ENERGY PROFILE

COIMBATORE COMPRESSOR CLUSTER

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The Energy and Resources Institute

SHAKTI
SUSTAINABLE ENERGY FOUNDATION

Promoting Energy Efficiency in SMEs
SAMEEEKSHA

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Abbreviations

Abbreviation	Full form
CFM	Cubic Feet per Minute
CNC	Computer Numerical Control
COCIA	Coimbatore Compressor Industries Association
DI	Development Institute
DIC	District Industries Centre
GHG	Greenhouse Gas
HT	High Tension
kVA	kilo volt ampere
kW	kilo watt
kWh	kilowatt-hour
LT	Low Tension
MSME	Micro, Small and Medium Enterprises
PLC	Programmable Logic Controller
pmsm	Permanent Magnet Syncronous Motors
SEC	Specific Energy Consumption
SSEF	Shakti Sustainable Energy Foundation
t	tonne
TANGENDCO	Tamil Nadu Generation and Distribution Company Limited
toe	tonne of oil equivalent
tpd	tonne per day
tph	tonne per hour
VFD	Variable Frequency Drive

Acknowledgements

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TERI team is indebted to Coimbatore Compressor Industries Association (COCIA) for providing support and information related to air compressors and component units in the Coimbatore cluster. TERI extends its sincere thanks to Mr M Raveendran President, COCIA for organizing field visits and interactions with unit members during the study for the preparation of this cluster profile report. TERI would also thank Mrs G Krithiha and Mr Devendran for sharing information on the process of manufacturing air compressors.

Last but not least, our sincere thanks to MSME entrepreneurs and other key stakeholders in the cluster for providing valuable data and inputs that helped in the cluster analysis.

Coimbatore Compressor Cluster

Overview of the cluster

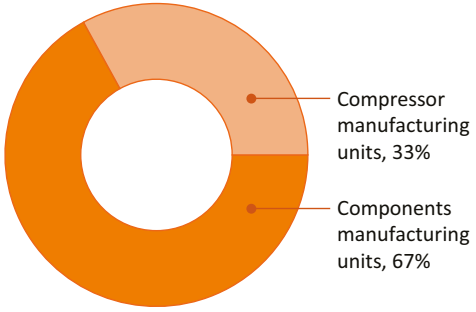
Coimbatore, located in the state of Tamil Nadu, is an important industrial cluster in India. Coimbatore is a well-known hub of small-scale-engineering industry. There are an estimated 50,000 MSMEs in Coimbatore. The industries are spread within Coimbatore and neighbouring industrial estates. The engineering industry is diverse in nature. Some of the major engineering segments include foundries, pumpsets and reciprocating air compressors, forgings, auto components, and diesel engines.

Location of Coimbatore (Source: Google Map)

Coimbatore is one of the largest producers of conventional reciprocating compressors in India. The manufacture of air compressor components started in the cluster in the 1960s when some units started supplying ancillaries to ELGi Equipments. EFCO was the first company to start manufacture of entire air compressors in the small scale sector in Coimbatore. At present, there are about 300 manufacturers of reciprocating compressors and allied components. The major concentration of compressor industries in Coimbatore units are in Peelamedu and Pappanaickenpalayam. Most of the small-scale units manufacture compressors' upto 5 hp capacity, while the medium-scale units make produce compressors upto 20 hp.

Products, market, and production capacities

A large number of castings, forgings, and engineering components are used in the manufacturing of air compressors. Some of the major components include foundation plates, engine cases, pistons, air receivers, sheet metal components, and connecting rods.



Types of units in the cluster

The compressors manufactured in the cluster are used in bore well pumps, automobile garages, paint shops, railways, paper cup manufacturing machines, blow moulding machines, packaging units, dairy units, and several small industries. Two major types of units, those manufacturing the air compressors and those manufacturing air compressor components, can be found in the cluster as given in the following table.

Categorization of units

Category	Number of units
Air compressor manufacturers	100
Compressor components manufacturers	200
Total	300

The air compressor manufacturers can be categorized further based on their production as shown in the following table.

Categorization of air compressor manufacturing units

Category	No. of units	Production, compressors/month (nos.)	Total production, compressors/month (nos.)	Annual production, compressors/yr (nos.)
Medium	10	250	2,500	30,000
Small	60	30	1,800	21,600
Micro	30	15	450	5,400
Total	100	295	4,750	57,000

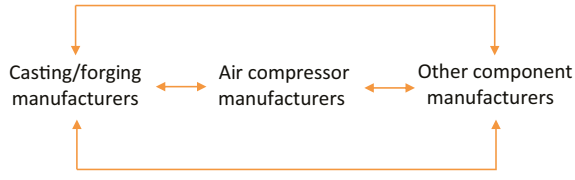
The air compressor component manufacturers can be categorized further as has been shown in the following table.

Categorization of air compressor components manufacturing units

Category	No. of units	Production (tonne/month)	Total production, (tonne/month)	Annual production, tonnes
Small	100	180	18,000	216,000
Micro	100	60	6,000	72,000
Total	200	240	24,000	288,000

The cast and forged components required by the compressor manufacturers are sourced from foundries and forging industries. The linkaged between air compressor manufacturing industries and the associated industries are shown in the given figure.

All manufacturers in the cluster are engaged in the production of conventional reciprocating air compressors. None of the MSME industries are manufacturing screw air compressors, which is the latest technology.



Linkages of air compressor manufacturers

Product categories

Reciprocating air compressors ranging from 0.75 hp to 20 hp are produced in the cluster. A wide range of components for the air compressors, such as connecting rods, receivers, and so on are also manufactured in the cluster.

Reciprocating air compressors and components

Production process

The manufacturing of air compressors encompass a number of steps starting with production planning based on customer requirements and design and the development of the product to raw material procurement (castings and accessories), machining of components, painting sub-assembly and assembly, inspection and testing, packing, and dispatching. The major process steps followed are summarized below. A simplified process flow diagram of a typical compressor manufacturing unit is given in the following section.

Assessment of customer requirements

Based on detailed discussions with customers, information such as specifications and capacity are prepared and forwarded to-the design and development department in medium-sized units. Most of the micro-and small-sized units directly manufacture standard air compressors based on designs which, through years experience they have developed.

Design and development

Based on demand, standard air compressor designs are used or design customization/ modification is done to suit the specific customer requirements. A bill of material is prepared as per the design.

Raw material procurement

Raw material cost accounts for about 60–80% of the total production cost of air the compressors. The major raw materials include cast components, such as engine case, forged components such as connecting rods, sheet metal components such as receivers and other materials such as bearings, shafts, belts, fasteners, motors, starter control panels and so on. Most of the raw materials are procured from the external suppliers and vendors.

Machining and heat treatment

Machining of castings and other parts, such as shafts, bushes, and pulleys are outsourced. Finishing the operation of critical components is done in-house to ensure accuracy and close tolerance. Some of the components require heat treatment, such as like normalizing, hardening, and stress relieving. Heat treatment is also outsourced as these units do not have the facility in-house.

Painting, sub-assembly, and assembly

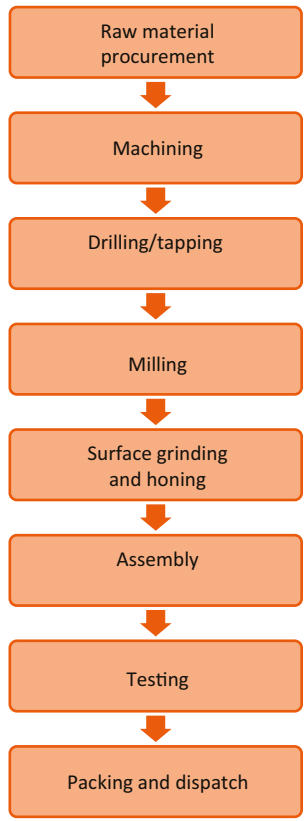
After the machining of the components, painting is done using spray guns. Sub-assembly of the metal components is done separately. Once all the components are assembled and electrical components such as motor, starter control panel, and proper cabling and complete lubrication systems have been fitted, the compressor is ready for inspection and testing.

Inspection and testing

Inspection of the 'fully assembled' machine is done to ensure quality. Testing of the machine is carried out as per the standards. In-house tests such as free air delivery and receiver leakage are carried out before final dispatch of the machines. Checks are also carried out on the outsourced machining jobs to check their precision and accuracy.

Packing and despatch

The inspected and tested machine is packed and sent for dispatch. Component manufacturing industries carry out usual machining jobs like honing, grinding, drilling, chemical testing and painting. These components are sourced by the compressor manufacturing units.



Typical manufacturing process of Air Compressors

Technologies employed

Some of the major processes/equipment used in the compressor manufacturing units are described below.

Conventional machining

Conventional machines are used by compressor units as well as components manufacturing units. The common conventional machines include lathe, milling, shaping, planning, grinding, and drilling machines. These machines are used for rough as well as finish machining of components, such as engine cases, shafts, key ways, pulleys, saddles, etc.

Conventional machines

CNC machining

Some component manufacturing units use Computer Numerical Control (CNC) machines. CNC machines help to reduce costs and improve the quality and productivity. CNC comes in different orientations - horizontal and vertical. The selection and use of CNC is based on the type of applications.

CNC Machine

Manual assembly

Most units in the cluster adopt the manual assembly process. The assembly work is modified depending on the machine and customization requirements. In some cases, electronic components such as PLC and CNC panels are added. The duration of assembly depends upon on the type of machine and nature of customization.

Manual assembly

Ovens

Ovens are used after spray painting components for solidifying the paint applied. Batch type LPG or diesel-fired ovens are commonly used. Some units have electric resistance-based ovens. Batch time is around 45–60 minutes. The capacity of these ovens range from 500 kg to 5 tonne per batch.

Energy scenario in the cluster

Electricity is the major source of energy used in the cluster. Small quantities of LPG and diesel are also used. Electricity is supplied by Tamil Nadu Generation and Distribution Company Limited (TANGENDCO). Diesel is used in ovens and as well as in DG sets to generate electricity during unscheduled power outage. Diesel is procured from the local market. As power outage is minimal in the cluster, diesel consumption in DG sets is insignificant. The details of the major energy sources and their tariffs are given in table.

Oven

Prices of major energy sources

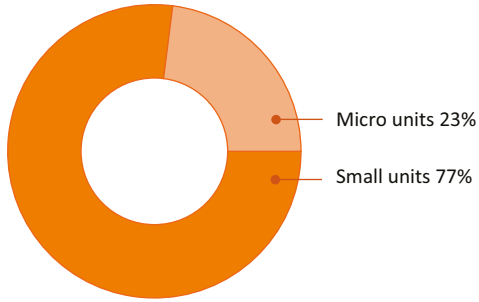
Source	Remarks	Price
Electricity	TANGENDCO	Rs 7.5 per kWh (inclusive of energy, demand charges, other penalty/rebate and electricity duty)
Diesel	From local market	Rs 69 per litre (price subjected to market fluctuations)
LPG	BPCL, HPCL, IOCL	Rs. 55 /kg (price subjected to market fluctuations)

Energy consumption

Unit level consumption

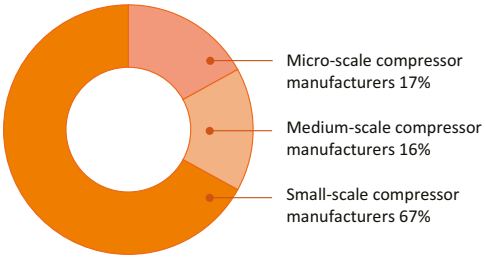
Electricity is used to run all machinery. Most of the units in the cluster have LT connections. HT connections, the power is supplied at 11 kV and is stepped down to 433 V using a common transformer of TANGENDCO and fed to the respective power distribution board (PDB) through an LT switchgear located at the main distribution. Diesel is mainly used in DG sets which are operated in the case of unscheduled power outages.

The major energy-consuming areas in compressor manufacturing



Share of energy consumption in component-manufacturing units

are motors used in various applications, such as lathe, CNC, drilling, honing machines, cranes, etc. Machining account for about 80% of the total energy consumption, followed by welding machines (10%), and air compressors (5–10%). The motor -driven presses in most units are operated without any control mechanism. The share of energy consumption in air compressor -manufacturing and component manufacturing units are shown in the figures.



Share of energy consumption in manufacturing units

The specific energy consumption (SEC) of the units vary considerably depending on the type of products being manufactured. The typical unit level energy consumption is given in table.

Typical energy consumption at unit level

Type of unit	Electricity consumption kWh/year	LPG consumption, kg/year	Diesel consumption, litres/year	Total energy toe/year	Equivalent CO_2 emission. tCO_2/year	Annual energy bill, Million Rs
Air compressor manufacturing units	28,800	0	0	2.5	23.6	0.2
Air compressor components units	26,000	16,364	13,043	33.4	103.4	1.1

Cluster level consumption

The overall energy consumption of the cluster is about 2,255 tonne of oil equivalent (toe) per annum leading to carbon emissions of 10,730 tonnes of CO_2. The overall energy bill of the cluster is estimated to be Rs. 151 million.

Energy consumption of the compressor cluster (2017-18)

Industry	Electricity consumption, kWh/year	Total LPG consumption, kg/year	Total diesel consumption, litre/year	Total energy (toe/year)	Annual energy bill (million Rs)
Air compressor manufacturing units	2,880,000	0	0	247	21.6
Air compressor components units	5,200,000	818,182	652,174	2,008	129
Total	8,080,000	818,182	652,174	2,255	151

Potential-energy-efficient technologies

Some of the major energy-efficient technologies relevant for the air compressor units and component manufacturing units in the cluster are discussed below.

Energy efficient IE3 standard motors

All the units in the cluster are using lathe machines, honing machines, drilling machines, etc. which use electrical motors. The rating of the motors vary from 0.5–5 hp depending on the capacity of the machine and the operation it performs. Most of the motors operate on low loads except during cutting or drilling operations. The power factor of these motors was observed to be generally lower than 0.85. Energy saving of upto 3% can be achieved by the replacement of old IE2 motor with IE3 motor, as is shown in the following table. The energy savings can go upto 7% by replacing the old IE1 motors with IE3 motors.

Due to the presence of significant variables and jerk-loading patterns in machines, failure rates of motors are high. Further, no load losses of these motors are high which increases the overall energy consumption. There is a lack of awareness about efficiency standards of motors. It was observed that most of the units use low efficiency standard motors. There is a significant potential for energy savings by replacing low efficiency motors with energy efficient IE3 motors. Depending on the operation period of the machines, the payback period for EE motors can vary between 10 months to 2 years.

Cost benefit analysis for IE3 motors

Parameter	Unit	3 hp motor	5 hp motor
Power consumption of the existing lathe motor	kW/hr	2.4	4.1
Efficiency of the existing motor	%	79.7	82.7
Efficiency of an IE3 motor	%	85.9	87.8
Power consumption of an IE3 motor	kW/hr	2.22	3.86
Annual energy cost savings (12 hr/day 350 days/year)	Rs /yr	4,956	6,480
Investment	Rs	7,500	12,500
Payback period	yr	1.5	1.9

Inverter-based welding machines

Inverter-based power sources allow delivering of more power output from new power electronics technology, resulting in a better performance-to-size ratio. These models also deliver a smooth operation with greater efficiency than the conventional welding power sources. Old transformer rectifier-based welding machines have-efficiency a 67% while inverter-based machines have 87% efficiency with better power factor. Inverter-based welding power sources offer the following advantages:

- Lightweight and portable

Energy inefficient IE1 motor

IE3 motor

- Able to obtain superior stick welding performance with all electrode types
- Multi-process welding output without sacrificing arc performance in any mode
- Quick response to changing arc conditions (e.g., maintains, a steady welding, output)
- Superior control over pulsed welding processes
- Line voltage independent uses a single or a three phase input power and multiple input voltages without any manual relinking mechanism
- Better power factor (more efficient use of power from the utility)
- Less susceptibility to primary voltage fluctuations

Inverter-based welding power sources can perform high as well as low amperage flux cored, stick, TIG, and MIG welding. The inverter-based models deliver multi-process welding capabilities, offer faster a arc response, smoother arc action, and a more consistent bead appearance.

Cost benefit analysis for inverter-based welding machines

Parameter	Unit	Value
Power consumption of transformer rectifier welding machine (for 160 Amps)	kW/hr	4.04
Power consumption of inverter welding machine	kW/hr	3.1
Annual energy cost savings (7 hours/day, 350 days/year)	Rs/yr	15,200
Investment	Rs	20,000
Payback period	yr	1.3

Air compressor

Units in the cluster use compressed air for various pneumatic utilities and cleaning purposes. Larger units use screw compressors whereas smaller units use reciprocating compressors. Screw compressors are designed to operate on more than 80% load for efficient performance. There is a huge potential for energy saving by adopting VFDs-based screw air compressors and Permanent Magnet Syncronous Motor (PMSM)-based air compressors having higher CFM to power ratio. Energy savings can range from 15% to 40% as compared with the existing system.

Reciprocating compressor (in smaller units)

Screw compressor with VFD (in larger units)

Cost benefit of VFD screw air compressor

Parameter	Unit	Value
Power consumption	kW/CFM	0.23
Power consumption of PMSM based screw air compressors	kW/CFM	0.15
Annual energy cost savings (5800 hours/year)	Rs/yr	2,96,000
Investment required	Rs	5,00,000
Simple payback period	yr	1.7

Cranes and hoists

Cranes and hoists are used to move heavy parts and components. Cranes and hoists have two motors for horizontal and vertical movement with rating of 7.5 hp to 75 hp depending on crane capacity. As these motors go under frequent on/off cycles along with jerk loading, application of Variable Frequency Drive (VFD) in crane operation

may lead to an energy saving of about 15%. VFDs will also facilitate soft starting thereby avoiding jerk starts, which will further help in increasing motor life.

VFDs installed in cranes and hoists

Cost benefit of VFDs in cranes

Particular	Unit	Value
Power consumption of conventional hoist motor	kW/hr	22
Power consumption of hoist motor with VFD	kW/hr	18
Annual energy cost savings (1700 hours/year)	Rs/yr	43,200
Investment required	Rs	75,000
Payback period	yr	1.7

Lighting

T-12 tube lights (52W, including choke) and halogen lamps (150W and 250W) are generally used by compressor- manufacturing units in the cluster. These inefficient lightings can be replaced with energy-efficient LED lighting (10W and 20W LED tube lights) and flood type and high bay-type induction lamps (20W, 40W and 80 W) 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.

T12 and T8 FTL

T5 FTL

High bay HPMV lamp

High bay Magnetic induction lamp

Cost benefit analysis of energy-efficient lighting

Particular	Unit	Value
Power consumption with 52W T-12 FTLs	Watt/hr	52
Power consumption with EE LED tube light of 20W	Watt/hr	20
Annual energy cost savings (3600 hours/year)	Rs/year	750
Investment required	Rs	350
Payback period	year	0.5

Ovens

Some of the components manufacturing-units in the cluster use paint ovens. The oven uses LPG or diesel as the fuel. The operating temperature for the ovens is 200 °C. Usually, the installed furnaces are bigger in size which end up being under loaded, thus consuming more fuel. Insulation improvement and reducing the heating volume could result in significant fuel savings.

Use of cogged V-belts

The drive motors generally use flat V-belts. The transmission efficiency of flat V-belts is around 90%–92%. Cogged V-belts use a trapezoidal cross section to create a wedging action on the pulleys to increase friction and the power transfer capability of belts. V-belt drives can have a peak efficiency of 95%–98%. They play a dynamic role in allowing for heat dissipation and better contact with the pulley. There are several other potential benefits of using cog belts which include (i) less slippage at high torque, (ii) low maintenance and re-tensioning and (iii) suitable for wet or oily environments.

It is recommended to use cogged V-belt instead of a flat V-belt. The transmission efficiency of a cogged V-belt is 3%–5% higher than a flat belt. Reciprocating compressors using flat V-belts can be replaced with vcogged V-belts.

Flat V-Belt

Cogged V-Belt

Major cluster actors and cluster-developmental activities

Industry associations

There are several industry associations in Coimbatore. The major industry association representing the small-scale compressor manufacturers is the Coimbatore Compressor Industries Association (COCIA). The association has around 300 members and is involved with activities related to addressing the common issues of industries and making representations in government platforms.

The District Industries Centre (DIC), Coimbatore, provides several incentives to MSMEs, such as capital investment subsidy, interest subsidy, venture capital quality, certification, energy and water audits, and so on. The DIC also promotes, awareness regarding trade information, import export and financial rules and regulations for the local MSMEs.

Cluster development-activities

There has been no major cluster developmental activities in the Coimbatore compressor 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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