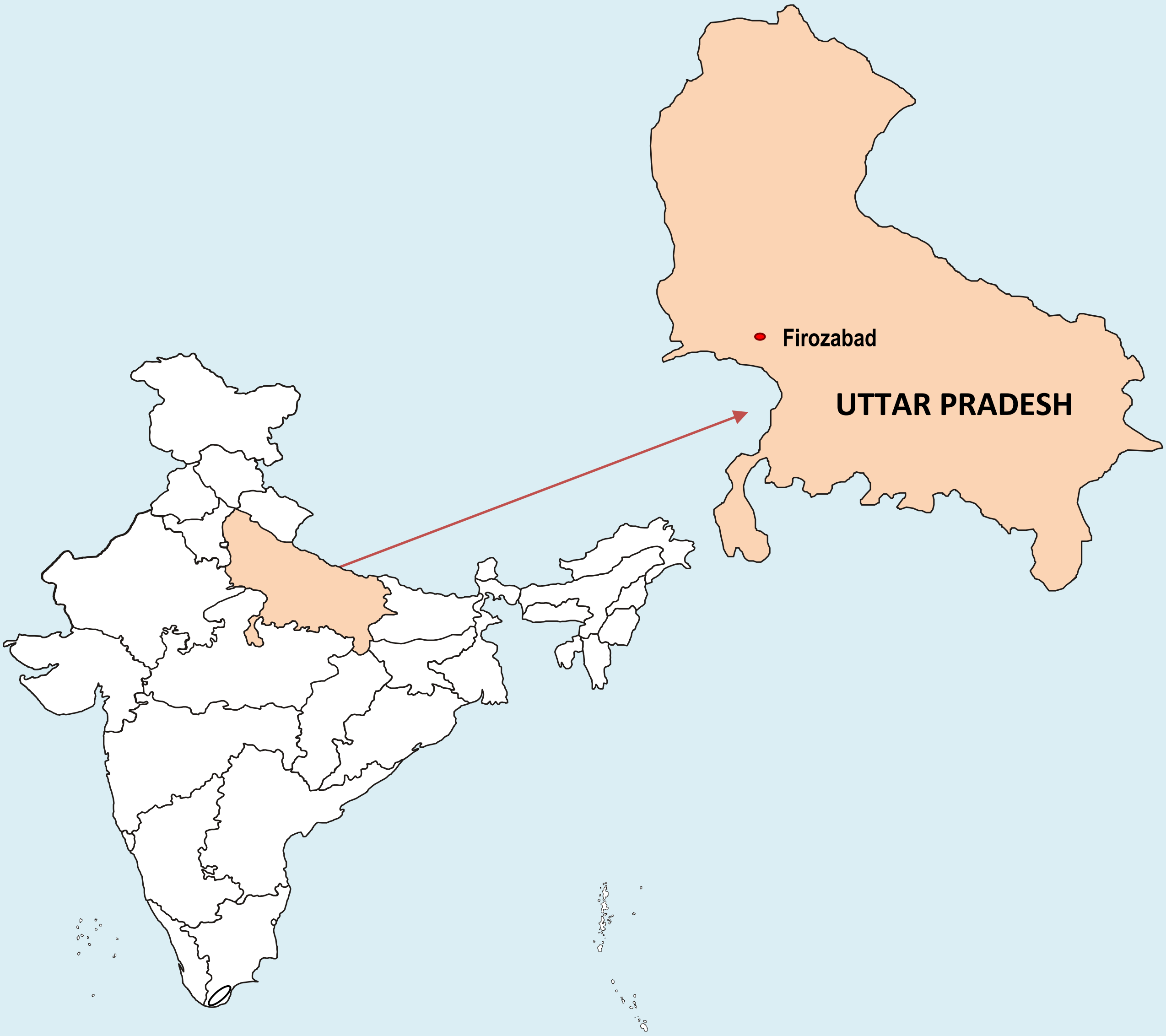
Cluster Profile
Firozabad glass industries



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TERI extends its sincere thanks to Mr Hanuman Prasad Garg (Director, Glass Industries Syndicate) and Mr B C Sharma and Mr Piyush Sharma, the Local Service Providers of TERI under SDC project to provide data and information related to Firozabad glass cluster.

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Firozabad glass industries

Overview of cluster

Firozabad glass cluster is located around 40 kilometres from Agra in the state of Uttar Pradesh. The cluster occupies a special position as it accounts for 70% of the total glass production in MSME (Micro Small and Medium Enterprises) sector. There is a large agglomeration of glass units engaged in the manufacture of different glass products. The cluster is very important because of the fact that glass bangles in India are almost exclusively produced in this cluster. Apart from basic glass production units, there are a large number of tiny units at domestic level in surrounding villages that are involved in various finishing operations of glass bangles.

Products and production capacity

The glass units have deployed different kinds of furnaces to manufacture a range of glass products. The major product of the cluster is the glass bangles of different colours, sizes and designs. The units manufacturing glass bangles have primarily deployed pot and muffle furnaces. Some of them are also using tank furnaces. The units manufacturing glass rods, and decorative items have deployed closed pot furnaces.

The production capacities of tank furnaces are quite higher 25 to 40 tonne per day (tpd) whereas pot furnaces have generally low production capacities (4 to 7 tpd). There are about 55 tank furnaces and 115 pot furnaces (Open & closed). Apart from glass melting units, there are an estimated 400 number of muffle furnaces which are mainly involved in baking or heat treatment of glass bangles. The total estimated glass melt processed in the cluster is 3100 tonne. Tank furnace units are important as about 80% of glass production from the cluster is accounted by them. Different types of glass industries operating in the cluster and their average melting capacities are shown in table.

Glass industries in Firozabad cluster

Type of unit	Number of units	Melting capacity (tpd)
Open pot furnace	90	6 – 7
Closed pot furnace	25	4 – 5
Tank furnace	55	25 – 40
Muffle furnace*	400	0.23 million bangles

* *annealing of glass bangles*

Various types of glass products manufactured in the cluster include jars, tumblers, signal lamp covers, and headlight covers for automobiles, lamp shades, thermos flasks and their refills and laboratory wares and glass bangles. While glass bangles are exclusively produced in open pot furnaces, tank furnaces are producing other glass products. The glass industries in the cluster can be divided into three different types based on the type of furnaces used for glass melting.

- *Open pot furnace units*, which produce mainly glass bangles.
- *Closed pot furnace units*, which produce glass rods, beads and export quality mouth blowing products.

- *Tank furnace units*, which have largest production capacities as compared to other types of melting furnaces. Tank furnace units are generally engaged in the production of container glass, table ware, bulb shell, tubes, etc. except some of the tank furnaces where glass bangles are also made

- *Muffle furnace units* are used for annealing (heat treatment) of glass bangles at the final step to yield the finished products.

Furnace types and production capacities

S No	Type of product	Glass units	Number of units	Average capacity (tpd per unit)
1	Glass bangle	Open pot furnace	95	7
2	Glass rods, beads, decorative items	Close pot furnace	25	5
3	Bangle, bulb and tubes	Tank furnace	30	40
4	Bulb, tube and container glass	Tank furnace	10	50
5	Container glass, tableware	Tank furnace	5	120
6	Bangle baking	Muffle furnace	300	
Number of glass industries in the cluster			465	
Total glass melt processed (tonne per day)			3100	

Energy scenario in the cluster

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. Apart from NG, the glass units use electricity – either grid based which is generally negligible. The units also use in-house power generation using NG. Each glass industry having either pot or tank furnace has been allocated NG quota, which is priced as per the 'Administered Pricing Mechanism' (APM). The additional consumption over and above the allocated quota by individual unit is charged based on the price of Re-gasified Liquefied Natural Gas (RLNG) which is higher than APM pricing.

The prices of NG A large number of muffle furnaces use coal as fuel along with firewood with only few muffle furnace units are using natural gas. The availability of natural gas at the locations of muffle furnace units is constrained by factors such as accessibility of units for gas supply, small quantity of gas requirements per muffle furnace and lower costs of coal as compared to escalating NG prices.

Production process

(i) Tank furnace units

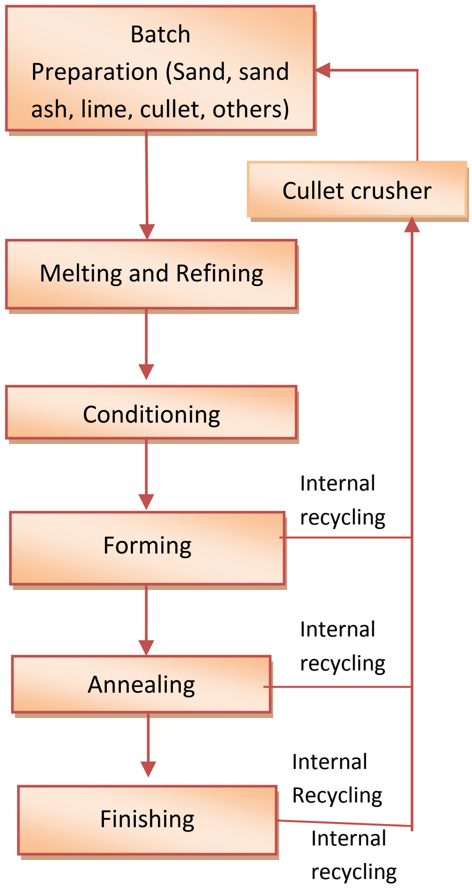
Different process steps followed in a tank furnace unit is briefed below.

(a) 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 process whereas large tank furnaces say use mechanized systems. The batch material is fed to the 'doghouse' through a belt conveyor arrangement.

(b) Glass melting

An end-fired tank furnace is used for continuous melting of glass. Melting is the most energy intensive operation in a tank furnace unit, using thermal energy. Many of the larger units use tank furnaces built of refractory blocks. Zirconium based electro-cast refractory blocks are used in areas having direct contact with glass melt. Sillimanite blocks are used in other high temperature zones. The temperature of the glass melt is maintained at about 1450oC. The molten glass is flown through 'refiner zone' to get rid of air bubbles. The melt is tapped from the feeder chamber for shaping and forming.



(c) Shaping and forming

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. Electricity is primarily used in press machines and compressors to operate pneumatic systems.

(d) Annealing

The shaping and forming operations will induce stress in the glass products. It is necessary to remove these strains from the glass products so that they do not brittle. The annealing process removes this stress through gradual heating, soaking and cooling of the products.

(e) Finishing

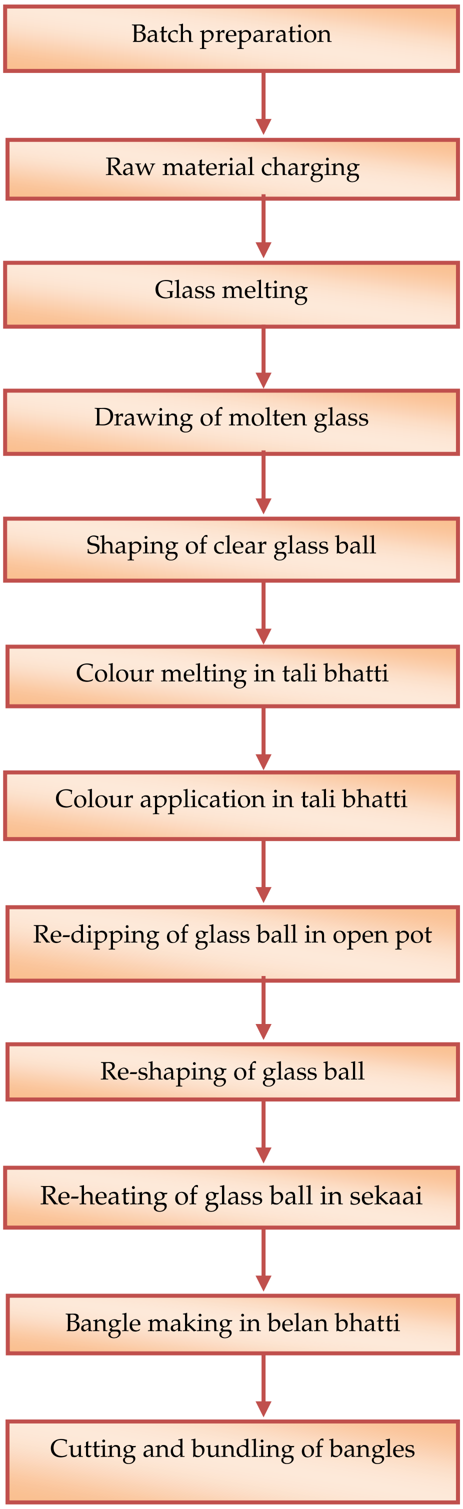
The glass products after annealing are sent for finishing operations like cleaning, grinding, polishing, cutting, painting and grading as per requirements. The final products are packed after inspection for defects. Electrical energy is used for different finishing operations

(ii) Pot furnace units

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.

(a) 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 the pots containing coloured glass.



Process flow of bangle making in pot furnace unit

(b) Glass melting

In an open pot furnace, 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 1250-1280 oC 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 so as to reach to 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 is dependent on raw material composition and colouring additives in a charge batch.

(c) 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 'mild steel' (MS) rod inside the pot through the charging door. When the molten glass gets ready, it is taken out with using MS rods. These rods are of 10-18 mm in diameter and about 2.5 metre in length. These rods have a small notch at the end, which facilitates lifting of molten glass.

(d) Shaping of glass ball

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

(e) 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 next operation of making bangle spiral in bangle making furnace. Ready loom is brought manually to the operator of bangle making furnace.

(f) Bangle making

Bangle making furnace (belan bhatti) has rotating shaft with 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 either manually or with motor. As the belan rotates, the lead screw slowly comes out. The reheated glass loom is made to touch the rotating shaft, which starts spiralling around the shaft.

(g) Cutting and bundling

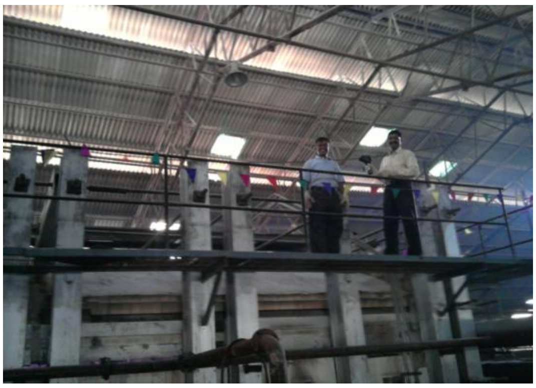
The spiral glass is cut in one plane with a diamond tip cutter to get round shaped bangles. After this cutting process, bangles are counted and are packed by a string to a bunch of 320 pieces, which is also called one toda. This is the final product of bangle making pot furnace unit, which is sent for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

Technologies employed

The main system in a glass industry is the melting furnace, which are generally continuous type furnaces. That is, a melting furnace operates non-stop for 24 hours each day from the moment it is commissioned till its final shutdown. The reason is simple. If a melting furnace is shut down in the middle of operation, charge material and fuel worth several tens of thousands of rupees is irretrievably lost. Furthermore, the costs of cleaning up the furnace and reheating it, along with the costs of the labour and time required to do this, add up to enormous losses for the unit. There are two basic kinds of melting furnaces used in the Firozabad cluster to make glass: the tank furnace and the pot furnace

(i) Tank furnace unit

(a) Tank furnace



The tank furnace is the main system in a tank furnace unit which accounts for main energy consumption in the unit (about 60-70%). Prior to 1996, there were two types of tank furnaces operating in Firozabad cluster - coal-fired and oil-fired. At present, all tank furnace units are NG fired. A tank furnace consists of melting chamber, refining chamber, feeder chamber and regenerative air preheater. The pilot ignition takes place with compressed air (known as primary air) supplied from compressed air system. The furnace is equipped with blower to supply secondary air to complete the combustion.

The secondary air (about 80% of total combustion air) is preheated about 600ºC 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. These devices recover heat from flue gases and use it 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 production of the glass products. A schematic of tank furnace unit is shown in figure.

(b) Annealing lehr

Annealing lehr is used for the heat treatment of glass products to relieve induced stresses during shaping and forming operations, which otherwise would lead to brittle of glass. Annealing helps in strengthening of glass products. Two types of annealing lehrs are used in the cluster, continuous and batch. Both type use NG for heat treatment.

Annealing lehr

(ii) Pot furnace unit

(a) Pot furnace

The pot furnace units comprise pot furnace (for glass melting), reheating furnace (sekai bhatti) and bangle making furnaces (belan bhatti). Pot furnace accounts for about 60% of NG consumption in a pot furnace based glass melting unit. A pot furnace is an integrated system where small capacities multiple pots are charged with manually mixed glass making material composition and heated simultaneously inside furnace periphery to produce glass melt of different colours. It is continuously operated and its temperature is always maintained to the required level. Except melting pot furnace, other process steps are carried out for about 9 hours in 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 operation out of factory premises.

Pot furnace

(b) Reheating furnace

Reheating furnace (sekai bhatti)helps in raising the temperature of glass loom which drops due to intermittent operations like colouring, etc. and provides compatibility for bangle making operation. Reheating furnaces are also NG fired in the cluster. The cluster uses conventional reheating furnaces and does not have chimney for disposal of hot flue gases which leads to poor work environment. Further, the furnace does not have any waste heat recovery system to recover the waste heat available in flue gases.

Reheating Furnace

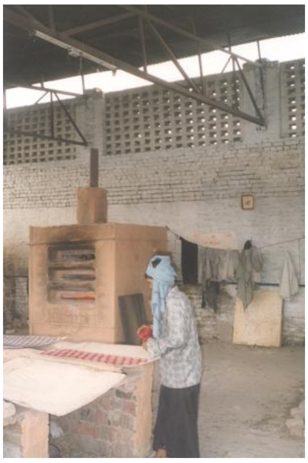
(c) Bangle making furnace

Bangle making furnace (belan bhatti) has rotating shaft with 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 either manually or with motor. As the belan rotates, the lead screw slowly comes out. The reheated glass loom is made to touch the rotating shaft, which starts spiralling around the shaft

(ii) Muffle furnace unit

Muffle furnaces units are standalone units which receive bangles from pot furnace units to improve the strength of bangles. Muffle furnace units generally consist of more than two furnaces in a unit. These are coal fired units which do not have any control/ monitoring systems for temperature control and are completely dependent on the skill of operators.

Natural gas fired muffle furnaces were demonstrated under TERI-SDC partnership project. However, their adoption at cluster level is dependent on availability of natural gas at the premises of muffle furnace units. The concept of 'Common Facility Centre' (CFC) for muffle furnace units was also promoted under TERI-SDC project.



Muffle furnace

Energy consumption

The major energy form used in the cluster is natural gas in tank furnace units and pot furnace units. Majority of muffle furnaces in the cluster uses coal and a small fraction of units have switched over to natural gas.

(i) Unit level consumption

The major energy consumption is accounted by tank furnaces which are larger in capacities. NG is the major energy source used in glass melting. The unit level NG consumption of major furnaces used in the cluster is shown below. The Specific Energy Consumption (SEC) of melting furnaces varies from 0.20 to 0.35 Sm^3 per kg of melt depending on type of furnaces used.

Energy consumption of different furnaces

Type of unit	NG consumption per unit (Sm^3 /day)
Open pot furnace	3500
Close pot furnace	3500
Tank furnace	52000
NG based muffle furnace	240

(ii) Cluster level consumption

Apart from natural gas, the cluster also uses other energy forms such as coal, LPG, kerosene, diesel, etc. The total annual energy consumption of the cluster is estimated to be 310,000 toe and the break-up is given below.

Cluster level energy consumption

Fuel type	unit	Energy consumption		Annual energy bill (million INR)
		(Unit/day)	toe/year	
NG	Sm^3	879280	264663	6155
Coal	tonne	121	16940	22
Pet coke	tonne	36	11340	63
LPG	tonne	8	3332	19
Kerosene	kL	21.5	6290	113
Diesel	kL	23.5	7434	453
Total energy consumption			310000	7185

Energy saving opportunities and potential

(1) Tank furnace units

(a) Improved tank furnaces

A majority of the existing tank furnaces in the cluster have poor design and use comparatively inferior materials for furnace and regenerator construction. Use of non-compatible insulating materials has increased structural losses leading to poor thermal efficiency of furnaces. Further, inefficient burners are being used leading to poor combustion. Absence of monitoring & control system along with manual control of regenerator has further deteriorated the efficiency of tank furnaces of different capacities in the cluster.

Improved tank furnaces will have optimum furnace design with improved structural stability. Use of high quality refractories and compatible insulating materials would lead to reduced structural losses. Other features of improved design would include (1) compatible burners, (2) optimum heat recovery from regenerator, (3) improved instrumentation for monitoring & control and (4) automatic damper system to control furnace draft. The envisaged energy saving is 30-35% equivalent to 48 million Sm^3 per year at cluster level. The estimated investment requirement is Rs 400 lakh per tank furnace.

(b) Other energy saving options in tank furnaces and auxiliaries

The energy saving options in existing tank furnaces include (i) Waste heat recovery in flue gases and (ii) Reduction of structural loss by providing proper insulation in glass melting furnace and regenerative air pre-heater. The existing annealing lehrs are quite inefficient, which can be replaced with energy efficient annealing lehrs with an energy saving potential ranging from 40-50%.

(c) Energy saving options in utilities

Other potential energy saving options in utilities include (i) energy efficient compressed air system, (ii) replacement of old motor with energy efficient motor and (iii) replacing inefficient pumps with energy efficient pumps and (iv) energy efficient lighting system.

(2) Pot furnace units

Almost all pot furnace units have adopted energy efficient pot furnace design in the cluster under the TERI-SDC partnership project. Pot furnaces which are used for glass melting account for about 60% of total energy consumption in a pot furnace based glass industry and achieve a consistent energy saving of 30-35%. The energy saving options in auxiliary processes in pot furnace units are briefed below.

(a) Reheating furnaces

The reheating furnaces that are operating in the cluster are conventional design and do not have any monitoring & control, waste heat recovery or chimney arrangement. An energy efficient reheating furnace will have (i) Waste heat recovery system (recuperator) (2) compatible burners, (iii) appropriate instrumentation and draft system. The envisaged energy saving is about 25% of natural gas consumption in reheating furnaces equivalent to 4.9 million Sm^3 per year at cluster level.

(b) Other energy saving measures

Other areas of energy saving include (i) efficient bangle making furnace (ii) use of proper size blowers in pot furnaces and (iii) energy efficient lighting.

Major stakeholders

The major stakeholders include different industry associations in the cluster as shown below:

Category	Name of association
Tank furnaces	• Uttar Pradesh Glass Manufacturer Association
Pot furnaces	• The Glass Industrial Syndicate
Muffle furnaces	• Allied Coal Consumers Association, • The Firozabad Coal Consumer Association • Kada Bangle Association • Laghu Udhyog Pakai Bhatti Chamber • Kaanch Audhyogic Sehkari Samiti Ltd • Bajrang Pakai Bhatti Samiti • Sahara Nagla Mirza Churi Pakai Bhatti Samiti • Durbin Samiti • Janhit Pakai Bhatti Seva Samiti • Firozabad Sangh • Kadachaal Pakai Bhatti Cottage Works

Other stakeholders include GAIL (India) Limited who provide piped supply of NG in the cluster, Centre for Development of Glass Industry (CDGI) and District Industries Centre Firozabad.

Cluster development activities

TERI had undertaken a major initiative during the period 1994 to 2012 with support from the Swiss Agency for Development and Cooperation (SDC) for demonstration and dissemination of energy efficient pot furnaces and muffle furnaces. At present, there is no on-going intervention in the cluster.

About TERI

A dynamic and flexible not-for-profit organization with a global vision and a local focus, TERI (The Energy and Resources Institute) is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy problems to tackling issues of global climate change across many continents and advancing solutions to growing urban transport and air pollution problems, TERI's activities range from formulating local and national level strategies to suggesting global solutions to critical energy and environmental issues. The Industrial Energy Efficiency Division of TERI works closely with both large industries and energy intensive Micro Small and Medium Enterprises (MSMEs) to improve their energy and environmental performance.

About SDC

SDC (Swiss Agency for Development and Cooperation) has been working in India since 1961. In 1991, SDC established a Global Environment Programme to support developing countries in implementing measures aimed at protecting the global environment. In pursuance of this goal, SDC India, in collaboration with Indian institutions such as TERI, conducted a study of the small-scale industry sector in India to identify areas in which to introduce technologies that would yield greater energy savings and reduce greenhouse gas emissions. SDC strives to find ways by which the MSME sector can meet the challenges of the new era by means of improved technology, increased productivity and competitiveness, and measures aimed at improving the socio-economic conditions of the workforce.

About SAMEEEKSHA

SAMEEEKSHA (Small and Medium Enterprises: Energy Efficiency Knowledge Sharing) is a collaborative platform set up with the aim of pooling knowledge and synergizing the efforts of various organizations and institutions - Indian and international, public and private - that are working towards the development of the MSME sector in India through the promotion and adoption of clean, energy-efficient technologies and practices. The key partners are of SAMEEEKSHA platform are (1) SDC (2) Bureau of Energy Efficiency (BEE) (3) Ministry of MSME, Government of India and (4) TERI.

As part of its activities, SAMEEEKSHA collates energy consumption and related information from various energy intensive MSME sub-sectors in India. For further details about SAMEEEKSHA, visit http://www.sameeeksha.org