ENERGY PROFILE

GOKAK JAGGERY CLUSTER

The Energy and Resources Institute

SHAKTI SUSTAINABLE ENERGY FOUNDATION

Promoting Energy Efficiency in SMEs
SAMEEEKSHA

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ABBREVIATIONS

ACKNOWLEDGEMENTS

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Abbreviations

Abbreviation	Full form
CFL	Compact Fluorescent Lamp
DG	Diesel generator
EE	Energy efficient
GHG	Greenhouse Gas
hp	horsepower
kcal/hr	kilocalorie per hour
kWh	kilowatt-hour
LED	Light-Emitting Diode
LT	Low Tension
Lit	Litre
MSMEs	Micro Small and Medium Enterprises
MSME DI	MSME Development Institute
PV	photovoltaic
SSEF	Shakti Sustainable Energy Foundation
t	tonne
toe	tonne of oil equivalent
tph	tonne per hour
tpy	tonne per year
VSD	Variable Speed Drive

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Gokak Jaggery Cluster

Overview of cluster

Jaggery is made from sugarcane in most parts of India. It is a concentrated product of sugarcane juice and brown in colour. It is colloquially called 'gur' or 'gud' in most states, but other names such as 'gul', 'vellum', 'khandsari' and 'bella' are also common.

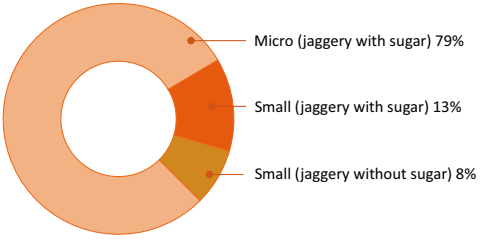
Gokak, in the state of Karnataka, is one of the largest clusters of jaggery units in India. The units are spread within Gokak district with highest concentration in areas like Kudchi and Raibag. Gokak is close to Belgaum which is a well-known industrial cluster. Sugarcane is extensively grown in the region due to availability of water throughout the year and sufficient seasonal rainfall.

Location of Gokak and Belgaum
Source: Google Maps

There are about 120 jaggery making units in the cluster. Most of these industries are registered under the micro and small categories. The total turnover of the cluster is estimated to be around ₹150 crores.

Product, market and production capacities

Jaggery is a natural, traditional sweetener made by the concentration of sugarcane juice. Jaggery, which is a natural mixture of sugar and molasses, is consumed extensively in rural areas of the country. Jaggery contains all the minerals and vitamins present in sugarcane juice and hence is also healthy compared to white sugar.



Distribution of jaggery units in the cluster

The cluster produces two types of jaggery: jaggery with sugar and jaggery without sugar. Jaggery with sugar has more demand in the market. Major markets catered by the cluster are rural areas of Mahalingpur, Kolhapur, and Gadhinglas districts in Maharashtra and Belgaum and Hubli districts in Karnataka.

Categorization of units and estimated production

Category	No. of units	Production (tonne/year)
Micro units (jaggery with sugar)	95	28,500
Small units (jaggery with sugar)	15	13,500
Small units (jaggery without sugar)	10	2,700
Total	**120**	**44,700**

Raw material usage in the cluster

The primary raw material for the manufacture of jaggery in the cluster is sugarcane. The sugarcane is sourced from farmers in Belgaum and Gokak districts. Units producing jaggery with sugar, buy sugar from (sugar) industries located in Belgaum, Gokak and Hubli districts. Some of the units also buy sugar from sugar industries in Kolhapur. The cost of the raw materials depends upon their quality and source. Typically, the cost of sugarcane is around ₹2,800 per tonne while cost of sugar is ₹33 per kg.

Sugarcane

Sugar

Apart from sugar, small quantities of kesari, cooking oil, phosphoric acid, sodium bicarbonate, and lime are also added during the manufacturing process.

Production process

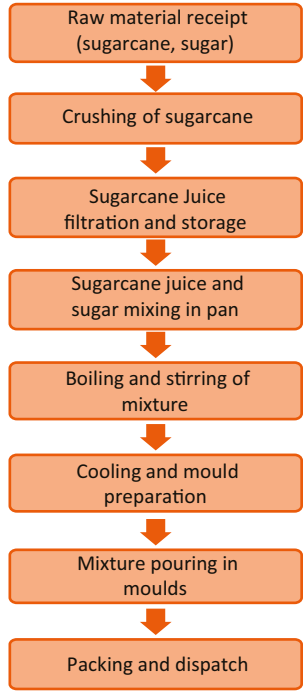
Jaggery production is a batch process. The typical process of manufacturing jaggery is shown in the flow chart. The major raw materials, namely, sugarcane and sugar, are purchased in bulk. The steps involved in jaggery making are as follows:

Extraction of juice from sugarcane

The juice from the sugarcane is extracted using a cane crusher, driven by electric motors. About 1.5–2 tonne of sugarcane is crushed to make a single pan of jaggery. The requirement varies upon the quality of the sugarcane and its sucrose content.

Boiling of juice for purification

The extracted juice from the sugarcane is taken for boiling. The juice is boiled in big open pans. While heating, the juice it is continuously stirred and dirt particles floating on the surface are taken out. Bagasse (the fibrous residue left after the extraction of juice from sugarcane) is used as fuel for boiling.



Process flow chart

Juice extraction from sugarcane

Sugarcane juice boiling for purification

Purification of juice

The juice, when heated and boiled, releases many impurities which have to be removed. Proper purification of the juice decides the colour, texture, taste, and durability of the jaggery. For purification of juice, materials like lime and sodium bicarbonate are used. These materials help to bring the impurities to the surface of the pan. The scum is skimmed out from the juice.

Cooling, moulding and crystallization of juice

The next step after purification of juice is concentration. Here, the juice is boiled at 100 °C. Subsequently, the pan is removed from the furnace and stirred for some time. The boiled liquid jaggery is then transferred into a cooling pan. As the temperature falls, the jaggery begins to crystallize. After stirring the juice slowly and intermittently, to avoid the loss of its granular structure, the semi-solid mass is put into moulds to solidify. These lumps or moulds are made to take the shape of a bucket. These buckets are of different sizes and weight. Typically, mould bucket size varies from 1 kg to 30 kg. The jaggery, after cooling, is removed by inverting the moulds.

For making jaggery with sugar, the purified juice is taken in a pan for boiling and mixed with sugar in the ratio of 1:3. The juice is continuously stirred while boiling for about an hour and then poured into the moulds manually.

Cooling and moulding

Technologies employed

Most of the equipment used in the manufacture of jaggery are of local make. The crushers used by the units and the furnaces are locally manufactured.

Sugarcane crusher with dryer

The crushers used by the units are continuous type with crushing capacity of 1–2 tonne per hour. Usually, the small scale units operating throughout the year have mechanical crushers while the rest of the micro units use manual crushing systems. The juice produced after crushing is passed through strainers for filtration and is collected in storage tanks. The bagasse which remains after juice extraction is passed through a continuous type dryer to remove moisture and kept as fuel for the furnace. The micro units usually dry the bagasse in the sun.

Sugarcane crusher with dryer

Furnace

Jaggery units use traditional open pan type furnaces for boiling the sugarcane juice. The dried bagasse is used as fuel for these furnaces. The calorific value of the dried bagasse is in the range of 3,000 to 4,000 kcal/kg. While heating, the dirt and unwanted parts, float to the surface and are manually removed. This purified juice is then stored in a tank for further processing.

Open pan type furnace

Pumps

Mono-block centrifugal pumps with flexible plastic piping are used for juice conveying. These pumps are small in size (of 1hp rating) and are used to transfer the juice to storage tanks and process pans. These pumps are operated intermittently as required.

Juice pump

Juice pans

All the units use open pan method for jaggery making where juice is boiled in open pans. The juice pans are made of iron sheets and are between 230–280 cm diameter and about 50 cm depth. For better colour of jaggery, galvanized iron or copper pans are also used. Some units have two pans which are used alternately or simultaneously. The pans are locally manufactured in Belgaum district.

Juice pan

Energy scenario in the cluster

Bagasse, produced from the crushed sugarcane, is used in the units as primary thermal source for heating. Moisture from bagasse is removed by drying in the dryer, which is in line with the crusher machines. Electricity provides the main source of energy for rotary applications like crusher motors and juice pumps. Almost all the units are dependent on electricity from grid to meet their energy needs. The average connected load per unit depends upon the product manufactured and installed capacity of the plant. Majority of the units have LT connection between 40–60 hp. DG set is used only as standby in case the grid supply fails in between the process. The primary energy sources in the jaggery units among the cluster are given in the following table.

Prices of major energy sources

Source	Remarks	Price
Bagasse	In house (by product of sugarcane)	NA
Electricity	Low Tension (LT) connection	₹8 per kWh (inclusive of energy, demand charges, other penalty/rebate and electricity duty)
Diesel	From local market	₹65 per litre (price subjected to market fluctuations)

Unit level consumption

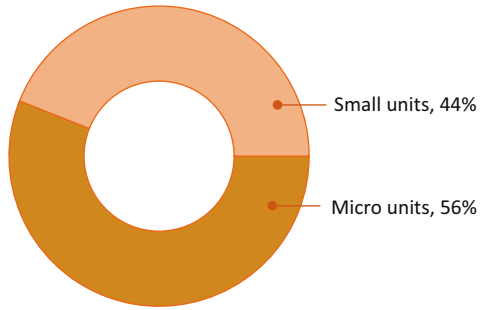
The unit-level energy consumption in jaggery units includes electricity and bagasse.

Unit level energy consumption

Type of jaggery unit	Electricity (kWh/year)	Bagasse (tpy)	Diesel (ltrs/year)	Total energy (toe/year)
Micro units	18,461	460	500	204
Small units	55,384	1,380	750	613

Cluster-level consumption

The overall energy consumption of the cluster is estimated to be 34,735 toe. The estimated greenhouse gas (GHG) emissions at the cluster level is 2,742 tonne of CO_2. The overall energy bill of cluster is estimated to be ₹29 million/year.



Share of energy consumption

Energy consumption of the jaggery cluster (2017-18)

Type of jaggery unit	Electricity, million kWh/year	Bagasse kT/year	Diesel kL/ year	Tonnes of oil equivalent	Tonnes of CO_2 equivalent	Annual energy bill (million ₹)
Micro units	1.75	43.7	47.5	19,420	1,559	17.1
Small units	1.38	34.5	18.8	15,315	1,183	12.3
Total	**3.13**	**78.2**	**66.3**	**34,735**	**2,742**	**29.4**

Energy saving opportunities and potential

Some of the major energy saving opportunities among the jaggery units in the cluster are discussed below.

Waste heat recovery from open pan furnaces

Thermal efficiency of open pan furnaces used in jaggery units is low. A lot of heat is wasted in the flue gases. Recovering the waste heat would substantially improve the efficiency of the furnaces.

Replacement of rewound motors with energy efficient motors

Rewinding of motors result in a drop in their efficiency by 3%–5%. It is better to replace all old motors, especially the motor in the crusher machine, if it undergoes rewinding three or more times. The old rewound motors may be replaced with EE motors (IE3 efficiency class). This would result in significant energy savings with simple payback period of 2 to 3 years.

Application of variable speed drive in crusher motor

The crusher machine has two motors of around 15 hp rating. Depending on manual feed rate of sugarcane and weight of sugarcane, load on the crusher machine is variable. The motor-driven systems are often oversized and inefficiently controlled. Variable speed drive (VSD) could be installed for these motors with feedback of the weight on the conveyor. Use of VSD in place of constant speed will reduce the power consumption between 10%–15%.

Rooftop solar PV plants

Jaggery units have huge roof spaces. The region receives good amount of sunlight throughout the year. Partial load sharing is possible by implementing solar PV on the roof tops. Net metering is also permissible in Karnataka.

Lighting

T-12 tube lights (of 52W including choke) and CFL lamps (36W and 45W) are generally used by the units in the cluster. These inefficient lightings can be replaced with energy efficient LED lighting (LED tube lights of 10W and 20W) which would provide better illumination and energy savings. Since a large number of lamps are used in the units, the existing lighting may be replaced with EE lighting in a phased manner. Payback period for EE lighting is generally within 2 years.

Pumps

Presently monoblock centrifugal pumps are being used in the cluster for sugarcane juice conveying. All these installed pumps are very old with low efficiency. These pumps can be replaced with new energy efficient monoblock pumps with high efficiency which will save energy.

Major cluster actors and cluster development activities

Major stakeholders

The MSME Development Institute (MSME DI), Belgaum, under the Ministry of MSME, Government of India, is the key support institution for the units in the cluster.

Cluster development activities

Although a major contributor in the economy of the region, there are hardly any developmental efforts to improve the jaggery industry in Gokak. There is a scope to establish a jaggery research center to support the production of quality jaggery. There is a lack of awareness among unit owners regarding energy conservation and resource efficiency. MSME-DI and some industry associations from Belgaum have reached out to jaggery unit owners in the past for skill development activities. However, there is a need to expand these activities 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 SSEF

Shakti Sustainable Energy Foundation established in 2009, is a section-25 not-for-profit company that works to strengthen the energy security of the country by aiding the design and implementation of policies that encourage renewable energy, energy efficiency and sustainable transport solutions. Based on both energy savings and carbon mitigation potential, Shakti focuses on four broad sectors: Power, Transport, Energy Efficiency and Climate Policy. Shakti act as a systems integrator, bringing together key stakeholders including government, civil society and business in strategic ways, to enable clean energy policies in these sectors.

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 of SAMEEEKSHA platform are (1) Swiss Agency for Development and Cooperation (2) Bureau of Energy Efficiency (3) Ministry of MSME, Government of India (4) Shakti Sustainable Energy Foundation, and (5) The Energy and Resources Institute.

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

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