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Cluster Profile Report

Firozabad Glass Cluster

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Bureau of Energy Efficiency (BEE)
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The Energy and Resources Institute
Darbari Seth Block, India Habitat Centre, Lodhi Road, New Delhi – 110 003, India

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TEAM

Mr Girish Sethi, Project Advisor
Mr Pawan Kumar Tiwari, Team Leader
Mr Piyush Sharma, Sector Expert
Dr Sachin Kumar, Reviewer & Cluster Coordinator
Mr A. M. Ghosh, Energy Manager/Auditor
Mr Yatharth Kumar Sharma, Graduate Engineer
Mr Kavita Sisodiya, Secretarial Assistance

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The Energy and Resources Institute (TERI)

FOR MORE INFORMATION
Project Monitoring Cell, TERI, Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi 110 003, India
Tel.: +91 11 2468 2100 or 2468 2111 | Fax: +91 11 2468 2144 or 2468 2145
Email: pmc@teri.res.in | **W**eb: www.teriin.org

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List of abbreviations

APM	Administered Pricing Mechanism
BEE	Bureau of Energy Efficiency
BoB	Bank of Baroda
CAGR	Compound Annual Growth Rate
CDGI	Centre of development of glass industry
CFC	Common Facility Centre
DIC	District Industries Centre
DPR	Detailed Project Report
DVVNL	Dakshinanchal Vidyut Vitran Nigam Limited
EE	Energy Efficiency
FI	Financial Institute
GAIL	Gas Authority of India Ltd
GEF	Global Environmental Facility
GHG	Greenhouse Gas
GIS	The Glass Industrial Syndicate
GoI	Government of India
HT	High Tension
ID	Induced Draft
IDBI	Industrial Development Bank of India
KPI	Key Performance Indicators
LSP	Local Service Provider
LT	Low Tension
MoEF	Ministry of Environment and Forests
MS	Mild Steel
MSME	Micro Small and Medium Enterprises
MSME-DI	MSME-Development Institute
MT	Million Tonnes
NG	Natural Gas
NIC	National Industrial Classification
OBC	Oriental Bank of Commerce
PNB	Punjab National Bank
PNG	Piped Natural Gas
RLNG	Re-gasified Liquefied Natural Gas
SBI	State Bank of India
SCM	Standard Cubic Metre
SDC	Swiss Agency for Development and Cooperation
SIDBI	Small Industries Development Bank of India
SWOT	Strengths Weaknesses Opportunities and Threats
TCs	Technology Centers
TCSP	Technology Centre Systems Programme
TERI	The Energy and Resources Institute
toe	Tonnes of Oil Equivalent

TTZ	Taj Trapezium Zone
UBI	Union Bank of India
UPGMS	Uttar Pradesh Glass Manufacturers Syndicate
WHR	Waste Heat Recovery

Acknowledgements

The Energy and Resources Institute (TERI) is grateful to the Bureau of Energy Efficiency (BEE) for its progressive management and also for vesting its confidence in TERI to carry out this prominent assignment "Energy and Resource Mapping of MSME Clusters in India (Glass and refractory Sector)" and providing full-fledged coordination and support during the study.

The study team is thankful to Mr. Raj Kumar Mittal (President), U.P. Glass Manufacturers Syndicate, and Mr. Hanuman Prasad Garg (Director), Glass Industries Syndicate for showing keen interest in the study and providing wholehearted support and cooperation for the preparation of this cluster profile report. We would like to extend our special thanks to Mr. Amresh Kumar Pandey (General Manager), DIC, Firozabad for sharing details of the ongoing promotional scheme of the UP Government for the Firozabad cluster. TERI team also acknowledges the support of Mr. B C Sharma, Local Service Providers for providing support in data and information collection in the Firozabad glass cluster.

Last, but not least, the interactions and deliberations with the industries associations, MSME entrepreneurs, technology providers, and all others who were directly or indirectly involved throughout the study, were exemplary and a rewarding experience on the whole, for TERI.

TERI Team

Certificate of originality

This is to certify that this report is an original work of TERI. The TERI team held detailed discussions and collected data from numerous industry stakeholders, which included MSME entrepreneurs, plant engineers, industries' associations, local energy distribution companies, key local bodies, local service providers, suppliers, fabricators, experts, testing labs, academic institutes/ITIs, and banks/FIs. In addition to this, the team reviewed secondary literature available in the cluster. The cluster profile is an end product of both first hand interactions/data and secondary literature in the cluster. Appropriate references have been indicated in places where TERI has utilized secondary sources of data and information.

Chapter 1

1.0 About the Project

1.1 Project overview

The Micro, Small, and Medium Enterprise (MSME) sector in India is a unique mix of enterprises using conventional as well as modern technologies. Most of the enterprises in the MSME sector are traditional and deploy technologies that are inefficient and resource intensive. The MSMEs are generally located as clusters. There are several such clusters that are highly energy intensive in their operations.

At national level, the data/information of energy intensive MSME sectors on various parameters like production, type and quantity of fuel consumption, energy saving potential, details on energy efficient technologies, future growth scenarios, etc. are not readily available. This in a way limits the design of appropriate policy instruments to ensure sustainable growth of these sectors. To address this barrier, the Bureau of Energy Efficiency (BEE), Ministry of Power, Government of India, has initiated an ambitious project of mapping the energy intensive MSME sector across the country. Glass industry is one of the energy intensive sectors identified under the project. The BEE has entrusted The Energy and Resources Institute (TERI), New Delhi to undertake a detailed study of the glass industry sector in India.

1.2 Project objectives

The objectives of the study include the following:

- Map energy intensive glass and refractory manufacturing sector from energy perspective
- In-depth study of existing scenarios on energy consumption and identify opportunities for energy and resource saving
- Prepare a roadmap to develop the intervening sector energy and resource efficient as well as environment friendly

The five targeted glass & refractory clusters covered under the project are shown in table 1.2:

Table 1.2: Targeted clusters under the project

S. No.	Cluster	State	Sector
1	Chirkunda	Jharkhand	Refractory
2	Ambala	Haryana	Glass
3	E & W Godavari	Andhra Pradesh	Refractory
4	Jaipur	Rajasthan	Glass
5	Firozabad	Uttar Pradesh	Glass

1.3 Major components of the project

The major components of the project and their activities are shown in Table 1.3.

Table 1.3: Major component of the project

Components	Major activities
Component-1: Field study and data analysis	• Conduct detailed energy audits covering 10 representative units in each cluster • Conduct benchmark study to develop Key Performance Indicators (KPI) and Energy Efficiency (EE) benchmarks • Develop a sectorial profile for the refractory sector • Develop sectorial brochure
Component-2: Development of roadmap and outreach	• Prepare and publicize sectorial roadmap for refractory industry • Disseminate outreach and knowledge through; ○ Cluster level workshops ▪ Project inception workshops ▪ Post activities workshops ○ National workshops ▪ Stakeholder consultation ▪ Result dissemination

Chapter 2

2.0 Cluster Scenario

2.1 Background

Glass is a non-crystalline solid, often transparent, and has widespread practical, technological, and decorative applications in our daily lives. Most of the glasses are generally made by melting basic raw materials of sand, soda ash, and limestone at very high temperatures.

The glass industry in India is quite old and well established. From a humble beginning in 1908 with rudimentary mouth-blown and hand working processes, the industry in recent years has evolved to adopt modern processes and automation in a big way. Accordingly, the Indian glass sector has evolved from a small-scale, decentralized manufacturing business to a relatively organized sector. The growing demand for glass in the automobile and construction sector along with increased use of glass in packaging is expected to result in higher growth in this sector.

The Indian glass industry represents one of the largest markets and the manufacturing capacity for glass products in the Asia region. Apart from few major manufacturers, there are more than 1,000 medium and small manufacturers. The majority of these glass manufacturing units are located in Firozabad, which has more than 500 hundred in number and generates huge employment for the unskilled rural population. The primary products of the Firozabad glass cluster include bangle, container glass, glass handicraft products, etc. The large glass manufacturers are mainly located in Baroda, Ahmedabad, Mumbai, Kolkata, Bengaluru, Chennai Bahadurgarh, and Hyderabad.

The Indian glass industry consists of seven segments namely, sheet and flat glass (NIC1-26101), glass fibre and glass wool (NIC-26102), hollow glassware (NIC- 26103), laboratory glassware (NIC- 26104), table and kitchen glassware (NIC- 26105), glass bangles (NIC- 26106) and other glasswares (NIC – 26109).

The Indian glass sector is growing across all segments. This growth has been driven primarily by India's booming automotive and construction sectors which have been key drivers of the economy for the past few years. It is reported that the Indian glass sector will experience growth of around 12% (CAGR) during 2019 – 2027.

The majority share of the Indian commercial glass market mainly holds by container glass, which is equal to 50% of market value.

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[1] NIC 26101 - Division 26 represents National Informatics Centre classification for manufacture of other non-metallic mineral products, group 261 and class 2610 represents manufacture of glass and glass products and 26101, 26102, 26103, 26104, 26105, 26109 represents sub-class for manufacture of different types of glass

2.2 Overview of Firozabad glass cluster

Firozabad glass cluster is one of the important glass manufacturing clusters in India. The cluster houses a large agglomeration of MSME (Micro Small and Medium Enterprises) units that manufacture various types of glass products. The cluster is located around 40 kilometers from Agra city in the state of Uttar Pradesh. It occupies a special position as it accounts for more than 70% of the total glass production by MSME glass industries across India. The cluster also finds its prominence because most of the glass bangles in India are exclusively produced in this cluster.

Apart from basic glass production units, there are a large number of tiny units at the domestic level in surrounding villages that are involved in various finishing operations of glass bangles and producing handicraft products. The glass products of the Firozabad cluster are sold not only in the domestic market but also exported in the international market. The value of exported glass products from the cluster was about 280 crore (INR 2800 million) during the FY 2017-18.

2.2.1 Classification of glass units

The glass units in the Firozabad cluster can primarily be classified based on the type of furnace being used. Most of these units have deployed either Pot furnaces (both Open & Closed types) or Tank furnaces to manufacture their wide range of glass products, while some of these also use Lehr furnaces for baking the glass products.

The glass industries in the cluster can be divided into four different types based on the type of furnaces used for glass melting (figure 2.2.1).

Pot furnace units, which produce mainly glass bangles, glass rods, beads, and export quality mouth-blowing products.

Tank furnace unit producing primarily container glass, tableware, bulb, and other glassware. Units are having large production capacities as compared to other types of melting furnaces in the cluster.

Muffle furnace units are used for annealing (heat treatment) of glass bangles and other semi-finished glass products to yield the finished products.

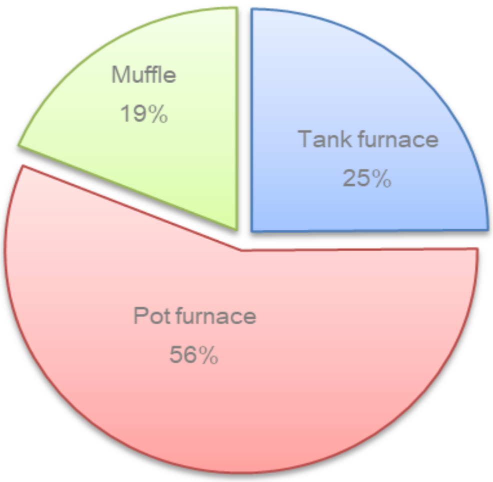


Figure 2.2.1 : Share of different types of furnaces used

The production capacities of tank furnaces are quite higher (25 – 200 tonnes per day) whereas the pot furnaces have generally low production capacities (5 to 8 tonnes per day). There are about 53 tank furnaces and 120 pot furnaces (including both Open & Closed types). Apart from glass melting units, there is an estimated 40 muffle furnace units that are mainly involved in the baking or heat treatment of glass bangles.

The total estimated glass melt processed in the cluster is in the range of 3,000-3,500 tonnes per day. Despite the small number of units (only 10%) using Tank furnaces, these units constitute about 80% of the glass production from the cluster. Different types of glass industries operating in the cluster and their average melting capacities are shown in table 2.2.1 below;

Table 2.2.1: Classification of glass industries in cluster

Unit classification	Total units (Nos)	Production range (tpd/unit)
Tank furnace[2]	53	20-155
Pot furnace	120	5-8
Muffle furnace	40	NA

2.2.2 Major products

The major product of the cluster is the glass bangles of different colours, sizes, and designs. Various other types of glass products manufactured in the cluster include jars, tumblers, signal lamp covers, and headlight covers for automobiles, lampshades, thermo flasks along with refills, and laboratory wares. The percentage share of different glass products manufactured in the cluster is shown in figure 2.2.2a.

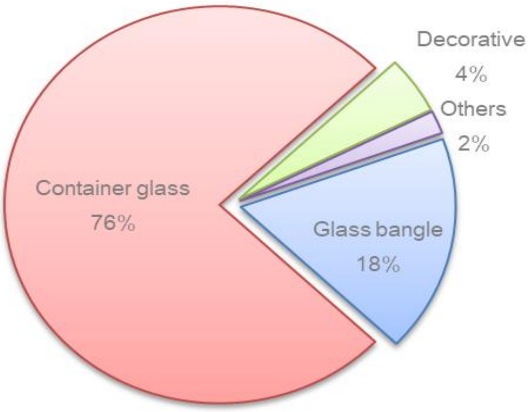


Figure 2.2.2a: Share of glass products

Different type of the glass products manufacturing in the Firozabad glass clusters is shown in figure 2.2.2b.

Figure 2.2.2b: Pictorial representation of the different types of products

2.2.3 Market scenario

Most of the glass industries of Firozabad sell their products in the domestic market through retailers and traders. Glass handicraft products are being exported through traders/exporters.

The glass bangles are traditionally rigid bracelets worn mostly by women in the Indian Subcontinent, South-Eastern Asia, and Africa. It is common to see a bride wearing glass bangles at her wedding in India, Bangladesh,

[2] A few large units also exist in the cluster having installed capacity more than 150-200 tpd

Pakistan, Nepal, Sri Lanka, and other Asian countries. The container glasses are mainly used for packaging purposes by different industrial segments such as pharmaceutical, fragment, distilleries, etc. The products like tableware, kitchenware, etc. are used by a domestic household as well as exported to different countries.

2.2.4 Raw materials

The primary raw materials required for the manufacturing of the glass products are;

- Silica sand
- Soda ash
- Calcium carbonate
- Glass cullet (recycled glass)

2.3 Cluster level initiatives

The programs and initiatives undertaken by various organizations are listed in table 2.3.

Table 2.3: Cluster level initiatives

Organisation	Programme/initiatives	Brief description	Status
The Energy and Resources Institute (TERI) and Swiss Agency for Development and Cooperation (SDC)	Demonstration and dissemination of energy efficient pot furnaces and muffle furnaces.	TERI had undertaken a major initiative with support from the SDC for demonstration and dissemination of energy efficient pot furnaces and muffle furnaces	Completed (1994-2017)
Technology Centre Systems Programme (TCSP) project	Technology centre development	It is a national initiative under the Ministry of Micro, Small and Medium Enterprises (MoMSME) with financial support from the World Bank. The objective of the programme is to upgrade the technology and skill base of the glass industries sectors to enhance the competitiveness of MSMEs through upgraded local Technology Centers (TCs), CDGI. KPMG is implementing this project in association with CDGI.	Ongoing (2018 – 2021)

Chapter 3

3.0 Major cluster stakeholders

The primary stakeholder of the cluster is the glass manufacturing units. The other stakeholders include industry associations, government agencies including regulatory bodies, research and academic institutions, and testing facilities and training institutes. These cluster level stakeholders provide a range of services to the glass manufacturing units. Some of the major stakeholders in the Firozabad glass industry cluster along with their roles and activities are briefed below;

3.1 Industries associations

There are several industry associations active in the Firozabad glass cluster. Some of these associations are listed in table 3.1.

Table 3.1: Industry Associations

Category	Name of association
Tank furnace	Uttar Pradesh Glass Manufacturers Syndicate (UPGMS)
Pot furnace	The Glass Industrial Syndicate (GIS)
Muffle furnace	Pakai Bhatti Vikas Sahakari Samiti Ltd.
	Kanch Udyog Pakai Bhatti Sahakari Samiti
	Pakai Bhatti Hitkari Odhoyogik Sahkari Samiti

3.1.1 Uttar Pradesh Glass Manufacturers Syndicate

Uttar Pradesh Glass Manufacturers' Syndicate (UPGMS) has been playing a key role in accelerating the development of the tank furnace based glass industries in the Firozabad region since its formation in 1951. Some of the key activities of UPGMS include (i) redressal of grievances of member industries, (ii) infrastructural development, (iii) environmental preservation and pollution control.

3.1.2 Glass Industrial Syndicate

The Glass Industrial Syndicate (GIS) represents the pot furnace units of the Firozabad glass cluster and deals with the relevant government policies for the development and growth of the pot furnace based glass industries in Firozabad.

3.1.3 Muffle furnace Samiti

The operators of muffle furnaces have come together to form a few Samiti to shift to a common working shed to obtain piped natural gas supply from GAIL as a gas connection to individual muffle furnace site is infeasible. The formation of Samiti helped the muffle furnace to perform baking of glass bangles using a natural gas-based muffle furnace instead of a coal-fired traditional muffle furnace. There are four such Samiti (s) that are provided with gas supply and are operated by its members.

Table 3.1.3: Contact details of industries associations

Name of association	Contact details
Glass Industrial Syndicate	**Address:** Chadamilal Jain Building, Chotti Chapeti, Firozabad – 283203 (Uttar Pradesh) **Contact person:** Mr. Ajay Bihari Sharma (Secretary) **Contact No:** +91 92596 44700
Glass Manufacturers Syndicate	**Address:** C/o General Traders, A-10, Industrial Estate, Firozabad – 283203 (Uttar Pradesh) **Contact person:** Mr. Kailash Verma (Secretary) **Contact No:** +91 98974 38354
Pakai Bhatti Vikas Sahakari Samiti Ltd.	**Address:** Near Mathur Glass, Ashafabad Road, NH-2 Firozabad – 283203 (Uttar Pradesh) **Contact person:** Mr. Narayan Das Gupta (President) **Contact No:** +91 92587 03199
Kanch Udyog Pakai Bhatti Sahakari Samiti	**Address:** Firozabad – 283203 (Uttar Pradesh) **Contact person:** Mr. Mukesh Bansal (President) **Contact No:** +91 98370 95756
Hitkari Pakai Bhatti Sahakari Samiti	**Address:** Firozabad – 283203 (Uttar Pradesh) **Contact person:** Mr. Ashish Bansal (President) **Contact No:** +91 98370 95756

3.2 Government bodies

The government agencies involved in the cluster and their key activities in the cluster are given in table 3.2.

Table 3.2: Government bodies and key responsibilities

Name of organisation	Key roles
District Industries Centre (DIC), Firozabad	• Identify the new entrepreneurs and assisting them regarding their start-ups. • Provide financial and other facilities to smaller blocks for industrialization at the district level. • Enhance the rural industrialization and also the development of handicrafts. • Reach economic equality in multiple areas of the district. • Allow various government schemes to the new entrepreneurs. • De-size the regional imbalance of development. • Make all the necessary facilities to come under one roof
MSME-Development Institute (MSME-DI) Agra	• MSME-DIs field offices of the Ministry of Micro, Small & Medium Enterprises provide a wide range of extension/ support services to the MSMEs in their respective state of operation.

3.3 Technical, academic, and R&D institutions

Firozabad glass industry cluster has a centrally supported Centre for the Development of Glass Industry (CDGI), a fully equipped technology center to provide required technical help for the growth of the local glass industries. It has been set up in collaboration with UNDP/UNIDO and the Government of UP. CDGI aims to assist the glass industry in improving its overall performance particularly in the areas of technology up-gradation, energy conservation, the introduction of value-added glass articles, and skill development.

3.4 Financial institutions

There are multiple branches of nationalized, commercial, and cooperative banks operating in the cluster. The two national banks such as the State Bank of India and Punjab National Bank have more than 10 branches each within the industrial town of Firozabad. Some of the important banks in the cluster include State Bank of India (SBI), Bank of Baroda (BoB), Axis Bank Ltd., ICICI Bank, HDFC Bank, Punjab National Bank (PNB), Industrial Development Bank of India (IDBI), Oriental Bank of Commerce (OBC), Bank of India, Union Bank of India (UBI), Canara Bank Ltd., UKO Bank and Bank of Maharashtra. Most of these banks provide both working capital and financial assistance towards expansion and infrastructural up-gradation of glass industries.

Chapter 4

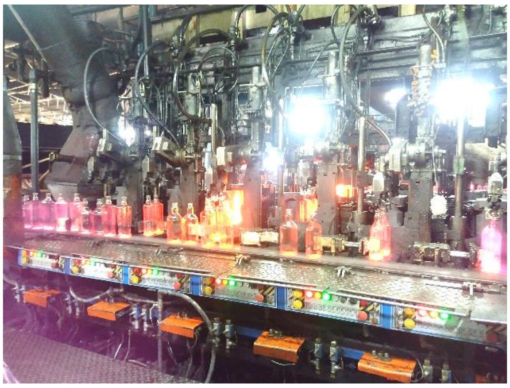
4.0 Production process and technology use

4.1 Manufacturing process

The manufacturing process of the glass industry varies according to the type of products being manufactured. The generic production of glass involves batch preparation, melting, refining, forming, annealing, and finishing. A brief description of various processes followed in a typical glass manufacturing unit using either tank furnace or Pot furnace glass melting technology is provided in this section. A process flow chart for the different manufacturing processes is shown in Figure 4.1.1 and Figure 4.1.2.

4.1.1 Tank furnace Unit

Different process steps followed in a tank furnace unit is briefed below;



Batch preparation: The batch charge for glass making consists of raw materials such as silica sand, soda ash, calcium carbonate, and cullets (recycled glass). The composition of raw materials may vary depending on the type of products being manufactured. The preparation of the batch material (weighing and mixing) may be manual or mechanized. Smaller tank furnace units generally use manual processes whereas large tank furnaces say use mechanized systems. The batch material is fed to the 'doghouse' through a belt conveyor arrangement.

Glass melting: An end-fired tank furnace is used for the continuous melting of glass. Melting is the most energy intensive operation in a tank furnace unit, which uses thermal energy. The temperature of the glass melt is maintained at about 1450 ^{0}C. The molten glass is flown through the "refiner zone‟ to get rid of air bubbles. The melt is tapped from the feeder chamber for shaping and forming.

Forming & shaping: The glass melt is used to produce various glass products either in automatic presses or blowing machines. In some of the units, mouth blowing is also practiced for specialized glass products. The press machines are powered either by electricity or by compressed air (pneumatic systems).

Annealing: The shaping and forming operations will induce stress in the glass products. It is necessary to remove these stains from the glass products so that their brittleness can be removed. The annealing process removes this stress through gradual heating, soaking, and cooling of the products.

Finishing: The glass products after annealing are sent for finishing operations like cleaning, grinding, polishing, cutting, painting, and grading as per requirements. The final products are packed after inspection for defects. Electrical energy is used for different finishing operations.

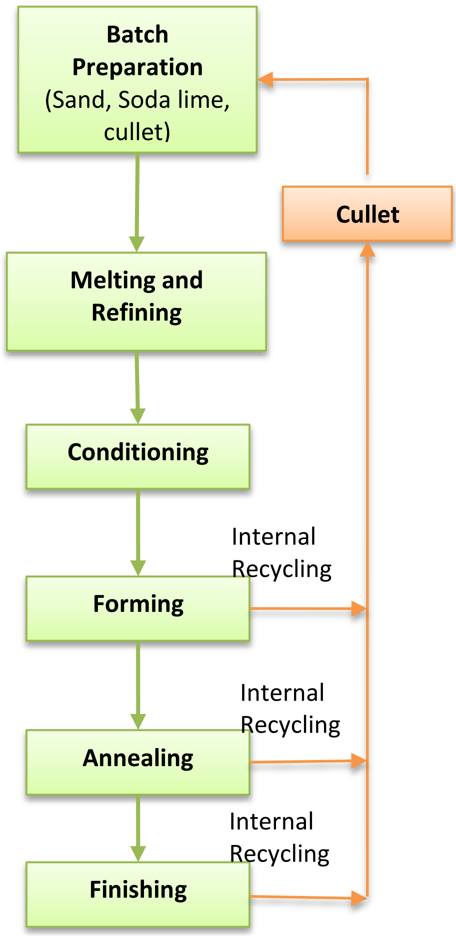


Figure 4.1.1: Process flow in a typical Tank furnace unit

4.1.2 Pot Furnace

The pot furnace units are engaged mainly in bangle making. The production process followed in an open pot furnace unit producing glass bangles is shown below;

Batch preparation: The batch charge for glass making consists of raw materials such as silica sand and soda ash. The raw materials are sieved, weighed, and mixed in required proportions. The composition required for pots containing transparent glass is different from that required for pots containing colored glass.

Glass melting: In an open pot furnace, the charge is melted into glass in open pots placed within the furnace. Based on production capacities, the number of pots in a furnace varies between 10 and 12. Preheated pots are placed within the furnace along its circumference. The charge is fed into the pots through the openings provided in front of each pot on the furnace boundary wall. The pots filled with raw material are heated to the required temperature of 1,250-1,280 ^{0}C and the total time required for melting is about 20-22 hours. During routine melting operation, each pot is charged consecutively three times after completion of melting of the previous charge material to reach its melt glass holding capacity. After first filling, as the batch melts, its volume decreases which is again filled after about 8 hours. As the volume decreases upon further melting, the pot is again filled after about 5 hours from the previous filling. The third filling is done after about 3 hours from the second filling. The quality and colour of melt glass in a pot are dependent on raw material composition and coloring additives in a charge batch.

Drawing of molten glass: The quality of melt glass is inspected visually to confirm whether it is ready for bangle making or not. This is done by dipping the Mild Steel (MS) rod inside the pot through the charging door. When the molten glass gets ready, it is taken out using MS rods. These rods are 10-18 mm in diameter and about 2.5 meters in length. These rods have a small notch at the end, which facilitates the lifting of molten glass.

Shaping of glass ball: The operator (loom maker) provides the required shape (cuboidal) to the glass ball using a mason's trowel. The rod is taken to the colouring workplace where molten colour is applied on the shaped glass ball. Normally, the colour is applied on the three sides. After the application of colour, the rod is taken back to the pot furnace and dipped in the pot containing the same coloured glass. This composite glass ball is called the loom. The glass ball is taken to the loom maker and again shaped.

Reheating (Sekai) of glass lump: The temperature of the glass after final shaping of glass loom drops resulting in inadequate plasticity. It is therefore heated in a reheating furnace to increase the temperature to make it soft and compatible for the next operation of making bangle spiral in bangle making furnace. Ready loom is brought manually to the operator of bangle making furnace.

Bangle making: Bangle making furnace (belan bhatti) has a rotating shaft with a lead screw (belan), which is driven in a manner to have both linear forward movement and rotary motion along the same axis simultaneously. The shaft is rotated either manually or with the motor. As the belan rotates, the lead screw slowly comes out. The reheated glass loom is made to touch the rotating shaft, which starts spiraling around the shaft.

Cutting and bundling: The spiral glass is cut in one plane with a diamond tip cutter to get round shaped bangles. After this cutting process, bangles are counted and are packed in a string to a bunch of 320 pieces, which is also called one "toda". This is the final product of bangle making pot furnace unit, which is sent for finishing operations.

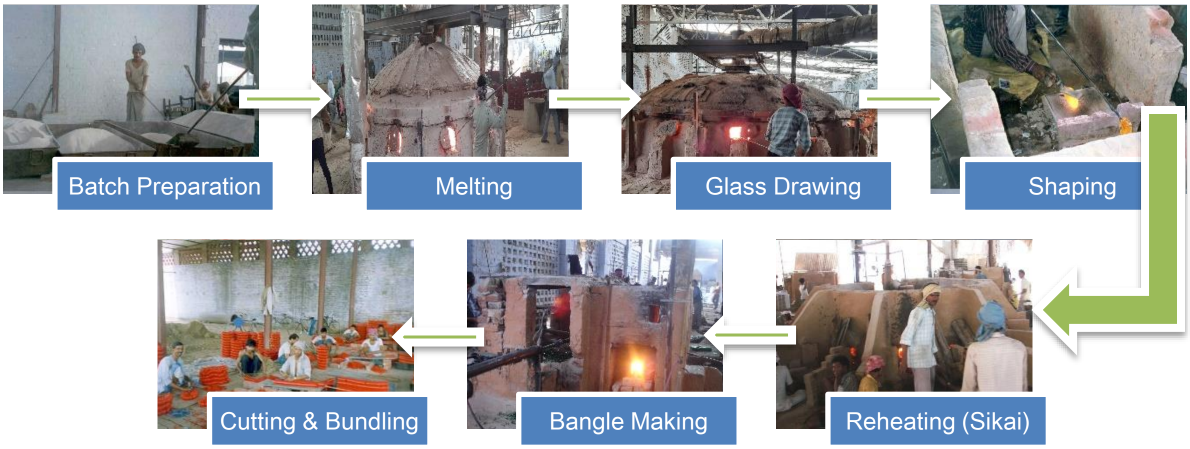


Figure 4.1.2: Process flow in a typical Bangle making Pot furnace unit

4.1.3 Major technologies and equipment

A variety of glass products like bangles, glass rods, container glass, thermos flasks, products are manufactured in the Firozabad cluster. However, the technology use and type of process equipment used in the manufacturing of these products are quite similar. The major technologies and equipment used in process areas and utility sections are provided in table 4.1.3.

Table 4.1.3: Major technologies/equipment used in glass industries

Process/application	Technology/equipment
Glass melting furnaces	• Tank Furnace • Pot furnace
Bangle baking furnace	• Muffle furnace
Auxiliaries/utilities	• Blowers • Fans • Cooling Towers • Air Compressors

4.1.4 Details of process equipment

The main process equipment in the glass industry of Firozabad is the melting furnace. Tank furnaces are continuous type large production capacity furnaces whereas the pot furnaces are batch type. The melting furnaces in the cluster operate 24X7 since commissioned. The muffle furnace is used for the annealing of the glass bangles.

The brief details of these furnaces are provided below;

i) Tank furnace unit

Tank furnace: In a tank furnace unit, the furnace itself accounts for the maximum energy consumption (about 50-55%). All tank furnace units in Firozabad are NG fired. NG is also used as the primary energy source for the gas generators being used in these units. A tank furnace consists of a melting chamber, refining chamber, feeder chamber, and regenerative air preheater. The pilot ignition takes place with compressed air (known as primary air) supplied from a compressed air system. The furnace is equipped with a blower to supply secondary air to complete the combustion.

The secondary air (about 80% of total combustion air) is preheated at 1000^{0}C or more in the regenerator, a "waste heat recovery‟ (WHR) system before entering into the furnace. The regenerator is made up of an array of refractory bricks and comprises two separate chambers. It recovers heat from flue gases and uses to preheat combustion air. The supply of secondary air and the hot flue gases at the regenerator is controlled manually using a reversing valve. Preheating of the combustion air helps in reducing the fuel consumption in the tank furnace. The molten glass flows down to the feeder chamber for the production of the glass products.

Annealing furnace (Lehr): Annealing lehr is used for the heat treatment of glass products to relieve induced stresses during shaping and forming operations, which otherwise would make glass products more brittle. Annealing helps in strengthening glass products. Annealing furnaces (lehrs) associated with the tank furnace are continuous and in line with the shaping machine. The primary energy type is natural gas and electricity is used for the operation of air circulation fans and conveyor systems.

ii) Pot furnace unit

Pot furnace: Typical Pot furnace unit comprises a pot furnace (12 pots for glass melting) and associated process cycle (reheating furnace, bangle making furnaces, etc.). The glass melting pot furnace consumes about 60% of the total energy consumption (natural gas) of the unit. A pot furnace is an integrated system where small capacities of multiple pots are placed inside its periphery and charged with glassmaking material composition manually. These pots are heated simultaneously using a centrally NG fired burner from the furnace crown to produce glass melt of different colors. It is continuously operated and its temperature is always maintained to the required level. The produced glass melt is either used for bangle making during production days (Monday to Saturday) or stored as glass, locally known as chips during holidays and Sundays. These chips are recycled during the production day. Except for glass melting in a pot furnace, other process steps are carried out for about 9 hours a day. Bangle-making units produce unfinished bangle having a cut face in each bangle and the finishing operation is normally completed through various home-based operations out of factory premises.

Reheating furnace (Sekai Bhatti): Reheating furnace helps in raising the temperature of glass loom which drops due to intermittent operations in shaping the loom. The heated loom becomes soft and provides compatibility for bangle-making operations. Reheating furnaces are also NG fired in the cluster. The cluster uses conventional reheating furnaces and does not have a chimney for disposal of hot flue gases resulting in a poor workplace environment. Further, the furnace does not have any waste heat recovery system to recover the waste heat available in flue gases.

Bangle making furnace: Bangle making furnace (belan bhatti) has a rotating shaft with a lead screw, which is driven in a manner to have both linear forward movement and rotary motion along the same axis simultaneously. The shaft is rotated with the help of a connected motor. The reheated glass loom is made to touch the rotating shaft to form a glass spiral around the rotating shaft.

iii) Muffle furnace unit

Muffle furnace: These furnaces are standalone system which is used to anneals finished bangle to improve its strength and luster. These are NG fired either horizontal or vertical furnaces and usually operated continuously once started during the shift operation.

4.1.5 Details of auxiliaries equipment

The brief details of auxiliaries/utilities used in the glass manufacturing units are provided below;

Fans and blowers: The blowers are used to supply both primary and secondary air that is used as combustion air in NG fired furnace operation. The different capacity blowers are employed as needed depending upon air volume requirement for the combustion process. These are used in all types of fuel-fired furnaces like tank furnaces, pot furnaces, annealing lehr furnaces, and glass bangle baking muffle furnaces.

The induced draft (ID) fans are used in the furnaces to maintain adequate furnace pressure for complete combustion and maximum heat generation in the furnace. The induced fans are common in tank furnace units for expelling exhaust gases through the chimney. Pot furnace systems are operated using the natural draft to expel exhaust gases through the chimney.

Cooling tower: The cooling towers are used to remove the heat carried by the coolant liquids used in the process for cooling purposes. The application of a cooling tower is typical observed in the tank furnace based units.

Air compressors: The air compressors are used to meet compressed air requirements in the processes to operate the assorted pneumatic system and special instrumentation in the glass units. The units using a tank furnace require a high volume of compressed air for molding operation. The modern progressive units use VFD-based automatic screw compressors unlike two-stage reciprocating types of air compressors, which are employed in old and comparatively lower capacity tank furnace based units.

Chapter 5

5.0 Energy consumption profile and conservation measures

5.1 Details of energy use

The major cost heads in the glass industries are energy (fuel and electricity), the raw material (silica sand, soda ash, and cullet), and manpower. In glass melting industries energy in the total production cost is significant (~41%). The absolute amount of energy consumption in these units is dependent on the type of glass melting furnace and scale of operation.

The majority of the energy consumption share is thermal, which is around 99%, which also includes a share of thermal energy used for electricity generation using a gas-fired generator. The Firozabad industrial zone falls within the Taj Trapezium Zone (TTZ), which is mandated to use only clean fuel like natural gas. The source of thermal energy is piped natural gas (PNG) that is supplied by the Gas Authority Of India Ltd (GAIL).

5.1.1 Thermal energy

Thermal energy is used to meet the heating requirements of the processes followed in the glass industry. The major energy form used by all units is thermal energy. The cluster is supplied with Natural Gas (NG) through pipelines by GAIL to meet the energy requirements. The cluster is supplied with a fixed amount of subsidized gas, which is priced as per the "Administered Pricing Mechanism" (APM). The additional consumption over and above the allocated subsidized quota by the cluster is priced based on the calculated rate of Re-gasified Liquefied Natural Gas (RLNG) which is higher than APM pricing. Based on the total NG consumption in the cluster within the billing cycle period, GAIL arrives at an average price per unit NG consumption for the cluster ensuring every consumer is billed with the same price, which is equal to the calculated average price. The lowest average price is equal to APM price when total NG consumption in the cluster is equal to or less than the APM quota.

5.1.2 Electricity

The electricity used in glass units is either grid supply or in-house power generation. The grid electricity consumption is usually negligible as against the thermal energy. The in-house power is generated using natural gas. Electricity is primarily used to run the prime movers connected to the different processes and auxiliary equipment in the plant.

The Different energy forms used in the unit, sources, and price details are given in table 5.1.2.

Table 5.1.2: Energy type, sources, and standard tariffs

Energy source	Availability	Tariff details
Natural gas	GAIL Gas Limited	Rs 400 – 550 per Metric Million British Thermal Unit (MMBTU)
Electricity	Dakshinanchal Vidyut Vitran Nigam Limited (DVVNL)	Tariff category: LMV 6 Voltage supply: 0.415 kV Fixed charges: Rs 290 per kW/month Energy charges on entire consumption: - Rs 7.3 per kWh up to 1000 kWh per month - Rs 7.4 per kWh up to 2000 kWh per month - Rs 7.9 per kWh above 2000 kWh per month

5.2 Energy consumption pattern

The energy consumption pattern of the glass units varies based on product type, the technology deployed, and production capacities. The unit-level energy consumption of typical production capacities and cumulative cluster level energy consumption of the Firozabad glass industries are summarised below;

5.2.1 Unit level

NG is the major energy source used in this cluster, both as a source of direct thermal energy as well as in the on-site power generation. The major energy consumption is accounted to tank furnace units which are having high installed production capacity in comparison with other melting units (open and closed pot furnace). The unit-level gas consumption of major furnaces used in the cluster is shown below. The specific energy consumption of the glass melting furnaces varies in the range of 0.20-0.35 SCM of NG per kg of melt, depending on the type of furnaces used.

Table 5.2.1: Unit level NG consumption

Type of unit	Energy consumption	
	NG (SCM/day)	Grid electricity (kWh/year)
Pot furnace	3,000-3,500	30,000-40,000
Tank furnace	12,000-15,000	90,000-1,10,000
Muffle furnace	450-550	Nil

5.2.2 Cluster level

The cluster uses natural gas for glass melting in tank furnaces, day-tank furnaces and pot furnaces (open pot and closed pot). The units in the cluster have installed natural gas based power generator sets to meet the electricity requirements. The total energy consumption of the Firozabad glass cluster is estimated to be 2,64,930 tonne of oil equivalent (toe) during 2019-20.

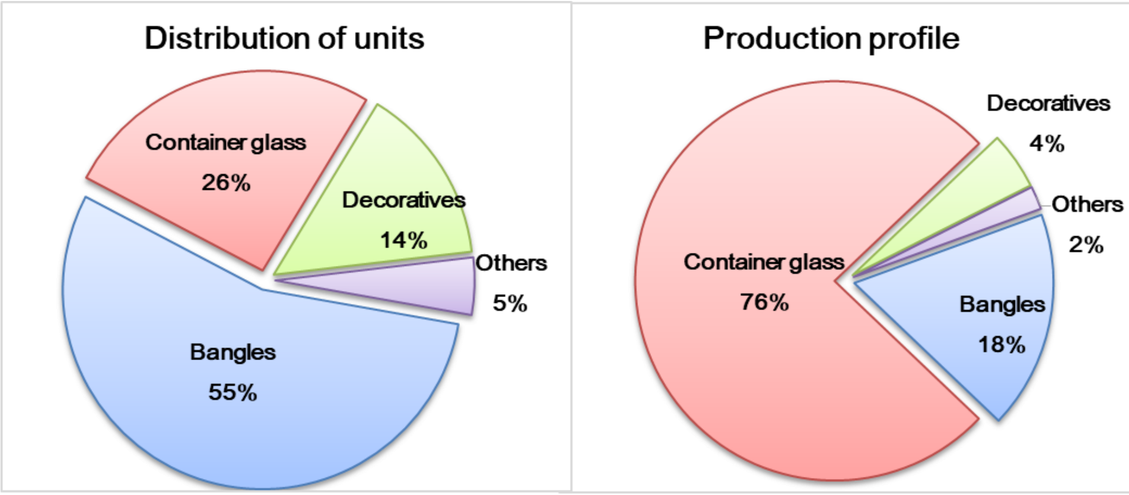


Figure 2.4.2.1a: Distribution of units and production profile of Firozabad

Container glass is account for about 76 percent of total production while consuming about 56 percent of the total energy consumption. The share of bangle production using pot furnaces is about 18 percent and consuming only 34 percent of total energy (Figure 2.4.2.1b).

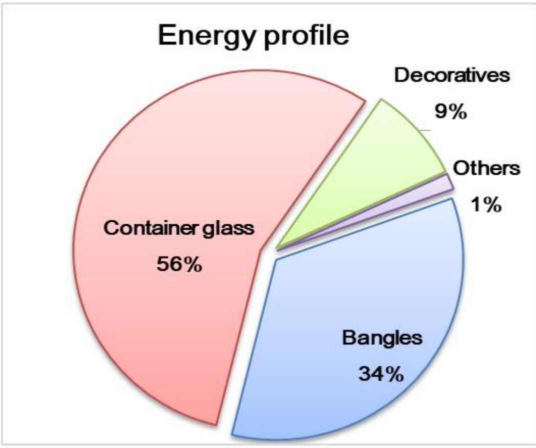


Figure 2.4.2.1b: Share of energy consumption

Heat treatment process of bangles is outsourced and consuming about 2 percent of total energy consumption. The equivalent GHG emissions are estimated to be 5,27,804 tonnes of CO2 per year.

5.2.3 Energy consumption summary of the unit

The summary is of the energy consumption share of the unit is given in table 5.2.3.

Table 5.2.3: Summary of energy consumption share

Energy type	Equivalent energy (toe/year)	GHG emission (tCO_2/year)	Total energy cost (Rs lakh/year)
Thermal energy	2,64,142	5,20,291	588666
Electricity	788	7,513	641
Total	2,64,930	5,27,804	5,89,307

The total energy consumption of the unit is estimated to be 2,64,930 toes per year with equivalent energy costs of Rs 5,89,307 lakh. Thermal energy accounts for about 99.7% of the total energy consumption of the unit (figure 5.2.3). The GHG emissions with energy use are estimated to be 5,27,804 tonnes of CO_2 per year.

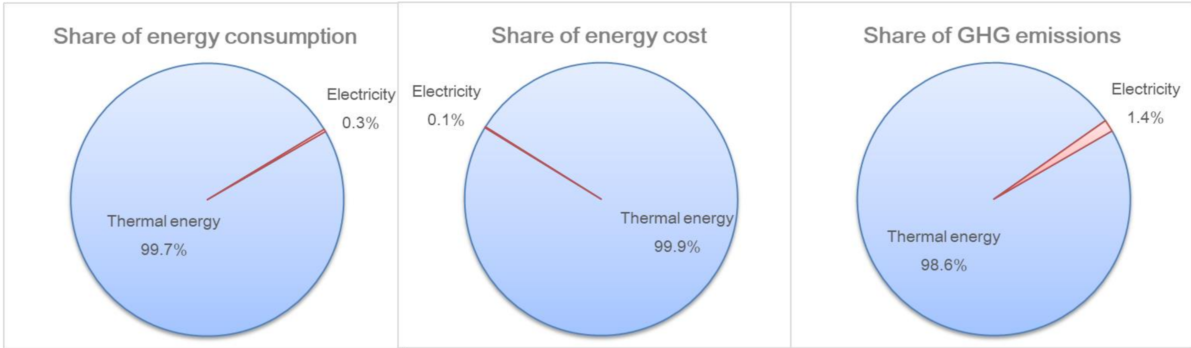


Figure 5.2.3: Share of energy consumption and GHG emissions

5.3 Other resources

Apart from thermal energy and electricity, no other non-conventional sources of energy are utilized in the glass manufacturing units of the Firozabad cluster.

5.4 Energy conservation opportunities

The existing technologies/ equipment used in the glass manufacturing units in the Firozabad cluster are often energy inefficient. There are significant scopes that exist for energy saving in the cluster. A list of different energy conservation measures applicable for Firozabad glass units is provided in table 5.4.

Table 5.4: Major energy conservation opportunities in the cluster

Equipment/section/utility	Potential energy conservation measures
Tank furnace	• Installation of the online pyrometer and close loop operation of fuel firing system • Minimization of air ingression across the regenerator to avoid heat loss • Installation of premium efficiency class (IE3) motors • Installation of energy efficient lighting • Installation of BLDC ceiling and comfort coolers fans • Performance optimization of NG fired lehr furnace • Electrification of NG fired lehr furnace • Switch over to natural draft chimney from venture chimney • Installation of energy efficient screw compressor system • Improvement in insulation and use of high-quality refractories • Improved instrumentation for monitoring & control • Automatic damper system to control furnace draft • Augmentation of furnace melting capacity by adopting Electrical boosting hybrid furnace • Replacement inefficient pumps with energy efficient pumps
Pot furnace	• Development better quality Pot • Installation of optimum waste heat recovery system in Sekai Bhatti • Use of proper burner assembly

Equipment/section/utility	Potential energy conservation measures
	• Appropriate instrumentation and draft system to control excess air inside the furnace • Optimization of WHR system in glass melting furnace • Electrification pot arching furnace to optimize sintering profile • Optimization of surface insulation • Installation of BLDC ceiling and man coolers fans • Electrification of reheating furnace (Sikai Bhatti) • Use of efficient bangle making furnace • Use of proper size blowers • Installation of energy efficient lighting system • Installation of energy efficient recuperative day tank furnace
Muffle furnace	• Electrification of NG fired horizontal muffle furnaces • Conversion of 3 tier vertical NG fired muffle furnace to horizontal electricity based muffle furnace • Installation of BLDC fan

Chapter 6

6.0 Major challenges in the cluster

The cumulative energy consumption of the Firozabad glass manufacturing cluster is quite significant. The analysis of energy consumption by various sub-processes reveals the use of inefficient technologies and equipment by the cluster units. There exists significant scope for energy saving in the cluster. However, the cluster needs to address several challenges for the large-scale adoption of energy and resource conservation measures. Some of the major challenges related to technology, energy pricing, availability and quality of raw material, manpower skill sets, etc.

6.1 Technology

The industries in the cluster use a mix of conventional and new technologies. Lack of awareness on the availability of new and energy efficient technologies, weak linkages with technology suppliers, and limited knowledge of local service providers on modern technologies are the major bottlenecks hindering technology up-gradation in the cluster.

6.2 Energy pricing

The glass manufacturing units in the cluster uses both forms of energy, electrical and thermal (natural gas). The electricity tariff for different industrial consumer categories is well structured and defined based upon the connection category (LT/HT), contract demand (kW/KVA/hp), and electricity consumption (kWh/kVAh) with applicable taxes. Unlike electricity tariff, the existing price mechanism of natural gas is the same for all segments of industrial consumers irrespective of their NG consumption within the billing cycle. This becomes very challenging for small consumers whose consumption is very low compared to the large consumers in the cluster.

As Firozabad industrial area falls within the TTZ, earlier local industrial consumers were used to get NG at a subsidized APM price. The price mechanism was later revised to bill excess NG consumption above the agreed quantity at a different price, which is higher than the APM price. Subsequently, at present common pull price is introduced to arrive at a single pricing rate for all industrial consumers in the cluster irrespective of their consumption quantity by an industrial consumer, which may exceed the agreed APM quota. The pull price is always more than the APM price if the total consumption within the billing cycle is more than the APM NG quota allocated for the cluster. Instead of existing pull pricing, differential pricing similar to the tariff mechanism of local DISCOM for electricity consumers may be beneficial for the smaller industrial consumer of NG in the cluster.

6.3 Raw material

The basic raw materials for producing molten glass are consist of silica sand, soda-lime apart from special-purpose chemical composition and colouring chemicals. Most of these chemicals are imported, which directly influences the manufacturing costs. The scale of operation of micro and small scale units hinders the capacity to purchase raw materials in bulk to make it economical. The absence of a big business quantum prevents the cluster units from effective negotiation for prices with raw material suppliers.

6.4 Manpower and skillsets

Glass manufacturing facilities have gradually switched over from manual mode to machine mode to automation mode of operation as the scale of operation is increased with higher demand. With the up-gradation of processes and machinery, involvements of skilled manpower with suitable experience are essential to ensure quality control and smooth operation of various equipment and sub-systems in the process.

In addition, some of the areas like the utilization of supporting utilities require semi-skilled manpower. However, there is a shortage of both skilled and semi-skilled workforce in the cluster. Most of the employees are trained through hands-on work and develop their skills from working experience. Comparatively, a very small percentage of manpower receives formal training from established institutions.

6.5 Accredited laboratories

Firozabad glass cluster makes various handicraft product, which is sold both in domestic as well as internal market through either with the help established trader or directly by the manufacturer. Export of handicraft and artisan glass products are to be provided with mandatory quality confirmation certificates from recognized accredited laboratories. It is a great challenge for such exporters to obtain the required certificate due to the lack of such facility at the cluster level within Firozabad

6.6 Product development

Artesian and handicraft glass products of the Firozabad cluster have been evolved on their own to cater to the market demand using available local resources and human skills. There is a lack of proactive initiatives among the manufacturers to develop new products for the expansion of both market and user segments. This may be due to a lack of adequate creative facilities with specialised expertise to develop unique colouring chemical, raw material mixture with readymade batch composition to manufacture an export category product in different colour combinations. This approach will enable handicraft exporters to develop a basket of product profiles for the international customer to select, which will lead to an increase in export business for the entrepreneur of the Firozabad cluster.

Chapter 7

7.0 SWOT Analysis

The glass industries in Firozabad face several challenges on regulations on fuel pricing, pollution standards as well as production capacities and exports that can affect the adoption of energy efficiency measures by units in the cluster. The units also face challenges of increasing cost of energy and lack of specialized chemicals, resulting in the increased level of imports of finished products in the domestic market. Firozabad glass cluster has many regional advantages that help the cluster remain at the forefront of the Indian glass industry. There is a need for the glass units to become efficient and maintain a better profit margin which would require the adoption of energy-efficient technologies in their processes and auxiliaries.

A SWOT (Strength, Weakness, Opportunities, and Threats) analysis of the glass manufacturing units in the Firozabad cluster was performed to understand the cluster situation. The SWOT analysis of the Firozabad glass cluster is given below:

Strength	Weaknesses
• Large number of self-reliant & independent glass units in Firozabad • Active industry associations • Adequate supply of energy sources like natural gas, electricity, etc. • Locally available basic raw materials • Huge domestic market • Entrepreneurship zeal in local community	• Polluting nature of the glass units • Limited scope for expansion in the cluster • Shortage of skilled manpower • Use of conventional technologies leading to inefficient production processes • Absence of cluster level institution for quality certification and development of chemicals
Opportunities	**Threats**
• Demand of products in domestic as well as international market • High energy cost for individual unit • Significant potential for energy saving • Potential for automation of processes • Product customization and demand for new and alternative products • Potential in the international market	• Low cost imported products/material • Subsidized pricing mechanism of natural gas • Unavailability of skilled manpower • Substitute products in the packaging industry • Ban on capacity expansion • Limitation on new product introduction in the cluster (TTZ limitations)

Chapter 8

8.0 Conclusions

Firozabad glass cluster with about 213 units is an important industry cluster under the MSME sector in the country. The glass units use both thermal energy and electricity to meet their energy demands. The analysis of the Firozabad glass cluster shows that thermal energy accounts for a major share of energy consumption. The energy intensities of these units are also quite high as compared to large units, which may be attributed to the use of inefficient technologies and equipment in both process and utilities. This also results in increased energy costs.

Optimum use of energy and resource conservation emerge as appropriate solutions for the Firozabad glass cluster to achieve competitive manufacturing costs through the adoption of new and energy-efficient (EE) technologies in processes and utilities. However, to ensure large scale adoption, the cluster has to address a number of barriers which include non-availability of energy efficient technologies, weak linkages with EE technology suppliers, lack of manpower and skillsets, etc.

The technical assistance with the support of the project would help the glass industries in the Firozabad cluster to (i) identify potential process/ utility areas for energy saving, appropriate EE technologies, energy saving potential through detailed energy audits of cluster units (ii) adopt EE technologies through increased awareness and by strengthening linkages with EE technology providers.

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TERI, Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi 110 003, India
Tel.: +91 11 2468 2100 or 2468 2111 | Fax: +91 11 2468 2144 or 2468 2145
Email: pmc@teri.res.in | Web: www.teriin.org