Low Carbon and Resource Efficient Technology: Scaling Up of Fly Ash Brick Technology in India

Development Alternatives

Low Carbon and Resource Efficient Technology: Scaling Up of Fly Ash Brick Technology in India

Key Messages

- The fly ash generation in India has increased immensely due to increased energy requirements of the population of the country. The utilisation of fly ash in various sectors has also increased progressively over the years.
- Use of fly ash in the manufacture of bricks gives an opportunity not only to manage the increasingly generated fly ash but also to reduce the environmental footprint of the brick sector of India.
- Few pockets of the country have successfully adopted fly ash brick technology. Several drivers have been instrumental in accelerating the adoption of this technology
- Policy push in the form of regulations and incentives by the central and state government is a major driver for the promotion of fly ash brick technology
- The market demand of fly ash bricks is fuelled by increasing construction and decreasing profitability of red bricks
- Increasing level of awareness among the consumers and entrepreneurs is helpful in alleviating the concerns regarding the fly ash bricks
- The active engagement of civil society organisations has been crucial in scaling up the technology
- Barriers remain in terms of weak enforcement of policies, lack of quality control and the reluctance of banks in granting loans

Executive Summary

Fly ash is produced during the combustion of coal in thermal power plants. As a result of the increased energy requirements of the country, fly ash generation in the country has increased massively. A 99.31 percent increase has been observed from 1947 to 2012-13. Such a quantum of increase is a cause of concern due to its inadequate management and disposal. With the increasing fly ash generation in the country, the utilisation levels have also increased. 61.37 percent of fly ash was utilised in 2012-13.

It can be used as a raw material in various sectors including construction. Its prime use is in the use of Portland Pozzolana cement. Other emerging use of fly ash is in the manufacture of bricks. Fly ash bricks are made from fly ash, lime, and gypsum and/or cement. These bricks are a suitable alternative to red bricks. Apart from the conservation of top soil, they also don't emit greenhouse gases during the production process. India is one of the largest producers of bricks in world, second only to China. However, the current practices of brick production are dependent on resource and energy inefficient technologies like the Fixed Chimney Kilns (FCKs). The sector emits 41.6 million tonnes of carbon-dioxide, accounting for 4.5 percent of the total GHG emissions from India. With the rising demand of bricks, the environmental implications will only worsen. Therefore, it is necessary to mainstream low carbon and resource efficient brick production technology like fly ash bricks. Currently, only 9.94 percent of the total fly ash utilised is used for the production of building materials like bricks/blocks/tiles. According to calculations, around 2800 fly ash units are present in the country producing 6.65 billion bricks annually. The major fly ash brick producing areas in the country are Maharashtra, Chhattisgarh, West Bengal, Andhra Pradesh, Tamil Nadu, Delhi, Odisha and Bihar. The use of fly ash bricks has picked up in the country, though their usage is disproportionate across the country. They are increasingly being used for construction of buildings rather than merely boundary walls.

The task of promotion of use of fly ash as a resource material for use in construction and other purposes was undertaken by various stakeholders including government departments and ministries and academic and R&D institutions. The responsibility of formulation and implementation of policies and schemes to promote fly ash brick technology lies with the central and state government. The notification numbered S.O. 763 (E) of Ministry of Environment, Forests and Climate Change and the Fly Ash Mission of Department of Science and Technology have played a crucial role in the uptake of the technology through technology demonstration, easy access to fly ash and mandatory use of fly ash bricks in construction. Initiatives by the state government include incentives for fly ash units under their industrial policies and preferential procurement of fly ash bricks for public construction. Fly ash is supplied to the entrepreneurs by both public and private coal based power plants. Other stakeholders include support agencies like research institutes, banks and financial institutes and civil society organisations, technology service providers and consumers including private builders and government departments.

Policy push is a major driver for accelerating the uptake of the technology. The concerns of the government regarding the management of fly ash is reflected in the policies and schemes formulated by the government. However, better enforcement of these policies is required. More states need to incentivise entrepreneurs to set up more units. Market is the most important factor in facilitating a shift from the conventional resource inefficient technologies to fly ash brick technology. Increasing brick demand presents an opportunity to shift towards low carbon and energy efficient fly ash

brick technology. Reduced profit margins of red bricks due to increased coal prices aid this transition. Other drivers include heightened awareness among the entrepreneurs as well as consumers, ease of access of technology and the active engagement of civil society organisations in promoting the technology. However, a few barriers like weak enforcement of policies, lack of market demand of fly ash bricks, lack of access to finance and the lack of quality control needs to be addressed to popularise the use of fly ash bricks in other parts of the country. The success of the uptake of fly ash technology in few pockets of the country like Odisha should be replicated in other parts as well.

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1. INTRODUCTION

163.56 million tonnes of fly ash were generated in India in 2012-13 (CEA, 2014). The massive amount of fly ash generated in the country has been the topic of discussions and discourse across government and industries alike. Increasing fly ash generation is fast becoming a menace for the country.

Fly ash, a finely divided residue is produced during the combustion of coal in thermal power plants. Electricity generation in the country is predominantly coal based. As of 2013, the installed capacity of coal based power plants is 134,388.39 MW which is 58.75 percent of the total installed capacity of the country[1]. Unfortunately, Indian coal is of low grade having ash content as high as 45 percent in comparison to imported coals which have a low ash content of 10-15 percent (CEA, 2014). Hence, large quantities of fly ash are generated at the coal/lignite based thermal power plants. It not only requires a huge area of land for disposal, but is also one of the sources of air and water pollution.

1.1. Trends in Fly Ash Generation and Utilisation

The energy requirements of the country have increased tremendously over the years. This is evident by the fact that the installed capacity of thermal power has increased from 1362 MW in 1947 to 228,721.13 MW in 2013 (Chandra and Chandra, 2004; CEA, 2011). As a result, the production of fly ash has also increased progressively in the country. The annual generation of fly ash increased from 1 million tonnes in 1947 to around 40 million tonnes in 1994 (Singh and Gupta, 2014). The quantity of fly ash generated has increased to 145.42 million tonnes in 2011-12 from 68.88 million tonnes in 1996-97. In a space of one year, the ash generation increased by 11 percent to 163.56 million tonnes in 2012-13. Maximum fly ash has been generated in Uttar Pradesh (22.25 million tonnes in 2012-13). Six other states including Odisha, West Bengal, Maharashtra, Madhya Pradesh, Chhattisgarh and Andhra Pradesh produced more than 10 million tonnes of fly ash each. These seven states generate over 71.5 percent of the total fly ash generated in the country. However, the utilisation of fly ash has also increased. Over the years, the utilisation has increased to 61.37 percent in 2012-13 (CEA, 2014).

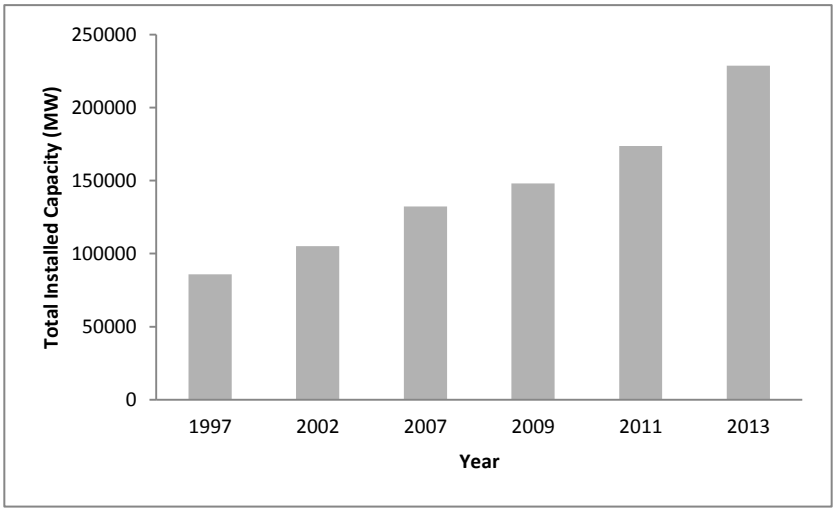


Figure 1: Growth in Total Installed Capacity of the Country (Source: CEA, 2011; www.powermin.nic.in)

[1] www.powermin.nic.in

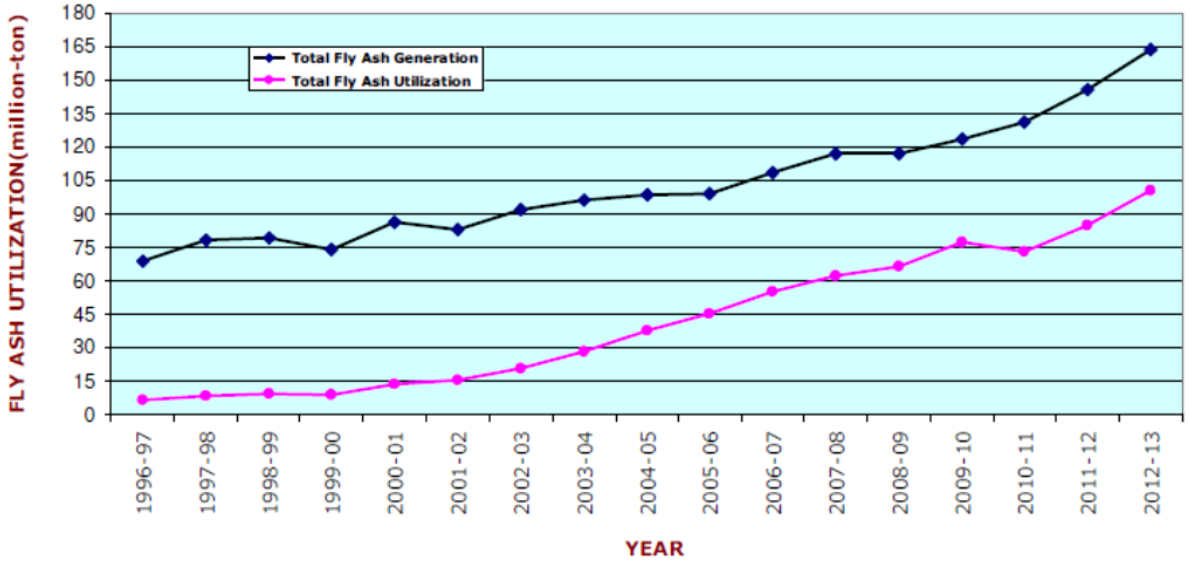


Figure 2: Progressive Fly Ash Generation and Utilisation in India (Source: CEA, 2014)

1.2. Uses of Fly Ash

Fly ash is increasingly being used as a resource material rather than waste. Extensive researches have proved that fly ash can be used in various sectors. It can be used for the reclamation of low-lying areas, resulting in conservation of top soil. It can also be used for backfilling of open cast mines and stowing of underground mines which results in saving of top fertile soil and river sand. Fly ash is particularly suitable for use in the construction sector. The varied uses of fly ash in construction are elucidated below.

As Raw Material for Production of Building Materials

- Aerated light-weight cellular blocks and slabs
- Precast blocks for footpaths
- Clay bonded fly ash bricks/blocks
- Sand lime fly ash bricks
- Precast fly ash concrete building elements/components

As Pozzolana in Cement

- Portland pozzolana cement
- Lime-pozzolana binders as masonry cement

Infrastructural Applications

- Fly ash-soil mix for soil stabilization in road construction
- Lime-fly ash bound macadam in upper layers of road pavements
- Lime-fly ash stabilization of silty/black-cotton/red soils in sub-base course of road pavements.
- Bituminous concrete in surfacing of roads
- As fill-in highway embankments

The use of fly ash in Portland Pozzolana cement has emerged as prime method of utilisation in the country. Conservation of both limestone and coal and enhancement of the durability of resulting structures has amplified the use of fly ash. This practice will reduce the environmental footprint of the cement sector, especially when the cement production is poised for further increase on account of infrastructure development and construction boom in the country. During the year 2012-13, the maximum utilization of fly ash to the extent of 41.18 percent of total fly ash utilized was in the cement sector. It was followed by 11.78 percent in reclamation of low lying area, 10.89 percent in ash dyke raising, 10.30 percent in mine filling, 9.94 percent in making bricks & tiles, 6.00 percent in roads & embankments etc (CEA, 2014).

1.3. Use of Fly Ash in the Production of Building Materials

Fly ash can be used for the manufacture of building materials like bricks, blocks, tiles etc. They are appropriate alternative to clay based conventional building materials. The use of fly ash bricks for construction is slowly gaining popularity in India.

Usually, such bricks are made from fly ash, lime and gypsum and/or cement. They are subjected to curing and drying to produce non-fired fly ash bricks. Similar to red bricks, these bricks are also suitable for use in construction (BIS, 2002).

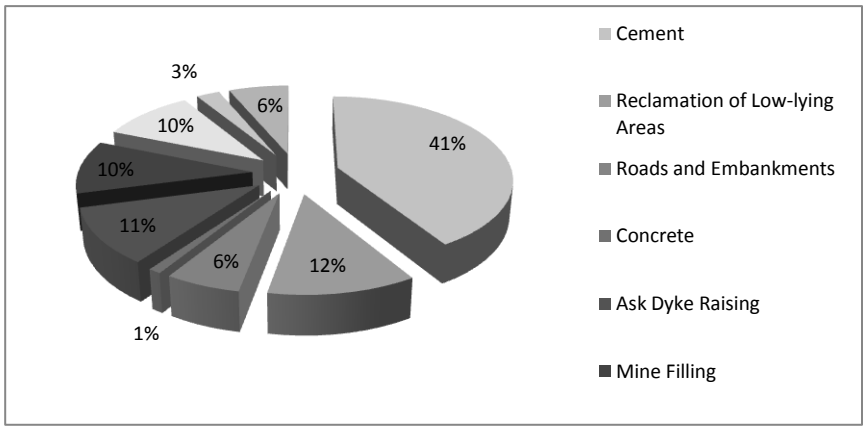


Figure 3: Modes of Utilisation of Fly Ash in 2012-13 (Source: CEA, 2014)

Fly ash bricks can have high compressive strength upto 35-350 kg/cm2 and low water absorption capacity (15-20 percent) (BIS, 2002). The strength of the bricks depends on the ratio of the raw materials. These bricks have a low environmental footprint as compared to the red bricks produced by conventional technologies as greenhouses gases are not emitted during their production. They also conserve top soil (BMTPC, ND).

1.4. The Need for Accelerating Fly Ash Brick Technology

India is the second largest producer of clay fired bricks, second only to China. It accounts for more than 10 percent of global brick production. With over 150,000 brick kilns, India produces a whopping 150-200 billion bricks annually (Maithel et al. 2012). Unfortunately, the brick industry of the country mostly employs conventional techniques such as clamps and Fixed Chimney Bull's Trench Kilns (FCBTKs). These conventional technologies are highly energy intensive and resource inefficient. Brick kilns consumed about 35 million tonnes of coal per year (Lalchandani and Maithel, 2013). The total carbon-dioxide (CO_2) emissions are estimated at 41.6 million tonnes accounting for 4.5% of total GHG emissions from India (DA, 2012). This makes the industry one of the

primary drivers of climate change. It is also responsible for other harmful emissions like sulphur-dioxide (SO2), nitrous oxide (NOX), carbon monoxide (CO) and particulate matter, affecting the local population and agricultural land. In addition to coal, fertile top soil is also utilised as raw material for brick production. The industry is estimated to consume 350 million tonnes of top soil every year, exerting enormous pressure on the agricultural land and food security of the country (DA, 2012).

Economic mutations and rapid urbanisation has resulted in a surge in construction activity. In India, the urban population has grown at a rate of 3.35% a year since 2001, fuelling a huge demand for urban housing2. The total housing shortage in the 12th plan period (2012-17) was estimated to be 62.47 million. (Ministry of Housing and Urban Poverty Alleviation, 2012; Ministry of Rural Development, 2011). These baffling numbers will fuel an increase in the brick demand. With the current practices, the environmental implications will only worsen. Therefore, it is necessary to adopt low carbon and resource efficient brick production technologies. Fly ash brick technology is a suitable alternative to conventional red brick production.

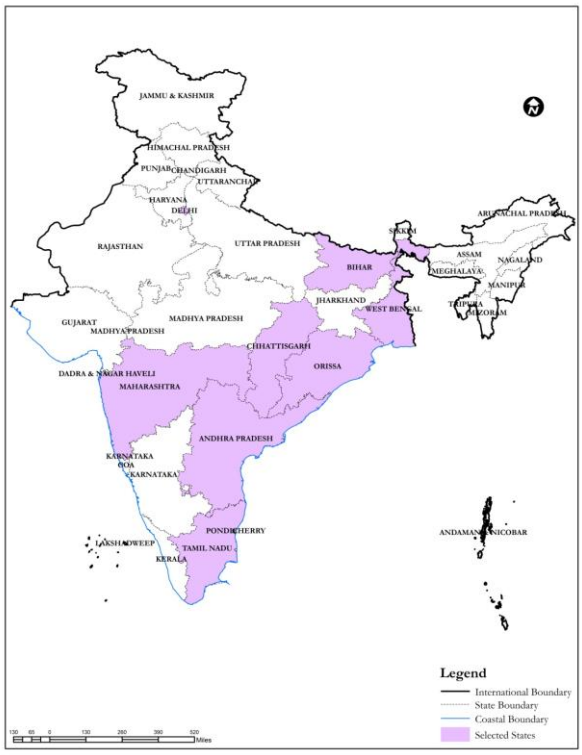


Figure 4: Major Fly Ash Brick Producing States in India

Currently, only 9.94 percent of the total fly ash utilised is used for the production of building products like bricks/ blocks/ tiles etc. In absolute numbers, the utilisation in building products has increased from 0.70 million tonnes in 1998-99 to 9.98 million tonnes in 2012-13. Around 2800 fly ash units are present in the country producing approximately 6.65 billion bricks annually[3]. Currently, the market share of fly ash bricks is only 3 percent as compared to the red brick production. The major fly ash brick producing areas in the country are Maharashtra, Chhattisgarh, West Bengal, Andhra Pradesh, Tamil Nadu, Delhi Odisha and Bihar.

[2] www.censusindia.gov.in

[3] Calculated by DA assuming 50 percent of a 3 kg brick is made of fly ash and the average brick production capacity is a plant is 24 lakhs per year

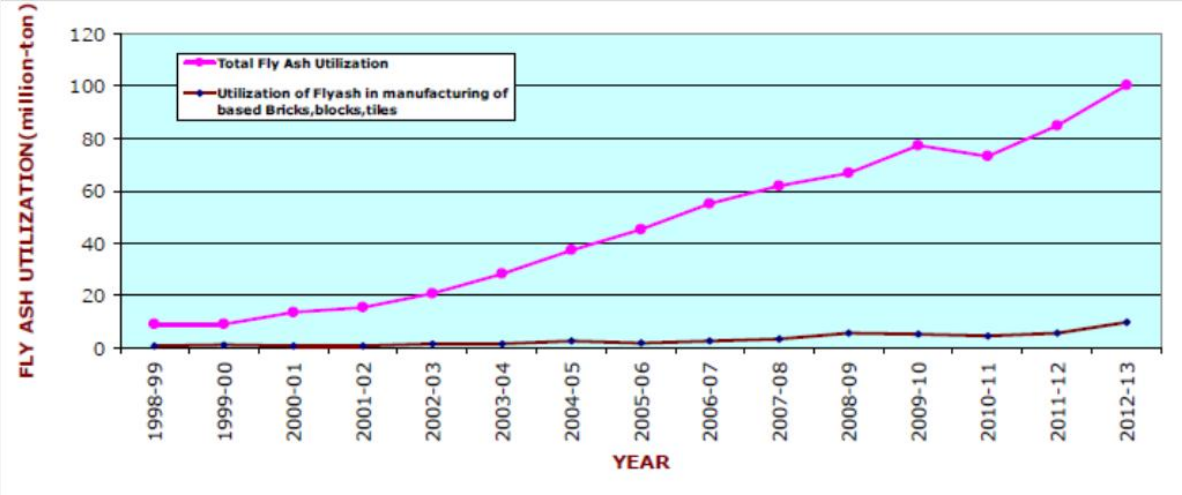


Figure 5: Progressive Utilisation of Fly Ash in the Manufacture of Fly Ash Based Bricks/Blocks/Tiles (Source: CEA, 2014)

The use of fly ash bricks has also picked up in the country. A transition has been seen in the use of bricks. Fly ash bricks are increasingly being used for construction of buildings rather than boundary walls. However, their usage is disproportionate across the country. Few examples of successful utilisation of fly ash include the offices of National Thermal Power Corporation (NTPC), American Embassy and Greater Noida Development Authority.

2. KEY STAKEHOLDERS

The brick sector of India is unorganised. Due to its inherent nature of working, various stakeholders are associated directly or indirectly with the sector. The task of promotion of use of fly ash as a resource material for use in construction and other purposes was undertaken by various stakeholders including government departments and ministries and academic and R&D institutions.

The stakeholders involved can be divided into the following categories:

2.1. Government Ministries and Departments

Government ministries and departments are involved in the formulation and implementation of the policies related to fly ash brick production.

Central Ministries and Departments

- **Ministry of Environment, Forests and Climate Change** : Leading the efforts in promotion of fly ash utilisation is the Ministry of Environment, Forests and Climate Change (MoEF). The MoEF issued the notification numbered S.O. 763 (E)[4] on fly ash utilisation in 1999 and made it mandatory for construction agencies near thermal power plants to utilise fly ash bricks. The Clean Technology Division of the MoEF promotes the adoption of cleaner technologies by facilitating their demonstration through pilots and establishment of clean technology park and training of entrepreneurs on cleaner production measures. The work on parks will be initiated after the model of a park is finalised. This division also focuses on fly ash utilisation methods.
- **Ministry of Micro, Small and Medium Enterprises** (MSME) : MSME facilitates the promotion, development and enhancement of competitiveness of micro, small and medium enterprises. MSME promotes fly ash brick industry as it is a small enterprise. Schemes like the Prime Ministers Employment Guarantee Fund (PMEGP) also fall under the purview of the MSME.
- **Ministry of Power** : The Ministry is concerned with perspective planning, policy formulation, processing of projects for investment decision, monitoring of the implementation of power projects, training and manpower development and the administration and enactment of legislation in regard to thermal power generation. It handles all the matters related to the National Thermal Power Corporation (NTPC) and Central Electricity Authority (CEA). CEA monitors the generation and utilisation of fly ash in the country and makes the information available for public use.

  Coal based **thermal power plants** are the major ash producers in the country. The total installed capacity of coal based thermal power plants of the state and central level is 155,795.08 MW. According to the notification numbered S.O. 763 (E) of MoEF, the thermal power plants are mandated to utilise the 100 percent of generated fly ash from the date of the issue of the notification. In order to utilise the fly

[4] Ministry of Environment and Forests (2009). Notification, 14th September 1999, Part II – Section 3, Subsection (ii).

ash, they should provide 20 percent of the fly ash free of cost to entrepreneurs manufacturing fly ash bricks.

- **Department of Science and Technology** (DST) : DST supports research and development of new technologies, commercialization of indigenous technology or adaption of imported technology to wider domestic application and entrepreneurship development. DST has been instrumental in increasing the fly ash utilisation in the country through development and demonstration of technology by the Fly Ash Mission. Fly Ash Mission is a joint initiative by the DST, Ministry of Power and MoEF. The focus of the mission is on demonstration of fly ash related technologies for developing confidence and thus ensuring large scale adoption.
- **Central Public Works Department** (CPWD): CPWD is entrusted with the construction of roads, buildings and bridges in the state. They have a schedule of rates with the basic materials in which fly ash bricks are included. The schedule of rates is updated regularly updated by PWD. Inclusion of fly ash bricks in the schedule of rates mandates the utilisation of fly ash bricks in public construction, promoting the uptake of the technology.
- **Bureau of Indian Standards** (BIS) : BIS formulates technical standards. It has formulated standards for fly ash lime bricks and burnt clay fly ash bricks.
- **Central Pollution Control Board** (CPCB) : CPCB advices the Central Government on matters related to pollution. It also provides technical assistance and guidance to State Pollution Control Boards for prevention of pollution. Action plans for the utilisation of fly ash have to be submitted to CPCB by the thermal power plants.
- **Building Materials Technology Promotion Council** (BMTPC) : The Building Materials Technology and Promotion Council was set up in 1990 under the aegis of Ministry of Housing and Urban Poverty Alleviation (MHUPA). It strives to bridge the gap between research and development and large scale application of innovative building material technologies. It has been instrumental in the introduction of fly ash brick technology. It also lends policy support to the Government of India in matters related to natural resource conservation, environmental degradation, waste minimisation etc. In order to spread awareness and create confidence in the area of energy efficient and environment friendly technologies, the Council regularly takes up construction of demonstration structures such as houses, informal markets, school buildings, community buildings etc. It also has been involved in the formulation of BIS standards of fly ash bricks.
- **Housing and Urban Development Corporation** (HUDCO) **:** HUDCO is a premier techno-financing company promoting sustainable habitat development. Apart from the financing operations, HUDCO offers consultancy services, promotes research and studies and help propagate use of local building materials, cost-effective and innovative construction technologies. The scheme of National Network of Building Centres was implemented through HUDCO. This scheme promotes building materials produced out of industrial wastes like fly ash through demonstration of the technology and training of the workforce. HUDCO also supports the entrepreneurs by extending term-loan support to them.

State Departments and Ministries

The departments at the state level are responsible for the implementation of the regulations and policies formulated by the central ministries and departments.

- **Department of Environment and Forests** (DoEF) : DoEF is responsible for the improvement of the environmental quality and safeguard the forests and wildlife of the state. DoEF also ensures compliance with the notification of MoEF, S.O. 763 (E). The thermal power plants are stipulated to submit their action plans for utilisation of fly ash and annual implementation reports to DoEF.
- **State Pollution Control Boards** (SPCBs) : SPCBs implement the national guidelines on pollution control. They provide the Consent to Establish and Operate to micro and small enterprises including fly ash brick units. SPCBs also ensure compliance to the notification on fly ash utilisation issued by MoEF.
- **Department of Industries** : Department of Industries promotes the growth of industries. They administer subsidies and incentives for fly ash units. For example, the Department of Industries in states like Odisha, Bihar, Chhattisgarh incentivise fly ash units according to their state industrial promotion policies. District Industries Centre (DIC) prepares viable project reports, promote small scale industries for employment generation, train entrepreneurs and grants PRC to prospective entrepreneurs. Khadi Village Industries Board (KVIB) Khadi Village Industries Board (KVIB) grants subsidies to the entrepreneurs based on the Prime Ministers Employment Generation Programme (PMEGP) as approved by the Department of Industries.
- **State Public Works Department** (SPWD) : The work of the State Public Works Department is similar to CPWD. They have a schedule of rates. States like Bihar and Odisha have included fly ash bricks in their schedule of rates. Inclusion of fly ash bricks in the schedule mandates the utilisation of fly ash bricks in public construction.

2.2. Private Sector

The private sector has also played a major role in the promotion of fly ash brick production technology. The key stakeholders of the private sector are mentioned below:

- **Power Plants** : Coal based thermal power plants and captive plants are the major fly ash producers. The private sector has a total installed capacity of 72,926.66 MW which is 31.88 percent of the total installed capacity of the country. the thermal power plants are mandated to utilise the 100 percent of generated fly ash from the date of the issue of the notification. In order to utilise the fly ash, they should provide 20 percent of the fly ash free of cost to entrepreneurs manufacturing fly ash bricks.
- **Entrepreneurs** : One of the most important stakeholders are the entrepreneurs involved in the production of fly ash bricks. They set up enterprises for the production and sale of fly ash bricks. Currently, there are approximately 2800 fly ash bricks entrepreneurs in the country.
- **Technology Service Providers** : The entrepreneurs are aided in setting up of plants by technology service providers. Over the years, the number of technology service providers has increased in the country. Some of the major service providers include TARA Machines and Tech Services Pvt Ltd, Jayem

Manufacturing, Dass Engineering, Lakshmi and Co, Engineers Enterprises etc. A range of services are provided by them, including testing of raw materials, layout and design of the site, installation of equipments, training of manpower and troubleshooting services.

2.3. Supporting Agencies

Supporting agencies include research institutes, banks and financial institutes and civil society organisations.

- **Research and Academic Institutes** : Institutes like Council for Scientific and Industrial Research (CSIR) laboratories Indian Institute of Technology (IITs), Central Building Research Institute (CBRI) have conducted extensive research to determine the feasibility of use of fly ash as a raw material for the production of various products. They have been instrumental in the improvement of technology.
- **Financial Institutes** : Banks and financial institutes grant loans to the entrepreneurs for setting up new enterprises. Both public (banks like State Bank of India, Punjab Nationa Bank etc.) and private sector banks (Canara Bank, HDFC Bank etc.) grant loans to the entrepreneurs. However, banks don't consider brick units to be credit-worthy.

  Financial institutes like the Small Industries Development Bank of India (SIDBI) also finance small and medium enterprises like fly ash units. SIDBI administers the scheme of Credit Linked Capital Subsidy Scheme. It also provides financial assistance to MSMEs towards development, up scaling, demonstration and commercialization of innovative technology based projects.
- **Civil Society Organisations** (CSOs) : CSOs play a crucial role in accelerating fly ash utilisation. They supplement the efforts of the government. They are instrumental in commercialization of technologies, skill development of entrepreneurs and awareness generation. CSOs have also been actively involved in policy advocacy, both at the national and state level to create an enabling policy environment for entrepreneurs.

  The efforts of a few CSOs in the scaling up of the fly ash brick technology are worth mentioning. Apart from innovating the fly ash lime technology, Institute for Solid Waste Research & Ecological Balance (INSWAREB) has played a crucial role in promoting the fly ash technology in order to achieve sustainable development and mitigate the impacts of carbon emissions in India, the developing and under developed countries with emphasis on community development. Development Alternatives (DA) group has been involved in research and dissemination of fly ash technology in various clusters of the country. DA has also been involved in policy research and advocacy. The Energy Research Institute (TERI) conducts research and assessment to promote sustainable habitats. It is also involved in policy advocacy for promoting fly ash technology.

2.4. Consumers

Consumers make use of fly ash bricks for construction purposes. Government departments like the Department of Building Construction, PWD and others are involved in the construction of government buildings. Use of fly ash bricks by these government buildings will have a positive impact on the demand of

fly ash bricks. Other consumers include private builders and individual home owners. Currently, private builders are the major consumers of fly ash bricks. The use of fly ash bricks in public construction is currently minimal.

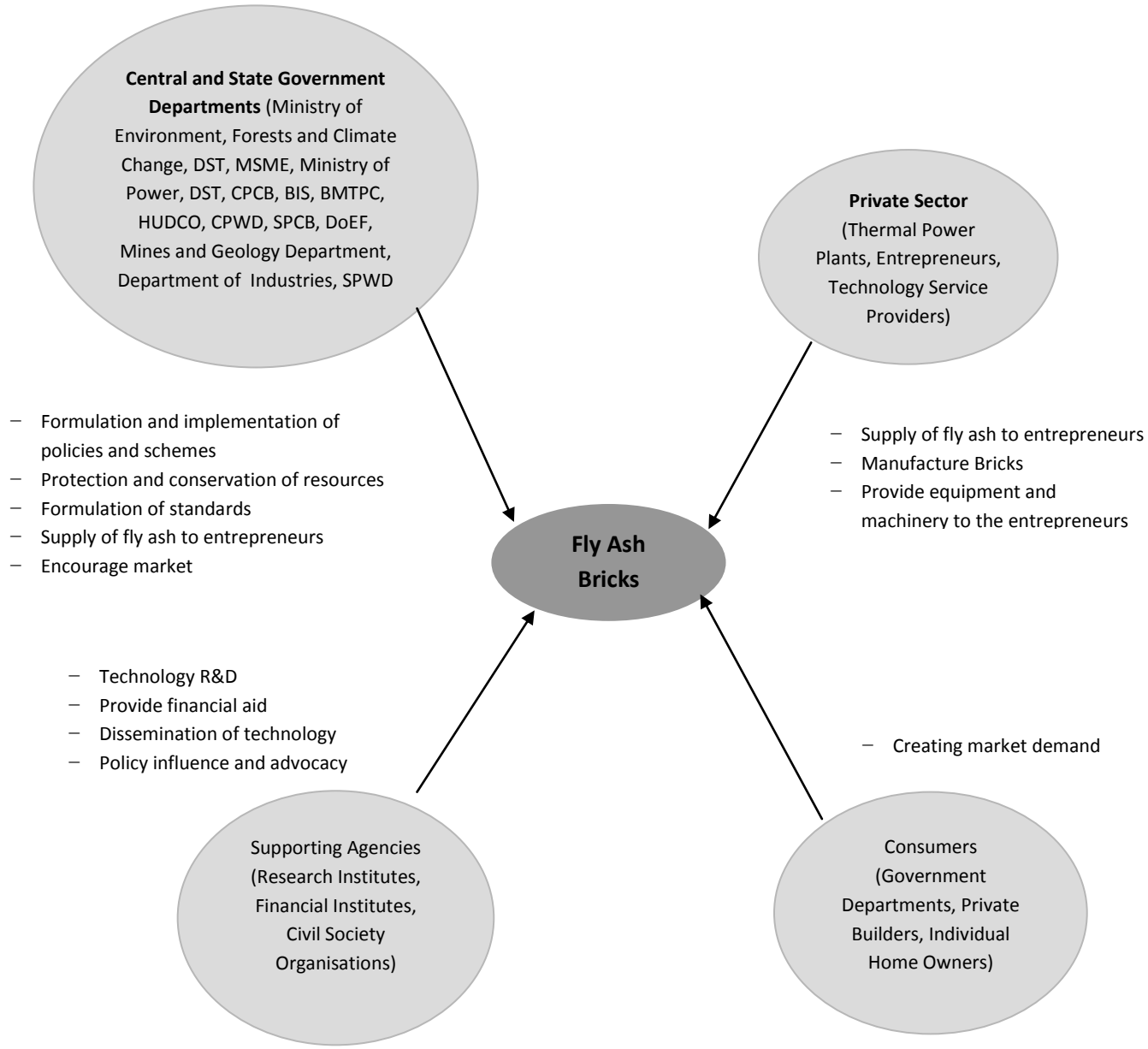


Figure 6: Major Stakeholders

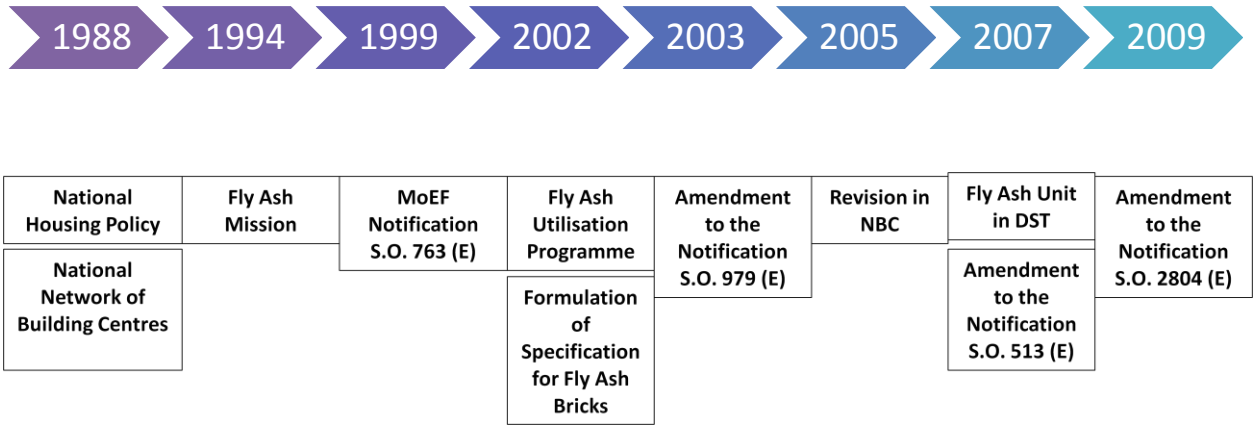
3.

The significance of accelerating the use of fly ash in brick making can't be denied. Recognising this, several efforts in terms of regulations and policies have been made, both at the national and at the state levels. All the policies encourage the use of bricks produced by low carbon and resource efficient technologies. Policies

at the state level focus mitigating climate change through mainstreaming fly ash brick technology. In order to achieve this, they encourage entrepreneurs to set up more units by incentivising them and alleviating the market demand of these bricks.

3.1. Policies at the National Level

The use of fly ash in the production of bricks as a way to utilise the waste produced by the thermal power plants has been engaging the attention of the Government. The initiatives majorly focused on promoting research and development of technology and the commercial application of the technology in construction. One of the first initiatives to promote fly ash bricks was through the National Housing Policy in 1980s. The timeline below explores the evolution of the efforts of the government in promoting the fly ash technology over the years. The major policy initiatives have been the MoEF notification S.O. 763 (E) and the Fly Ash Mission. The policies are explained in a chronological order.



- **The National Housing Policy** (1988) : The National Housing Policy (1988) aimed at improving the housing conditions of the inadequately housed and providing basic amenities to all. Since then, the policy has been updated twice in 1998 and 2007. The policy recognised the unsustainable patterns of consumption of resources like coal and top soil by the construction sector. It advocated the use of low cost building materials including fly ash. The revised policy of 2007 reiterated the concerns on sustainability of its predecessor, especially in view of increasing urbanisation. It also promotes research to facilitate transition from conventional to innovative, cost effective and environmental friendly technologies.
- **National Network of Building Centres** (1988) : A scheme to set National Network of Building Centres (Nirman or Nirmithi Kendras) was introduced in 1988. It focused on demonstration of the manufacture and use of low cost, appropriate and indigenous based building materials, and materials produced out of industrial and agricultural wastes. These centres also imparted training to artisans in low cost construction skills and produce building materials and components including fly ash bricks and stabilised mud blocks through innovative techniques. Materials produced at the Nirmithi Kendras have been exempted from excise duty.

The decision to set up a national network was taken after the success of Nirmithi Kendra in Quilon in Kerala. 584 building centres were sanctioned across the country for a grant assistance of Rs. 2248.10 lakhs. The scheme was discontinued in the 10th plan period. During the Zero-based budgeting exercise for 2002-03, it was felt that promotional role of the Ministry in respect of Building Centre was fully discharged; hence this scheme was discontinued.

- **Fly Ash Mission** (1994) : Demonstration of various ash disposal and utilisation technologies including brick making technologies is crucial to impact the percentage utilisation in the country. Keeping this in mind, the Government of India launched Fly Ash Mission in 1994. It was a joint initiative of Technology Information, Forecasting and Assessment Council (TIFAC), Department of Science and Technology (DST), Ministry of Power and Ministry of Environment and Forests (MoEF). It was renamed as Fly Ash Utilisation Programme (FAUP) in 2002 and thereafter since May 2007, is being provided a new focus & thrust under Fly Ash Unit (FAU), Department of Science and Technology (DST). The Mission's efforts may broadly be categorised in three groups:
    - Technology development and demonstration
    - Facilitation and hand holding for the multiplier effects
    - Policy measures for sustainable use

  The utilisation of fly ash in building materials was one of the ten thrust areas of the Fly Ash Mission. Task Force was constituted to guide, steer & monitor the project. Experts from R&D, academia, industry, regulatory/facilitating bodies & electricity board / bodies were the members of Task Force. The demonstration of technologies managed to create awareness among the stakeholders. As a result, entrepreneurs came forward to adopt the technologies. All possible support and guidance were provided to these agencies/ individuals right from technical know-how to the logistics and operational aspects like availability of fly ash, approvals from authorities etc. Information generated through these projects was also disseminated among other organisations. Consultations were also held with stakeholders in the form of technical seminars, workshops, brainstorming sessions etc. At the policy end, the mission was involved in the formulation of standards and specifications for fly ash utilisation.
- **Fly Ash Notification** (1999) : The efforts of the government and other stakeholders were given a boost by the notification numbered S.0.736 (E), issued by Ministry of Environment and Forests, Government of India in 19995. The notification was further amended in 2003, 2007 and 2009. It placed restrictions on the excavation of top soil for manufacture of bricks and promotes the utilization of fly ash for the same. According to it, all construction agencies such as Housing Boards or private builders, within a radius of 100 kilometres from a coal or lignite based thermal power plant shall use only fly ash based products for construction. These fly ash products will have minimum 50 percent of fly ash by weight.

  In order to encourage the entrepreneurs, thermal power plants should provide atleast 20 percent of dry fly ash free of charge to units manufacturing fly ash or clay fly-ash bricks, blocks and tiles on a priority basis over other users. Along with Central and State Government agencies and the State Electricity

[5] Ministry of Environment and Forests (1999). Notification, 14th September 1999, Part II – Section 3, Subsection (ii).

Boards, they should also facilitate in making available land, electricity and water for manufacturing activities and provide access to the ash lifting area for setting up ash based units.

- **Standards and Specification for Fly Ash Bricks** (2002) : The Bureau of Indian Standards (BIS) formulated standards for fly ash bricks. IS 12894: 2002 establishes the specifications for fly ash-lime bricks. It specifies the dimensions and other physical characteristics like compressive strength, water absorption and efflorescence. IS 13757:1993 specifies standards for burnt clay fly ash bricks. Standards also exist for use of fly ash in cement. IS 3812 specifies standards for use of fly ash as Pozzolona in cement, cement mortar and concrete.
- **National Building Code** (2005) : Originally prepared in 1970, the National Building Code (NBC) was revised in 2005. In this latest version, aspects of energy conservation and sustainable development have been consistently dealt with in various parts and sections through appropriate design, usage and practices with regard to building materials, construction technologies, and building and plumbing services. A new chapter (Part 11) is being added to the National Building Code 2005 titled 'Approach to Sustainability' to provide required guidance with respect to all relevant aspects involved during planning, design, construction, operation & maintenance of buildings. It looks at the life cycle concerns of building materials and advocates the use of low carbon sustainable alternatives

  In order to promote the use of fly ash bricks in public construction, the Central and State Public Works Department issue their schedule of rates. Bricks fall in the raw materials category and only public sector manufacturing units such as the Public Works Department and Indian Railways procure raw materials. The CPWD and State PWDs consider only those for contracts who register with them. The PWD has a schedule of rates with the basic rate of materials in which fly ash bricks are included. The rates of fly ash bricks are less than the rates of clay bricks in the schedule of rates of CPWD. Common burnt clay modular bricks of class designation 12.5 cost Rs. 5250 per 1000 bricks as compared to Rs. 4700 per 1000 bricks of fly ash bricks (CPWD, 2013).
- **Fiscal Measures**: Other schemes and policies relevant to the fly ash brick sector are the Prime Minister's Employment Generation Programme (PMEGP), Credit Linked Capital Subsidy Scheme (CLCSS) and Credit Guarantee Fund Scheme for Micro and Small Enterprises (CGMSE).

M/S Rupa EcoBricks

M/S Rupa EcoBricks is a PMEGP unit set up in Murshidabad, West Bengal. This fly ash brick manufacturing unit is set up by Shri Debpriya Gope, a graduate degree entrepreneur. He believes that fly ash bricks have a bright future and will replace conventional red bricks. The unit was set up after availing bank loan from Bangiya Gramin Vikas Bank, West Bengal. The unit provides employment to around 26 people.

The unit has an annual turnover of around 2 crores. Shri Debpriya Gope is content with the growth of the unit.

Source: www.kviconline.gov.in

The PMEGP was launched in 2008 and is a credit linked subsidy programme for generation of employment opportunities through establishment of micro enterprises in rural and urban areas. The upper limit of the cost of project that could be set up in the manufacturing sector is Rs. 25 Lakh. At the state level schemes will be implemented through State Directorates of Khadi and Village Industries Commissions and Boards, State and District Industries centres (DICs) in rural areas and in urban areas, the scheme will be implemented by the DICs.

CLCSS aims at facilitating technology upgradation by providing upfront capital subsidy to SSI units, on institutional finance (credit) availed of by them for modernization of their production equipment (plant and machinery) and techniques. CGMSE provides credit guarantee cover to the collateral free credit provided to Micro & Small Enterprises by the bank. New or existing Micro and Small Enterprises availing credit facilities up to Rs.100.00 lakh without any collateral security and or third party guarantee are eligible for CGMSE. These schemes are applicable to fly ash units as they are mostly, small scale enterprises6.

The Ministry of Finance also announced fiscal measures including exemption/reduction of excise duty on the production of building materials using minimum 25 percent fly ash; reduction in custom duty on the import of equipment, machinery and capital goods required for the production of building materials such as fly ash bricks etc.

3.2. Policies at the State Level

Complementary to the efforts of the Central government, State governments have also made efforts to accelerate effective utilisation of fly ash.

- **Climate Change Action Plan** : With increasing emphasis on climate change related concerns, the National Action Plan on Climate Change (NAPCC) was introduced in 2008 and outlines the existing and future policies and programmes addressing climate mitigation and adaptation. Based on NAPCC, individual states have prepared their State Climate Change Action Plans to set priorities to tackle climate change. The Odisha Climate Change Action Plan (2010-2015) also promotes effective utilisation of fly ash. It also highlights the necessity of capacity building of State Pollution Control Boards. It outlines the strategy to develop an effective operational plan for effective utilisation of fly ash. The Madhya Pradesh State Action Plan on Climate Change prescribes the need for policies for low carbon societies and regulations to ensure strict implementation of low carbon technologies. It also outlines the need for introduction of government schemes incorporating subsidies on green technologies and incentives.
- **State Industrial Promotion Policies** : Every state has in the country has an Industrial Promotion policy. These policies outline the priority sectors for industrial development and the initiatives of the state for the development of industrial sectors. Usually, these initiatives are in the form of incentives or subsidies. States like Odisha and Chhattisgarh have identified fly ash bricks/products are their priority sectors. Financial and marketing support as well as support for the development of infrastructure is provided for the priority sectors. The industrial policy of Tamil Nadu identifies cost effective building materials as a priority sector. Even though conventional brick making units are ineligible for incentives, fly ash units are exempted from this list in Bihar and Tamil Nadu.

[6] Investment in machinery between 25 lakh and 5 crore

- **Preferential Procurement of Fly Ash Bricks** :Few states promote fly ash brick production by giving preference in the purchase of bricks for use in public construction. Odisha state government has made the use of fly ash bricks mandatory in all government buildings located within a radius of 100 km from the thermal power plants. 50 percent of the brick requirement in government buildings has to be fulfilled by fly ash bricks, irrespective of their location. The new procurement policy of Jharkhand will enable the government departments to procure 20 percent of their annual purchases from enterprises producing fly ash bricks.

Table 1: Initiatives in Industrial Policies of Various States wrt to Brick Sector

S.No	Policy Heads	Initiatives of Various States		
		Tamil Nadu	Odisha	Chhattisgarh
1.	**Year (last revision/validity)**	2007-2014	2007	2009-2014
2.	**Priority Sector (wrt bricks)**	Cost effective building materials	Fly ash brick industry	Fly ash product (except cement)
4.	**Infrastructural Support**		• Promote industrial parks for priority sector • Exemption from payment of premium on production of eligibility certificate: Priority sector: 50% Thrust sector: 100%	
5.	**Financial and Other Support**			
6d.	**Stamp Duty**		• No stamp duty for Govt. allocated land. In case of transfer of land by Govt/ IDCO/private industrial estates to new units: Priority: 50% Thrust: 100%	
6e.	**VAT and taxes**		• 50% VAT reimbursement for 5 years and 75% for priority sectors. • 75% VAT reimbursement for thrust sectors for 10 years. • 2% CST for fly ash for a period of 10 years in thrust sector	
6f.	**Interest Subsidy**	• *Capital subsidy of 15% on plant and machinery* • *15% capital subsidy to priority sectors upto 30 lakhs*	• 5% per annum on term loan for 5 years to SMEs and thrust sector	• 50 % of the total interest paid upto 6 years for priority industries; • 30 % of the fixed capital investment. The maximum limit was increased upto 60 lakhs for priority sectors in SMEs in economically developing areas.
6g.	**Power**		• 100% exemption of electricity duty up to a contract demand of Five Megawatt for thrust sector.	• 100% exemption of electricity duty for 7 years for priority industries in economically developing areas. • 100% exemption of electricity duty for 10 years for priority industries in economically backward areas.

4. CATALYSTS AND CONSTRAINTS IN THE ADOPTION OF FLY ASH TECHNOLOGY

Fly ash is freely available in the country. With increased energy requirements, the amount of fly ash generated will only increase. Efforts are necessary to increase the fly ash utilisation levels beyond 60 percent. Use of fly ash in bricks presents a unique opportunity to increase the utilisation levels. Fortunately, several catalysts have been instrumental in accelerating the uptake of the technology.

Policy Push is a Major Driver for the Promotion of Fly Ash Brick Technology

Over the years, there has been an increasing recognition by the government on the issues of management and utilisation of fly ash. This is reflected in the policies formulated by the government. The Ministry of Environment, Forests and Climate Change issued a notification in 1999 numbered S.O. 763 (E) stipulating the use of fly ash bricks in construction in a radius of 100 km around the thermal power plants. The compliance to the notification is yet to be achieved. Fiscal measures like reduction of excise duty are also granted to the entrepreneurs. However, the entrepreneurs lack support from the state governments in terms incentives and schemes and a preferential regime to switch to fly ash bricks.

Accelerated Adoption of Fly Ash Bricks in Bihar

Of the 3 power plants in Bihar, National Thermal Power Corporation (NTPC), Kahalgaon (2,340 MW) produces around 40 lakh MT of fly ash annually[1]. In future, the projected expansion of the installed capacity of plants to approximately 12,000 MW will lead to generation of 60,000 TPD of fly ash. The current utilization is only about 34 percent of the ash produced annually. However, the increase in use of fly ash for brick making can be observed across the state. The initiatives of the Government of Bihar have also played a crucial role in this transformation.

Government of Bihar, in association with Development Alternatives has been actively promoting the adoption of low carbon and resource efficient technologies especially fly ash brick technology in the state. An Inter Departmental Task Force (TF) on Accelerating Cleaner Production Systems in the Building Materials Sector in Bihar was set up in June 2012. Various government departments like the Bihar State Pollution Control Board, Department of Environment and Forests, Department of Building Construction, Department of Industries and organisations like National Thermal Power Corporation (NTPC) etc. Over the last two years, the TF has emerged as a decision making venue where policy ideas are discussed and vetted. They are then forwarded to the concerned departments for further action. Use of fly ash in construction has been one of the thrust areas of the TF. Policy interventions along with awareness generation activities have garnered immense interest among the entrepreneurs in the state.

The Bihar brick sector has seen an upsurge of fly ash brick production units in the last two years. A total of 25 units have been commissioned in various districts. Currently, fly ash brick units have the capacity to produce approximately 60 million bricks per year. This has increased by 1,150 percent from 2007, when the production capacity was approximately 4.8 million bricks.

A few states provide incentives to the fly ash entrepreneurs through their industrial policies. A major boost to the entrepreneurs is given through the preferential procurement of fly ash bricks by the government departments. Unfortunately, this is not prevalent in all the states. Only a few states like Odisha, Jharkhand have made the use of fly ash bricks compulsory in construction near the thermal power plants. Odisha has gone one step ahead by mandating the use of fly ash bricks in construction of government buildings across the state, irrespective of their locations. However, more states need to incentivise the entrepreneurs to encourage them to set up more units.

Quality Control of Fly Ash Bricks

Consumers are reluctant to use fly ash bricks because of the false mindset that fly ash bricks are of poor quality. Low quality bricks distort the market. Even though standards for the bricks have been published by BIS, there is no quality control system in place to ensure that the production units stick to these standards. There are two ways to mitigate this. The first is to engage in awareness and plan demonstrations, or educate entrepreneurs on the merits of fly ash bricks. The second is to create a rating standard that rates bricks on their compressive strength, their absorptiveness, and their dimensions, through independent laboratories. If the products surpass the BIS standards and are of the highest quality, they will be highly rated. This will show that the state is certifying the bricks, regulating the product, and rewarding those entrepreneurs who are producing high quality products.

The Market Demand of Fly Ash Bricks is Fuelled by Increasing Construction and Decreasing Profitability of Red Bricks

India is currently witnessing a construction boom owing to rapid urbanisation and increased housing and infrastructure needs of a growing population. Addressing the current housing shortage and meeting the future demand, together with the likely need for reconstruction due to property damage caused by climate change, will drive growth in construction sector. Bricks form the backbone of the construction sector. It is evident that the demand for bricks will increase. The environmental implications will only worsen with the current practices of the brick sector. Nevertheless, this is seen as a tremendous opportunity by the entrepreneurs for scaling up of the technology.

Despite the availability of the market, the demand of fly ash bricks is affected by the low level of awareness of entrepreneurs as well as consumers on the technology and the perception of poor quality. Government departments are also reluctant to use these bricks in their own construction due to concerns on timely supply of good quality bricks. Lack of market demand deters the entrepreneurs from setting up more units.

However, the reduced profit margins of red bricks along with the construction boom in the country are viewed as a boon by the fly ash brick entrepreneurs. The cost of red bricks is also increasing due to increased coal prices. As a result, the profit margins of the entrepreneurs reduce. On the other hand, fly ash bricks are cheaper than red bricks. Therefore, increased profitability is forcing more and more entrepreneurs to shift towards fly ash bricks.

Accelerated Adoption of Fly Ash Bricks in Odisha

Odisha is a national hub for thermal power with a proposed capacity installation of over 58,000 MW in next 7-8 years. Major power generators are NTPC, NALCO, Rourkela Steel Plant (RSP), HINDALCO, JINDAL among others. The state faces the problem of management and disposal of massive amounts of fly ash. Comprehending the gravity of the situation, the government has already drafted policies to promote fly ash utilization. In fact, the Odisha Climate Change Action Plan (2010-2015) clearly states the effective utilization of fly ash as its priority. 45.34 percent of fly ash was utilised in the 2012-13 (CEA, 2014). 3.98 percent of fly ash was utilised in brick manufacturing[1]. Over the years, an inncreasing trend of use of fly ash in brick production has been observed. 75 percent increase in the use of fly ash was observed between 2000-01 and 2004-05.

The major reason for the increased use of fly ash in bricks is the increasing cost of red bricks. In the areas of Sambalpur, Jharsuguda and Sundergarh, the production cost of red bricks from FCKs increased to Rs 2200 from Rs. 1800 in a span of two years. The selling price increased to Rs 3000 per 1000 bricks from Rs. 2000. On the other hand, fly ash bricks were available at Rs 2700 per 1000 bricks. In Angul, Dhenkanal and Cuttack, the selling price of red bricks reached Rs. 4800 per 1000 bricks as opposed to Rs. 3500 per 1000 fly ash bricks. Looking at the increased profitability, fly ash units mushroomed in the areas of Angul, Dhenkanal and Cuttack.

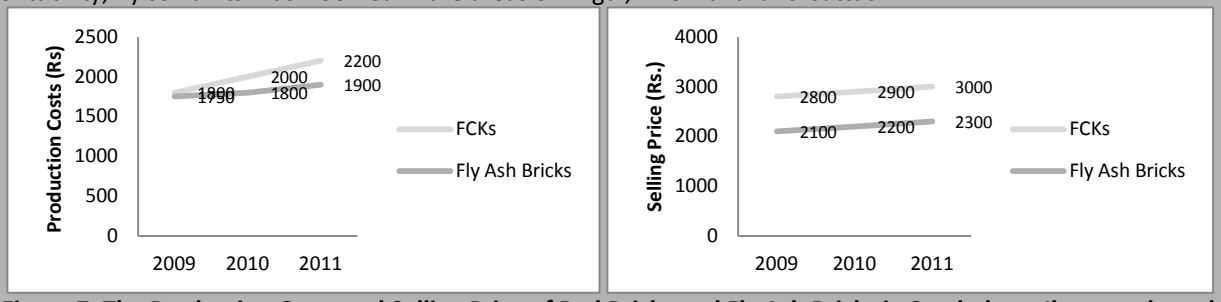


Figure 7: The Production Costs and Selling Price of Red Bricks and Fly Ash Bricks in Sambalpur, Jharsuguda and Sundergarh Region of Odisha

Source: DA, 2012

The lack of easy access to finance acts as a constraint in the scaling up of fly ash brick technology. The credit-worthiness of the brick entrepreneurs are not viewed favourably by the banks. Therefore, they are averse to provide loans to the entrepreneurs. The entrepreneurs also face massive delays in the grant of loans. Entrepreneurs are also averse to availing subsidies. One of the major reasons is the delay in approvals. Cumbersome procedures for the approval also deter entrepreneurs from applying for subsidies. The government needs to incentivize banks to provide low-interest loans that don't heavily affect the start-up costs and the profit margins of such small businesses. Additionally, most entrepreneurs aren't aware of available subsidies from the government, and those who are find the paperwork cumbersome and unhelpful. For rural entrepreneurs, the subsidization process needs to be advertised. The single window mechanism should also be operationalised in all the states.

Increasing Level of Awareness among the Consumers and Entrepreneurs is Helpful in Alleviating the Concerns regarding the Fly Ash Bricks

The level of awareness of entrepreneurs and end-users on fly ash brick production technology and the production process has been low. The benefits from the production of these bricks-such as reduction in top soil consumption, waste management, coal savings and reduction in carbon emissions were not well known to the stakeholders. Due to the low level of awareness, perception of the reduced quality of bricks prevailed.

There are instances of poor quality bricks in the market as well. This could be attributed to the lack of knowledge of the production process and reduced curing time. The lack of trained and skilled workforce to cope up with the technology changes as well as technology service providers also hampered the uptake of technology.

Over the years, the level of awareness about fly ash bricks has increased. This could be attributed to the awareness generation activities held by government and various other organisations. Initiatives like the Fly Ash Mission have been instrumental in increasing the awareness of technology through technology demonstration and knowledge dissemination via workshops, seminars and brainstorming sessions. Training programmes for the entrepreneurs and workforce have also been conducted through initiatives like the Nirman Kendras. However, continuous awareness campaigns on the financial and environmental merits of the fly ash bricks and the subsidies and incentives provided by the government are necessary.

Ease in the access to technology know-how is also a key catalyst in the scaling up of the technology. The number of technology service providers has increased throughout the country. Apart from supplying equipments and machinery, they also provide a range of services including raw material testing, site design and layout, installation of equipment and troubleshooting services. Quite a lot of service providers like the TARA Machines and Tech Services Pvt. Ltd (TMTS) also conduct training of the workforce on the aspects of the production processes.

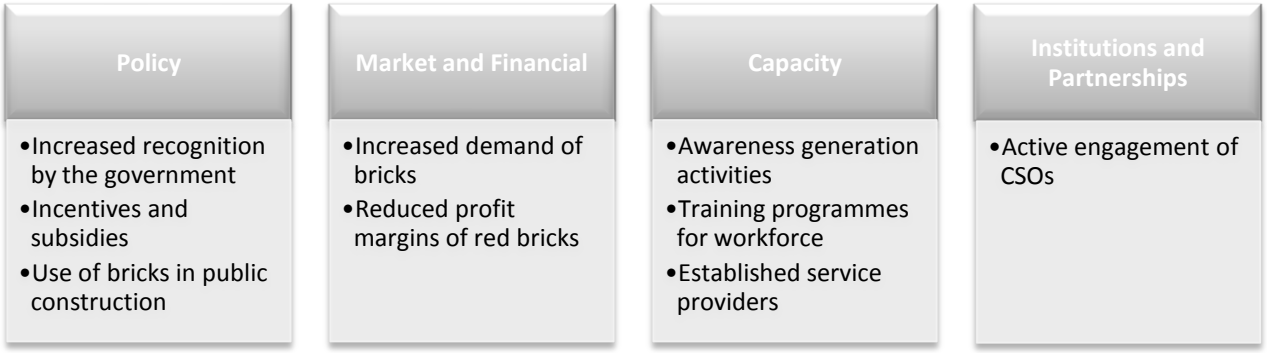


Figure 8: Catalysts for the Promotion of Fly Ash Brick Technology

The Role of CSOs is Crucial in the Scaling-up of Fly Ash Brick Technology

The government has taken several initiatives to accelerate the fly ash utilisation in the country. These initiatives are in form of regulations, standards and specifications and financial schemes. The onus of implementing these policies lies with the state departments. Despite the formulation of policies and regulations, the enforcement of these policies is weak. The notification on fly ash utilisation stipulates the state government to ensure compliance. However, the condition is dismal. The use of fly ash bricks in the construction of buildings near the thermal power plants is minimal.

The role of CSOs in promoting fly ash brick technology through policy influence and advocacy in crucial. CSOs like INSWAREB and DA have engaged with various government departments to not only influence the

policies wrt to fly ash bricks, but also encourage compliance with the already formulated policies. Apart from influencing the policies, they have also been instrumental in increasing the awareness of the technology through workshops and seminars. These workshops and seminars not only disseminate information on the technologies, but they also provide a platform for the entrepreneurs to network with the technology service providers and policy makers. An important contribution of the civil society has been capacity building and training of entrepreneurs as well as the workforce.

5. CONCLUSION

Climate change is a concern to national security and the well-being of Indian citizens, and its impacts are being felt everywhere. Scientists deem that increasingly unpredictable weather cycles, more extreme rainfall, and stronger droughts are results of climate change, which itself has been caused by activities that increase the concentration of greenhouse gases in the atmosphere, such as deforestation, burning fossil fuels, and the emission of pollution. A major contributor to greenhouse gases and to the direct impact on soil is the clay brick making industry. Fired clay bricks use clay from the land, consume about 18 tons of coal per 1,00,000 bricks, often burn wood for fuel, and emit carbon dioxide (CO2), sulfur dioxide (SO2), nitrogen oxides, and suspended particulate matter (SPM)through coal and wood burning.

On the other hand, India is heavily dependent on coal based power plants for production of electricity. With the growth in population, the energy requirements will only increase. As a result, fly ash generation will increase in the country creating problems for its management and disposal. Use of fly ash in bricks presents an opportunity to deal with this. The impact is twofold: coal is not burned directly in the production method, thus emitting fewer greenhouse gases and mercury; and it uses waste produced in power plants and boilers, which saves space in landfills and prevents soil contamination. Brick sector has been internationally heralded as one of the cheapest avenues for climate change mitigation. It will also help in reducing the environmental footprint of the brick sector. Keeping in mind the increasing demand of bricks, it has become necessary to ensure that the use of fly ash in brick making increases beyond 9.98 percent. The success of the uptake of fly ash technology in few pockets of the country should be replicated in other parts as well.

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