt. fly ash addition)	1009	1558	0.14	1547
Solid burnt clay - Zigzag kiln	1760	1680	0.15	368
Perforated burnt clay - Zigzag kiln	1584	1512	0.14	331
Hollow clay blocks - Tunnel kiln	815	1275	0.12	178
Autoclaved aerated concrete blocks	224	1276	0.14	151
Cellular light-weight concrete blocks	338	1003	0.15	210
Pulverised fuel ash - lime bricks	450	1025	0.08	83
Pulverised fuel ash - cement bricks	711	811	0.12	161
Solid concrete blocks	2153	774	0.12	167
Hollow concrete blocks	1615	581	0.09	125
Compressed stabilised earth blocks	1976	653	0.10	139
Construction and demolition waste bricks	540	1533	0.24	327

Note: Resource efficiency parameters have been computed using data collected by monitoring of manufacturing units in case of burnt clay bricks; data from literature and from industries have been used for other types of bricks.

4.2 Regional options for resource efficient bricks

"Different regions in the country require different set of resource efficient bricks options."

A basic assessment of options for REBs in different regions of the country is shown in Table 4.3 The assessment has been based on a preliminary analysis of the raw material availability and type of construction. The analysis shows that in all the regions, more than one type of REB option is needed, and the solution set of REBs show regional differences and differs between urban and rural areas. More detailed analysis considering long-term raw material availability and construction trends is needed at state and regional levels.

Table 4.3. Results of preliminary analysis: regional options for resource efficient bricks

		Hollow concrete block	Autoclaved aerated concrete blocks	Flyash bricks	Burnt clay hollow blocks	Burnt clay perforated bricks	Compressed stabilised earth blocks
Himalayan and north-eastern hilly region (except Assam and Tripura)	Rural	✓	X	X	X	✓	✓
	Urban	✓	✓	X	✓	✓	X
Indo-Gangetic plains, Assam, and Tripura	Rural	X	X	✓	X	✓	✓
	Urban	X	✓	✓	✓	✓	X
Peninsular, desert, and coastal India	Rural	✓	X	✓	X	✓	✓
	Urban	✓	✓	✓	✓	✓	X

5. POLICY ROADMAP FOR RESOURCE EFFICIENT BRICKS

5.1 Demand for bricks

The projection of demand for brick till 2047 has been carried out. The demand projections have been done for four categories: residential buildings (rural), residential buildings (urban), commercial buildings, and others. The framework used in NITI Aayog's India Energy Security Scenarios to project future building stock is used as the basis for making the projections. The demand for bricks is expected to increase rapidly and reach a peak of about 1000 billion SBUs a year by 2032–37 as shown in Figure 5.1 At present, the rural: urban demand is nearly 50:50; by 2032–37 the demand will be predominantly urban (70%). The expected rapid increase and peaking of demand for bricks by 2032–37 underlines the need for immediate actions to regulate new manufacturing capacities of bricks to be resource efficient and upgrading or replacing existing brick enterprises.

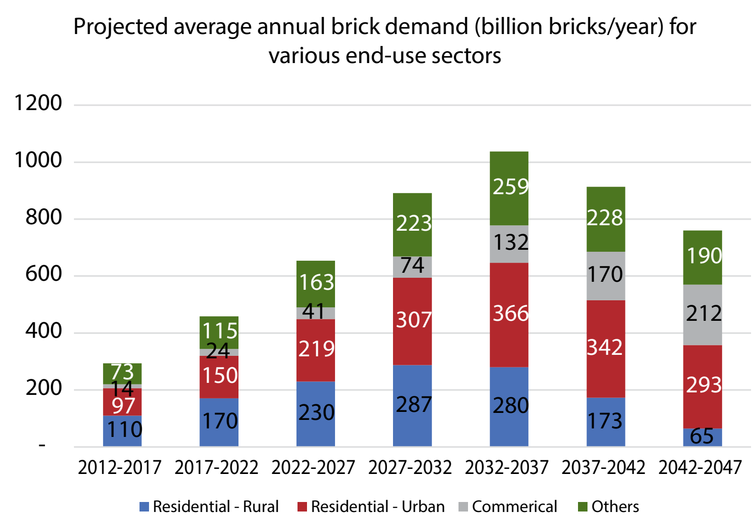


Figure 5.1. Projected demand for bricks (2012–17 to 2042–47)

5.2 Future Scenario

Two scenarios have been developed for the future development of the brick sector in India.

"Resource efficient scenario assumes that 70% of brick demand will be met by REBs by 2032."

Reference scenario: The reference scenario assumes that no fresh policy initiatives are taken to promote REBs and there is no change in the existing environment policies and implementation structure. According to this scenario (Figure 5.2), solid burnt clay bricks will retain more than 70% of the market in 2032 and the share of the new walling construction technologies and REBs will be about 25%.

Resource efficient scenario: In the resource efficient scenario (Figure 5.3), it is assumed that new policy initiatives will be undertaken for promoting REBs and 70% of brick demand will be met by REBs. The scenario has been built considering the regional differences in raw material availability and requirements of bricks by different segments of the building construction industry.

In the next sections, a policy roadmap that can lead to the resource efficient scenario is presented.

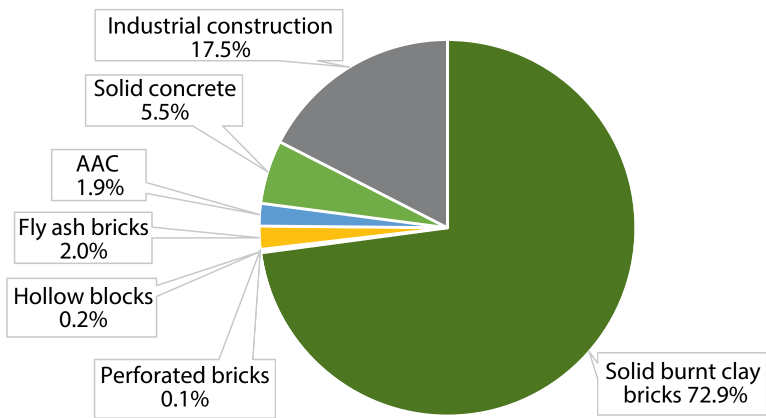


Figure 5.2. Brick market distribution in 2032 under 'Reference Scenario'

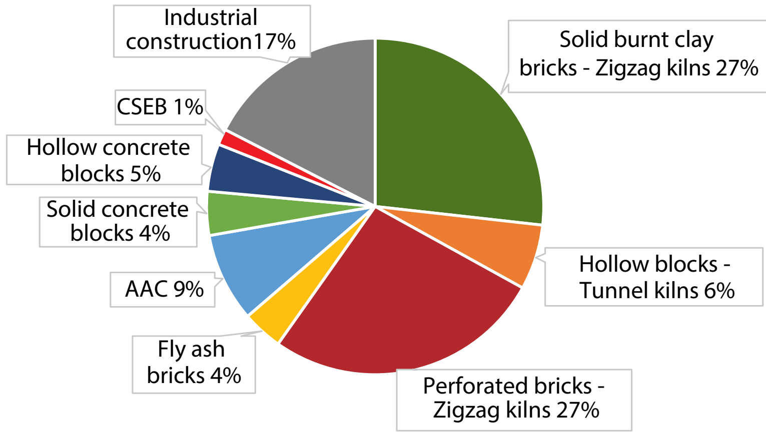


Figure 5.3. Brick market distribution in 2032 under 'Resource Efficient Scenario'

5.3 Goal

The roadmap for resource efficient scenario not only addresses the issue of environment sustainability but also contributes in providing affordable and good quality building materials for housing as well as in creating sustainable livelihood opportunities (Figure 5.4). These policy goals address several key national proprieties and can galvanise political and social support for an REB initiative.

These goals are enumerated below.

- To help India in reducing air pollution, reducing wastage of energy, and in meeting India's obligations under international agreements such as the Paris Agreement on Climate Change.
- To meet the demand for high quality bricks at affordable prices for 'Housing for All' and other building and infrastructure requirements of the country.
- To promote local entrepreneurship and provide sustainable livelihoods to skilled workforce engaged in brick production.

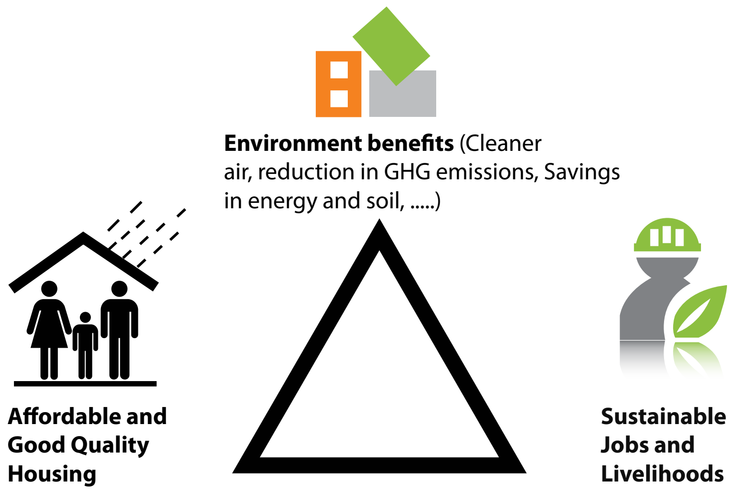


Figure 5.4. Key policy objectives of resource efficient brick initiative

> *"Implementation of resource efficient brick scenario can result in savings of 500 million tonnes of coal and about 800 million tonnes of CO_2 during 2017–32."*

5.3.1 Targets

Based on the resource efficient scenario, the following targets are being proposed:

- Achieving savings of 30% (or 800 million tonnes) in cumulative CO_2 emissions during 2017–32 period compared to the reference scenario.
- Achieving savings of 35% (or 500 million tonnes) in cumulative coal consumption during 2017–32 period compared to the reference scenario.
- 200% increase in annual flyash consumption in brick making compared to the reference scenario by 2032.
- Mobilise investment of about INR 60,000 crore by 2022 and INR 1,80,000 crore by 2032 in the upgradation/expansion of REB production.
- Train and provide employment to 1 lakh skilled technical personnel in the production and application of REBs by 2022 and 5 lakh personnel by 2032.

5.4 Policy Roadmap: Key action points

The main objective of the policy roadmap is to put in place a conducive policy environment to take the brick sector in the country towards a resource efficient path. Key policy action points (Figure 5.4) are elaborated in the following sections.

Figure 5.5. Key policy action

There is a need for an over–arching policy framework to transform the brick industry.

5.4.1 National policy on resource efficient bricks

Piecemeal environment policies and regulations combined with poor implementation have not led to any substantial changes in the sector. A recent study[33] on financing has found that one of the main barriers in attracting new finance to the sector is the presence of regulatory risks (e.g., uncertainty over mining of raw materials). Transformation of the brick sector is not possible through environment policies and regulations alone. Complementary policies and actions are needed in the areas of financing and technical assistance for technology upgradation, market development for resource efficient products, R&D, and skill development and training. These are lacking at present. Thus, there is a need to develop a policy, that is transformative in nature so that the sector can respond to the larger environmental challenges and opportunities. Developing a national policy will require taking an integrated view of various policies shown in Figure 5.6 and involving

[33] Water Energy Food Transitions (WEFT) Research. 2017. Report on 'Financing Indian Clay Bricks Sector Upgradation, 2017'. Report prepared by WEFT Research with technical inputs from Greentech Knowledge Solutions Pvt. Ltd for Climate and Health Research Network. New Delhi: WEFT Research.

all concerned ministries and departments. As this task involves multiple ministries, an organisation like NITI Aayog, which recently has published a strategy paper on resource efficiency[34] can play a key role in developing this policy.

As there has been a general lack of understanding about the importance of the brick sector and need for a policy to transform the sector, a concerted policy advocacy effort will be required by various stakeholders to reach out to NITI Aayog and other government agencies so that they can be convinced to initiate action to formulate a policy for REBs.

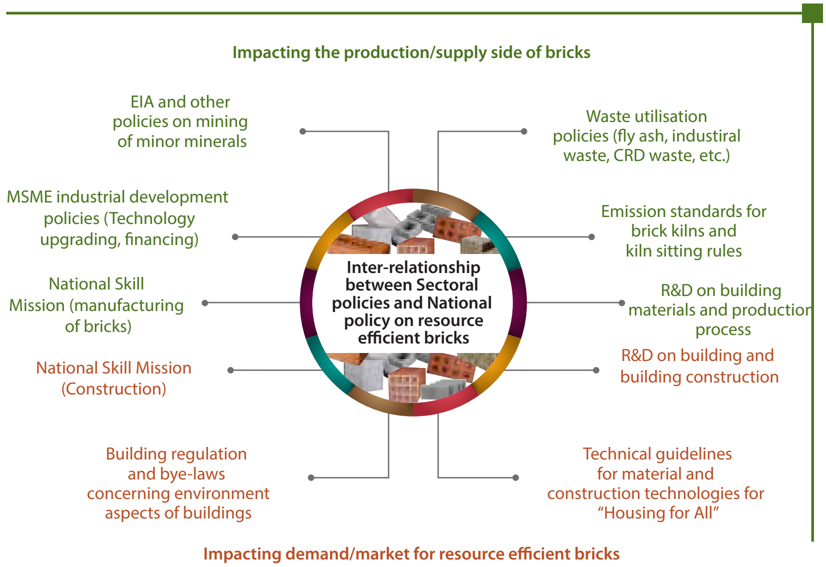


Figure 5.6. Various policies that needs to be considered while developing the national policy on resource efficient bricks

In line with the development of a national policy on REBs, amendments would be needed in the existing environment policies and regulations to make them consistent, easy to implement, and effective. Some of the policies and regulations that can be taken up for amendments are listed below (Table 5.1).

[34] http://niti.gov.in/content/strategy-paper-resource-efficiencythe-comments-discussion-paper-are-invited-15th-july-2017

Table 5.1. Amendment required in existing policies

Existing policies/ regulations	Agency	Amendments required
Model building bye-laws 2016	Town and Country Planning Organisation, Ministry of Housing and Urban Affairs	Making use of resource efficient bricks mandatory in different types of buildings (Chapter 14: climate resilient construction – integration of environmental clearance with sanction)
Fly ash regulation	Ministry of Environment, Forest and Climate Change (MoEFCC)	Replacing fly ash regulation with a comprehensive resource efficiency regulation, which covers all type of industrial and other types of wastes for the manufacturing of bricks
Emission standards for brick kilns	MoEFCC, Central Pollution Control Board	Revision in emission standards to cover all types of brick kilns, methodology for the measurement of emissions, clear instructions for implementation

5.4.2 National Resource Efficient Brick Mission/ Programme

To implement the national policy on REBs, putting in place a national REB mission/programme could be the next logical step. The mission can be tasked to coordinate actions across different central government departments and ministries. Some of the key action points for such a programme/mission could be as follows:

- Developing synergies with the 'Pradhan Mantri Awas Yojana' being coordinated by the Ministry of Housing and Urban Affairs (MoHUA) to create sustainable demand for REBs.

- Work on the issue of facilitating financing industries for REB production. This may lead to establishing a 'Brick Industry Financing Facility' to make available finance for establishing new or for upgrading existing brick enterprises.
- Updation/new standards for different kinds of REBs to be done by the Bureau of Indian Standards (BIS).
- Inclusion of different types of REBs in the schedule of rates of different government construction agencies by the Central Public Works Department (CPWD). The schedule of rates already include AAC block and fly ash brick masonry. Other types of REBs such as perforated and hollow burnt clay bricks need to be included.
- Programme on R&D and technology transfer in the area of REB production by the Department of Science and Technology (DST). Synergies with existing DST programmes on R&D in energy efficient buildings and waste management need to be explored.
- Labelling or certification of REBs under the eco-labelling scheme of MoEFCC or other similar labelling programme.
- Establishing a sector skill council for brick industry and start country-wide skilling initiative on both production and application of REBs by the National Skill Development Council (NSDC).
- Technology upgradation scheme for REB production by the Ministry of Micro Small and Medium Enterprises (MoMSME).

> *"A national mission on resource efficient bricks is the need of the hour."*

5.4.3 State Resource Efficient Brick Programmes

The responsibility of implementation of various national policies on REBs lies with states, district administrations, and urban local bodies. Also, the brick industry plays an important role in the economy of a state as shown by the statistics of the brick industry in Uttar Pradesh (Table 5.2). Given the large-scale socio-economic-environment-political implications, it will be in the interest of state governments to take a lead in developing their own programmes to promote REB production and use.

Table 5.2. Brick industry in Uttar Pradesh

Parameter	Number
Total number of enterprises	20,000
Total annual production	50 billion bricks a year
Industry turnover	INR 25,000 crore
Contribution to state gross domestic product	2%
Employment	2–3 million
Tax revenue from mining	INR 200 crore

The resource efficiency pathway for each state and in some cases for different regions within a state will be different. While in the case of Uttar Pradesh, located in the Indo-Gangetic plains, with good availability of clay for brick making throughout the state and several power plants, the resource efficiency pathway would consist of resource efficient burnt clay bricks and fly ash-based bricks. On the other hand, for Maharashtra, with large variations in raw material availability and market demand amongst six administrative regions, the pathway will differ from region to region. For example, in the Konkan region, which has limited clay and fly ash resources, the solution may lie in moving towards resource efficient concrete blocks; Nagpur and Amravati have higher availability of fly ash and hence resource efficient fly ash bricks can play an important role; the remaining three regions of Aurangabad, Nashik, and Pune do not have good availability of fly ash and hence the solution may lie in promoting resource efficient clay and concrete bricks.

The following sequence of steps is suggested for initiating action at the level of states.

- Background study on raw material resource mapping, demand assessment, and developing a pathway for REB production for the state.

- Setting up of an inter-departmental committee to develop a state policy/action plan and oversee its implementation. The committee may be chaired by the Chief Secretary.
- The specific actions by various state departments may include:
  - Making available necessary infrastructure like roads, electricity or development of special zones for brick production
  - Streamlining mining, collection, and distribution of raw materials for making bricks, e.g., silt, sand, and fly ash.
  - Strengthening the state pollution control boards, mining departments, etc. for the enforcements of the environment regulations
  - Inclusion of different types of REBs in PWD schedule of rates
  - Technical support programme for REB production through district industry centres (DICs).
  - Amending building bye-laws and development of control rules by urban local bodies (ULBs) and development authorities for making use of REBs mandatory for building construction.
  - Skill development by state-level skill development missions
  - Developing state-level technical capacities for performance monitoring, technical consulting, quality testing, etc.

> *“Role of state governments would be key to transform the brick industry.”*

6 SUMMARY AND NEXT ACTION POINTS

Summary

Listed below are a few points that summarise the arguments in favour of developing a comprehensive roadmap for REBs in the country.

- Masonry construction using bricks is the main type of building construction technology used in the country.
- It is expected that in the next 15 years, masonry construction will retain its dominant position and the average annual demand for bricks will increase from about 250 billion standard brick units (SBUs) a year during 2012–17 to a peak of about 750–1000 billion SBUs a year during 2032–37.
- Brick manufacturing is resource intensive and the brick sector has a large environmental footprint as it consumes about 800 million tonnes of raw material per year, 40 million tonnes of solid fuel (coal and biomass) per year, and is an important source of CO_2, $PM_{2.5}$ and black carbon emissions.
- Resource efficient bricks (REBs) like perforated and hollow burnt clay bricks, clay-fly ash bricks, AAC blocks, and fly ash bricks have multiple environment benefits in the form of (a) lower primary material consumption, (b) consumption of less energy for manufacturing, and (c) lower CO_2 and air pollution emissions during manufacturing.
- A programme to bring about a transformation in the brick industry and make it resource efficient by 2032 is being proposed. The programme will have multiple environmental and socio-economic benefits:
  - Achieving more than 25% savings in the primary raw materials compared to the reference scenario by 2032.
  - Achieving savings of 30% in CO_2 emissions compared to the reference scenario by 2032.

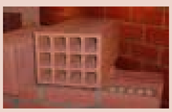
- Achieving savings of 35% in coal consumption compared to the reference scenario by by 2032.
- Substantial increase in the utilisation of industrial and other wastes for brick making, e.g., 200% increase in annual fly ash consumption in brick making compared to the reference scenario by 2032.
- Making available good quality bricks for the construction of housing.
- Assist in the transformation of large 'informal' small-scale brick manufacturing sector consisting of 250,000–300,000 enterprises into 'formal' small-scale sector and in the process generating/transforming millions of seasonal jobs into 'round the year green jobs'.

Next Action Points

The next action points to bring about the much-needed transformation in brick industry are listed below.

- Concerted efforts by a network of institutions for carrying out advocacy for a national initiative on REBs.
- Development of an overarching national policy/strategy on REBs.
- Revision of existing environment policies, e.g., fly ash regulation, environment standards for brick kilns, and make them coherent with the national policy/strategy on REBs.
- To implement the national policy on REBs, put in place a national resource efficient brick mission/programme that covers actions on financing and technical assistance for technology upgradation, market development for resource efficient products, R&D, and skill development and training.
- Development of state-level resource efficiency programmes for brick industry taking into account the raw material availability, demand for bricks, and socio-economic development priorities of the state.

Annexure 1: Brief description of types of bricks

Solid Burnt Clay Bricks 	The primary material used in the production of burnt clay bricks is clay. The various steps involved in the production process of burnt clay bricks are (a) mining of clay, (b) preparation of clay-mix, (c) moulding of bricks, (d) drying of green bricks, and (e) firing in brick kiln. In India, most of the solid brick production employs manual moulding and open sun drying. The energy consumption and air emissions during the production of bricks primarily depends on the brick kiln technology employed and fuel used. Several types of kilns are used for firing bricks. In India, Fixed Chimney Bull's Trench Kiln (FCBTK) and Clamp Kilns are the main technology used for firing bricks (also referred as traditional kiln technology); efficient kiln technologies include Zigzag Kilns, Vertical Shaft Brick Kiln (VSBK), and Tunnel Kiln.
Hollow Burnt Clay Bricks/ Blocks 	The primary material used in the production of these blocks is clay. Hollow clay blocks are manufactured in mechanised industries and the production set-up includes extruders for moulding, artificial dryers (e.g., tunnel dryers) for drying of blocks, and tunnel kilns for firing the blocks. Volume of perforations of hollow burnt clay blocks found in practice in India ranges from 25% to 50% of the gross block volume. These blocks are light in weight, have low thermal conductivity, and precise in size and surface. Large block sizes ensure rapid construction so that more wall area can be laid per man-hour than in conventional brick wall constructions.
Perforated Burnt Clay Products 	The primary material used in the production of these blocks is clay. Manufacturing of perforated bricks mainly requires mechanised moulding using an extruder. The drying could be shed drying or artificial drying. In India, Zigzag kilns and Hoffman kilns are the main technologies used for firing perforated clay bricks. In practice, perforated bricks, usually having 3 to 10 holes, have perforations ranging from 7% to 22%.

Hollow Concrete Blocks 	These are manufactured by controlled mechanical compaction of a mixture of cement, sand (fine aggregates), and stone chips (coarse aggregates) in a mold. Usually the blocks are cured by water only. Manufacturing units employ concrete mixer, hydraulic or vibro-press block making machines. A hollow concrete block has one or more large holes or cavities, which either pass through the block (open cavity) or do not effectively pass through the block (closed cavity) and has the solid material between 50% and 75% of the total volume of the block.
Autoclaved Aerated Concrete (AAC) 	It is a lightweight, precast building material that is produced by mixing silica-rich material with fly ash/sand, cement, lime, gypsum, aluminum powder/paste, and water. The blocks are cured with steam in an autoclave. The manufacturing set-up requires a complete mechanised production line. AAC blocks are large (in size), light in weight, and have low thermal conductivity. Large block sizes ensure rapid construction so that more wall area can be laid per man-hour than in conventional brick wall constructions.
Cellular Light-Weight Concrete (CLC) 	It is a lightweight concrete that is produced by making a slurry of cement, fly ash, sand, and water, which is further mixed with stable foam, in a concrete mixer, under ambient conditions. The manufacturing set-up requires low-cost machinery and relatively low investment. CLC blocks are large (in size), light in weight, and have low thermal conductivity. Large block sizes ensure rapid construction so that more wall area can be laid per man-hour than in conventional brick wall constructions.

Construction and Demolition (C&D) Waste Bricks 	These are dense solid block produced by compacting a mixture of cement (20%–25%), crushed demolition waste (65%–70%), admixture (5%–15%), and water. As of now these bricks use special admixtures in their manufacturing, which reduces their curing time. C&D waste bricks are still in a nascent phase of product development. The challenge lies in optimising the compressive strength vis-à-vis density to achieve cost efficiency.
Compressed Stabilised Earth Blocks (CSEB) 	CSEBs are dense solid blocks produced by compacting a mixture of soil, sand, stabiliser (cement/lime), and water using press machine. CSEB production is usually done on the site through soil excavated from project sites or from nearby location, which saves the transportation and fuel costs. Equipment for making CSEB is available in manual or mechanised models ranging from village to semi-industrial scale.
Pulverised Fuel Ash (fly ash) Lime/ Cement Bricks 	Pulverised fuel ash-lime bricks are produced from materials consisting of pulverised fuel ash (fly ash) in major quantity, lime, and an accelerator acting as a catalyst. Pulverised fuel ash-cement bricks are made from materials consisting of pulverised fuel ash (fly ash) in major quantity, cement, and admixtures. These bricks are generally manufactured by blending various raw materials, which are then moulded into bricks in a press and subjected to curing (mostly using water).

About Shakti Sustainable Energy Foundation

Shakti Sustainable Energy Foundation works to strengthen the energy security of the country by aiding the design and implementation of policies that encourage energy efficiency, renewable energy and sustainable transport solutions, with an emphasis on sub-sectors with the most energy saving potential. Working together with policy makers, civil society, academia, industry,and other partners, Shakti takes concerted action to help chart out a sustainable energy future for India. (www.shaktifoundation.in)

About Greentech Knowledge Solutions Pvt. Ltd (GKSPL)

Greentech Knowledge Solutions Pvt. Ltd (GKSPL) is a research-based advisory firm in the domains of clean energy and sustainable buildings. Key areas of expertise at GKSPL are: (a) reducing air pollution and improving energy efficiency in industrial processes to manufacture building materials such as bricks; (b) designing buildings that provide better thermal comfort to occupants and require less energy for air-conditioning; and (c) application of renewable energy technologies.

GKSPL provides technical services to develop and test technical solutions, undertakes policy studies and participates in policy advocacy, and disseminates knowledge through reports, website, and training programmes. (www.gkspl.in)

About the Study

Given the large anticipated growth in the building construction, the annual demand for bricks in India is expected to peak to 750–1000 billion bricks a year during 2032–37 from about 250 billion bricks a year during 2012–17. Brick manufacturing is resource- and pollution-intensive. It is against this background of rising demand for bricks and growing concerns about the environment sustainability that this study was conducted by Greentech Knowledge Solutions.

This publication is culled out of the larger study report. It presents the current status of the brick sector in India, including the status of market, manufacturing industry, and the environment policies. It proposes a resource efficiency framework, compares different types of bricks available in India, and identifies various options for resource-efficient bricks in the Indian context. The report also puts forward a strategy and a road map for the next 15 years to transform the brick sector.

The publication is primarily targeted at policy makers, decision makers, and other important stakeholders of the brick industry. We strongly believe that this audience can shape and give direction to the future of the brick industry in the country and help the country in its quest for environment sustainability, providing quality housing and sustainable livelihoods to all its citizens.

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