MAKEOVER

Conversion of brick kilns in Delhi-NCR to a cleaner technology

A STATUS REPORT

Centre for Science and Environment

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INTRODUCTION

The Delhi-National Capital Region (NCR) is facing a severe air pollution problem. The issue is not only confined to the National Capital Territory (NCT) but is dogging all the 22 districts of the NCR. Hence, it calls for a coordinated response to combat pollution and its adverse effects on the health of the people living in these areas.

In order to find a long-term solution to this issue, the Environment Pollution (Prevention and Control) Authority (EPCA) had asked the NCR states (Uttar Pradesh, Haryana and Rajasthan) to work on a Graded Response Action Plan (GRAP) to reduce pollution emanating from different sources. Vehicles, household fuel and waste burning, coal-fired power plants, and industrial activities have been identified as the major sources of air pollution in Delhi-NCR. The contribution from brick kilns is also significant and the brick-making sector has been identified as one of the key sources of air pollution in the region.

To deal with the issue of pollution from brick kilns, the EPCA had ordered all kilns in Delhi-NCR to switch to a cleaner technology. However, the kiln owners demanded some time to continue operations (with old kilns) for one last season, and offered to submit an undertaking to switch over to the zigzag technology before they start operations in the next season, i.e. winter 2018. A deadline of 30 June 2018 was given for operations of Fixed Chimney Bull Trench Kilns (FCBTK) beyond which operations will be seized. The Central Pollution Control Board (CPCB) had, in June 2017, also ordered brick kilns across India to shift to a cleaner and more efficient zigzag technology; however, no timeline was mentioned in the order.

Objective of the survey

Following the May 2017 EPCA order for conversion from FCBTK to zigzag technology by June 30, 2018, this study was undertaken to assess the status of conversion. The focus was to understand the ground reality and analyse the quality of conversion.

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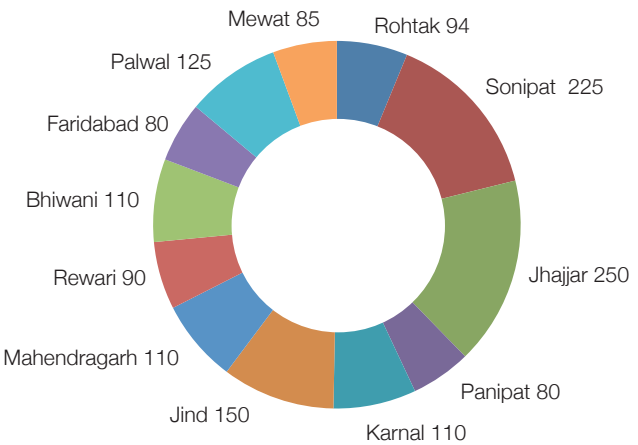
THE BRICK KILN SECTOR IN DELHI-NCR

There are 3,823 brick kilns in the Delhi-NCR region, with the maximum number of kilns in the district of Baghpat in Uttar Pradesh. The distribution of brick kilns in different districts of the NCR (state-wise) is as follows:

Haryana

According to the data submitted by the Brick Kiln Association, Haryana, there are around 1,509 kilns in the NCR districts of the state. The maximum number of kilns is in Jhajjar district followed by Sonipat, Jind, Palwal, Bhiwadi, Mahendragarh, Karnal, Rohtak, Rewari, Mewat, Faridabad and Panipat respectively (see *Graph 1: Number of brick kilns in different NCR districts of Haryana).*

Graph 1: Number of brick kilns in different NCR districts of Haryana



Source: CSE

What is a zigzag kiln?

A zigzag kiln is an annular, moving-fire kiln of rectangular shape. In zigzag kilns, green bricks are arranged in chambers, and after each chamber a gate is made where air vents are provided in alternate sides that forces hot air to travel in a zigzag path. The length of the zigzag air path is about two–three times that of a straight line air path in a FCBTK which improves the heat transfer from the flue gases to the bricks due to the repeated change in the direction of flow, making the entire operation more efficient. In addition to this, since better mixing of air and fuel takes place, it helps in near complete combustion of fuel which further reduces coal consumption in zigzag kiln to about 20 per cent. The zigzag path also ensures a more uniform distribution of heat and this increases the number of class-I bricks to about 90 per cent. Emissions from the kiln are also reduced considerably.

A zigzag kiln operating under draught created by a chimney will be considered as natural draft zigzag kiln. A zigzag kiln will be considered an induced/high draft kiln if it has a fan operating with minimum 50 mm water gauge draught.

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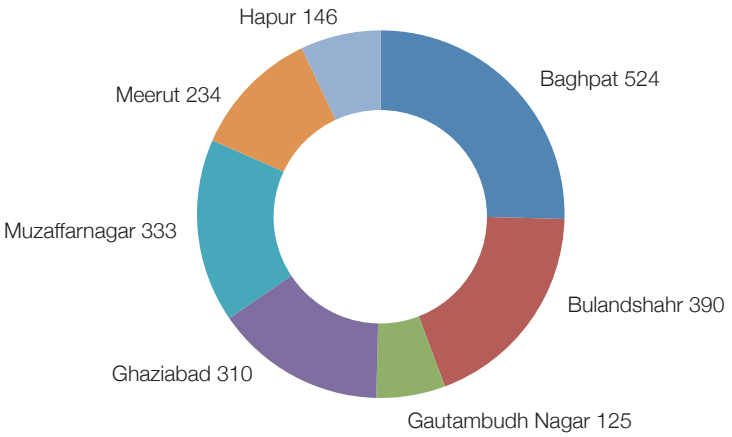
Uttar Pradesh

There are around 2,062 kilns in the NCR districts of Uttar Pradesh. The district of Baghpat has the most number of kilns followed by Bulandshahr, Muzaffarnagar, Ghaziabad, Meerut, Hapur and Gautambudh Nagar, respectively (see *Graph 2: Number of brick kilns in different NCR districts of Uttar Pradesh*).

Graph 2: Number of brick kilns in different NCR districts of Uttar Pradesh

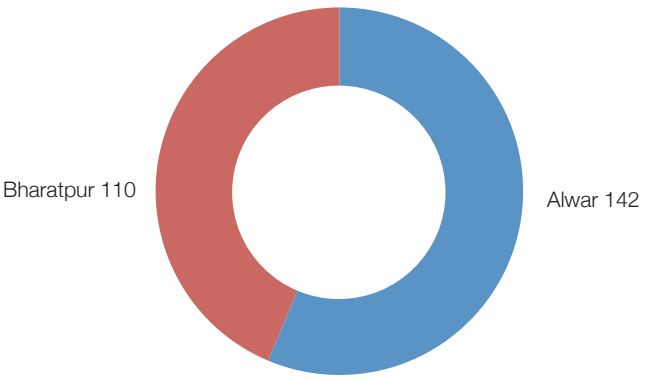


Source: CSE

Rajasthan

Rajasthan shares only two districts with the NCR — Bharatpur and Alwar. According to the data submitted by Rajasthan State Pollution Control Board, there are around 252 kilns in the NCR districts of the state (see *Graph 3: Number of brick kilns in different NCR districts of Rajasthan).*

Graph 3: Number of brick kilns in different NCR districts of Rajasthan



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STATUS OF CONVERSION

According to the latest data, received from the regional offices of state pollution control boards and state brick kiln owners associations. Out of 3,823 kilns, 1,003 have converted to zigzag technology, and owners of around 1,500 kilns have submitted an undertaking to switch to the recommended technology before they start operations in the next season.

The total conversion, as of now, is only 26 per cent. But after including the undertakings received, this percentage rounds up to 65 per cent. (See *Table 1: District-wise distribution of kilns and their conversion percentage*)

Table 1: District-wise distribution of kilns and their conversion percentage

State	District	Kilns	Converted kilns	Remaining kilns	Percentage conversion
Haryana					
	Rohtak	94	44	50	47%
	Sonipat	225	160	65	71%
	Jhajjar	250	160	90	64%
	Panipat	80	50	30	63%
	Karnal	110	50	60	45%
	Jind	150	60	90	40%
	Mahendragarh	110	35	75	32%
	Rewari	90	30	60	33%
	Bhiwadi	110	60	50	55%
	Faridabad	80	30	50	38%
	Palwal	125	30	95	24%
	Mewat	85	20	65	24%
	Gurugram				
Uttar Pradesh					
	Baghpat	524	65	459	12%
	Bulandshahr	390	60	330	15%
	Gautambudh Nagar	125	15	110	12%
	Ghaziabad	310	30	280	10%
	Muzaffarnagar	333	40	293	12%
	Meerut	234	5	229	2%
	Hapur	146	20	126	14%
Rajasthan					
	Alwar	142	24	118	17%
	Bharatpur	110	15	95	14%
	TOTAL	**3,823**	**1,003**	**2,820**	**26**%

Source: CSE

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THE CSE SURVEY

METHODOLOGY

The survey of brick kilns in Delhi NCR was conducted in two parts;

A) Analysing the construction quality
B) Monitoring the combustion performance

Part A was divided into three phases;
1. Preparation of a questionnaire
2. Preparation of an indicator
3. Survey of the unit

The questionnaire was used to collect data from the kiln site. The key parameters which affected the performance of the zigzag kilns were selected and the assessment of the surveyed kilns was carried out based upon the parameters.

Part B analyses flue gases of selected kilns to understand the combustion performance. Poor the conversion; higher the emission.

STUDY AREA

A total of 76 brick kilns from 13 different districts of NCR were surveyed, of which 63 were converted and 13 were non-converted (see *Map 1: Number of kilns surveyed district-wise*). The converted kilns were surveyed to analyse the quality of conversion and the non-converted kilns were chosen to understand the problems they were facing in conversion.

Kilns operating on FCBTK technology

Thirteen FCBTKs were surveyed on random basis to understand the reason for their non-conversion. A common problem found throughout was the lack of knowledge about the technology. Some kiln owners expressed that financial constraints was one of the reason for their non-conversion this year. Most of the kiln owners were willing to convert but they first wanted to observe the success and failure of the converted kilns. In Uttar Pradesh and Rajasthan, kiln owners shared that there is a rumor that the deadline for the conversion would be extended due to the parliamentary elections next year.

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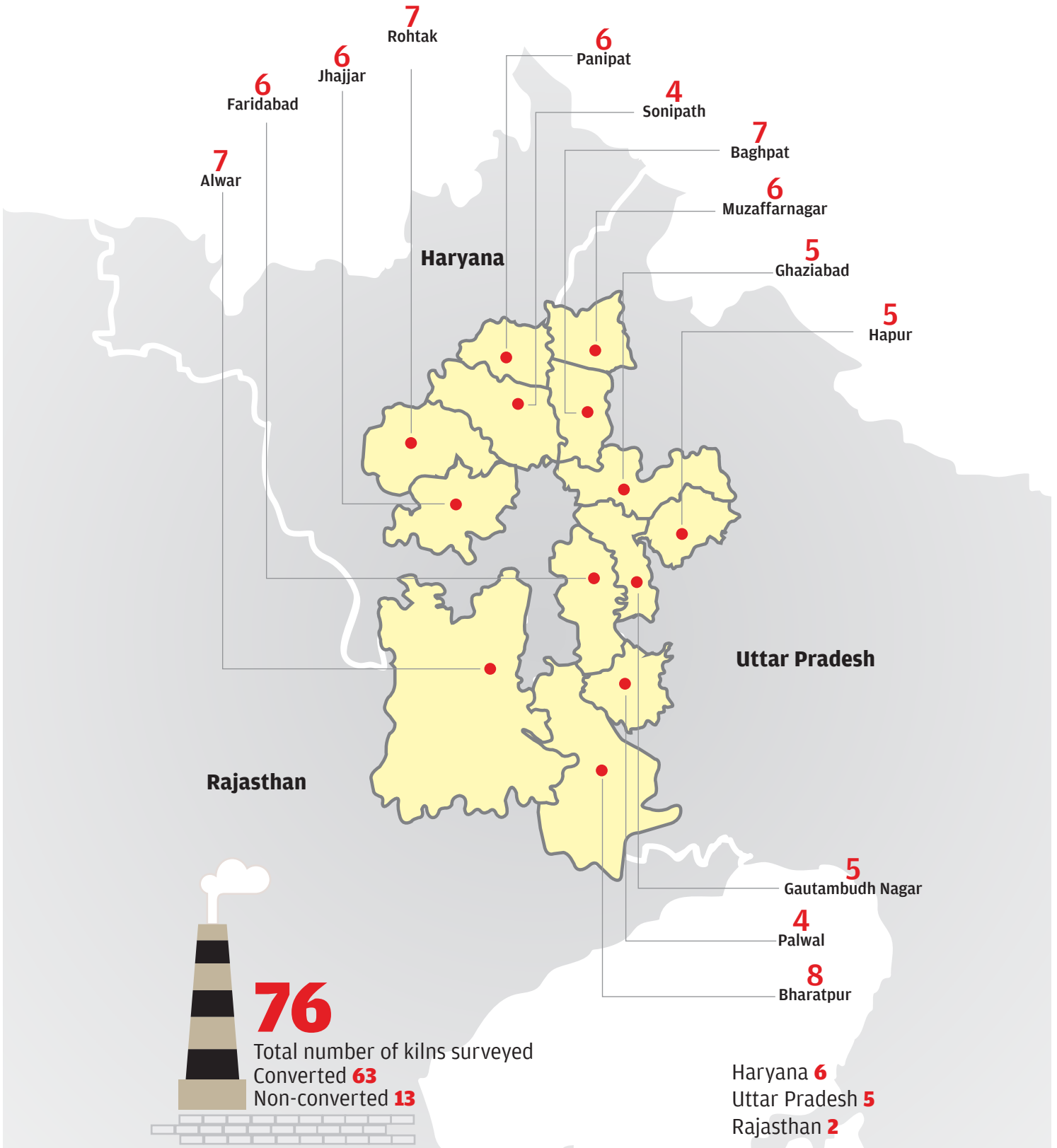
Map 1: Districts surveyed in NCR



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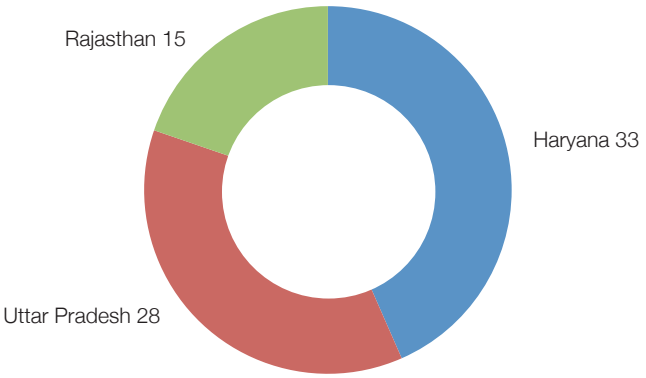
Graph 4: Number of kilns surveyed in different states



Source: CSE

Further study concentrates specifically on the conversion quality and performance of the surveyed converted kilns. Out of the total 63 converted kilns surveyed, 29 were from Haryana, 22 from Uttar Pradesh and 12 from the two districts of Rajasthan.

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ASSESSMENT OF THE QUALITY OF CONVERSION

Maximum heat utilization and minimizing ingress of cold air are key performance parameters for achieving a quality product from any kiln. Heat utilization and minimizing ingress of cold air depends upon the design and construction of the key components of a kiln. A proper design and construction of each component of the kiln can help in accomplishing the maximum heat utilization by trapping the heat inside the kiln and minimizing ingress of cold air.

The temperature inside a kiln is higher (can go upto 1000°C) compared to the ambient temperature which is why heat loss from the walls is a major concern. About 50 per cent of the heat supplied to the kiln is lost through its surfaces—the walls, roof and floor. Components such as the *miyan*, outer wall, kiln floor, wicket gate and the apparatus used at the kiln constitutes a major part of all the surfaces that let heat escape from a kiln.

Apart from the design and construction, operational practices being followed at the kiln also have a large impact on its performance. The operational practices include parameters such as fuel handling and feeding, wicket gates closing mechanism, chamber temperature monitoring, and record keeping. These parameters affect the quality as well as the efficiency of the kiln.

The assessment of kilns was carried out based on 12 important parameters and combustion performance. The parameters fall in three broad categories:

- Design and construction quality
  - Construction of the miyan
  - Construction of the outer wall
  - Kiln floor
  - Fuel storage

- Operational practices
  - Fuel feeding process
  - Wicket gate closing mechanism
  - Chamber temperature monitoring and record keeping
  - Type of fuel being used

- Facilities provided at the kiln site
  - Shed kiln
  - Water sprinkling facility
  - Proper electrical connection
  - Personal protective equipment (PPE)

Depending upon these parameters, all kilns are divided under four categories—Very good, Good, Average and Poor. The state- and district-wise performance assessment of the converted kilns on each indicator is as follows:

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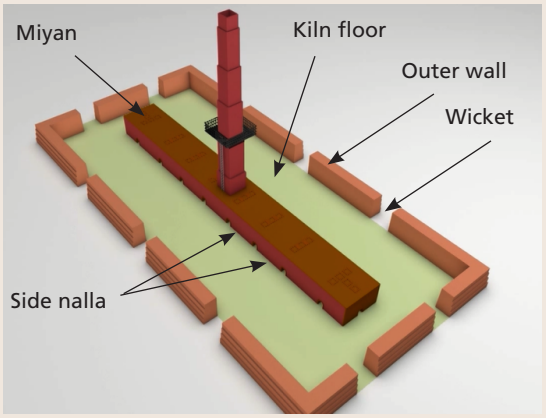
What is a good zigzag kiln?

A construction of a well operating zigzag kiln starts with demolition of the existing FCBTK. Once the process of demolition is complete, it is followed by the construction of miyan. Miyan is the central part of the kilns within which the chimney is placed along with nalis through which the colder air (flowing at the bottom) and the water vapors (accumulated at the bottom) near the kiln floor passes into the main nali. The ideal design for miyan includes providing the side nalis at equal intervals, and the dimensions of nalis should be 2.5¬-3 feet in height and 2.5 feet in width. Providing the miyan wall with a well-maintained coat of clay is ideal to increase insulation along with the expansion joints being provided between the two side nalis.

The second phase of the construction of brick kiln involves construction of a kiln wall. In an ideal condition, for construction of the solid wall, it is recommended that the width of the wall be 6.5 ft. Cement plastering should be provided on the outside of the kiln wall, including an extension in the wall which helps in storing the insulating material properly, and acts as a wind breaker which prevents fugitive emission and loss of the insulating material. The wicket gates which are provided in order to allow access to the kiln are ideally closed following a double wall closing mechanism with inner wall and outer wall having a width of 18 inches each and 4 inches of insulation between them. The gates should also be provided with an appropriate amount of clay coating and a plastic sheet covering just to avoid an additional flow of air into the kiln.

Once the central part of the miyan is constructed, it is time for the third phase which involves construction of kiln floor. The recommended floor design includes providing a layer of sand bed topped with aluminium foil followed by another layer of sand, which is then topped by two layers of fired bricks — one on the edge on soling pattern and the other with a flat brick soiling pattern. After construction of all these main components of a brick kiln is complete, the construction process heads into phase four. This phase includes providing a motor and fan in the case of induced draft kiln. This is followed by the construction of a boundary wall along the kiln, an entry gate to provide security of the kiln, construction of a hauled cemented road within the kiln premises.

Demolition and reconstruction of a chimney depends entirely on the decision of the brick kiln owners. In case of an induced draft kiln, the chimney is not required to be changed as the draft is created with a fan but in case of natural draft kiln, the height of the chimney has to be increased as the draft is created by the difference of temperature inside the kiln and on the top of the chimney.



Anatomy of a zigzag kiln

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DESIGN AND CONSTRUCTION QUALITY

Construction of *miyan*

Miyan is an important component of the kiln. It is basically the flue duct system of the kiln, which constitutes of the side *nalla*, the main nalla and the vertical hall. The main *nalla* runs through the length of the *miyan* and is finally connected with the chimney, whereas the side *nalla* are placed at equal intervals and are the one which connects the trench to the main *nalla*. The flow of flue gasses from the kiln depends upon the designing of the three components.

The *miyan* wall should be capable of withstanding temperatures as high as 1,000°C at which the bricks in the kiln are fired, and should be well insulated so that there is no leakage from the wall. The recommended design of the side *nalla* is such that it allows only the colder air (flowing at the bottom) or the water vapors (accumulated at the bottom near the kiln floor) to pass to the main nalla.

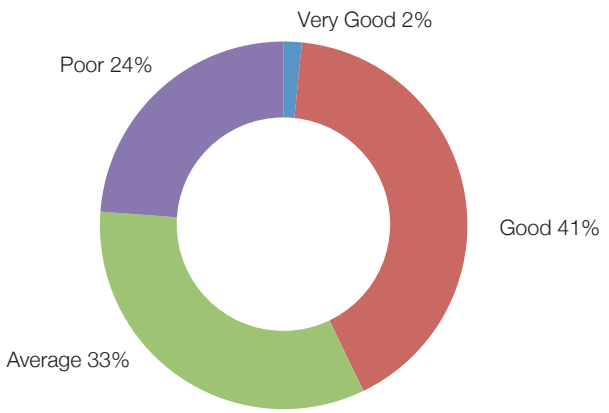
It was found that not all kilns have reconstructed *miyan* while converting. In Uttar Pradesh, approximately 50 per cent of the converted kilns are using the older *miyan* without any change. The situation in Haryana is slightly better as around 80 per cent of the total kilns have constructed new *miyans*; whereas, in Rajasthan all surveyed kilns had newly constructed *miyans*.

Approximately 60 per cent of the surveyed kilns were found with improper design and dimensions of the side *nalla*. This was a common issue in all the three states. (See *Graph 5: Overall miyan construction quality).*

Table 2: State-wise percentage of kilns using older *miyans* and improper design of the side *nalla*

Percentage of kilns	Haryana	Uttar Pradesh	Rajasthan
Using older *miyan*	17	46	0
With improper design of side *nalla*	55	68	50

Graph 5: Overall *miyan* construction quality



Source: CSE

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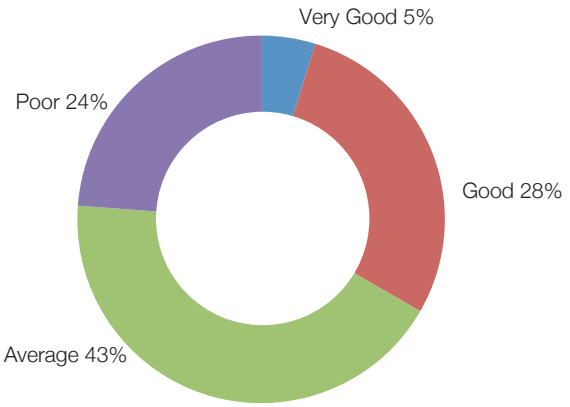
Construction of outer wall

The bricks are stacked and fired between the outer wall and the *miyan* wall. The temperature difference across the wall is huge. The temperature of the inner surface, which is in contact with the bricks being fired, is around 1,000°C and the outer surface is at an ambient temperature; therefore, the width of the outer wall becomes very important. The cold air tries to escape through the least resistant path and sometimes if the outer wall has cracks, the cold air leaks into the kiln. A solid outer wall of proper thickness and without cracks is recommended for maximum efficiency and heat utilization. Generally, the outer wall is constructed as a double brick wall, in which the cavity is filled with clay for insulation, which helps in reducing air leakage and saves on the cost of construction as well.

Twenty four per cent of the kilns surveyed had not changed their outer walls. Cracks and leaks where found in around 70 per cent of the surveyed kilns. Such kilns will fail to give the desired results and will ultimately not provide any benefit to the environment. (See *Graph 6: Overall outer wall construction quality).*

Graph 6: Overall outer wall construction quality



Source: CSE

Table 3: Percentage of kilns found with faulty construction

Percentage of kilns	Haryana	Uttar Pradesh	Rajasthan
Using older outer wall	7	36	0
With cracks and leaks	66	55	42

Kiln floor

Out of all the surveyed kilns, none of them were found to be using the recommended floor design which can help minimize heat loss. A common practice used among kiln entrepreneurs is to make the floor of the kiln with single brick soling and a layer of sand. It was found that both flat-brick soling and edge-on brick soling was used to make the floor of the kilns. Ratings in cases where the whole kiln was rebuilt, including the floor above the old floor, have been slightly higher than the others. Kilns made with fired bricks have better insulation property than the ones made with the green or un-fired bricks. (See *Graph 7: Kiln floor insulation).*

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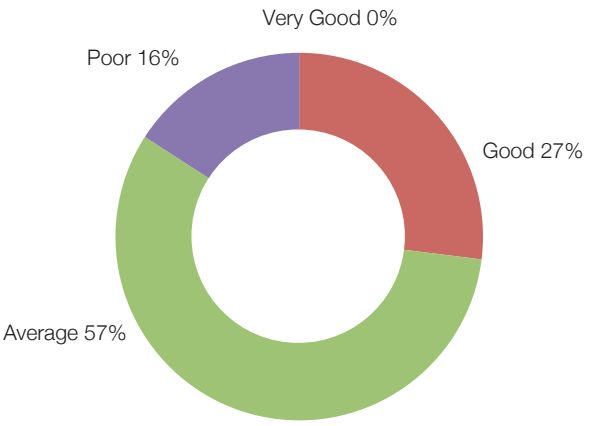
Graph 7: Kiln floor insulation



Source: CSE

In most of the cases — where jugaad technology has been adopted — no new floors have been constructed, and kiln owners have been using the same old floor. Heat loss to the surface would affect the energy efficiency of such kilns. In Uttar Pradesh, the number of kilns using old floor is the maximum. In Ghaziabad, all the surveyed kilns had used green bricks for flooring. In Rajasthan too, the use of green bricks in making the floor was found to be a common practice in both the districts

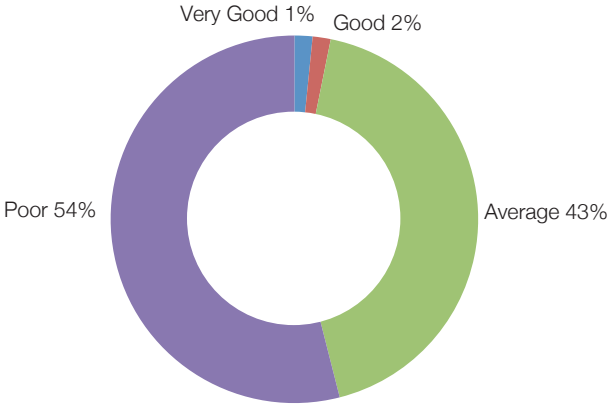
Table 4: Percentage of kilns using green brick and older kiln floors

Percentage of kilns	Haryana	Uttar Pradesh	Rajasthan
Using green bricks to make the floor	21	50	42
Using older kiln floor	7	23	0

Fuel storage

During the survey, it was found that the fuel storage facility in most of the districts were poor (see *Graph 8: Assessment of the surveyed kilns on the basis of fuel storage facility*). It was observed that some kiln entrepreneurs don't even cover the fuel with plastic sheets which can atleast help in reducing the loss of their resources in strong winds. Less than 40 per cent of the surveyed kilns had provisions to cover the fuel.

Graph 8: Assessment of the surveyed kilns on the basis of fuel storage facility



Source: CSE

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Hiding the hazardous fuel

During a survey in Muzaffarnagar, all the kilns were found to have covered their fuel with plastic sheets. One of the kiln owners then informed that a message was circulated among all the entrepreneurs informing them about the survey. The plastic sheets were placed in order to hide the hazardous fuel they were using rather than acting as a preventive method to control the emission.

Plastic sheets used for covering hazardous fuel

In Rajasthan, three cases were found where the kilns had a designated platform and an area made especially for storing fuel. However, out of all the surveyed kilns, only one — Anand Sagar Ventures in Alwar, Rajasthan — had a proper fuel storage system. In Haryana, the situation was worse as 67 per cent of the kilns were found without any designated area, cover or mechanism to control fugitive emission. A similar situation could be seen in Uttar Pradesh with 45 per cent kilns not having any designated area, cover or mechanism to control emission.

OPERATIONAL PRACTICES

Fuel feeding

Fuel feeding is an important operational practice which affects the quality of the brick directly. It is a technical job which should be carried out by skilled labors only. In zigzag kilns, the combustion zone is larger than that of the FCBTKs. The larger combustion zone provides sufficient time to the hot air flowing inside the kiln to mix with the fuel properly, heating it to the ignition temperature and resulting in complete combustion of the fuel. The proper heat utilization of the fuel helps in reduced fuel consumption.

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Another important aspect of fuel feeding in zigzag kilns is the concept of single man continuously firing fuel into the chambers, in small amounts without any breaks. It is important to use different-sized spoons for feeding different kinds of fuel — such as a smaller spoon for feeding coal and a slightly bigger spoon for feeding saw dust — into the chambers.

- *Single man firing*: One man feeds the fuel in all six chambers. This provides sufficient time for the fuel to burn completely, further solving the problem of fuel accumulation at the bottom. The accumulation of fuel at the bottom results in wastage of fuel and over-burning of the bricks at the bottom, affecting its quality.

- *Double men firing*: Two men simultaneously feed the fuel in different chambers in alternate rotations of 15–20 minutes before feeding again. The fuel fed into the chamber doesn't get sufficient time for burning and accumulates at the bottom.

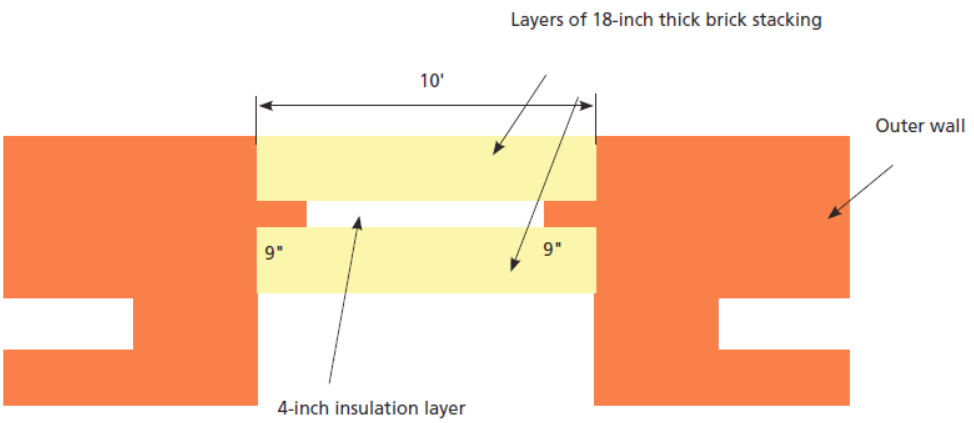
The recommended feeding process in zigzag kilns is the single man firing; however, at all the surveyed kilns, the technique of double men firing was being practiced. If complete combustion of the fuel does not take place, the overall fuel consumption will increase, which is the main reason for the black smoke from the chimney.

Wicket gate closing mechanism

In zigzag kilns, the recommended closing mechanism is to construct two 18-inch brick walls with a four-inch gap in the middle filled with ash, for better insulation (see *Figure 1: Recommended wicket-gate closing mechanism for reducing heat loss*).

Out of all the surveyed kilns, none of the kilns had the recommended wicket-gate closing mechanism. It was ony at two places, both in Uttar Pradesh, that a double wall closing mechanism was observed, that too without the recommended width of the two walls. The rest of the surveyed kilns had a single-wall closing mechanism. (See *Graph 10: Assessment of kilns on the basis of wicket wicket-gate closing mechanism)*

Figure 1: Recommended wicket-gate closing mechanism for reducing heat loss



Source: CSE, 2017

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Adopting shortcuts

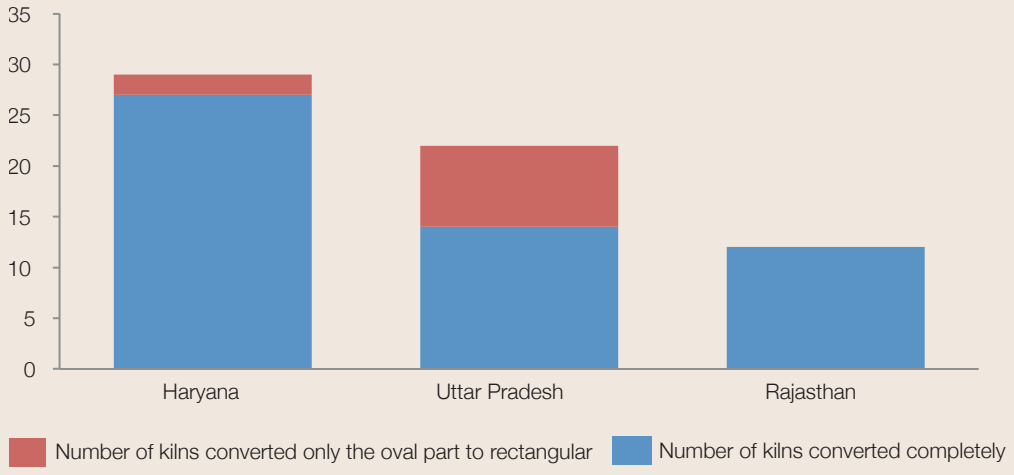
In a hope to comply with the CPCB order, most of kilns in NCR have chosen a shortcut approach. The kiln owners have used the shortcuts, where they have converted only the oval section of the kilns into rectangular ones and have not even changed their miyan. The performance of such kilns would hamper the ultimate goal of reducing emissions.

The situation in Uttar Pradesh was found to be worse after 36 per cent of the kilns were found using the shortcuts. In Haryana, two kilns were found operating with the shortcuts, while no such case was reported in Rajasthan. (See *Graph 9: State-wise distribution of kilns using shortcuts)*

Another common observation found in a few districts — such as Jhajjar, Ghaziabad, Bharatpur, Alwar and Gautambudh Nagar — was that though the kilns have been converted to zigzag they are still firing the brick in a straight line. This means that they have changed the shape of their kiln from oval to rectangular but have not changed the brick setting. This practice was found to be prominent in some of the districts.

Out of the surveryed kilns, CSE found out that around 13 per cent of the kilns were using this technology. In Jhajjar, 50 per cent of the surveyed kilns were found using the jugaad technology.

Graph 9: State-wise distribution of kilns using shortcuts



Source: CSE

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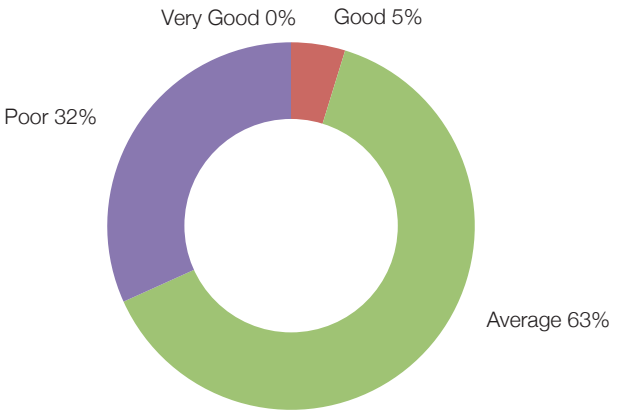
Graph 10: Assessment of the surveyed kilns on the basis of wicket-gate closing mechanism

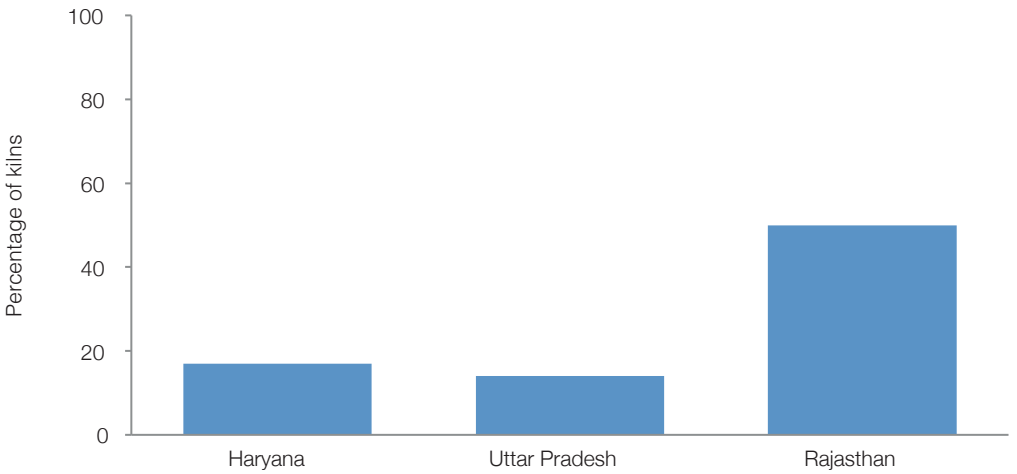


Source: CSE

Type of fuel being used

The primary fuel used for firing is coal but agricultural waste has been adopted at many places in Haryana and Rajasthan as an alternate. The simple reason behind the use of agricultural waste is its easy availability and lower price. Twenty two per cent of the total surveyed kilns were found to be using agricultural waste. The maximum use of agricultural waste was found to be in Rajasthan. (See *Graph 11: State-wise percentage of surveyed kilns using agricultural waste)*

Graph 11: State-wise percentage of surveyed kilns using agricultural waste



Source: CSE

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Table 5: Percentage of surveyed kilns using hazardous fuel

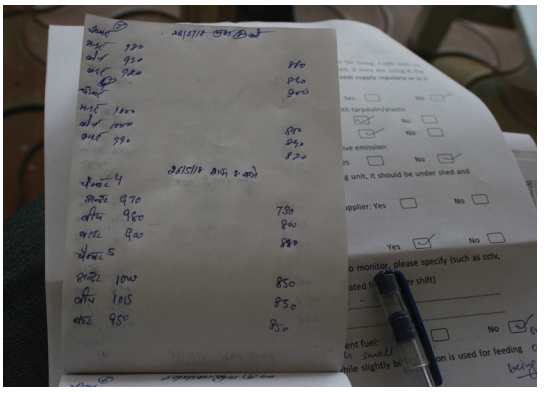
	Haryana	Uttar Pradesh	Rajasthan
Percentage of kilns using hazardous fuel	35	22	18

Apart from this, many other hazardous wastes such as carbon from tyre pyrolysis plant, rubber waste, shredded plastics, etc., were seen being used at different kiln sites. More than 30 per cent of the surveyed kilns were seen using hazardous fuel. *(See Table 5: Percentage of surveyed kilns using hazardous fuel)*

Chamber temperature monitoring and record keeping

Temperature monitoring and record keeping is also an important parameter which affects the fuel consumption pattern. Chamber temperature monitoring helps in keeping an eye on the temperature at which the bricks are being fired. It indicates when to open the new chamber for fuel feeding, and also denotes weather the chamber has reached the ignition temperature of the fuel to be fed in that particular temperature.

Out of the total converted surveyed kilns, only two (both in Haryana) had the temperature monitoring and record keeping concept. At a few other places, the kiln owners had the temperature monitoring instrument but didn't know how to use it or the significance of using it.



Temperature-monitoring and record-keeping facility at Gopal Brick Field in Rohtak, Haryana

FACILITIES PROVIDED AT THE KILN SITE

Stack monitoring facility

Emission monitoring facility is an important legal compulsion. For assessing the stack monitoring facility, the kilns were divided in two groups either good or poor depending upon whether a proper emission monitoring facility was available or not.

It was found that in only 12 per cent of the surveyed kilns, some emission monitoring facility was available. Haryana was found to be the worst state where none of the surveyed kilns had a proper monitoring facility where emission monitoring could be carried out. In Uttar Pradesh one kiln, out of the 28 surveyed, had stack emission monitoring facility. The situation in Rajasthan was little better as eight out of the 15 surveyed kilns had facility to conduct stack emission monitoring. (See *Graph 12: Assessment of the surveyed kilns on the basis of emission monitoring facility* and *Graph 13: State-wise availability of emission monitoring facility)*

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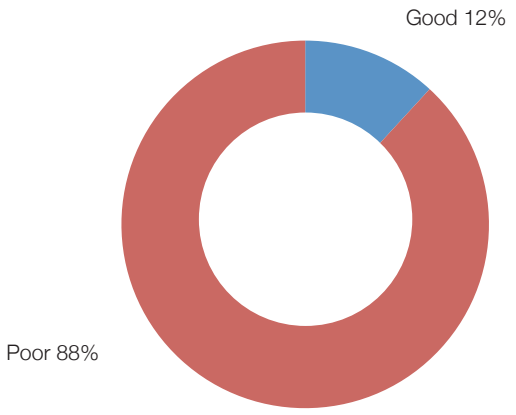
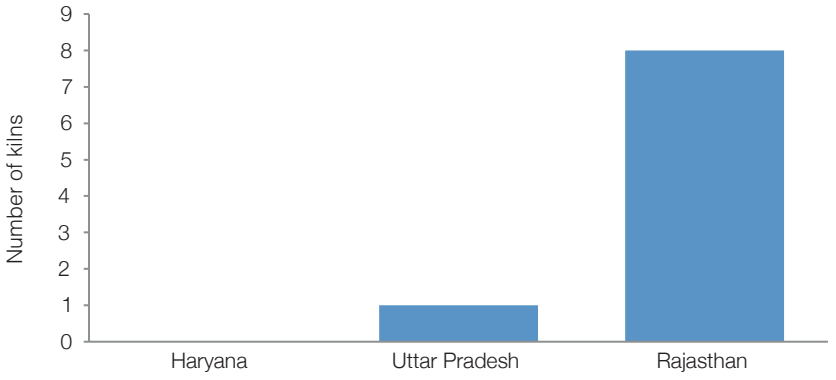
Graph 12: Assessment of the surveyed kilns on the basis of emission monitoring facility



Source: CSE

Graph 13: State wise availability of emission monitoring facility



Source: CSE

Shed provided at the kiln site

Continuous fuel feeding is one of the important parameters to improve the energy efficiency of the ZigZag kilns. For the *jalaiya*, (firemen) feeding the fuel in the kiln continuously at times becomes very difficult since there is no shed or any other facility to provide cover to the *jalaiyas*. The provision of a shed also helps in enhancing the performance of the workers and provides them with better working conditions.

Out of all the surveyed kilns, none had the shed. At the Gopal Brick Field in Rohtak, Haryana, a kiln had a few standing pillars. On further inquiry it was found that construction of a shed has been planned and will most probably be completed before next operating season.

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Pillars for a shed at Gopal Brick Field in Rohtak, Haryana

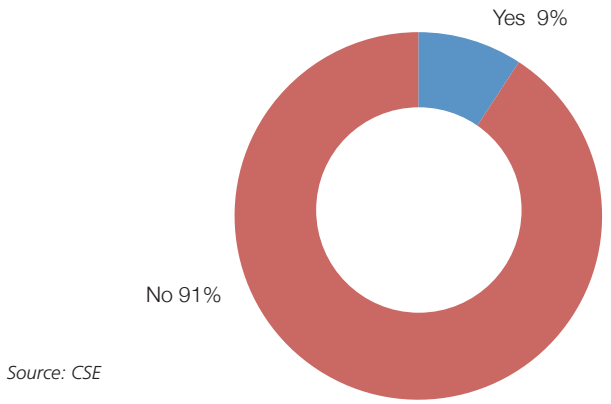
Water sprinkling facility

Fugitive emission is common at all kiln sites. The sources of emission are:

- Coal crushing unit
- Openly stored fuel
- Dust on the road within the premises of the kiln
- Rubbish stored at the kiln
- Area where green bricks are prepared

At less than 10 per cent of the total surveyed kilns, water sprinkling facilities were observed.

Graph 14: Availability of water sprinkling facility across surveyed kilns



Source: CSE

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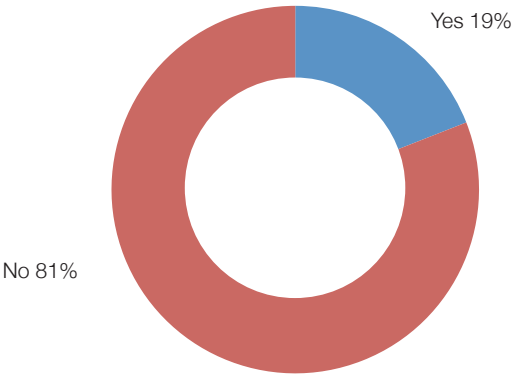
Proper electrical connection

Out of all the surveyed kilns, less than 20 per cent of the kilns were found to be having safe electricity connection with fixed lamp posts.

Graph 15: Availability of proper electrical connection across surveyed kilns



Source: CSE

The situation in Haryana and Rajasthan was a little better as around 25 per cent of the surveyed kilns were found with a proper electricity connection. In Uttar Pradesh, only two kilns out of the 22 converted kilns surveyed had proper electricity connection.

Personal protective equipment (PPE)

There has been a lot of hue and cry over the poor working and living conditions around most of the kilns and the sufferings of the workers. Brick kiln workers are mostly a 'migratory work force', and protecting their health is not a priority for the employers. The use of PPE — which

A worker with protective eye-wear at Arush Brick Field in Gautambudh Nagar, Uttar Pradesh

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is a must for the workers working under such adverse condition — was not observed even at a single site. Out of all the surveyed kilns, only one site, the Arush Brick Field in Gautambudh Nagar, Uttar Pradesh, was found to be providing protective eyewear to the workers.

COMBUSTION PERFORMANCE

The main reason why regulatory agencies have asked the kiln entrepreneurs in the region to convert to zigzag kiln was because the latter emits lesser amount of particulate matter (PM) through the chimney. This is because the combustion of the fuel takes place much more efficiently in a zigzag kiln than in the FCBTKs. The combustion performance of a zigzag kiln is influenced both by the operating practices (type of fuel, fuel-feeding practice, amount of air flow, etc.) as well as by the construction quality (amount of air leakages in the kiln, heat losses from kiln walls, etc.) of the kiln.

In order to assess improvement in combustion performance due to conversion from FCBTK to zigzag, monitoring of seven (10 per cent of the sample) kilns were carried out by CSE. Out of the seven kilns, six used zigzag technology and one used FCBTK. The six zigzag kilns were selected such that it has three each from Uttar Pradesh and Haryana. For FCBTK, monitoring was done in Haryana.

During the monitoring flue gas analysis was carried out in the flue duct system of the kilns. Each measurement lasted for 30–60 minutes duration and covered both fuel feeding and non-feeding period. The main parameters that were recorded were carbon monoxide (CO), carbon dioxide (CO_2) and oxygen (O_2). These parameters were recorded continuously at an interval of one minute. Fuel feeding status during the monitoring period was also recorded. A record was made about the general operating practices.

The results of the monitoring are summarized in Table 6: Monitoring Results. The value for CO, CO_2, O_2 and CO/CO_2 ratios have been averaged over the entire duration of the monitoring and covers both feeding and non-feeding intervals.

Incomplete combustion of the fuel (fossil fuel as coal or agricultural waste) is the major cause of emission from brick kilns. The ratio of carbon monoxide (CO) to carbon dioxide (CO_2) (i.e. the CO/CO_2 ratio) in flue gases is a good indicator of the completeness of combustion of fuel.

In an ideal case, all the carbon present in the fuel reacts with oxygen and forms carbon dioxide. This is the case when complete combustion of the fuel takes place. During incomplete combustion, all the carbon present in the fuel does not get converted to carbon dioxide but also forms carbon monoxide, and some carbon may remain unburned as carbon particles. Therefore, in the case of complete combustion, no carbon monoxide will be formed and the CO/CO_2 ratio will be zero. A lower CO/CO_2 ratio indicates better combustion and higher CO/CO_2 ratio indicates inefficient combustion, and higher combustion related particulate matter emission. (See *Graph 16: Average CO/CO_2 ratio of monitored kilns including one FCBTK)*

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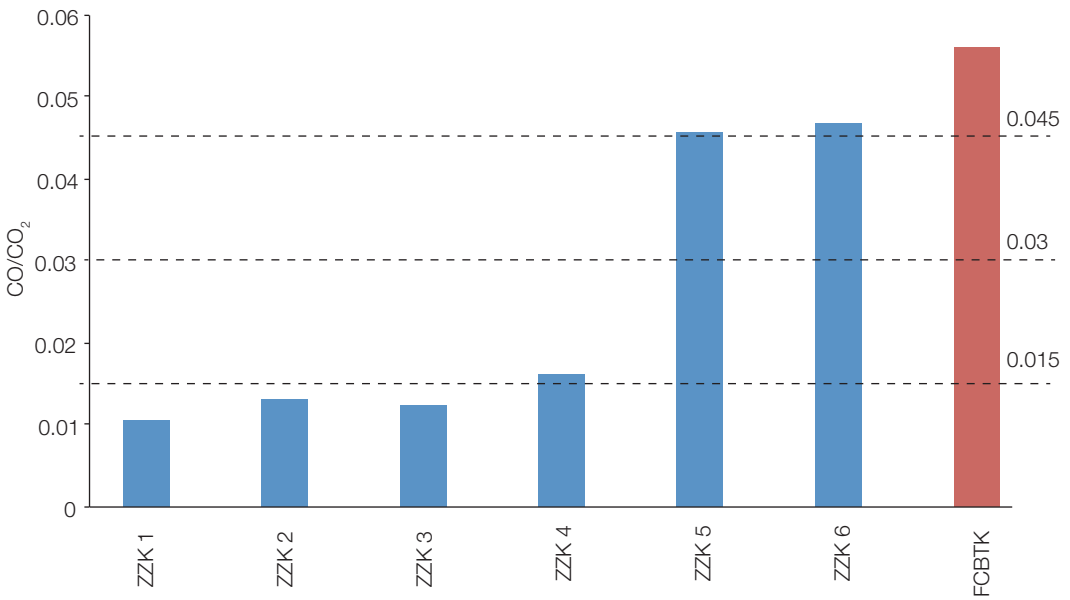
Table 6: Results of the monitored flue gas

Kiln Number	Type of Technology	State	District	Avg CO (ppm)	Avg CO2 (%)	Avg O2 (%)	Avg CO/CO2	% fuel feeding Time during monitoring	Construction quality	Operation quality
1	Zigzag	UP	Gautambudh Nagar	301	3.1	17.92	0.0101	53%	Good	Good
2	Zigzag	UP	Gautambudh Nagar	588	4.24	16.72	0.013	45%	Good	Good
3	Zigzag	UP	Gautambudh Nagar	429	3.1	18.00	0.013	47%	Good	Good
4	Zigzag	Haryana	Faridabad	708	4.02	16.93	0.016	71%	Good	Good
5	Zigzag	Haryana	Faridabad	784	1.65	19.2	0.046	62%	Average	Poor
6	Zigzag	Haryana	Faridabad	2,565	5.51	14.3	0.046	40%	Good	Poor
7	FCBTK	Haryana	Faridabad	2,692	4.51	15.96	0.056	31%	FCBTK	

Source: CSE

Graph 16: Average CO/CO_2 ratio of monitored kilns including one FCBTK



Source: CSE

It was observed that:

a) The CO/CO_2 ratio for the measured FCBTK is 0.056. This matches with the data on FCBTKs available from past monitoring which showed that average CO/CO_2 ratio for FCBTK is usually greater than 0.055 .

b) The CO/CO_2 ratio for all monitored zigzag kilns was lower than FCBTK, which indicates improved combustion performance. However, there was a wide variation in CO/CO_2 ratio of zigzag kilns. Based on the CO/CO_2 ratio values, zigzag kilns are divided into three categories — better performing, average performing and poor performing.

c) Better performing zigzag kilns (three out of six zigzag kilns) having good construction and operating practices were found to be having the CO/CO_2 ratio below 0.015, which is 70 per

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cent or more reduction compared to FCBTKs.

d) Average performing zigzag kilns (one out of six) have CO/CO_2 ratio between 0.015 and 0.03 and shows almost 50 per cent reduction compared to FCBTK.

e) Poor performing zigzag kilns (two out of six) have CO/CO_2 ratio between 0.03 and 0.045 and show only marginal improvement over FCBTK.

The results indicate that variation in the combustion performance of zigzag kilns is large and there is a vast scope of improvement in the emission profile of average and poor performing zigzag kilns by adopting good operational practices and having better design and construction quality. Then only the envisaged benefits of conversion can be achieved.

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CONCLUSION

The conversion of FCBTK to ZigZag technology not only expects to reduce the emission from the kilns but also focuses on the conservation of natural resources by reducing wastage. The expected results can only be achieved if the conversion is carried out with proper design and most importantly, if the kiln entrepreneurs adopt the recommended operational practices.

The survey of the brick kiln in Delhi NCR highlighted the decision of the brick kiln entrepreneur to obey the law; however, there were a significant number of entrepreneurs who were looking out for the ways to bypass the law and switching to some *jugaad*. The construction quality of key kiln components such as miyan, outer wall and kiln floor, and operating procedure such as fuel feeding, wicket gate closing mechanism and type of fuel being used was found to be poor in the area. Majorly the environmental benefit that was associated with the conversion of kilns were overlooked and hence not achieved. It is also pertinent to mention that a few progressive entrepreneurs have completed the conversion process effectively in order to get the desired results.

Lack of skilled and trained manpower to operate the kiln is another major problem that was observed during the survey. A lack of technological understanding among the regulators who are responsible for the implementation of the order was another common issue. Commencing the use of new technology will not solve the purpose until the kiln owners and the workers are trained.

The usage of hazardous fuels such as carbon from tyre pyrolysis plant, shredded plastics, rubber waste, etc., which is banned, was observed to be used openly without any fear. These fuels have adverse affects on the environment and humans working in the kilns. In order to deter the use of hazardous fuels, not a single action has been taken against any kiln owner by the regional SPCB officials.

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RECOMMENDATIONS

A large number of kilns, close to 2,500, in the region are yet to be converted in the coming months. It is very important for the regulatory agencies to ensure that the remaining conversion takes place with proper design and the desired environmental benefits are achieved.

Based upon the survey findings and analysis, the following recommendations are being made in order to ensure that the kilns are constructed with proper design in order to improve the operational practices and get the desired result.

- *Seminar and training*
  - District level seminars and exposure visits to ZigZag kilns for brick entrepreneurs in order to acquaint them to the new technology
  - Regular training programmes for kiln entrepreneurs as well as workers and technicians
  - Course on ZigZag technology at institutes such as ITI, etc
  - Capacity building of regulators

- *Compliance and enforcement*
  - Setting up of an expert committee at the state/district level to monitor the conversion of the kilns
  - SPCBs to work jointly with other government departments and local NGOs to stop the usage of hazardous fuels
  - Enforcing construction of platform and approach ladder to reach porthole at chimney, to facilitate stack emission monitoring
  - Data falsification in any form should be dealt with strictly without any consideration
  - SPCBs and state government should work with other institute to perform regular energy audit
  - Ensuring covered fuel storage, water sprinkling facility, concretized haul road, and use of PPEs

- *CPCB guideline*
  - CPCB needs to come up with a guideline which clearly defines zigzag kilns, which will further help the officials from SPCBs to inspect the kilns.

- *Improving operational practice*
  - Adoption of single man fuel feeding process
  - Double wall wicket gate closing mechanism
  - Use of insulated apparatuses

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ANNEXURES

ANNEXURE 1:
The list of the surveyed kilns (district-wise) along with the conversion status, and total number of bricks produced per day.

State	District	Name of the kiln	Conversion status: Complete* or committed**	Production (number of bricks per day)
Haryana				
	Rohtak	Gopal Brick Field	Complete	45,000
	Rohtak	Super Bhatta Company	Complete	40,000
	Rohtak	Viswakarma Bhatta	Complete	40,000
	Rohtak	Jeevan Singh bhatta Company	Complete	40,000
	Rohtak	Durga Ji BKO	Committed	40,000
	Rohtak	R K Bhatta	Complete	40,000–45,000
	Rohtak	Chand & Sons Bhatta Company	Complete	45,000
	Panipat	Vijay Bhatta	Complete	40,000
	Panipat	Jaglan Bhatta Company	Complete	45,000
	Panipat	Ram Bhatta	Committed	50,000
	Panipat	Ganesh Bhatta	Complete	50,000
	Panipat	Kissan Bhatta Company	Complete	50,000
	Panipat	Prateek Bhatta	Complete	50,000
	Sonipat	Ram Karan and Sons BKO	Complete	45,000
	Sonipat	Gumar Bhatta	Complete	50,000
	Sonipat	Vikas Bhatta	Complete	50,000
	Sonipat	Shiva Bhatta	Complete	50,000
	Faridabad	Sahil Brick industry	Complete	40,000
	Faridabad	Mittal Bricks Company	Committed	60,000–70,000
	Faridabad	Aggarwal bhatta Company	Complete	40,000
	Faridabad	Gupta Bhatta Company	Complete	40,000
	Faridabad	Avon Brick Kiln Company	Complete	50,000
	Faridabad	Harsn Bhatta Company	Complete	35,000
	Jhajjar	Bhagat Singh BKO	Complete	40,000
	Jhajjar	Balvir Singh Bhatta	Complete	50,000
	Jhajjar	Ravi Bhatta Company	Complete	50,000

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	Jhajjar	R D Bhatta Company	Complete	50,000
	Jhajjar	K B C Bhatta	Complete	50,000
	Jhajjar	Shiv Bhatta	Complete	50,000
	Palwal	Maha Laxmi Ent Udyog	Complete	40,000
	Palwal	Shiv Bricks Udyog	Complete	50,000
	Palwal	Dev Bhatta	Complete	40,000–50,000
	Palwal	Hari Om Brick Kiln Company	Complete	50,000
Uttar Pradesh				
	Hapur	Classic Brick Field	Complete	40,000
	Hapur	Deepak Bricks Field	Complete	40,000
	Hapur	Avon Brick Work	Committed	36,000–40,000
	Hapur	Ent Udyog Kate Kheda	Under construction	NA
	Hapur	Bharat Brick field	Complete	36,000–40,000
	Baghpat	Devta Brick field	Complete	32,000
	Baghpat	Kohinoor Bhatta Company	Complete	32,000
	Baghpat	Dilli Brick Field	Complete	80,000—1,000,000
	Baghpat	Jyoti Brick field	Committed	50,000
	Baghpat	Shiv Janta Brick field	Committed	40,000
	Baghpat	Gangotri Brick field	Complete	40,000
	Baghpat	Hanuman Brick field	Complete	40,000
	Gautam Budh Nagar	Kartik Brick field	Committed	35,000
	Gautam Budh Nagar	Shri Gamesh Ent Udyog	Complete	35,000
	Gautam Budh Nagar	Arush Bhatti Brick field	Complete	50,000
	Gautam Budh Nagar	Om Ent Udyog	Complete	40,000
	Gautam Budh Nagar	Jai Baba Mohan Rao Brick Udyog	Complete	40,000
	Ghaziabad	Dev Brick Field	Complete	40,000–45,000
	Ghaziabad	Choudhary Bhatta Company	Complete	40,000–45,000
	Ghaziabad	B R Realcon Pvt Ltd	Complete	50,000
	Ghaziabad	Mukul Brick Field	Complete	40,000–45,000
	Ghaziabad	Ankit Bhatta Company	Complete	40,000–45,000
	Muzaffarnagar	Shakombri Brick field	Complete	45,000–50,000
	Muzaffarnagar	Aakash Brick field	Complete	40,000
	Muzaffarnagar	Pawnan Brick field	Complete	40,000

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	Muzaffarnagar	Kissan Ent Bhata	Complete	40,000
	Muzaffarnagar	Sri Shiv Brick field	Complete	40,000
	Muzaffarnagar	Sharma Brick field	Committed	35,000
Rajasthan				
	Bharatpur	Zamindar Bricks Company	Complete	50,000
	Bharatpur	Balaji Eent Udyog	Complete	20,000–25,000
	Bharatpur	R.B Kapttan Eent Udyog	Not commited	35,000–40,000
	Bharatpur	Sri Ganga Eent Udyog	Complete	40,000
	Bharatpur	Jai Shree Krishna Bricks Udyog	Complete	40,000–45,000
	Bharatpur	Goyal Eent Udyog	Committed	55,000
	Bharatpur	Faujdar Brick Udyog	Complete	40,000–45,000
	Alwar	Anand Sagar Ventures	Complete	45,000–50,000
	Alwar	Gulati Bricks	Complete	45,000–50,000
	Alwar	Surya Bricks	Committed	40,000
	Alwar	Mangla Bricks	Complete	40,000
	Alwar	Raja Bricks	Complete	50,000
	Alwar	Ajay Bricks	Complete	45,000–50,000
	Alwar	Sammer Bricks	Complete	45,000–50,000
	Alwar	Aman Bricks Bhatta	Complete	10,000–12,000

**Complete refers to the status of brick kiln being converted to ZigZag from FCBTK*
***Committed refers to the status of brick kiln yet not converted to ZigZag from FCBTK but willingness to convert in following season*

ANNEXURE 2:
Indicators of assessment and analysis

Indicator	Very good	Good	Average	Poor
Miyan wall	Newly constructed miyan, side nali dimensions height 2.5–3 ft; width 2.5 ft, clay coating on the miyan wall in good condition, expansion joints provided, without any cracks and leaks, side nali at equal intervals	Newly constructed miyan, side nali dimensions height 2.5–3 ft; width 2.5 ft, clay coating on outer miyan walls, no cracks or leaks on walls, side nali at equal intervals	(3) Newly constructed miyan, side nali dimensions height 3.5–4 ft; width 2–2.5 ft, clay coating on miyan walls, no cracks or leaks on walls, side nali at equal intervals (2) old miyan with side nails dimensions of height 2.5–3 ft; width 2.5 ft, clay coating on miyan walls, no cracks or leaks on walls, side nali at equal intervals	Old miyan, side nali dimensions height 3.5– 6 ft; width 1.5–2.5 ft, side nails at equal intervals

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Outer wall	Newly constructed, solid wall with adequate width (above 6.5 ft), cement plastering on the outside and clay coating on the inside, without cracks/leeks, and an extended wall to store the rubbish	Newly constructed, walls with insulation width above 7.5 ft, cement/clay plastered on the outside and clay coating on the inside, in good condition, without cracks/ leaks, and an extended wall to store the rubbish If the wall is solid but no plastering on the outside with width above 7 ft, and an extended wall to store the rubbish	(3) newly constructed, walls with insulation width between 6–7.5 ft, clay plastering on the outside, in good condition with minor cracks, and an extended wall to store the rubbish (2) old walls, walls with insulation width above 7.5 ft, clay plastering on the outside, in good condition with minor cracks	Old walls, walls with poor insulation, width below 7.5 ft, with/without any plaster on the outside, in poor condition with major cracks/ leaks
Fuel feeding	Continuous feeding in six chambers, coal and saw dust being used, different spoon used for feeding of different fuel, temperature monitoring and recording keeping mechanism for fuel feeding	Continuous fuel in six chambers, coal and saw dust used for firing, different spoons available for fuel feeding. Temperature monitoring mechanism available, no record keeping	(3) Continuous fuel feeding in six chambers, coal and saw dust, and wherever agricultural waste is being used—firing in two chambers (in a ZigZag setting), feeding done with the same spoon, no temperature monitoring mechanism. (2) Fuel feeding not continuous, but being done in six chambers, same spoon used. No temperature monitoring mechanism.	Intermittent feeding. Using other fuels than recommended such as carbon, plastic waste, waste from rubber industries, etc.

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Wicket gate closing	Double wall closing mechanism implemented. With an 18-inch inner wall and an 18-inch outer wall, separated by 4-inch insulation, Clay plastering in good condition and plastic covering No cracks/leaks at the gate	Double wall closing mechanism implemented. With a 15-/18-inch inner wall and a 15-/9-inch outer wall separated by insulation, Clay plastering in good condition and plastic covering, No cracks/leaks at the gate	(3) Single wall closing mechanism, wall construction of atleast three bricks, Wall should be plastered with clay and in good condition, plastic cover should also be provided, minor cracks and leaks observed in the gate. (2) single wall closing mechanism, Wall constructed with equal to or more then 2 bricks, Provided with clay plaster or clay coating and plastic cover, Minor cracks observed in the wall.	Single wall closing mechanism made of equal to or less than two bricks. Wall not provided with any plaster or clay coating, no plastic coveringMajor cracks observed on the wall.
Kiln floor	New floor made of two layers of fired bricks and two sand layers separated by an aluminum sheet	New floor made of single-layer fired bricks with edge on soling and sand layer, new floor is constructed above older floor	(3) Made of single layer fired bricks with edge on soling and sand layer for labeling (2) New floor made of single layered green bricks with flat/edge on soling	Older floor being used
Fuel storage	Designated area with proper platform, shed and walls on all sides, coal crushing machine with provisions to control fugitive emissions present, and fuel covered with plastic sheets.	Designated area with proper platform and side walls without shed, coal crushing machine with provisions to control fugitive emissions present, and fuel covered with plastic sheets.	(3) Either a proper platform or shed provided for storage of fuel, fuel covered with plastic sheet, no side walls present and coal crushing mechanism without provision to control fugitive emissions. (2) No provision of a proper platform or shed provided for fuel storage, fuel covered with plastic sheet, no provisions of controlling fugitive emissions	No designated area for the purpose of fuel storage. Fuel is not covered with plastic sheet, and no provisions made for controlling fugitive emissions.

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Overall housekeeping	Premises gated and surrounded by a solid boundary wall, kiln details on a board at the gate; GST number as well as the latitude and longitude of the kiln. Construction of concrete haul road within the premises, Presence of greenery around the premises along with a separate water sprinkling system, PPE provided to workers for their security Well-equipped and well-constructed hostel with a permanent roof and toilet facilities for workers. Shed on the kiln and shed for storing green bricks.	Premises gated and surrounded by a solid boundary wall, kiln details on a board at the gate, gst number and latitude and longitude of the kiln. Construction of concrete haul road within the premises, Presence of greenery around the premises along with separate water sprinkling system, PPE provided to workers for security of the workers and presence of well equipped and well Constructed hostel, permanent roof and toilet facilities for workers.	(3) Premises not gated and surrounded by a solid boundary wall, Kiln details on a board at the entrance,, GST number as well as the latitude and longitude of the kiln. Haul road within the premises are not concretized, presence of greenery around the premises along with a separate water sprinkling system, PPE provided to workers for security of the workers and presence of well-constructed hostel with tin sheds and toilet facilities. (2) Premises not gated but surrounded by a solid boundary wall. Kiln details on a board at the gate, the kiln's GST number, as well as the latitude and longitude of the kiln. Haul road within the premises are not concretized, presence of greenery around the premises No separate water sprinkling system, No PPE provided to the workers but a well-constructed hostel with tin sheds and toilet facilities for workers is available.	Premises not gated but surrounded by solid boundary wall No board at the entrance with kiln details, the GST number or the latitude and longitude of the kiln. Haul road within the premises are not concretized, Presence of greenery around the premises is very less, No water sprinkling system, No PPE Hostel facility with tin sheds is provided but no toilet facilities for workers.

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Apparatus used	The shunt on the kiln has been provided with glass wool insulation and a shunt meter to manage and monitor the flue gas. The site has been provided with an insulated *tawa* to prevent the heat loss. Temperature meter for monitoring chamber temperature.	The shunt on the kiln has been provided with glass wool insulation and a shunt meter to manage and monitor the flue gas. The site has been provided with an insulated tawa to prevent the heat loss. No chamber temperature monitoring mechanism is available.	(3) The shunt on the kiln has been provided with glass wool insulation but shunt meter is not present to manage and monitor the flue gas. An insulated *tawa* is being used to prevent the heat loss. No chamber temperature monitoring mechanism is available. (2) The shunt on the kiln has been provided with glass wool insulation but shunt meter is not present to manage and monitor the flue gas. The *tawa* being used is not insulated to prevent the heat loss. No chamber temperature monitoring mechanism is available.	The glass wool coating on the shunt is not provided neither any temperature meter is present to manage and monitor the flue gas. *Tawa* being used is not insulated to prevent the heat loss. No chamber temperature monitoring mechanism is available.

- *Stack emission monitoring facility* – For assessing kilns on emission monitoring facility, the kilns were divided in two groups either good or poor, depending upon whether a proper emission monitoring facility was available or not.

- *Proper electrical connection keeping in mind the safety of the workers* – The assessment of the kilns was also done in two groups—either good or poor depending upon whether the kiln has a proper lighting system throughout with a fixed lamp post and wiring within the conduit pipe or not.

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The Delhi-National Capital Region (NCR) has been in the grip of severe air pollution. The crisis is not confined just to the National Capital Territory (NCT) but affects all the 22 districts of the NCR. The contribution from brick kilns is significant—the brick-making sector has been identified as one of the key sources of air pollution in the region.

To deal with pollution from brick kilns, the EPCA in May 2017 ordered all kilns in Delhi-NCR to switch to cleaner technology. This study was undertaken to assess the status of conversion following the EPCA order. The focus was to understand the ground reality and analyse the quality of conversion.

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