LEVERAGING GREEN INITIATIVES IN INDIA'S BRICK KILNS

Research Study as part of the Project:

Empowering CSOs for Decent Work and Green Bricks in India's Brick Kilns

SAMEER MAITHEL

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Foreword

This research report is being published as part of a European Union (EU) funded project—"Empowering CSOs for Decent Work and Green Bricks in India's Brick Kilns", which is being implemented by Centre for Education and Communication (CEC), Prayas Centre for Labour Research and Action (PCLRA) and Terre Des Hommes, Germany-India Programme (TDH). The report is significant to the project because it demonstrates the benefits, challenges and potentials of green technology conversion in India's brick kilns.

The report discusses various brick-kiln technologies currently in use in India, their fuel consumption, contribution to air pollution and potential ways for technological transformation. The report also provides short and long-term strategies to deal with the challenges of green transformation in India's brick kilns. The report provides a set of recommendations crucial for industry associations, national and international initiatives and institutions, as well as the authorities for further promoting the green brick agenda. I am convinced that the study findings will not only be useful for the project but also for other stakeholders working on promoting green brick kilns, and can be used as a crucial advocacy tool.

I thank Mr. Sameer Maithel from Greentech Knowledge Solutions Private Limited for preparing the report. I also congratulate the entire 'Empowering CSOs for Decent Work and Green Bricks in India's Brick Kilns' Project Team for the successful preparation and publication of the report.

Lokesh **December 2020**
Executive Director
Centre for Education and Communication (CEC)

Preface

The study "Examining the Potential of Leveraging Green Initiatives in India's Brick Kilns" was undertaken as a part of the European Union funded project "Empowering Civil Society Organisations (CSOs) for Decent work and Green Bricks in India's Brick Kilns". The project seeks to usher sustainable change through decent work and green technology in India's brick kilns. It seeks to increase the capacity of CSOs, brick kiln manufacturers associations, workers' associations, and local authorities to perform their roles more effectively to ensure inclusive 'decent work' in brick kilns and produce 'green' bricks.

The Indian brick industry plays a crucial role in the economy and the construction sector. This study was undertaken over a short period of ten weeks (October-December 2020) in the background of developing a revival plan for the brick kiln sector post COVID-19 national lockdowns, which had deeply affected brick kilns. This study examines various environmental challenges being faced by the brick industry, reviews the existing environmental policy framework, lists green technology options and provides suggestions for the way forward to mainstream green initiatives in the Indian brick industry.

The study is the continuation and further development of the thought process based on the experience gained by the author working with the brick industry over the last two decades. The author would like to thank the Centre for Education and Communication (CEC) team (Shri Mayur Chetia & Ms Lokesh) for providing an opportunity to undertake this study and for reviewing and providing inputs on the draft paper. The author is extremely grateful to Shri Om Prakash Badlani, Shri Ashok Tiwari, Shri Manish Gupta, Shri J John and Shri Sudhir Katiyar for sparing time to speak to the author. The author would also like to thank colleagues at Greentech Knowledge Solutions Pvt. Ltd., particularly Shri Sonal Kumar for assisting with some of the analysis and more importantly for contributing over the years in brick sector related work and helping in developing a better understanding.

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December 2020

CHAPTER 1

Introduction

1.1 Burnt Clay Brick as a Building Material

Burnt clay bricks are produced by baking clay bricks in a kiln. They are the most popular building material in the country, primarily used for the construction of walls. As per Census 2011, more than 12 crore households (almost 50 percent of the households in the country) were houses constructed using burnt clay bricks. Burnt clay bricks are the dominant material for the construction of walls in both urban (64 percent of households as per Census 2011) and rural areas (47 percent of households as per Census 2011). The last 50 years have seen a surge in the use of burnt clay bricks for house construction. The number of households living in burnt clay brick houses doubled from 5.16 crore households in 1991 to 11.73 crore households in 2011[1].

Apart from wide-scale availability and affordable prices, technical reasons that make burnt clay bricks popular include:

- Long life: Properly baked clay bricks can last for hundreds of years, as shown by the 4,000-year-old bricks found in excavations of Harappan settlements.
- Good structural strength: Good quality burnt clay bricks have a high compressive strength between 100 kg/cm^2 and 300 kg/cm^2.
- Safety in case of natural disasters: Burnt clay bricks are incombustible and hence resist the spread of fire. They also withstand rains and flooding quite well. Bricks absorb moisture through pores when wet and dry quickly once water recedes.
- No toxicity: Burnt clay bricks are made from natural materials and generally do not contain any toxic material. Hence, they do not pollute the environment.

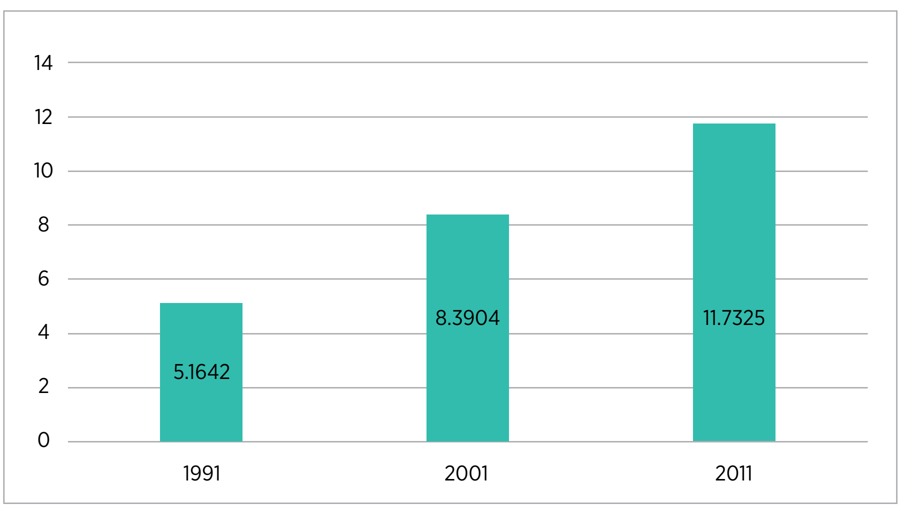

Figure 1: Number of households with burnt clay brick walls (Census, 2011) (in crores)

[1] https://www.gkspl.in/wp-content/uploads/2018/10/REBM5.pdf

- Reusability: Burnt clay bricks can be salvaged during building demolition and be reused or recycled as full bricks for wall construction, as aggregates or can be powdered and used as *surkhi (brick dust)*.

1.2 Indian Brick Industry

Industries making bricks are micro and small enterprises located in rural and peri-urban areas. Brickmaking is a seasonal industry with kilns generally operating during the dry season from November to June. An estimated 1.4 lakh brick enterprises operate in the country and the annual production is estimated at around 25,000 crore bricks, making India the second largest producer of bricks in the world, after China[2].

Burnt clay bricks are manufactured in almost all states of the country, though there are considerable variations in the quality and availability of the primary raw material, brick earth, the scale of production, the technology employed and the quality of bricks produced. The intensity of brick manufacturing across different states is shown in Figure 2 in terms of bricks manufactured per capita per year. The calculations[3] are based on data on the number of units and the typical production capacity collected from brick industry associations and literature. Indian states are accordingly divided into three categories:

a) **States with High Intensity of Brick Production**: States with high intensity brick production (Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal & Tripura) are almost all located in the Indo-Gangetic plains, where good quality clay is abundantly available, and the availability of other natural building material like stone is scarce. The intensity of brick production varies from 200 bricks per person per year to 450 bricks per person per year. Some of these states not only manufacture bricks for their own consumption, but also export bricks to neighbouring states (for example Uttar Pradesh to Uttarakhand and Madhya Pradesh and Punjab to Himachal Pradesh). The total number of brick manufacturing enterprises in these states is estimated to be between 35,000 and 40,000. Each enterprise produces anywhere between 3 million and 8 million bricks per year. These states account for almost 50 percent of the total burnt clay brick production in the country. The brick kiln technology employed is either Fixed Chimney Bull's Trench Kiln (FCBTK) or its improved variation, the zigzag kiln. Due to the good availability of high quality brick earth, the quality of bricks produced is best in the country. The brick industry in these states employs some local workers but depends predominantly on migrant workers originating from states such as Uttar Pradesh, Bihar, Jharkhand, Chhattisgarh and Odisha.

b) **States having Medium Intensity of Brick Production**: These states and union territories have annual per capita brick production ranging from 100 to 200 bricks per person per year. These include some large and populous states such as Tamil Nadu, Maharashtra, Gujarat, Rajasthan and Assam as well as less populous smaller states & Union Territories such as Jharkhand, Uttarakhand, Himachal Pradesh and Jammu & Kashmir. These states have some isolated large clusters (mostly FCBTK kilns) in and around cities or regions having availability of good quality brick earth. Some of these states like Maharashtra and Gujarat also has large number of smaller clamp type kilns. All have a good availability of stone and other alternate walling materials such as concrete blocks or fly ash bricks.

c) **States having Low Intensity Clay Brick Production**: These states and Union Territories have annual clay brick production lower than 100 bricks per person per year. This means that these states also have substantial supply of alternate walling materials such as stone, concrete blocks or fly ash bricks. These states also include Kerala, which is known for its clay brick and tile industry, but where environmental concerns have drastically reduced the availability of clay. Similarly, some states such as Karnataka and Odisha have several big brick kiln clusters. A large number of brickmaking units in these states employ clamps as firing technology, while down-draught, Hoffmann and FCBTK technology is also employed.

[2] 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.

[3] GKSPL estimates

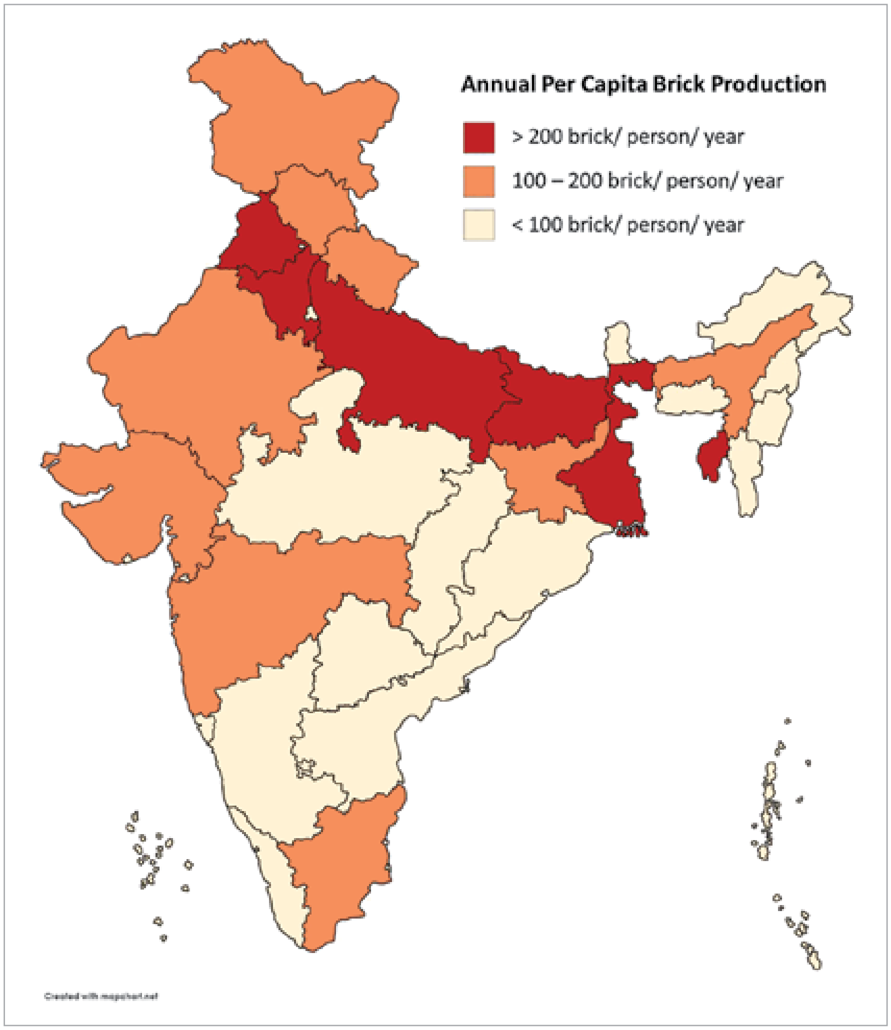

Figure 2: Classification of States as per the intensity of burnt clay brick production

1.3 Brick Making Process & Technology Used

Brick manufacturing consists of five basic operations:

- Clay or brick earth is either dug up from agricultural fields or collected from the desilting of tanks, dams and rivers.
- Water is added to the clay and clay-mix is prepared. The mixing is done manually or using machines such as pug mills.
- Clay-mix is shaped or moulded into 'green' bricks. Almost all bricks in India are moulded manually. In some cases, machines, such as soft-mud moulding machines or extrusion machines are used.
- Drying operation in which the "green" bricks are dried. Mostly bricks are dried in the open under the sun. In case of machine moulded bricks and regions which experience rains during the brick making season, bricks are dried in a drying shed and in a few cases in an artificial drier.
- Firing operation where the dried green bricks are baked in a kiln. There a are various types of kilns which are used for baking of bricks. FCBTK or zigzag kilns are used in the Indo-Gangetic plains and some other pockets in the country. In peninsular India, different varieties of clamp kilns along with down draught kilns and Hoffmann kilns are used. In India, bricks are typically baked at a temperature of around 1000^{o} C.

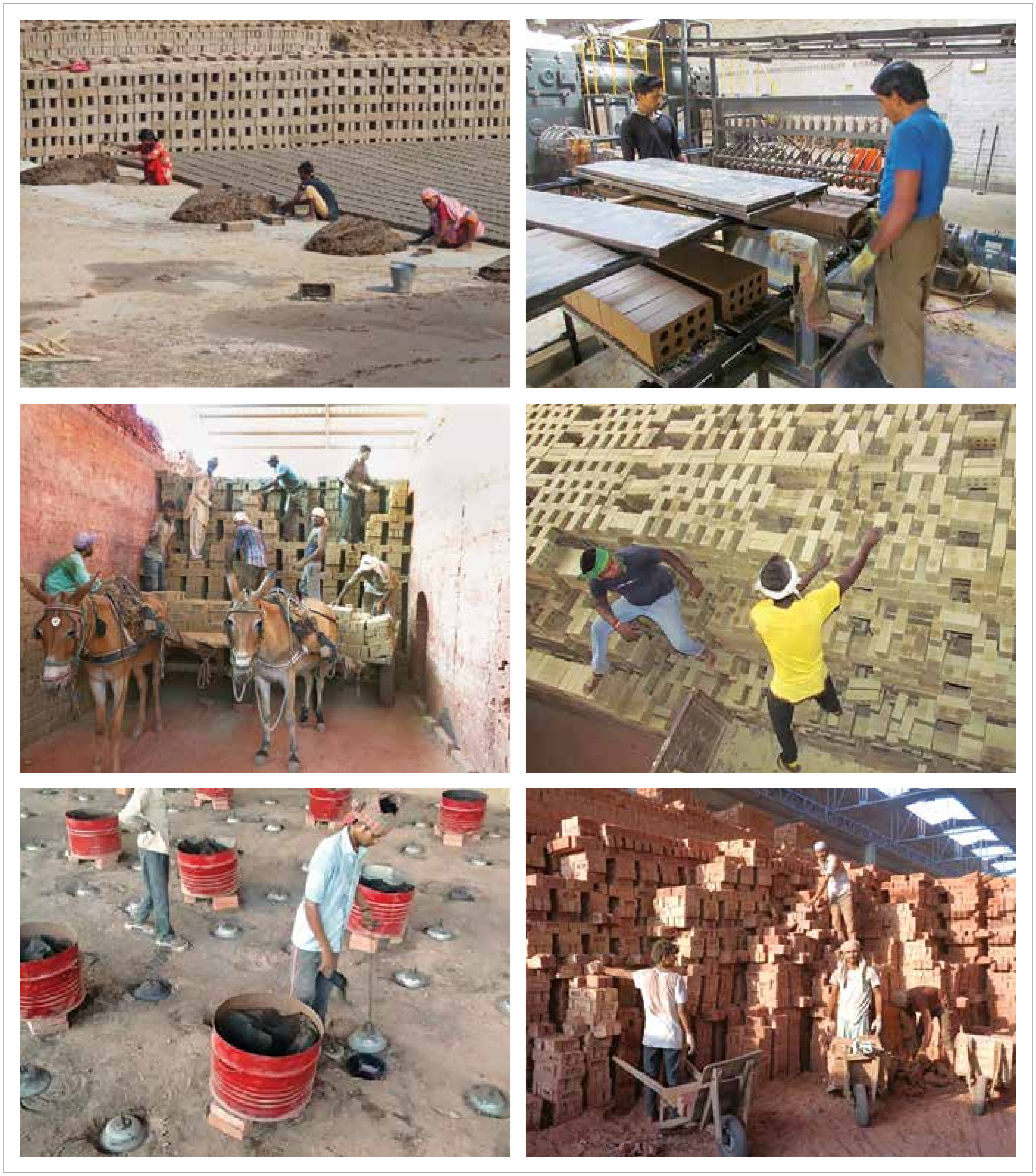

Figure 3: Some operations in brick manufacturing

In addition to these five basic operations, material handling is also an important aspect of the process as huge quantities of raw materials need to be transported from one stage of the process to another.

The manufacturing of bricks in India is still labour intensive. Approximately 1 crore workers are employed in the brick industry, with most belonging to rural areas. A large number of them are migrant workers. In recent years, the use of machines in brickmaking has increased. Currently, the use of machines is restricted to certain operations such as digging of clay (use of JCBs), preparation of clay mix (clay mixers/ pug mill) and transportation such as tractors, trucks, and electric vans. Most workers are employed in brick moulding, which is predominantly manual. Operations such as stacking bricks in the kiln, feeding fuel and removing burnt bricks from the kiln are done manually.

1.4 About the Study

The study titled "Leveraging Green Initiatives in India's Brick Kilns" was undertaken as a part of the European Union funded project "Empowering CSOs for Decent Work, not work and Green Bricks in India's Brick Kilns". The project seeks to usher sustainable change through decent work and green technology in India's brick kilns. It seeks to increase the capacity of CSOs, brick kiln manufacturers associations, workers' associations and local authorities to perform their roles more effectively so as to ensure inclusive 'decent work' in brick kilns and produce 'green' bricks.

This study was undertaken over a short period of ten weeks between October and December 2020 in the background of developing a *revival plan* for the brick kiln sector post COVID-19 national lockdowns, which had deeply affected the brick kilns. This study examines various environmental challenges being faced by the brick industry along with the existing environmental policy framework (Chapter 2). Various green technology options and their potential are presented in Chapter 3. Chapter 4 provides suggestions for the way forward to mainstream green initiatives in the Indian brick industry.

The author of the study has been working for more than two decades on measuring the environmental performance of brick kilns, developing technological solutions for kilns as well as in developing and implementing programmes to improve environmental performance of brick kilns. The study is the continuation and further development of the thought process based on the experience gained over the last two decades. An attempt has been made to synthesise and compile information and knowledge available on multiple environmental challenges and potential solutions at one place. One-to-one discussion with some brick industry stakeholders in industry and in Civil Society Organisations (CSOs) has helped refine the chapter on the way forward.

CHAPTER 2

Environmental Challenges & Policy Framework

2.1 Key Environmental Challenges Facing the Brick Industry

A discussion on the green initiatives in Indian brick kilns requires an understanding of the key environmental challenges facing the brick industry. While discussing the environmental challenges, it would be useful to distinguish between low output brick producing units with less than 10 lakh bricks per year located in rural areas and producing bricks for rural consumption on one hand and medium to large output units manufacturing 10 lakh to 1 crore bricks per year on the other. The latter are often found in clusters located around urban centres. In terms of the negative environmental impact, it is these clusters that are seen to pose a greater challenge.

Environmental challenges facing the Indian brick industry can be broadly classified into three categories:

2.1.1 Air Pollution and Health

Air pollution is the presence of substances (gases, particulates, and biological molecules) in the atmosphere that are harmful to the health of humans and other living beings or which cause damage to the climate or to materials[4]. There are several sources of air pollution in brick kiln operation. The combustion or burning of fuel, mostly coal and biomass, for brick firing produces air pollution. Pollutants consist of particulate matter of various particle sizes ($PM_{2.5}$, PM_{10}) produced due to incomplete combustion (thus giving a black colour to the smoke) along with gaseous pollutants such as sulphur dioxide (SO_2), carbon monoxide (CO) and hydrogen fluoride (HF). Combustion-related pollution is often called stack emission. In addition to stack emission, dust pollution is caused by the large amount of clay, ash and powdered fuel trapped in the air at the brick making site and by the movement of machines such as trucks and tractor trolleys on the unpaved and dusty roads around a brick kiln.

Air pollution is a major environmental health problem and India is one of the most polluted countries in the world in terms of the concentration of particulate matter ($PM_{2.5}$, PM_{10}) in the air. Particulates are the deadliest form of air pollutants due to their ability to enter the lungs and bloodstream. PM_{10} are inhalable coarse particles between 2.5 micrometres (μm) and 10μm and $PM_{2.5}$ are fine particles with a diameter of 2.5μm or less. The latter are more harmful as they can easily penetrate into the bloodstream via the lungs. As per a recent report, 21 of the world's 30 cities with the worst air pollution are in India[5]. Most of those Indian cities are located in the Indo-Gangetic plain. Vehicles, industries, thermal power plants, construction, biomass burning, diesel gensets and commercial and domestic use of fuel are identified as major sources of air pollution.

Many brick kilns are located in clusters around major urban areas in India and these clusters contribute to air pollution. A recent study[6] has identified the presence of around 1,500 brick kilns surrounding Delhi, which were found to be contributing to air pollution in the region.

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4 Entry 'Air Pollution', Wikipedia, <https://en.wikipedia.org/wiki/Air_pollution>

5 "21 of the world's 30 cities with the worst air pollution are in India", report, CNN, February 25, 2000 https://edition.cnn.com/2020/02/25/health/most-polluted-cities-india-pakistan-intl-hnk/index.html

6 Prakhar Misra, et.al (2020) Mapping brick kilns to support Environmental Impact Studies around Delhi using Sentinel -2. International Journal of Geo-Informatics, 2020,9,544.

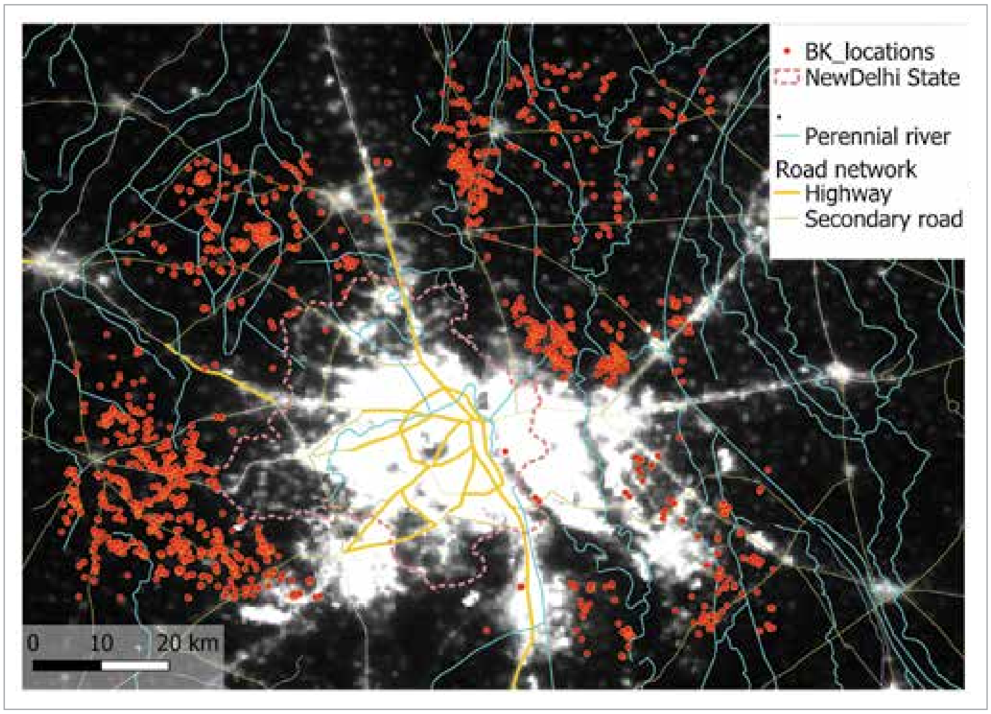

Figure 4: Location of brick kilns surrounding Delhi (Prakhar Misra et. al, 2020)

2.1.2 Emission of CO_2 and Global Warming

The greenhouse effect is a warming of the earth's surface and the troposphere, the lowest layer of the atmosphere, caused by the presence of carbon dioxide, water vapour, methane, and some other gases in the air[7]. This global warming is leading to changes in the earth's climate, which in turn impacts rainfall patterns, agriculture, forests, biodiversity and human health. The main reason for global warming is the increasing concentration of carbon dioxide in the earth's atmosphere due to the burning of fossil fuels such as coal and petroleum. Fossil fuels contain carbon, which on combustion produces carbon dioxide. Coal is the main fuel for brick kilns in India and the brick industry in India is estimated to contribute between 6.6 crore tonnes and 8.4 crore tonnes of CO_2 emissions per year,[8] about 3 percent of the total CO_2 emissions of the country.

2.1.3 Removal of Clay from Agricultural Fields and its Potential Impact on Agriculture

Clay is generated from the decomposition of rocks and is one of the most abundant natural mineral materials on earth. It is the primary raw material for manufacturing bricks. Clay used for brick manufacturing must have certain properties such as plasticity, which permits it to be moulded when mixed with water. It should also have the ability to retain its shape while drying and should vitrify so that it can be properly fired. Brickmaking clays are either surface clays or shales. While surface clays are found near the earth's surface, shales are clays that have been subjected to high pressures under the earth surface and must be mined. In India, brick production depends on surface clays such as clay obtained from agricultural fields and clay washed into water bodies and recovered by desilting or from river deltas.

[7] Entry – 'Greenhouse Effect', Encyclopaedia Britannica, online edition 'https://www.britannica.com/science/greenhouse-effect

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

India's annual production of 25,000 crore solid bricks requires approximately 75 crore tonnes[9] of brick earth or clay, with most coming from agricultural fields. There are concerns related to a loss in agricultural productivity and land degradation due to unplanned clay mining.

However, representatives of the brick industry[10] from the Indo-Gangetic plains who were interviewed for this study say that these claims are exaggerated. A significant number of brick kilns are located around urban centres and with the expansion of urban areas, brick kiln lands eventually come under construction. In addition, it is a common practice among farmers whose fields are at a higher elevation than adjacent fields or whose fields' topsoil has lost productivity due to the excessive use of chemicals and fertilizers to sell their topsoil to brick makers. This helps them level their fields or expose fresh layers of soil for agriculture.

2.2 Policy Framework

2.2.1 Air Pollution

In India, the Air (Prevention and Control of Pollution) Act, 1981 established the right of the government to set emission standards for industries. The first emission standards for brick kilns were notified in 1996 and specified limiting particulate matter (PM) in kiln stack emissions. In addition, the standards also specified the minimum chimney heights for various types of kilns so as to disperse pollutants. A process to amend the emission standards for brick kilns was initiated by the Central Pollution Control Board (CPCB) in 2009 and amended standards were placed for public comments in 2015 and 2018 by the Ministry of Environment, Forest and Climate Change (MoEFCC). However, the revised standards are yet to be notified.

In December 2015, the CPCB, under Section 18 (1) (b) of the Air Act 1981, issued directions to State Pollution Control Boards (SPCBs) of states such as Haryana, Uttar Pradesh, Rajasthan, Uttarakhand, and Punjab to take steps to control air pollution from brick kilns. These steps were proposed due to the worsening air quality in the National Capital Region (NCR) and other cities in the region. The SPCBs were asked to ensure that:

- No unauthorised brick kilns be allowed to operate.
- FCBTK brick kilns be replaced with zigzag kilns

The shift to zigzag kiln technology is underway in the country, with around 7,000 FCBTKs converting to zigzag kiln technology in the last 5 years. In the NCR, there have been instances where all brick kilns, including zigzag kilns, have been ordered to stop operations during severe air pollution episodes. There is ongoing litigation before the National Green Tribunal (NGT) on the operation of brick kilns, including zigzag kilns, in the NCR. In a recent NGT Order dated 15/10/2020, in *Utkarsh Panwar* vs *Central Pollution Control Board* the court has not vacated its direction to not operate brick kilns in the NCR till January 2021. The order states,

"…at this stage it is not possible to vacate direction not to permit operation of brick kilns in NCR beyond the carrying capacity found by the CPCB. All applications of the brick kiln owners seeking rejection of CPCB report and vacation of interim order against operation of brick kilns, without air quality assimilative capacity permitting such activity will stand rejected subject to further exploring viable options, including change to clean fuel like natural gas. We are conscious that brick kilns may be necessary. Object of this order is not to stop any legitimate business activity but to enforce the right to breathe fresh air which is right to life. The source apportionment studies, placed on record, show that brick kilns contribute 5-7 percent PM. Air pollution Control devices to be installed by the polluting sources including the brick kilns need to comply not only the consent standards but are also the Ambient Air Quality norms and available assimilative capacity of the region. If the right to fresh air is not enforced, the consequences of brick kilns beyond carrying capacity of the air quality in the area are disastrous in terms of deaths and air borne diseases. This will be contrary to the mandate of the Constitution and the environmental law, particularly the principle of 'Sustainable Development'. It is well established that deteriorated ambient air quality in terms of PM10 and PM2.5 affects respiratory system particularly, the lungs which may make individuals more vulnerable to get other related fatal diseases."

Essentially, the order states that meeting emission standards for an individual industry is not a sufficient condition to allow operation of that industry. If ambient air quality exceeds safe

[9] Assuming 3 kilogram of brick earth is required for the manufacturing of 1 solid clay brick.

[10] Personal Communication with Mr O P Badlani, Proprietor, Prayag Kiln Technologies

limits, even those industries meeting emission standards and CPCB directions (in this case, zigzag brick kilns) may not be allowed to operate.

2.2.2 Fly Ash Regulation

Most electricity production in India is generated by coal-fired plants. They generate more than 20 crore tonnes of fly ash every year. The safe disposal of this large volume of fly ash is a major environmental challenge. The Government has therefore been promoting its use in various applications, including for manufacturing cement and building materials.

The first regulation for fly ash utilisation was notified in 1999 and was subsequently revised in 2003, 2009, and 2016. As per the 2016[11] notification:

- All brick manufacturing units within 300km of a thermal power plant are required to use fly ash for the manufacturing of bricks.
- All towns with a population of greater than 10 lakh are required to amend building bye-laws to make the use of fly ash bricks mandatory.
- Fly ash bricks and products were made mandatory in all Government schemes or programmes such as Mahatma Gandhi National Rural Employment Guarantee Act, 2005 (MGNREGA), Swacch Bharat Abhiyan and in Urban and Rural Housing Schemes where the built-up area is more than 1,000 square feet and in infrastructure construction including buildings in designated Industrial Estates or Parks or Special Economic Zones.

For 2018-19 the total fly ash generation in the country was 21.7 crore tonnes, of which around 10 percent was used for brickmaking.[12] It is to be noted that even if 1 kg of fly ash were utilised per brick, this would mean the production of around 2,100 crore bricks, less than 10 percent of the annual production of 25,000 crore bricks.

2.2.3 Environment Impact Assessment

Through a notification issued in 2012 by the MoEFCC, the excavation of brick earth for the production of burnt clay bricks is permissible only after prior environmental clearance from the respective State Environment Impact Assessment Authorities (SEIAA). Through a notification issued in January 2016, the MoEFCC directed the formation of a District-level Environment Impact Assessment Authority (DEIAA) that would grant environmental clearance for Category 'B2' Projects for mining minor minerals, which is applicable to brick earth. For the purposes of assisting DEIAAs, the notification also directs the constitution of District-level Expert Appraisal Committees (DEACs) for all districts in the country. Since then, several states have exempted brick earth mining from EIA requirements.

2.2.4 E3 Certification Scheme

The Bureau of Energy Efficiency (BEE), which is responsible for leading energy conservation efforts in the country, has identified the clay brick industry as the largest energy consuming MSME sector in India. Recognising this, it has formulated the "Energy Efficient Enterprise" (E3) certification scheme for the clay brick industry[13]. E3 certification will be awarded to brick manufacturing enterprises that meet the minimum Specific Energy Consumption performance criteria specified in the scheme, which is set at 25 percent lower than the national benchmark for energy consumption in the brick manufacturing sector. This criterion can be met by adopting energy efficient kiln technologies and producing lighter density bricks, which also have better thermal insulation properties. Apart from providing E3 certification, BEE is expected to assist E3 certified enterprises in expanding their market and making available technical support, thereby incentivising investment in energy efficiency in brick industry. BEE has recently launched an EOI for registering eligible brick industries for the scheme.

2.2.5 Energy Conservation Building Codes

BEE has come out with an Energy Conservation Building Code for commercial buildings (ECBC, 2017) and Energy Conservation Building Code for residential building or Eco-Niwas Samhita (ENS, 2018). Both codes require better insulation of walls to reduce energy use for heating or cooling and hence favour bricks with better insulation properties such as hollow or perforated clay bricks. The production of hollow and perforated clay bricks requires less energy and less clay.

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[11] The Gazette of India, January 27, 2016 https://tspcb.cgg.gov.in/GOs/Fly%20Ash%20Notification_as%20amended_25.01.2016.pdf

[12] "Report on Fly Ash Generation at Coal/lignite Based Thermal Power Stations and Its Utilization in the Country for the Year 2018-19", Central Electricity Authority, Thermal Civil Design Division, Government of India, New Delhi January 2020, https://cea.nic.in/wp-content/uploads/2020/04/flyash_201819.pdf

[13] "E3 Scheme for Brick Sector", Bureau of Energy Efficiency website, https://beeindia.gov.in/content/e3-scheme-brick-sector

CHAPTER 3

Green Technology Options & Potential

A list of green technology options has been developed based on discussions and interactions over the course of the study and in the recent past with various stakeholders including brick makers, government officials, industry experts and CSOs. These options are discussed in the following paragraphs.

3.1 Converting FCBTKs to Zigzag Kilns and Other Cleaner Brick Kiln Technologies

Zigzag kilns in the form of High Draught kilns were introduced to India around 50 years ago by the Central Building Research Institute (CBRI) as an alternative to the FCBTKs. The main difference in the two kilns is in the brick setting and the airflow. In a zigzag kiln the bricks for firing are set or loaded in such a way that the air in the kiln follows a zigzag path while in a BTK the air follows a straight-line path. The introduction of a fan in the original design of the High Draught kiln also provided more air for combustion. Coal is crushed or powdered and is fed in small quantities. These changes aid efficient heat transfer and better fuel burning. A zigzag kiln uses between 20 and 25 percent less fuel and results in up to 50 percent reduction in particulate matter emission. In addition, the yield of good quality bricks is improved. The initial investment for constructing a new, high quality zigzag kiln is estimated to be around ₹40 lakhs.

Zigzag kiln technology spread slowly for several decades. It was further modified and simplified by innovative brick makers. The requirement of a fan and hence the need for a diesel engine or electricity was a major hindrance in initial

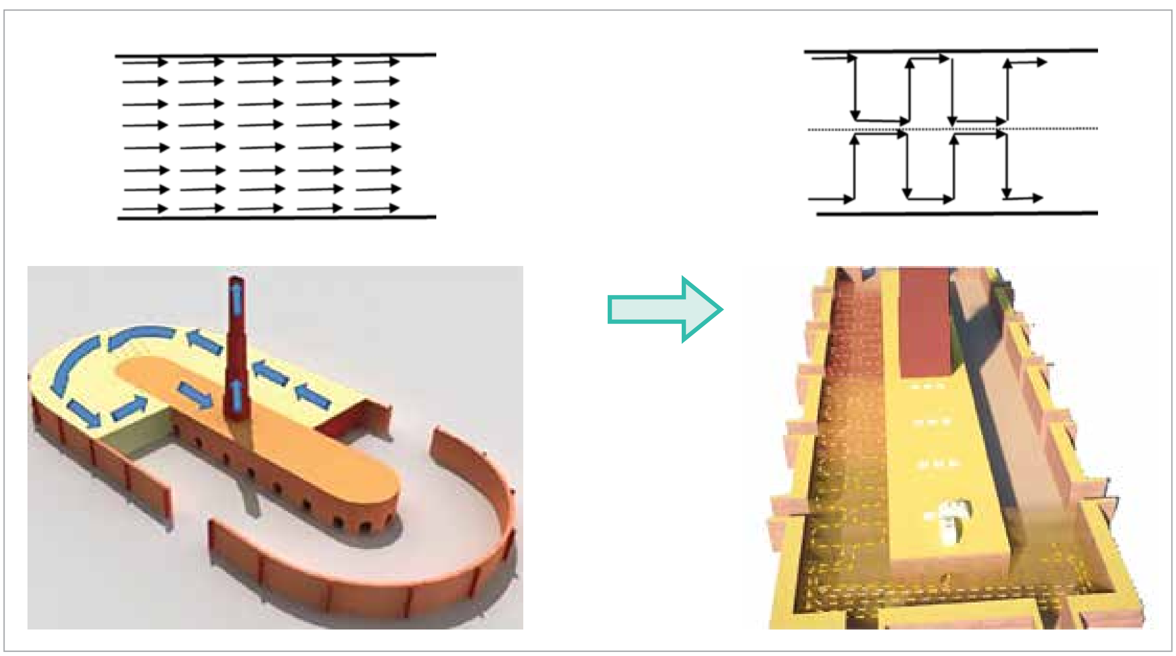

Figure 5: Conversion of FCBTK into zig-zag kiln

years. Later, a version was developed which worked on natural draft from chimneys alone. However, only around 1,750 kilns were constructed in the first 40 years, with most in West Bengal. Since then, the technology has seen rapid adoption particularly in Punjab, Haryana, Western Uttar Pradesh near the NCR, Bihar and in some districts of Eastern Uttar Pradesh. During this period, the technology was introduced in Tripura, Rajasthan, Maharashtra and Odisha. It is estimated that around 7,000 kilns have been converted or constructed during last 5 years, mainly driven by SPCB mandates. The cost of converting an existing FCBTK to a zigzag kiln can range from ₹10 lakh to ₹30 lakh.

Among brickmakers, there is agreement on the many benefits of zigzag kilns. The conversion of FCBTK to zigzag kilns benefits entrepreneurs as higher profits can accrue due to savings on fuel and as additional revenue due a better yield of good quality bricks. A survey carried out among brick makers in Patna after the completion of one season of brickmaking after the enforcement of the zigzag kiln mandate found that around 65 percent of brickmakers were able to realise the benefits of the technology, while around 35 percent faced problems with the new technology.[14] This survey and interactions with brick makers indicate that for successful conversion it is important to have access to standard kiln designs, trained construction masons and trained supervisors and workers for kiln operation.

Box 1:

Converting FCBTKs to Zig-zag Kiln Technology

Environmental Benefits:

- Reduction in coal consumption (20 percent to 25 percent) and associated CO_2 emissions
- Reduction in emission of particulate matter (up to 50 percent)
- Reduction in wastage and improved quality

Investment Requirement

- ₹10 lakhs to ₹40 lakhs per kiln

Status & Potential

- Adopted by around 10,000 kilns by 2020
- 40,000-50,000 FCBTKs yet to adopt; can result in savings of 50 lakh to 75 lakh tonnes of coal per year

Action Points

- Intense awareness campaign amongst brick enterprises
- Making available standard designs
- Skill training of kiln masons
- Skill training of supervisors and workers involved in brick setting and fuel feeding
- Financing arrangements for smaller kilns

Zigzag kiln is one of those cases where there is a win-win situation for both the brick makers and the environment. However, the natural dissemination of the technology takes considerable time. To give an example, zigzag kiln technology was introduced in the state of Tripura in 2 kilns under the EU supported programme in 2017-18. As per latest information till November 2020, around 7 kilns out of around 300 kilns have adopted the technology[15]. Thus, the rate of adoption of technology has remained slow despite most of the converted zigzag kilns reporting good results. There are potentially around 40,000 to 50,000 existing FCBTKs which are yet to be converted to zigzag kiln. The largest number of unconverted kilns is in the state of Uttar Pradesh. Taking a conservative estimate of savings of 100-150 tons of coal per year per kiln, if all the remaining kilns are converted that would result in savings of around 5 to 7.5 million tons of coal every year. It is expected that mandatory regulations by State Pollution Control Boards will force these conversions over next five years or so. However, there is a strong case for coordinated awareness generation among brick makers, making available standard designs and trained manpower for both construction and operations as well as providing access to finance to smaller brick makers so that they are able to adopt the technology.

Apart from the conversion to zigzag kiln technology, another option to reduce air pollution and improve brick quality is the conversion of existing FCBTKs to Hoffmann kilns or Tunnel kilns.[16]

- Tunnel kiln is a continuous moving ware kiln in which the clay products to be fired are passed on

[14] Sonal Kumar, Satyendra Rana and Sameer Maithel (2018). Transitioning to Cleaner Brick Kiln Technologies: Learnings from the Experience of Bihar Brick Kilns. Greentech Knowledge Solutions Pvt Ltd & Shakti Sustainable Energy Foundation

[15] Personal communication with Ms Anima Debbarma

[16] The fact sheet on Tunnel kiln and Hoffmann kiln can be downloaded from the website of Greentech Knowledge Solutions Private Limited, at https://www.gkspl.in/wp-content/uploads/2018/10/REBM3.pdf

cars through a long horizontal tunnel. The firing of products occurs at the central part of the tunnel. The tunnel kiln is considered to be the most advanced brick making technology. The main advantages of tunnel kiln technology lie in its ability to fire a wide variety of clay products, better control over the firing process and high quality of the products. Typical construction costs of tunnel kilns range from ₹5 crore to ₹10 crore. In India, there are only about 10 operational brickmaking tunnel kilns.

- The Hoffman kiln is a continuously moving fire kiln in which the fire is always burning and moving forward through bricks stacked in a circular, elliptical or rectangular shaped closed circuit with an arched roof. The fire movement is caused by the draught provided by a chimney or a fan. The typical construction cost of a Hoffmann kiln and its new variant the Hybrid Hoffmann kiln ranges from ₹1.5 crore to ₹5 crores. Hoffmann kilns have been primarily used in India to produce clay roofing tiles and more than 100 Hoffmann kilns are estimated to be operational in Kerala, Karnataka and Balaghat in Madhya Pradesh.

Both these options require large capital investments. If these technologies are used only for firing common solid bricks, the high costs will make it difficult for brick enterprises using these technologies to compete with zigzag kiln enterprises. The viability of these kilns improves if they are primarily used for the production of value-added products such as hollow and perforated bricks and clay tiles.

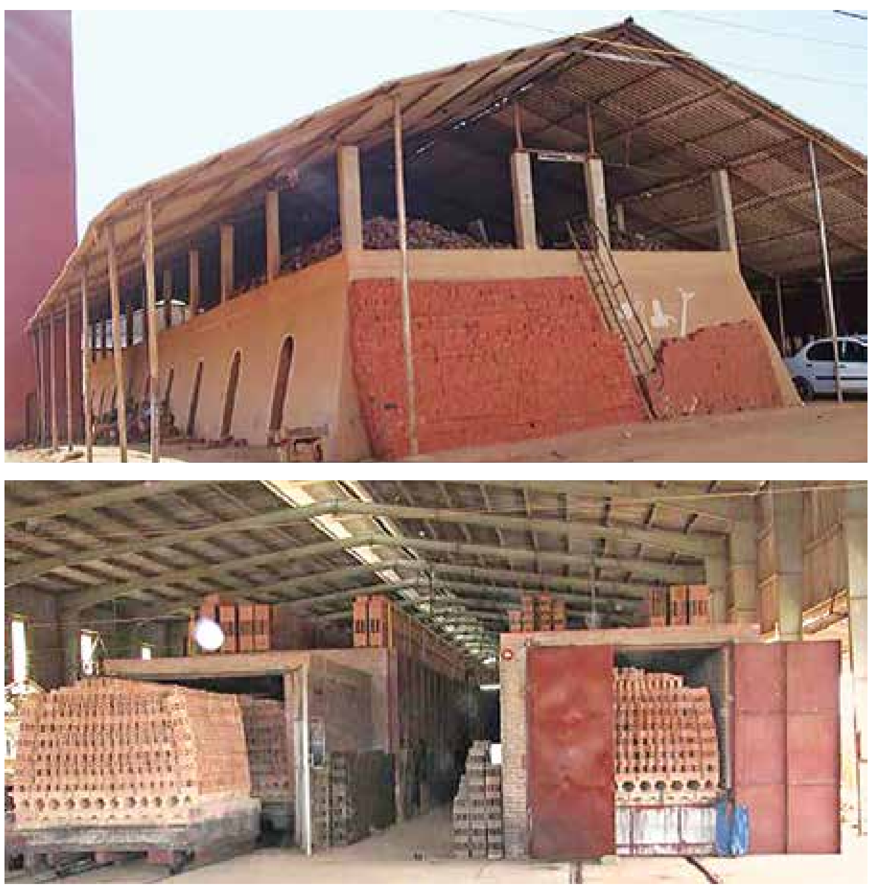

Figure 6: Hoffmann Kiln (Top) and Tunnel Kiln (Bottom)[17]

[17] https://www.gkspl.in/wp-content/uploads/2018/10/REBM3.pdf

3.2 Mixing Fly Ash, Other Industrial Wastes and Internal Fuel with Clay

The addition of fly ash and other industrial wastes such as boiler ash in clay brickmaking is widespread in central, western and parts of southern India. The mixing is done as a part of clay mix preparation before brick moulding. The addition of fly ash and wastes in clay helps reduce the amount of clay required for brickmaking. Moreover, fly ash, which also contains some unburnt carbon, also helps in reducing the amount of fuel needed for brickmaking. The addition of fly ash in black cotton soil, which is found widely in central and western India helps reduce soil plasticity and consequent breakages during drying and firing. In addition to fly ash, internal fuel such as powdered coal, rice husk, bagasse and boiler ash is also added to the clay, which can help reduce kiln air pollution. It can also help in reducing brick density and therefore improve thermal insulation.

There are many ways in which the mixing of fly ash or waste with clay is practised:

- Manual mixing (Figure 7)
- Mixing using a tractor attachment (Figure 7)
- Mixing using a mechanical mixer or pug mill

Depending upon the technology employed the investment can range from a few lakhs to ₹20 lakhs.

With multiple environmental benefits, there is a large potential for scaling-up the mixing of fly ash, industrial wastes and internal fuel with clay, particularly in the Indo-Gangetic region, where the use of internal fuel can also help reduce air pollution. It is to be noted that the amount of fly ash, industrial waste and internal fuel which can be mixed with clay varies depending the clay. For example, while it is possible to mix larger quantities of fly ash in clays in central and western India, only smaller amounts of fly ash can be mixed in clays in northern and eastern India. An organised initiative aimed at mapping available industrial wastes, potential internal fuel and working out feasible mixes of clay, waste and internal fuel is needed. Some improvements and modifications in mixing technologies and machinery may also be required depending on the type of waste and the scale of production.

Figure 7: Mixing of fly ash with clay (Maharashtra & Telangana)

Box 2:

Mixing Fly Ash, Other Industrial Wastes and Internal Fuel with Clay

Environmental Benefits

- Utilisation of industrial and other wastes
- Reduction in clay consumption
- Reduction in fuel consumption
- Reduction in PM stack emissions
- Potential to produce porous bricks with better insulation

Investment Requirement

- Up to ₹20 lakhs per kiln

Status & Potential

- Common practice in parts of Central, Western & Southern India
- Potential to expand to around 60,000 FCBTKs or zigzag kilns in the Indo-Gangetic plains

Action Points

- Testing clays
- Mapping the availability of wastes and internal fuel
- Demonstrating viable mixes of clay, waste and internal fuels.
- Adapting mixing technology as per the requirements of the Indo-Gangetic plains
- Skill training of supervisors and workers involved in brick setting and fuel feeding
- Financing arrangements for smaller kilns

Box 3:

Use of Mechanical Coal Feeding System in Zig-zag and Hoffmann Kilns

Environmental Benefits

- Reduction in fuel consumption
- Reduction in emission of particulate matter in stack gases
- Improvement in quality of bricks

Investment Requirement

- ₹10 lakh to ₹40 lakhs per kiln depending on the type of system

Status & Potential

- Trickle feeder in use on Hoffmann kilns at Balaghat
- Designs available, yet to be tested on zigzag kilns
- Potential to expand to kilns located in NCR and other heavily polluted regions in the Indo-Gangetic plains

Action Points

- Pilot testing
- Making available affordable technology
- Training of owners and workers in operation

3.3 Use of Mechanical Coal Feeding System in Zigzag and Hoffmann Kilns

Coal or fuel feeding in existing FCBTK, zigzag and Hoffmann kilns is done manually by firemen. They usually take coal in a spoon and feed it into feeding holes. At a time, coal is fed by one or two firemen. Usually, the feeding of coal is not continuous, coal is fed for around 10 minutes followed by a non-feeding interval of 15-20 minutes after which again the coal/fuel feeding is repeated. A graph of carbon monoxide and carbon dioxide concentration in a zigzag kiln is shown in Figure 8[18]. It can be observed that the burning of accumulated fuel produces periodic higher concentrations of carbon dioxide and carbon monoxide. Concentration levels return to base values after the accumulated coal has burned. Similar patterns are expected for PM emissions.

The results show that continuous feeding of properly sized fuel in zigzag kilns will reduce both coal consumption as well as emissions by ensuring cleaner combustion. Various types of mechanized coal stoking systems or solid fuel burners can be employed. Solid fuel burners of particular types are shown in Figure 9 and include a fuel crushing and distribution unit which delivers solid fuel mixed with positive airflow, thereby ensuring perfect and consistent firing. A trickle feeder to feed biomass fuel in a Hoffmann kiln firing clay tiles in Balaghat in Madhya Pradesh is shown in Figure 10.

The use of mechanical coal feeding systems will not only reduce the air pollution from brick kilns but can immensely improve working conditions for firemen. Currently, the

[18] "Assessment of Induced Draught Zigzag Brick Kilns & Preparing Guidelines for Reduction in Air Pollution", Greentech Knowledge Solutions Private Ltd, New Delhi, 2018

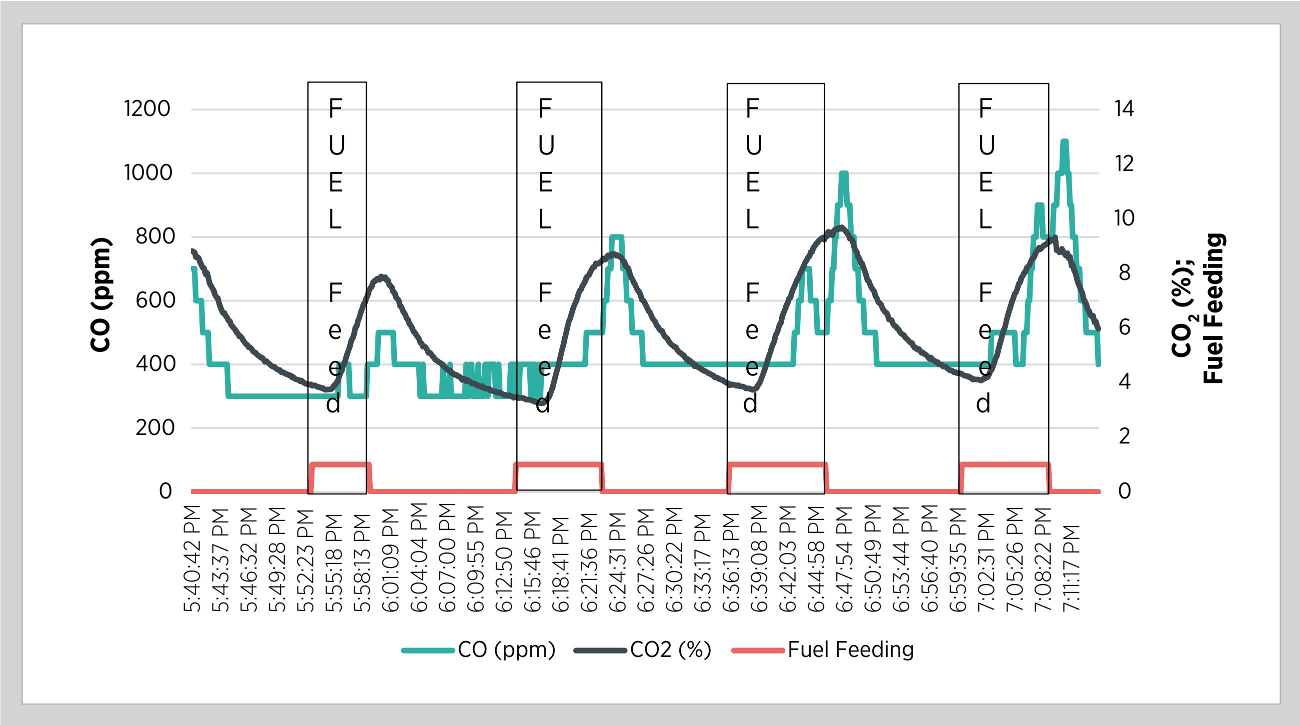

Figure 8: Graph showing relationships between emissions and fuel feeding pattern in a zigzag kiln

Figure 9: An octopus type coal feeder consisting of a coal crusher and delivery unit [19]

Figure 10: Trickle feeder for feeding biomass fuel in a Hoffmann kiln (Balaghat)

firemen walk on the kiln surface to feed fuel and are exposed to excessive heat between 80°C and 120°C. Zigzag kilns and FCBTKs offer some specific challenges for feeder use as they do not have permanent roofs. A technical solution is needed for the placement and movement of the feeder system.

[19] Source: http://www.beralmar.com

CHAPTER 4

Use of Air Pollution Control Device

As stated in chapter 2, a key environmental concern is PM emissions from brick kilns from solid fuels such as coal and biomass. The NGT in one of its recent orders has mentioned that brick kilns can only be allowed to operate if there is sufficient carrying capacity in an area. The existing emission standards for brick kilns puts the limit for particulate matter concentration in chimney gases at between 750mg/ Nm^3 to 1,000mg/Nm^3. Zigzag kiln monitoring shows that PM concentrations of around 250 mg/Nm^3 or lower are achievable without the use of any additional air pollution control device.[20] PM concentrations of 100 mg/Nm^3 and below in zigzag kilns can potentially be achieved through shifting brick kilns to gaseous fuels or installing a suitably designed air pollution control device using coal or biomass fuels to filter out particulate matter before the air is discharged to the atmosphere.

Common types of air pollution control devices that employed in industries are: electrostatic precipitators (wet and dry types), fabric filters (also called bag houses), wet scrubbers, and cyclones. Environment experts indicated that for brick kilns either bag filters or wet scrubber may be applied.[21] In wet scrubbers dust-laden flue gases come in contact with water and particulate matter gets washed with water. The treatment of wastewater is a general concern in wet scrubbers with brick kilns the waste water, which will contain carbon can be used to make clay. Wet scrubbers will require additional pumps for water circulation and higher capacity fans in chimneys, which would require additional energy.

Box 4:

Air Pollution Control System

Environmental Benefits

- Reduction in emission of particulate matter and pollutant gases

Investment Requirement

- Up to ₹10 lakhs/ kiln

Status & Potential

- Likely to get pilot tested during 2020-21
- Potential to expand to kilns located in NCR and other heavily polluted regions in the Indo-Gangetic plains

Action Points

- Pilot testing
- Making available the standard design
- Training of owners and workers in operation
- Putting in place a system that discourages the bypassing of the system by brick kilns.

4.1 Use of Gaseous Fuels in Brick Kilns

As stated in chapter 2, a key environmental concern is PM emissions from brick kilns. Gaseous fuels produce less PM emissions compared to solid fuels such as coal and biomass. The NGT in recent orders has mentioned the possibility of using gaseous fuels in brick kilns located in the NCR. Gaseous fuels such as piped natural gas, compressed natural gas or biogas are cleaner fuels which will produce less air pollution and help reduce CO_2 emissions.

[20] J S Kamyotra (2015). "Brick Kilns in India", presentation made at Anil Agarwal Dialogue 2015: Poor in Climate Change, India Habitat Centre, New Delhi, March 11 – 12, 2015. (http://cdn.cseindia.org/userfiles/JS-kamyotra.pdf)

[21] Personal communication with Mr Pritpal Singh, Punjab State Council for Science & Technology & Mr M A Patil, FICCI, December 20, 2020

Recently, Wienerberger India (a large international company involved in manufacturing of bricks), has converted their factory at Kunigal in Karnataka to natural gas firing.[22] In Tripura, three FCBTK brick kilns were using natural gas from 1998-2008[23]. In neighbouring Bangladesh, several Hoffmann kilns operate on natural gas (Figure 11). The conversion of zigzag kilns to gaseous fuels will require the development of appropriate technology in the Indian context. Some key questions arising from discussions with brick industry representatives[24] are:

- Is it technically possible to retrofit the zigzag kilns with natural gas firing?
- How would gas supply be ensured in remote agricultural areas where kilns are often located?
- Natural gas costs almost three times as much as coal and substantial investment would be required by kiln owners to convert their kilns to use gas. Would this switch make clay bricks costly and economically non-viable compared to products such as AAC blocks?
- Would gas companies be ready to supply piped natural gas to seasonal industries such as brick kilns?

Box 5:

Use of Gaseous Fuels in Brick Industry

Environmental Benefits

- Reduction in PM emissions and pollutant gases
- Reduction in energy consumption and CO2 emission
- Reduction in wastage and improvement in quality

Investment Requirement

- Estimates not available

Status & Potential

- Need for pilot testing to carry out techno-economic feasibility
- Could be a longer-term solution for NCR and other heavily polluted regions in the Indo-Gangetic plains

Action Points

- Pilot testing to carry-out techno-economic feasibility
- Understand implications on the industry and develop a roadmap

If we look at the example of Europe, the brick industry changed over from coal to natural gas over a 20 years period (1960 to 1980)[25]. This period was also characterised by mechanisation and the consolidation of the brick industry.

4.2 Manufacturing of Hollow & Perforated Bricks & Blocks

Currently almost all brick production in India is of solid bricks, with hollow and perforated bricks making up less than 1 percent.[26] However, a significant part of the demand for solid bricks can be replaced with hollow and perforated bricks. The production of hollow and perforated bricks addresses all major environmental concerns as it can help reduce the requirement of clay by up to 55 percent, reduce energy consumption and CO_2 emissions by up to 55 percent and can result in very large reductions in air pollution.[27] In addition, perforated and hollow products offer better thermal insulation so would help to reduce operational energy required for cooling or heating a building.

There are two routes to make a shift towards the manufacturing of hollow and perforated bricks:

a) Upgradation of existing zigzag or Hoffmann kilns: In this case existing brick kilns can mechanise their clay preparation process and install an extruder to manufacture green bricks with holes and hollows. Extruded bricks require controlled drying and hence drying under a shed or using an artificial dryer is required. Hollow and perforated bricks can be fired in the existing kilns. This upgradation has been operating in around 30 to 50 kilns in the country.

[22] https://www.wienerberger.in/Press/News0.html

[23] Information shared by Member Secretary, Tripura State Pollution Control Board, during the webinar on "Leveraging Green Initiatives for Green Brick Kilns in India" organized by CEC on December 23, 2020

[24] Personal communication with Mr Manish Gupta, Brick Kiln Owner, Faridabad, December 12, 2020

[25] https://www.brickguru.in/en/blog/moving-to-natural-gas-for-brick-firing-is-it-possible-in-india/

[26] GKSPL 2016. Market Assessment for Burnt Clay Resource Efficient Bricks (REBs), Greentech Knowledge Solutions Pvt Ltd, New Delhi

[27] http://www.resourceefficientbricks.org/pdf/REB_booklet_Mar2017.pdf

Figure 11: Use of Natural Gas in a Hoffmann Kiln in Bangladesh (Source: GKSPL)

Figure 12: A Hollow Block

Box 6:

Manufacturing of Hollow and Perforated Bricks

Environmental Benefits

- Reduction in clay usage
- Reduction in PM emissions and pollutant gases
- Reduction in energy consumption and CO2 emission
- Reduction in wastage
- Better wall thermal insulation

Investment Requirement

- Upgradation of existing facility: ₹2 crore to ₹6 crore
- New tunnel kiln based mechanised plant: ₹15 crore to ₹25 crore

Status & Potential

- Between 30 and 50 kilns have upgraded their processes to produce some hollow or perforated products
- Very few successful models of dedicated plants
- Medium to long term solution

Action Points

- Demonstration of business models
- Access to finance
- Medium to long term policy certainty, particularly around raw material supply
- Indigenous production of machinery, tunnel kiln and dryer systems

The initial investment of upgrading the clay preparation, installing an extruder and putting up a drying shed can range between ₹2 crore to ₹6 crore. This upgradation can help brick enterprises enter the perforated and hollow brick market. However, without artificial dryers the production volume remains small and it is difficult to reduce the cost of production.

b) Setting up a mechanised tunnel kiln and artificial dryer plant for exclusive production of hollow and perforated products: In this case a dedicated plant consisting of clay preparation machinery, deairing extruder, artificial dryer, tunnel kiln and mechanised material handling systems is installed. Such a plant can typically make at least 1 lakh regular bricks per day. In these plants it is possible to bring down the cost of production and maintain consistent quality. The initial investment in plant and machinery is between ₹15 crore to ₹25 crores.

Shifting to hollow and perforated bricks requires careful clay testing as not all clay is suitable for extrusion. Thus, a suitable clay mix must be prepared. For running a mechanised brick plant, unhindered supply of electricity is needed. Shifting to hollow and perforated bricks production means a structured transformation of the brick industry the conversion of the brick industry into an organised manufacturing industry. Such a transformation would require larger investments, access to credit and technology, technically skilled manpower for the operation of machinery, higher technical and managerial capacities and year-round operations. With year-round operations the brick industry will not be able to work with seasonal migrant workers. This would translate into better paying and more stable jobs for workers and also a reduction in drudgery and better working conditions. On the other hand, with a shift from manual to mechanised operations, there would a reduction in the number of workers and hence an overall reduction in employment in the brick industry. While a minority of progressive brick makers welcome the idea of such a transformation, most brick makers find this very intimidating. CSOs working with brick workers support the idea because of the possibility of improved working conditions and better-quality jobs for workers.[28]

[28] Discussion during "Ensuring Decent Work and Green Technology in India's Brick Kilns: Issues and Challenges" organized by CEC on December 23, 2020

CHAPTER 5

Green Initiatives in India's Brick Kilns: The Way Forward

Some key points can be concluded from the discussion presented in Chapter 1, 2 and 3:

- Clay fired brick is an important building material in the Indian context and has been able to retain an 80 percent market share even with the introduction of several new building materials and construction technologies over the last two or three decades.
- Clay brickmaking is widely spread across the country and is an important component of the rural economy. It plays an important role in providing entrepreneurship and non-farm employment opportunities in rural areas.
- There are three key environmental concerns associated with the brick industry: a) air pollution due to incomplete combustion of solid fuels in brick kilns b) potential land degradation due to unplanned mining of clay from agricultural fields and c) carbon dioxide emissions due to use of fossil fuels like coal in large quantities.
- There are several stand-alone environmental regulations addressing specific issues which are applicable to the brick industry and the construction sector in general. However, a comprehensive environmental policy for the brick industry is missing. Regulations have been formulated using a top-down approach and lack details needed for implementation. Implementation capacities of state governments are limited.
- Several technically proven solutions exist to improve the environmental performance of brick kilns. While they have been used extensively internationally, only some have been used and are commercially available in India, while some require adaptation.

From multiple environment policy standpoints, such as, reducing CO_2 emissions and air pollution, saving clay and fuel and the utilisation of waste, there is a huge potential for leveraging green technologies in brickmaking in India. Except for the adoption of zigzag kiln technology or to some extent the mixing of fly ash, waste and internal fuel with clay, none of the other measures described in Chapter 3 have seen wide scale adoption. Economies such as China and Vietnam are moving ahead with the transformation of the brick sector, but it is clear from their experience that a transformation would require a decade long focused programme implemented in a mission mode.

Any strategy to mainstream green initiatives in the Indian brickmaking industry should take into account the fact that most brick production takes place in the informal sector of the economy and that there is significant regional diversity. The strategy should be a combination of both short-term or immediate measures and medium or long-term measures which require a lot more preparatory work and resources. Short-term measures require fewer resources and can bring incremental improvements without causing large disruptions in the industry. Medium or long term measures require large amounts of resources and would cause large disruptions and hence would require careful planning and preparation. It is possible to immediately start work on short-term measures and implement them over the next five years. Simultaneously the work on planning medium and long term measures can be initiated but the implementation across the country is likely to take between 10 to 20 years.

5.1 Short-term Strategy for Green Initiatives

In terms of technology options, in the near term the focus could be on four measures (measures described in sections 3.1 to 3.4) described in chapter 3. The reason for focusing on these measures in the short term is that these measures can be retrofitted in existing brick kilns. Several, such as the conversion from FCBTK to zigzag kilns and the mixing of fly ash with clay have already been proven and are being used in a large number of brick kilns and the capital investment required is relatively low, ranging from a few lakhs to ₹40 lakh and can be raised by brickmakers themselves. In addition, most of these measures also bring in economic benefits for brick kiln owners and hence it is possible for the brick industry to take leadership in executing these measures with rather limited support from the Government and financing institutions. These measures are:

- The conversion of existing FCBTK to zigzag kilns
- Mixing fly ash, other industrial wastes and internal fuel with clay
- Further improvement in the environmental performance of zigzag kilns with the use of mechanical coal feeding systems or air pollution control systems or both.

While some of the specific action points for each of these measures have been provided in chapter 3, the overall strategy for short-term measures can focus on the following elements:

- Standard region-specific technology packages
- Workers' skill building
- Knowledge exchange

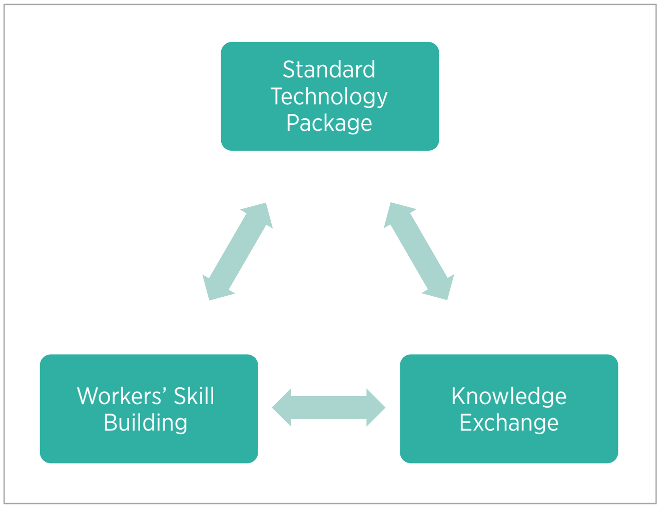

Figure 13: Main elements of the short-term strategy for green initiative

Standard Region-specific Technology Package & Trained Technology Providers

Based on the experience of dissemination of zigzag kiln technology, it can be inferred that retrofit solutions are sourced from local technology provider, for example by brick kiln masons / *mistris* in the case of zigzag kilns and a wide variance in the quality of the solutions and in their performance is observed. It has been observed that the performance of zigzag kilns constructed using a standard kiln design and a technically competent technology provider such as the design offered by the Punjab State Council for Science and Technology or Prayag Kiln Technologies performs better. One of the models used to develop these standard technology packages is through the formation of state specific expert groups. These expert groups can be composed of representatives from state governments, state brick kiln owners' associations and industry experts. Such an approach has been piloted in Bihar where a standard design of zigzag brick kiln technology for Bihar was developed in a short-period by an expert committee convened and chaired by the Bihar State Pollution Control Board. The committee involved members from the state brick kiln owners' association, industry, and research institutions. After a standard technology package is developed, a programme to disseminate the package among brick kiln owners in the state and organise training and certification programmes for technology providers is the next logical step.

Workers' Skill Building

Again, taking the example of zigzag kilns, it has been experienced that the performance of zigzag kilns depend significantly on the availability of skilled workforce for the loading or arranging of bricks in the kiln fuel feeding and firing. This requires skilled loaders and firemen. As thousands of FCBTKs are getting converted to zigzag kilns it is important to skill these two categories of workers in zigzag kiln operation. Currently, there are no approved training programmes for brick workers under the government skill development initiatives. There is a need to develop and implement specific skill upgradation programmes under the "Recognition of Prior Learning" stream of the National Skill Development Initiative.

Various studies as well as work carried out under the project have shown that while on one hand the brick industry provides employment to a large number of workers belonging to economically and socially backward communities, working and living conditions of the workers need to be improved significantly to achieve standards of "decent work". Thus, along with incremental technology improvements and skill upgradation, a dedicated programme to improve working and living conditions of the workers needs to be undertaken. The brick industry owners' associations, CSOs and Trade Unions and the state labour departments will be the key stakeholders for this initiative.

Knowledge Exchange

As demonstrated under this EU supported "Empowering CSOs for Decent work and Green Bricks in India's Brick Kilns" project, peer-to-peer knowledge exchange through site visits and training of brick kiln owners from Tripura and Fatehpur, UP to Prayag Clay Products Pvt Ltd in Varanasi, UP was critical in their decision to adopt zigzag kiln technology. Creating platforms and opportunities for knowledge exchange among brick makers from different parts of the country is critical for increasing the pace of adoption of green technologies. In case of Bihar, the use of social media such as WhatsApp has been extensively used for this knowledge exchange. Organised initiatives by CSOs, industry expert organisations and brick industry are needed to improve knowledge exchange.

5.2 Medium/Long Term Strategy for Green Initiatives

The implementation of measures given in section 3.5 (use of gaseous fuels) and section 3.6 (manufacturing of perforated and hollow bricks) may require or lead to a structural transformation of the industry. These measures differ from the short-term measures, because they require much larger capital investment between ₹2 crore to ₹25 crore. Government and financing institutions will need to play a central role.

The medium/long term strategy has three key elements:

- Comprehensive policy framework for clay brick sector
- Technology, finance and market development.
- Workers' Skill Building.

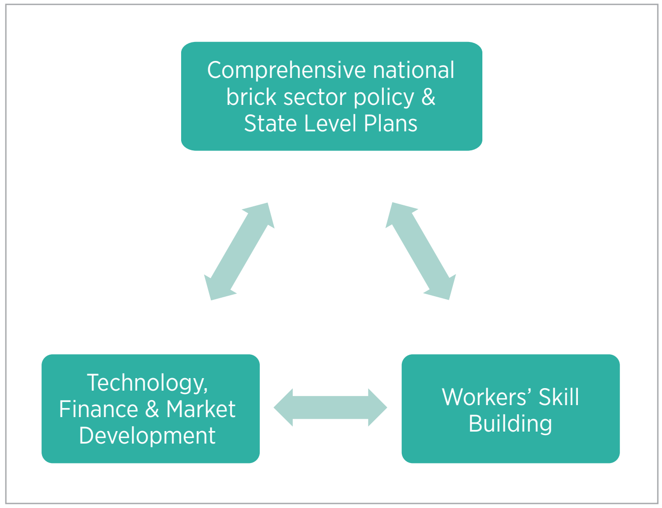

Figure 14: Elements of a medium or long term strategy for green initiatives

Comprehensive Policy Framework for the Sector & State Action Plans

The brick industry faces multiple environmental challenges. The existing environmental policy framework is piecemeal and lacks coherence. Often, policies have been formulated using a top-down approach without properly addressing the implementation issue, for example in the case of fly ash regulations. This piecemeal approach and a lack of clarity on implementation brings enormous uncertainty about the future of the sector and is impeding new investment. Also, despite being one of the largest MSMEs in the country, there is no sector-specific development policy for the brick sector and the brickmaking industry is generally not able to take advantage of the policies framed for the development of the MSME sector in India. Thus, there is a need to develop a comprehensive policy framework for the sector covering both environmental and developmental aspects. Both the Ministry of MSMEs and the MoEFCC would have a central role in such a policy development.

As shown chapter 1, clay brick making is a big industry in around 11 states of the country. A one-size-fits-all approach will not work given the diversity of the industry and the market across the country. Thus, state-specific action plans for transformation are needed for large brick manufacturing states. The preparation of such action plans will require background work on areas such as the mapping of clay resources, wastes, clean fuels, market demand for bricks, employment, and livelihood options for brick workers. Industry and environment departments in the states along state brick kiln owners' associations can take a lead in developing state-specific action plans.

The process used for the development of the national policy and the state action plans should be inclusive and should involve consultation with all key stakeholder groups.

Technology, Finance & Market Development

For mechanisation, a variety of machinery and equipment such as crushers, clay mixers, extruders, soft-mud moulding machines, mechanised coal feeders, artificial dryers and tunnel kilns is required. Currently, India has limited capacities to manufacture this machinery and equipment and depends on China and Europe. Thus, it is important to develop an indigenous brick machine and equipment manufacturing industry through either technology transfer or indigenous technology development. This is likely to result in reducing the cost of mechanisation and will bring also develop new entrepreneurship and employment opportunities. In addition to technology suppliers, a network of laboratories to test clay, fuel, product and properties and technical service providers in the fields such as energy, environment audit and techno-economic feasibility studies, etc is also needed.

Due to its informal nature, the brick industry is not able to access institutional finance. Mechanisation would require investments between ₹2 to ₹25 crore per enterprise. One study has estimated a requirement of around ₹2 lakh crore for sector transformation.[29] A dedicated line of credit is needed for the brick industry. Simplified processes may be required for such a credit scheme. In addition, a programme to help brick enterprises in areas such as improved bookkeeping, payment of taxes and registration with various government entities so that they can enter the formal sector would be needed.

A market-based approach which promotes the market for "resource-efficient" or "green" bricks is essential to drive a structural transformation in the industry. This could be achieved by leveraging green building rating systems, energy conservation building codes and the existing Energy Efficient Enterprise (E3) certification for the brick industry.

Workers' Skill Building

Any mechanisation and diversification to manufacturing new products would require a skilled workforce to operate the machinery. In addition, mechanisation will also lead to a reduction in the number of workers and it is important that existing workers are trained in diversified skill sets so that they can be gainfully employed in other sectors. A skill development strategy for the brick industry and workers engaged in manufacturing of bricks is needed. The skill development initiative would be part of a larger workers development initiative.

[29] http://www.gkspl.in/project/roadmap-promoting-resource-efficient-bricks-india-2032-strategy/

Annexure: Interviews

The author spoke on specific aspects with a few key persons. The author would like to sincerely thank all of them for sparing time and for providing valuable comments.

Name & Affiliation	**Date / Topic of discussion / quotes**
Shri Om Prakash Badlani *Chairman, Prayag Clay Products Pvt Ltd*	November 28, 2020 Discussion on dissemination of green technologies "A structural transformation of brick industry is needed and the production of hollow and perforated bricks needs to be promoted. Brick makers are looking for proven region-specific business and technology models. The government should provide grants to selected enterprises to make them *model units* in important brick making clusters".
Shri Manish Gupta *Treasurer, All India Brick & Tiles Federation*	December 12, 2020 Discussion on green technologies in the context of National Capital Region. "Brick industry in the NCR has invested heavily in conversion to zigzag technology in the last couple of years, with each enterprise investing up to ₹40 lakhs. NCR Brick entrepreneurs are not able to operate their kilns due to the recent NGT judgement and are extremely worried about their future."
Shri Ashok Kumar Tiwari *Senior Vice President, All India Brick & Tiles Federation & Former President, Bengal Brick Fields Owners Association*	November 28, 2020 Discussion on green technologies in the context of West Bengal. "Clean environment is concern for all of us. No development can be appreciated at the cost of environmental damage. We from the brick sector are eager and committed to do our little bit by adopting green technologies. Most brick kilns in West Bengal have adopted zigzag kiln technology. Now, we want to focus on skilling our workers to operate these kilns more efficiently".

Shri J John *Former Executive Director, CEC*	November 28, 2020 Discussion regarding the view of CSOs and TUs on mechanisation. "The current brick industry jobs are dirty, demeaning and dangerous. There is no justification in continuing with the current situation. I would favour a structural transformation and mechanisation". "Mechanisation does not necessarily mean an improvement in the protection of labour rights. A programme on mechanisation needs to be accompanied with a programme on diversified skill upgradation among workers as well as supporting efforts to organise workers". "Cooperative model of ownership is also be an option as mechanisation takes place leading to a consolidation in the brick industry"
Shri Sudhir Katiyar *Prayas Centre for Labour Research & Action*	November 28, 2020 Discussion regarding the view of CSOs/ TUs on mechanisation. "A structural change in the brick industry is badly needed. I personally favour mechanisation if it leads to such a structural transformation in the brick industry." "We have been hearing about mechanisation for several years now, but it has not taken place because we are told that the labour cost is very low and mechanised brick enterprises are not able to compete with the traditional brick enterprises".

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