SMALL AND MEDIUM ENTERPRISES: ENERGY EFFICIENCY KNOWLEDGE SHARING

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SAMEEEKSHA NEWSLETTER

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Promoting Energy Efficiency in SMEs

SAMEEEKSHA

VISION

SAMEEEKSHA envisages a robust and competitive SME sector built on strong foundations of knowledge and capabilities in the development, application, and promotion of energy-efficient and environment-friendly technologies.

Bureau of Energy Efficiency

SHAKTI SUSTAINABLE ENERGY FOUNDATION

teri The Energy and Resources Institute

MSME

A PLATFORM FOR PROMOTING ENERGY EFFICIENCY IN SMEs

IN THIS ISSUE...

This issue focuses on the Ambala laboratory glassware cluster, in which TERI is conducting a comprehensive study under the project 'Energy and resource mapping of MSME clusters' launched by BEE. There are close to 500 MSMEs in the Ambala laboratory glassware cluster, manufacturing a wide variety of high-quality glassware apparatus and other products for Indian and international markets. The studies include detailed energy audits that have been conducted on representative units in the cluster to identify energy efficiency measures that can be implemented by the concerned units to bring significant savings in energy costs—in many cases, against low investments—and increase their profitability and competitiveness.

The first article provides an overview of the Ambala laboratory glassware cluster, including a brief description of the different categories of MSME units, the processes and technologies in use, the major cluster-level stakeholders, and the barriers and challenges being faced by the units in day-to-day operations as well as in improving energy and resources efficiency—particularly in the context of their near-total dependency on imports for the primary raw materials (borosilicate glass tubing), the rising prices of liquid petroleum gas (LPG) which is a primary fuel for the units, and the continuing adverse market conditions within and outside India brought about by the Covid-19 pandemic.

The second article summarizes the findings and recommendations of the detailed energy audits conducted by TERI in 10 representative units in the Ambala laboratory glassware cluster. As the article describes, the DEAs helped in identifying a number of energy conservation measures that could be adopted by the concerned units to achieve significant reductions in energy consumption and costs, with attractive payback periods on investments.

SAMEEEKSHA Secretariat

ENERGY AND RESOURCE MAPPING STUDY IN AMBALA LABORATORY GLASSWARE CLUSTER

TERI is conducting a comprehensive energy and resources mapping study in the Ambala laboratory glassware cluster—among the largest glassware manufacturing clusters in India— under the project 'Energy and resource mapping of MSME clusters' launched by BEE [see *SAMEEEKSHA 11*(4), Dec 2020 issue for details on the project]. There are close to 500 MSMEs in the Ambala laboratory glassware cluster, manufacturing a wide variety of high-quality glassware apparatus and other products for Indian and international markets. The products include beakers, bottles, burettes, columns, condensers, culture bottles and tubes, crucibles, desiccator systems, distillation equipment, flasks, funnels, measuring cylinders, pipettes, test tubes, vials, etc. Some of the units also produce borosilicate glass bottles, baby feed bottles and tableware. There are 47 small and medium-sized units producing laboratory glassware and apparatus, and equipped with in-house facilities for glass blowing and annealing (heat treatment). They are mainly located in the industrial estates of HSIDC, Ambala Cantonment and HSIDC, Saha. The majority of MSMEs (about 450) are micro-sized units located in and around Ambala City and Kardhan village. They are equipped with glass-blowing facilities and produce semi-finished products, with the downstream processing and finishing operations either outsourced or performed by the laboratory glassware/apparatus manufacturers themselves. Table 1 provides a snapshot of the Ambala laboratory glassware units.

Table 1. Profile of Ambala laboratory glassware units

Category	No. of units	Main products and processes	Annual production (tonnes)*
Medium	7	Apparatus; glass blowing and annealing	950
Small	40	Laboratory glassware; glass blowing and annealing	2997
Micro	450	Glass blowing	8100
Total	497		12047

*estimated on the basis of raw materials consumed

The principal end-users of the Ambala laboratory glassware products in India and abroad are analytical and testing laboratories, educational and R&D institutes, and a range of industries such as beverages, chemicals, cosmetics, pharmaceuticals and plastic. A few Ambala units have acquired Indian (NABL) and international quality certifications, and export specialty products to European countries, Australia, Singapore and USA. The Ambala laboratory glassware cluster contributes about 60% of India's total glassware exports.

There are four major industry associations active in the Ambala glassware cluster:

Indian glass industry

The centuries-old glass industry in India has evolved from a small-scale, largely unorganized sector deploying traditional mouth-blown and hand working processes, to an increasingly organized sector in which units are adopting modern processes and automation to make diverse high-quality products for both domestic and international markets.

Apart from a few large-scale manufacturers of glass products, there are over 1000 MSME glass units. The large-scale glass plants are mainly located in Ahmedabad, Bahadurgarh, Bengaluru, Chennai, Hyderabad, Kolkata, Mumbai, and Vadodara. Ambala (Haryana),Firozabad (Uttar Pradesh) and Jaipur (Rajasthan) host large clusters of MSME glass units.

The Indian glass industry consists of seven segments: namely, sheet and flat glass; glass fibre and glass wool; hollow glassware; laboratory glassware; table and kitchen glassware; glass bangles; and other glassware. Barring the huge and unexpected adverse impacts of the Covid-19 pandemic, the Indian glass industry has been growing across all segments, driven primarily by the booming automotive and construction sectors which have been key drivers of the Indian economy for the past few years.

- Laboratory Glassware and Apparatus Industry Association
- The Ambala Scientific Instruments Manufacturers' Association (ASIMA)
- Scientific Apparatus Manufacturers & Exporters (SAME)
- Scientific Apparatus Manufacturer Association (SAMA)

Figure 1. Basic stages in the lab glassware production process

Other important cluster-level stakeholders include the Haryana Chamber of Commerce and Industries (Ambala Chapter); District Industries Centre (DIC), Ambala; MSME Development Institute (MSME-DI), Karnal; and over 25 banks (public sector, private and cooperative) that are operating in the region. However, there are no R&D organizations or institutions in the vicinity to provide support to the MSME units for product and technology development; nor have any significant cluster-level initiatives been undertaken so far on energy efficiency, technology up-gradation, or skills development.

Production process and technologies in use

The primary raw materials used by the Ambala laboratory glassware units are borosilicate glass tubes of different diameters and thicknesses. Borosilicate glass is used as base material for laboratory glassware because of its chemical and thermal stabilities.

Glass blowing is the foundational step of the laboratory glassware manufacturing process (Figure 1). In essence, glass blowing involves the heating of a borosilicate glass tube in an open flame till the glass softens close to its melting point, and inflating the molten glass with a blowpipe to form a glass bubble which is then moulded into the desired shape and size. Glass blowing demands high precision, and is performed by highly skilled and experienced workers who employ mouth blowing or paddle blowing with traditional equipment such as single chuck and double chuck glass blowing lathes, depending on the size of glassware being produced. The Ambala units employ liquefied petroleum gas (LPG) mixed with oxygen to provide high-intensity open flames for the glass blowing operations. The glass blowing lathes are locally made and driven by electricity (figure 2).

The blown glassware is subjected to cycles of annealing before and after further processing and finishing operations such as joining, sealing, grinding, scaling, printing, calibration, etc. Annealing helps relieve the stresses that are induced in the glassware products during the shaping and forming operations, and makes the glass products stronger. Most of the laboratory glassware units employ batch-type annealing furnaces that use LPG or electricity (figure 3). A few units with large production capacities deploy continuous type LPG-based annealing furnaces, with electricity used for operating air circulation fans and conveyor systems.

Figure 2. Glass blowing lathe

Figure 3. Annealing furnace

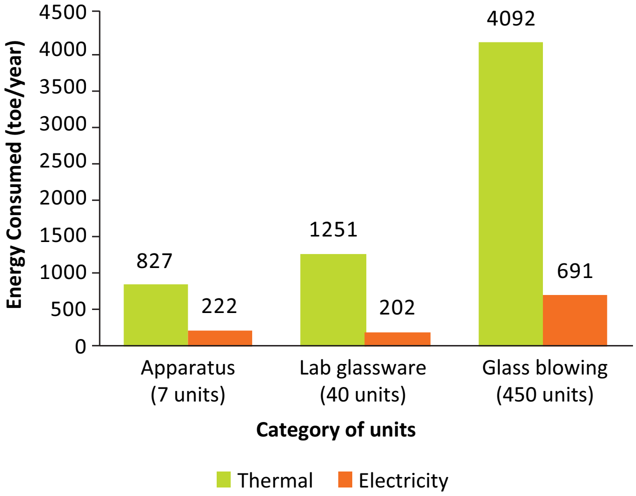

Figure 4. Energy consumption profile of Ambala laboratory glassware units

The major production cost heads in the laboratory glassware units are raw materials (borosilicate glass tubing and oxygen), manpower, and energy (fuel and electricity). Raw materials and manpower together account for about 80% of total production cost, while energy accounts for the remaining 20%.

Energy usage

The laboratory glassware units consume both thermal and electrical energy. All the units use LPG in the glass blowing process, while both LPG and electricity are used in annealing. Electricity is also used to run the motors, blowers, etc. associated with the different processes/equipment in the units.

The main source of thermal energy is LPG, which is supplied by the local authorized distributors of gas companies like IOCL, BPCL, and HPCL. A few of the larger (medium-sized) units have entered into bulk supply contracts with the gas companies, and have established bulk storage facilities and local distribution networks for gas within their unit premises. The small and micro units use LPG cylinders (19 kg) to meet their gas requirements for glass blowing.

The total cluster-level energy consumption is estimated at 7285 tonnes of oil equivalent (toe), of which thermal energy accounts for about 6170 toe (85%), and grid electricity, 1114 toe (15%). At the unit level, the total energy consumption depends on the sizes and types of products, annealing requirements, and the volume of production. In general, the apparatus manufacturing units have the highest production volumes, and hence show the highest unit-level energy consumption levels; while the glass blowing units are the most numerous as a category and hence account for the maximum share in cluster-level energy consumption (figures 4 & 5).

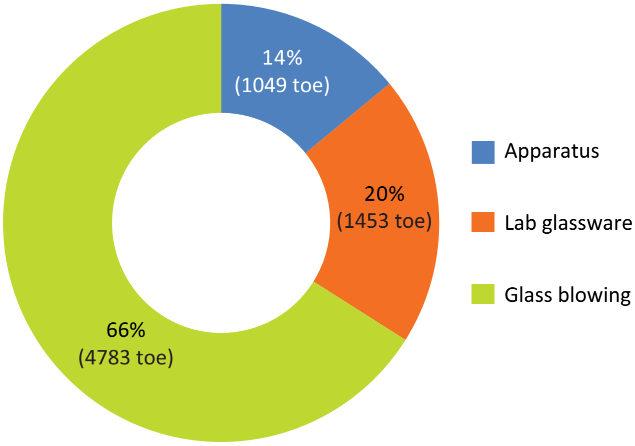

Figure 5. Category-wise shares in cluster-level energy consumption

Opportunities for energy conservation

The glass blowing lathe (single/double chuck) is the primary technology being deployed by most of the Ambala laboratory glassware units. These lathes are of conventional type, typically driven by low-efficiency (standard) motors, with the efficiency of production (i.e., productivity) and product quality being highly dependent on the skillsets of the lathe operators. At present, the project does not envisage replacement of the glass blowing lathes being used in the cluster with alternative technologies, because there are no readily available technological options.

However, the downstream process equipment, i.e., annealing furnaces and auxiliaries such as air compressors, are generally low in energy efficiency and offer significant scopes for energy saving. Table 2 lists some of the broad energy conservation measures (ECMs) identified for the Ambala glass units. The next article in this issue provides a more detailed account of the ECMs identified for implementation by specific units.

Table 2. Broad energy conservation measures (ECMs) identified for Ambala laboratory glassware units

Process area	ECM
Annealing	• Replacement of existing low-efficiency annealing furnaces with energy efficient LPG-fired /electrical annealing furnaces • Usage of low thermal mass material handling trays in annealing furnaces
Utilities	• Replace low efficiency air compressors with energy efficient air compressors (PMSM/VFD enabled) • LPG distribution network with a bulk storage facility • Energy efficient BLDC motors for glass blowing lathe • Energy efficient lighting throughout the plant • Installation of rooftop solar PV system

Key challenges

Interactions during the study with the entrepreneurs, industry association representatives and other cluster-level stakeholders have provided insights into a few major challenges that the Ambala laboratory glassware units face: challenges that have only been intensified by the ongoing Covid-19 pandemic, and that will have to be addressed and resolved through engagements between the industry representatives and the appropriate state agencies and organizations at the policy/institutional levels. These challenges are summarized below.

Import dependency for raw materials

In the absence of Indian manufacturers of glass tubing, the units have to import their entire requirements of this critical raw material: mainly from China (80%), Germany, and the Czech Republic. Another critical raw material that has to be imported in the absence of Indian suppliers is optical glass. The import of these key raw materials adds to their landed costs, and hence increases product costs and places the Ambala units at a great disadvantage in the highly competitive international marketplace, where their biggest competitor is China—the very country from which the Ambala units import much of their primary raw material!

Energy pricing

LPG is the primary source of energy used by the laboratory glassware units, and almost all the units are procuring LPG from local distributors. In India, the LPG price is set based on a formula, 'import parity price' (IPP). The IPP is determined based on LPG prices in the international market, assuming that the fuel is imported into the country. While there is no shortage of LPG supply at the cluster level, the major challenge for the Ambala units is the rising price of LPG.

Workforce skills

There are a number of government-supported skills development institutes such as ITIs in the vicinity of Ambala. The laboratory glassware industrialists have interacted with these institutes and underlined the need for training courses on glassware manufacturing techniques and practices, as well the ready employment opportunities that trainees would find among the local laboratory glassware units. However, till date these institutes do not offer any training courses related to glassware manufacture. Besides, the institutes lack the faculty to conduct such training programs. Hence, it is a constant challenge for the units to locate and recruit skilled workers, as well as to upgrade the skillsets of their existing workforce.

An example is the technique of glass blowing. The Ambala units depend on glass blowers who have learned their skills 'traditionally', i.e., from elders who have practiced glass blowing as a family occupation and passed their knowledge and skills down through the generations, typically from father to son. In the absence of formally trained glass blowers, there is great demand for these traditional glass blowers whose numbers are limited (if not shrinking).

Pandemic fallout on demand

Owing to the pandemic and the protracted closure of industries as well as of educational and research institutes (schools, colleges, engineering institutes, etc.), the demand for scientific /laboratory glassware has dropped drastically since 2020 and is yet to recover. At the same time, oxygen—an important raw material for the Ambala glassware units—has become very costly, and its availability for industrial use is constrained due to the mandated supply of oxygen on priority to hospitals etc. As a consequence of these factors, about 50% of the units in Ambala have not resumed operation even after lifting of lock-down.

ENERGY CONSERVATION MEASURES FOR LABORATORY GLASSWARE UNITS IN AMBALA CLUSTER

Under the BEE-supported energy and resources mapping project, TERI conducted detailed energy audits (DEAs) in 10 representative units in the Ambala laboratory glassware cluster. The DEAs helped identify a number of energy conservation measures (ECMs) that could be adopted by the units to achieve significant reductions in energy consumption and costs, with attractive payback periods on investments.

The two most significant energy consuming processes in laboratory glassware production are glass blowing and annealing. Glass blowing is essentially a batch process, in which highly skilled glass blowers operate individually on lathe machines, using blowpipes and open flames (generated by burning a mixture of LPG and oxygen) to produce 'blown' glass products, one at a time. The consumption of energy and resources in glass blowing depends in complex ways on the weight and shape of the product being blown, as well as on the skill sets of the operator. As a consequence, the specific energy consumption (SEC) too shows great variation when estimated for different products in the glass blowing process. This is illustrated by figure 1, which shows the estimated SEC values for glass blowing of three products of different shapes and weights: in this case, the smallest product with the lowest weight (i.e. flask rim weighing 6 g) showed the highest SEC value (4.52 kg LPG/kg product)!

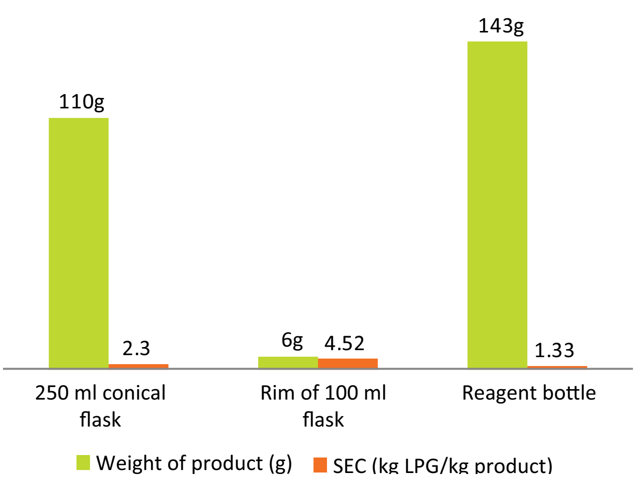

Figure 1. Variations in SEC for glass blowing of products with different sizes and weights

The project focused on identifying energy saving options in downstream process areas such as annealing, through upgrading technology as well as through the adoption of best operating practices and improved housekeeping measures.

Profile of units

Table 1 presents a brief profile of the 10 laboratory glassware units in which DEAs were conducted.

Table 1. Profiles of the 10 laboratory glassware units in which DEAs were conducted

Unit	Glass tubing consumed (t/year)	Energy consumption (toe/year)	SEC (toe/t glass tubing)
Unit 1	800	883	1.1
Unit 2	173	104	0.6
Unit 3	25	26	1.0
Unit 4	54	33	0.6
Unit 5	44	21	0.4
Unit 6	25	16	0.3
Unit 7	78	23	0.3
Unit 8	21	6	0.3
Unit 9	15	15	1.0
Unit 10	27	19	0.7

Energy conservation measures

A total of 44 ECMs were identified and recommended for implementation by the 10 glassware units. Some of the key ECMs are briefly described below, along with the typical simple payback period (SPP) on investment in each case. Table 2 summarizes the benefits from implementing the ECMs in terms of energy and cost savings.

Annealing

The units use LPG-fired annealing furnaces as well as electric annealing furnaces. The DEAs showed that the LPG-fired furnaces had very low energy efficiencies (between 5–17%), primarily due to heat loss through flue gases, structural heat losses, poor instrumentation & control systems, etc. The electric annealing furnaces were found to have relatively higher energy efficiencies (≈ 40%), but the useful heat (i.e., heat actually taken up by the glass products being annealed) was estimated at only about 10% because of the large deadweight of the material handling trays. Options identified to improve energy efficiency in the annealing furnaces included the following:

- Replace the existing LPG/electrical annealing furnace with energy-efficient annealing furnace equipped with IGBT control system (SPP: about 4 years)
- Retrofit the LPG-fired furnace to operate on electricity (SPP: 1.5 years)
- Use low-mass material handling trays in the electric annealing furnace to decrease the deadweight and thereby reduce energy consumption (SPP: about 2.5 years)
- Equipping the annealing furnace with an upgraded instrumentation & control system (SPP: about 2 years)

Motors

Motors are used to drive different machinery/ equipment like glass blowing lathes, combustion blowers, air compressors, conveyors, and circulation fans (pedestal, wall and ceiling). In general, the existing machinery and equipment were found to be operating with standard efficiency class motors, which are low in energy efficiency. Significant energy savings could be achieved through replacement of the existing low-efficiency motors with premium efficiency class IE3 motors. (SPP: 1–2 years)

Air compressors

Air compressors are used by units to meet the compressed air requirements of various processes and instrumentation. The specific power consumption (SPC) in the existing air compressors was found to be higher than the recommended range of values, indicating wastage of energy. The units were advised to replace the existing inefficient air compressors with energy-efficient air compressors of suitable capacities. (SPP: 2–3.5 years)

Air circulation systems

In the glass blowing process, open flames are used to heat the glass tubes for forming the required products. As a consequence, the working areas tend to become uncomfortably hot. In order to cool down the working areas, the glassware units use large numbers of air circulation and space cooling systems like conventional ceiling fans, pedestal fans, wall and table fans, man coolers, etc. Replacing these conventional fans by 'brushless DC' (BLDC) fans would significantly reduce overall power demand, as BLDC fans are much more energy-efficient than the corresponding conventional fans. For instance, a BLDC ceiling fan consumes 28–32 W compared to 75 W by a conventional ceiling fan, to deliver the same air volume. Furthermore, the life of a BLDC fan is higher than that of a conventional fan as the motor heating is reduced by about 75%. (SPP: 1.5–3 years)

Lighting systems

In most of the units, the illumination systems included large numbers of conventional lighting sources such as fluorescent tube lights (FTLs) and compact fluorescent lamps (CFLs) which are relatively low in energy efficiency and also have shorter working life. The existing lamps could be replaced with more energy-efficient and durable lighting options such as LED lamps and induction lamps to achieve sizeable savings in power consumption as well as improved illumination. (SPP: less than one year)

Rooftop solar photovoltaic systems

Some units have sufficient rooftop areas available for the installation of solar photovoltaic (SPV) systems, which could reduce the overall consumption of grid electricity. (SPP: 4–4.5 years)

Plant-level ECMs

Optimizing power consumption

In many units, the power factor (PF)—a measure of the efficiency with which the unit uses power drawn from the grid—was found to be less than the optimum value of unity at the main incomer. As the electricity utility applies energy charges on KVAh basis (i.e., based on the apparent power consumption by the unit), the unit was paying extra on its electricity bills. The PF could be improved to unity by installation of automatic power factor controller system at the main incomer. (SPP: less than one year)

Installation of centralized LPG distribution system

In general, the units meet their LPG requirements by procuring cylinders of 19 kg from retailer-agencies like HP and IOCL. Interactions with entrepreneurs and operators revealed that often, the 'spent' LPG cylinders returned to the retailers still contain residual LPG of 1.5–2 kg per cylinder. The primary reason for this residual gas is that the pressure of the cylinder is lower than the minimum pressure required for obtaining the desired length of flame. It was technically feasible for some units to curtail this wastage of LPG by procuring large-volume cylinders for LPG storage (of 425 kg or more), and installing a centralized LPG distribution system to meet plant requirements. (SPP: 1–2 years)

Table 2. Energy and cost savings from implementation of ECMs by the 10 laboratory glassware units

Unit	No. of ECMs	Annual energy saving		Investment (Rs lakhs)	Annual saving (Rs lakhs)	Simple payback period (years)
		LPG (kg)	Electricity (kWh)			
Unit 1	8	3040	785977	190.5	61.5	3.1
Unit 2	6	18900	(-)40681	27.7	10.6	2.6
Unit 3	7	–	145928	36.2	12.6	2.9
Unit 4	3	4154	969	9.3	3.6	2.6
Unit 5	4	–	90839	23.3	6.1	3.8
Unit 6	4	–	17512	4.7	1.4	3.4
Unit 7	3	1170	25267	7.0	3.0	2.3
Unit 8	2	–	3879	0.7	0.2	3.1
Unit 9	2	741	1878	1.4	0.8	1.7
Unit10	5	1295	13240	7.5	2.0	3.8
Total	44	29300	1044808	308.3	101.8	(Average) 3 years

ABOUT **SAMEEEKSHA**

SAMEEEKSHA is a collaborative platform aimed at pooling the knowledge and synergizing the efforts of various organizations and institutions—Indian and international, public and private—that are working towards the common goal of facilitating the development of the Small and Medium Enterprise (SME) sector in India, through the promotion and adoption of clean, energy-efficient technologies and practices.

SAMEEEKSHA provides a unique forum where industry may interface with funding agencies, research and development (R&D) institutions, technology development specialists, government bodies, training institutes, and academia to facilitate this process.

For more details, please contact

Mr Sachin Kumar
Secretary–SAMEEEKSHA
Industrial Energy Efficiency Division
TERI, Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003, India
Tel: +91 11 2468 2100, 2468 2111,
Fax: +91 11 2468 2144, 2468 2145
Email: sachink@teri.res.in
Website: http://sameeeksha.org