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Cluster Profile Report

VapiChemical Cluster

Prepared for

Bureau of Energy Efficiency (BEE)
Ministry of Power, Government of India
New Delhi

The Energy and Resources Institute
Darbari Seth Block, India Habitat Centre, Lodhi Road, New Delhi – 110 003, India

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TEAM

Mr Girish Sethi, Project Advisor
Mr C Vijayakumar, Team Leader
Mr N Vasudevan, Reviewer & Cluster Coordinator
Mr Nataraj Singh Sardar, Energy Manager/Auditor
Mr Lalit Sharma, Graduate Engineer
Mr Kavita Sisodiya, Secretarial Assistance

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The Energy and Resources Institute (TERI)

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

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API	Active Pharmaceutical Ingredient
BEE	Bureau of Energy Efficiency
CEMP	Comprehensive Environment Management Program
CETP	Common Effluent Treatment Plant
DGVCL	Dakshin Gujarat Vij Company Limited
DIC	District Industries Centre
EE	Energy Efficiency
ETP	Effluent Treatment Plant
FD	Forced Draft
FI	Financial Institute
GEDA	Gujarat Energy Development Agency
GHG	Greenhouse Gas
GIDC	Gujarat Industrial Development Corporation
GoI	Government of India
GRIMS	GIDC Rajju Shroff ROFEL Institute of Management Studies
GVA	Gross Value Added
HAG	Hot Air Generator
HT	High Tension
IBR	Indian Boilers Regulations
ID	Induced Draft
IIUS	Industrial Infrastructure Upgradation Scheme
ITI	Industrial Training Institute
KPI	Key Performance Indicators
LT	Low Tension
MSME	Micro Small and Medium Enterprises
MSME-DI	Micro, Small & Medium Enterprises Development Institute
PLC	Programmable Logic Controller
SBI	State Bank of India
SWOT	Strengths Weaknesses Opportunities and Threats
TERI	The Energy and Resources Institute
TFH	Thermic Fluid Heater
VFD	Variable Frequency Drive
VGEL	Vapi Green Enviro Limited
VIA	Vapi Industries Association

Acknowledgements

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

The study team is thankful to the officials of Vapi Industries Association (VIA), Vapi for showing keen interest in the study and providing their wholehearted support and cooperation for the preparation of this cluster profile report. We would like to extend our special thanks to Mr Kamlesh Patel, President (VIA) and Mr Sudipto Sarkar, Executive Assistant (VIA).

Last, but not the least, interactions and deliberations with MSME-DI, Gujarat Energy Development Agency (GEDA), industries associations, Micro Small and Medium Enterprise entrepreneurs, technology providers, and who were directly or indirectly involved throughout the study were exemplary and the whole experience was a rewarding one for TERI.

TERI Team

Certificate of originality

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

Chapter 1

1.0 About the Project

1.1 Project overview

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

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

1.2 Project objectives

The objectives of the study include the following:

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

The five targeted Chemical clusters covered under the project are shown in table 1.2.

Table 1.2: Targeted clusters under the project

S. No.	Cluster	State	Sector
1	Ahmedabad	Gujarat	Chemical
2	Karnal	Haryana	Chemical
3	Thane	Maharashtra	Chemical
4	Vapi	Gujarat	Chemical
5	Jamshedpur	Jharkhand	Chemical

1.3 Major components of the project

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

Table 1.3: Major component of the project

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

Chapter 2

2.0 Cluster Scenario

2.1 Background

The chemical industry is an integral constituent of the growing Indian Industry sector and ranks 6th in the world in chemicals sales. India is a leading dyes supplier at a global level and account[1] for about 16% of the world's production of dyestuff & dye intermediates. The chemical industry accounted for 1.34% of the "gross value added" (GVA) during 2018-19. This sector is highly diversified (Figure 2.1) and comprises both MSMEs as well as large scale units (including multi-national companies).

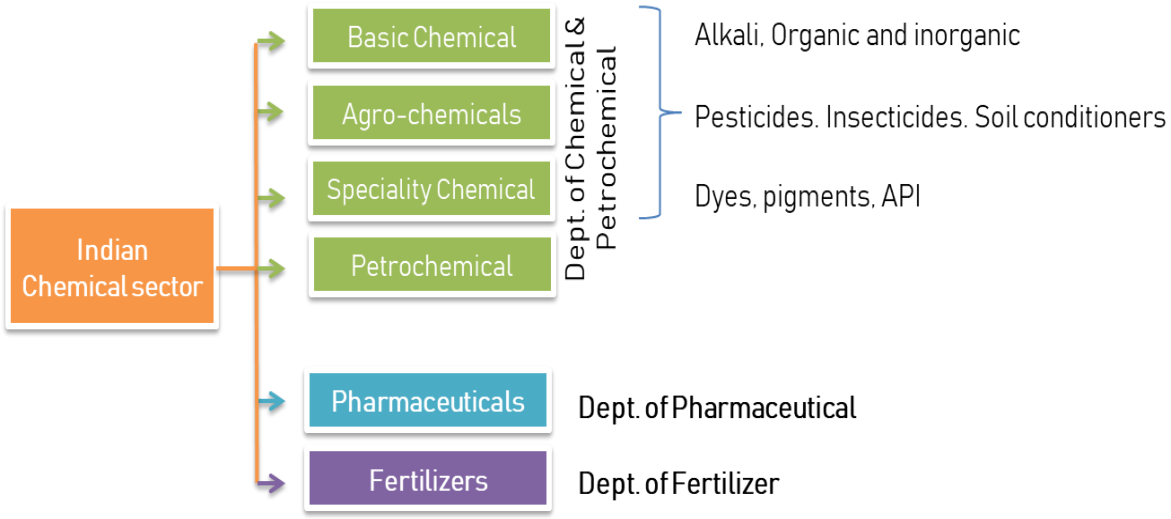

Figure 2.1: Classification of Indian chemical clusters

The chemical industry covers more than 80,000 commercial products[2]. It includes basic chemicals and its products, petrochemicals, fertilizers, paints, varnishes, gases, soaps, perfumes and toiletry, and pharmaceuticals. The industry occupies a pivotal position in meeting basic needs and improving the quality of life. It is the mainstay of industrial and agricultural development of the country and provides building blocks for several downstream industries, such as textiles, papers, paints, varnishes, soaps, detergents, pharmaceuticals, etc.

[1] https://www.investindia.gov.in/sector/chemicals

[2] As per National Industrial Classification (NIC) 2008, Chemical & Chemical products are covered under the industry division 20

The Indian chemical industry employs more than 20 lakh people[1]. Three independent departments, under the Ministry of Chemicals & Fertilizers Government of India, are responsible for the growth of the respective sub-sectors which include (1) Department of Chemicals and Petrochemicals, (2) Department of Fertilisers, and (3) Department of Pharmaceuticals.

The state of Gujarat is leading state in the manufacturing of chemicals, petrochemicals, and pharmaceutical in the country. The other major Indian states involved in the production of chemicals include Maharashtra, Tamil Nadu, and Uttar Pradesh.

2.2 Overview of Vapi Chemical cluster

Vapi chemical cluster is one of the important chemical clusters in Guarat. The cluster houses a number of large scale and MSME units, manufacturing various types of chemical products. There are 300+ chemical manufacturing units in Vapi cluster out of which about 277 units are presently operational. All these chemical manufacturing units are located in vapi phase-1,phase-2 & phase-3 of industrial area, few units are also located in Sarigram. Most of these manufacturing units are operational for the last 20 years. Some of the leading large scale industries like Aarti Industriesds Limited, Bayer Vapi Private Limited, Gujarat Polysol Chemicals Limited are also located in Vapi.

The chemical industries under micro, small and medium categories mostly manufacture pharma APIs, dyes and pigments. Such products not only supplied to Indian markets but also exported to international markets.

2.2.1 Classification of Chemical units

The chemical units in Vapi cluster can be classified either on the basis of the type of products or production capacities. Majority of the cluster produces dyes and pigments (46%) followed by other chemicals (36%) and API/Pharmaceuticals (18%) (Figure 2.2..2.1).

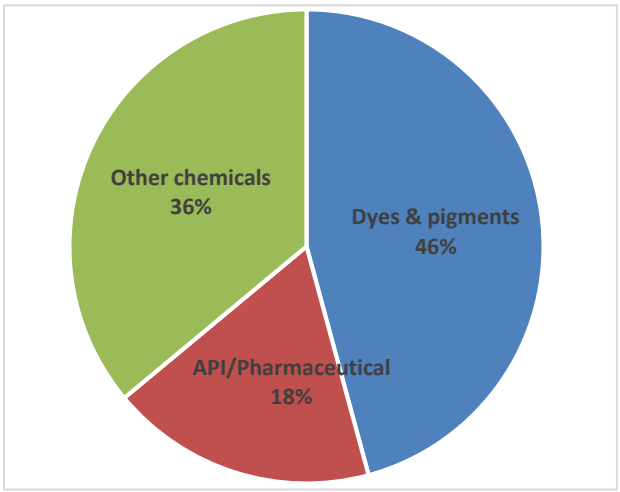

Figure 2.2.1: Percentage Distribution of Chemical Units based on Products Manufactured

2.2.2 Major products

The chemical industries in Vapi cluster manufacture a diverse range of products that come under Dyes & Pigments category which is 54% of production of the cluster. Apart from dyes & pigments, the cluster produces API/pharmaceuticals contributing 6% to the cluster production and other chemicals (40% of total cluster production) (Figure). The total production of the cluster is estimated to be 621,016 tonne per year. An estimation of annual production of different categories for the entire Vapi cluster are depicted in 2.2.2.

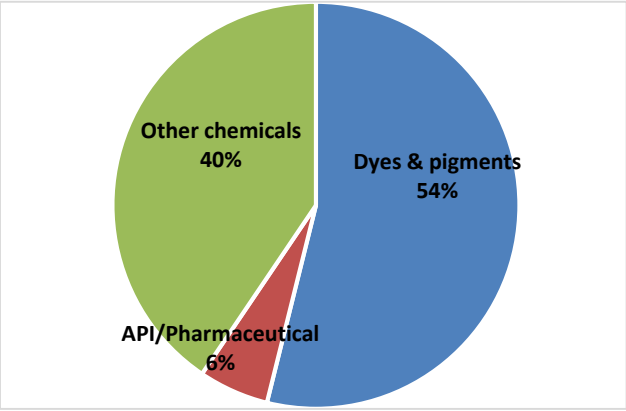

Figure 2.2.2: Production Percentage of Products Manufactured

Table 2.2.2: Chemical products manufactured in Vapi cluster

Category	Production (TPY)
Dyes & pigments	334,593
API/Pharmaceutical	34,675
Other chemicals	251,748

2.2.3 Market scenario

The various products produced in the chemical units of Vapi are majorly consumed within the country and few units export their products. In dyes & pigments, pigments are used for paint manufacturing, tanning agents are used in leather industry etc. In API/pharmaceuticals, fine chemicals, pharma APIs, intermediates, Sulfide Platinum sulfide (PtS), Sulfanylideneplatinum, Di Calcium Phosphate etc. are used in bulk drug industries.

2.2.4 Raw materials

A variety of basic chemicals are used as raw materials to manufacture major chemical products. These basic chemicals are of different types based on different factors such as chemical composition (organic and inorganic), origin of chemicals (mineral, vegetative, and animal), and state of aggregation (solid, liquid, and gaseous).

The types of raw material used generally in dyes & pigment manufavcturing units are FD&C and D&C Dyes, Acids (Sulphuric Acid, Hydrochloric Acid, Nitric Acid), Oxides (Titanium Dioxide, Chromium Oxide, Iron Oxide), Ferric Chloride, Iron Powder, Caustic Soda, Caustic Lye, Soda Ash, Soda Lime, Chlorine Gas, Glycerine, Carbon Black, Alcohol etc.

Raw materials used by chemical units under API/pharmaceuticals category are Acids (Sulphuric Acid, Nitric Acid, Acetic Acid, Formic Acid, Phosphoric Acid), Chlorides (Thioyl Chloride, Sodium Chloride), Oils (Castor Oil, Sulphonated Oils), Caustic Soda Flakes, Caustic Soda Lye, Lime, Diphenhydramine HCI, Lidocaine HCI & Base, Prilocaine HCI & Base, Glycopyrronium Bromide, Phenytoin Sodium, Acetic Anhydride, Nitrobenzene, Sulphur, Bentonite, Benzil, Urea, Methanol Beechwood Chips, Lower Alcohol Esters of Vegetable Oils etc. Other raw materials like Wax, Phenol, Cresol, Graphite, Phosphorus tri Chloride, Aluminium Powder, Zinc Powder, Yellow Phosphorous etc. are also used in industries producing other chemicals.

2.2.5 Cluster level initiatives

The programmes and initiatives undertaken by various organisations are listed in the table 2.2.5.

Table 2.2.5: Cluster level initiatives

Organisation	Programme/ Initiatives	Brief description	Status
Vapi Industries Association (VIA)	Innovation Facilitation Cell	Introducing enterprises to Innovation practices & helping them to develop system of Innovation by bringing together Industry and Academia (academic, R&D institutes; technical experts etc.)	Operational
	Common ETP	Majority of the MSME units in Vapi Industrial Cluster used to discharge untreated or partially treated effluents into river Damanganga. The concept of common ETP was introduce to minimize the untreated effluent discharge and endorsed by VIA, GIDC and GPCB. Under this initiative, effluent water treatment facility developed for common use in Vapi Industrial Cluster.	Operational
Vapi Green Enviro Limited	Common Solid Waste Management System	Vapi Green Enviro Limited (VGEL) has developed a common solid waste management facility in 1999. VGEL facilitates collection, transport, storage and disposal of hazardous solid wastes at this site. Furthermore, a small incineration system was also established in year 2002.	Operational
	Centre Of Excellence	The Centre of Excellence was established by Vapi Green Enviro Ltd., under the IIUS Scheme of Govt. of India. This facility ensures access to advanced analytical laboratory, research and development centre for the Industries at an affordable rates.	Operational
The Government of Gujarat	Common Steam Boiler under Gujarat Industry Policy, 2000	Common Steam Boiler Project is an initiative under the Gujarat Industry Policy, 2000. The objective is to eliminate operation of small boilers in individual units and secure proper monitoring and control of emission.	Operational

Chapter 3

3.0 Major cluster stakeholders

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

3.1 Industries associations

The major industry associations active in Vapi chemical cluster are Vapi Industries Associations (VIA), Vapi Waste Effluent & Management Co. Limited, Vapi Green Enviro Limited. The contact details of the industries associations are given in Table .

3.1.1 Vapi Industries Associations (VIA), Gujarat

Vapi Industries Association was established in the year 1971. Vapi Industrial Cluster enhouses more 2000 industrial units at present and all development activities are carried out under the supervision of VIA.
VIA renders invaluable services to its constituent members in all state of industrial activities and performs a catalytic role in implementing various policies and programs of the Government. Besides organizing seminars like VIA Impact talks, Safety Alert Program, Business Meets, Human Resources Development Programs etc., the association organizes an industrial exhibition once in every two years in which industries and trade from across the country participates. VIA has set up "Vapi Emergency Control Centre" to provide timely service to industries in the event of an emergency arising out of any accidental occurrence or anything of its kind.

3.1.2 Vapi Waste Effluent & Management Co. Limited

Vapi Waste Effluent & Management Co. Limited is a company engaged in land acquisition for hazardous waste disposal and under construction CETPs in agreement with GIDC. This company is engaged in manufacturing, designing, engineering and supplying of pollution control equipments, plants and operating the facilities for safe disposal of industrial waste such as landfill for solid wastes, incinerator hazardous solid/ liquid wastes, inorganic wastes. This company is also involved in creating pubic awareness, carrying out promotional activities on clean environment.

3.1.3 Vapi Green Enviro Limited

Vapi Green Enviro Limited was formed with an objective of providing a Comprehensive Environment Management Program (CEMP) for the Vapi Industrial oluster.

VGEL have installed common effluent treatment plant (CETP) and transport, storage, provided facility for disposal of hazardous solid waste, established Centre of Excellence to help industries in achieving global standards of quality. Following are the major development initiatives of VGEL:

i) Common Solid Waste Plant
ii) Common Effluent Treatment Plant
iii) Centre of Excellence

Table 3.1.3: Contact Details of Industrial Associations

Name of organisation	Contact detail
Vapi Industries Association (VIA), Gujarat	Address: Plot No. 135, VIA House, GIDC, Vapi, Gujarat 369195 Email Id: info@viavapi.org Phone No.: (0260) 2430950, (0260) 2431950
Vapi Waste Effluent & Management Co. Limited	Address: Plot No. 148, GIDC Road, Om Pipe Industries Compound, Phase 2, GIDC, near ICICI Bank ATM, Vapi, Gujarat 396195 Phone: 098791 99546
Vapi Green Enviro Limited	Corporate Office Address: VIA House, Plot No. 135, GIDC, Vapi - 396 195 Gujarat. India Phone No.: (0260) 2428950, (0260) 2429950
Common Solid Waste Plant	Address: CSWP, Plot 4807 etc. Phase IV, GIDC, Vapi - 396 195 Gujarat. India
Common Effluent Treatment Plant	Address: CETP, N.H.No.8, Near Damanganga Bridge, GIDC, Vapi - 396 195 Gujarat. India
Centre of Excellence	Address: Near Water Filtration Plant, 1st Phase, Survey No.863, P/864, 735/P, GIDC Vapi - 396 195, Gujarat. India Phone: 0260 2431597, +91 9714007068

3.2 Government bodies

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

Table 3.2: Goverment bodies and key responsibilities

Name of organisation	Key roles
Micro, Small & Medium Enterprises Development Institute (MSME-DI), Gujarat	Micro, Small & Medium Enterprises Development Institute (MSME-DI), Gujarat works on development of Micro, Small & Medium Enterprises sector of state of Gujarat through counselling, consultancy, training, different awareness programme, market promoting programme among MSMEs
District Industries Centre (DIC), Vapi	• To promote Small, Medium and Large scale Industries in the State. • Regulate the growth of Industries in the state. • Generate employment and self employment. • Contribute for the growth of GDP in the state economy.
Gujarat Energy Development Agency	GEDA (Gujarat Energy Development Agency) is the state nodal agency (SNA) for the Ministry of New and Renewable Energy Sources (MNRE) and the state designated agency (SDA) for Bureau of Energy Efficiency (BEE). GEDA has the responsibilities of promoting and implementing the initiatives on renewable energy and energy efficiency in Gujarat.
Gujarat Industrial Development Corporation	The main objective of Gujarat Industrial Development Corporation (GIDC) is to accelerate industrialization in Gujarat. GIDC has the responsibility to establish and organize the industries and look after development of the industrial estates in Gujarat. GIDC identifies ideal locations and developes industrial estates with infrastructure such as roads, drainage, electricity, water supply, street lights, and ready-to-occupy factory sheds.

3.3 Technical, academic, and R&D institutions

Both public and private academic and technical institutions, testing laboratories are available in Vapi and in the surrounding areas of the city. Some of the major engineering and polytechnic institutes GIDC Rajju Shroff ROFEL Institute of Management Studies (GRIMS) and R. K. Desai College of Commerce and Management offer a variety of courses in chemical engineering and chemical sciences relevant for the cluster.

Kaushik Haria Education Trust Private Industrial Training Institute (ITI), Vapi offers various industrial training courses which develops skills in managing operations and maintenance of plants, laboratories, processes etc.

3.4 Financial institutions

There are more than 20 nationalized, commercial, and cooperative banks operating in the cluster. The State Bank of India (SBI) is the leading bank in the Vapi having about 4 branches serving to MSME sector. The State bank of India is serving the Chemical industries of Vapi and is ensuring credit flow to MSMEs and addresses both financial and developmental gaps in the MSME eco-system. Most of these banks provide financial assistance towards expansion and infrastructural upgradation of chemical units. In addition, a large number of cooperative banks also operate in the cluster to meet the financial requirements of the cluster. A list of key banks located in Vapi with contact details have been provided in 3.4.

Table 3.4: Key Banks in Vapi

Sl. No.	Bank	Address
1	Andhra Bank	Address: Gunjan Shopping Centre, Gunjan Road, Vapi Industrial Estate, Vapi - 396195, Phone No+ (91)-260-2421433
2	Axis Bank Ltd	Address: Hotel Fortune Galaxy Complex, Commercial Plot No. C7/67, Vapi, Phone No+ (91)-260-2428231
3	Bank of Baroda	Address: Anavil Yuvak Mandal Bldg, Main Road, Vapi - 396191, Phone No+ (91)-260-2462849, 2460030
4	Bank of India	Address: P B No 39, Zanda Chowk, Vapi - 396195, Phone No+ (91)-260-2463165
5	Bank of Maharashtra	Address: 277, Main Road, Pelhar, Vapi - 396191, Phone No+ (91)-260-2571781
6	Central Bank of India	Address: 102, K P Tower, Vapi Silvassa Road, Vapi - 396191, Phone No+ (91)-260-2424355
7	Citibank	Address: The Emperor, Chala, Vapi Daman Road, Vapi - 396191, Phone No: + (91)-260-2322484, 2324653
8	Corporation Bank	Address: Cm 8/13, Ground Floor, Vapi Industrial Estate, Vapi - 396195, Phone No+ (91)-260-2420009, 2420004
9	HDFC Bank Ltd	Address: 1st Floor, Kanta Trade Centre, Vapi - 396191, Phone No+ (91)-260-6548104
10	IDBI Bank Ltd	Address: C-1, Advance Comlex, Near Hotel Green View, Vapi, Phone No+ (91)-9979085588
11	Indian Bank	Address: C-5/47-70, Char Rasta, Vapi Industrial Estate, Vapi - 396195, Phone No+ (91)-260-2421986

Sl. No.	Bank	Address
12	Indusind Bank Ltd	Address: Plot No C, 6/13, Shreenathji Chambers, Vapi Industrial Estate, Vapi - 396195, Phone No+ (91)-260-2428130
13	Kotak Mahindra Bank Ltd	Address: Plot No 5/6, Orbit Apartments, Vapi Daman Road, Vapi - 396191, Phone No+ (91)-260-2462722
14	Oriental Bank of Commerce	Address: Fortune Hotel, Galaxy Compound, Vapi Valsad, Vapi - 396191, Phone No+ (91)-260-2474859, 2422265
15	Punjab National Bank	Address: 1st Floor,Narayan Chambers, Vapi Valsad, Vapi - 396191, Phone No+ (91)-260-2433323
16	Saraswat Co Operative Bank Ltd	Address: Plot No P/50/1, Shanti Complex, Opposite Prime Hotel, Vapi, Phone No+ (91)-260-2425663, 2425664
17	State Bank of India	Address: C1/ B, Shed No 15, Vapi Industrial Township, Vapi - 396195, Phone No+ (91)-260-2432362
18	Syndicate Bank	Address: Holi Market, Azad Road, Vapi - 396191, Phone No+ (91)-260-2322216
19	UCO Bank	Address: Near Vaishali Cinema, Kaporali Road, Vapi - 396191, Phone No: 18001030123
20	Union Bank of India	Address: 246, Bazar Road, Vapi Valsad, Vapi - 396191, Phone No+ (91)-260-2463784

Chapter 4

4.0 Production process and technology use

4.1 Manufacturing process for Chemical Industries

The chemical manufacturing process varies with the products and production capacities. The industries use reactor vessel or mixing tank to facilitate chemical reaction by heating /cooling as needed. On completion of chemical reaction, mother liquor is passed through next step of operation to produce cake or paste, which is subsequently dried, seized, etc. before packaging of final products completed. However, the manufacturing process and technologies/ equipment used for primary chemical products such as (1) Dye and pigments, (2) API and pharma intermediate, (3) Other chemicals industries in the MSME sector are discussed in this section.

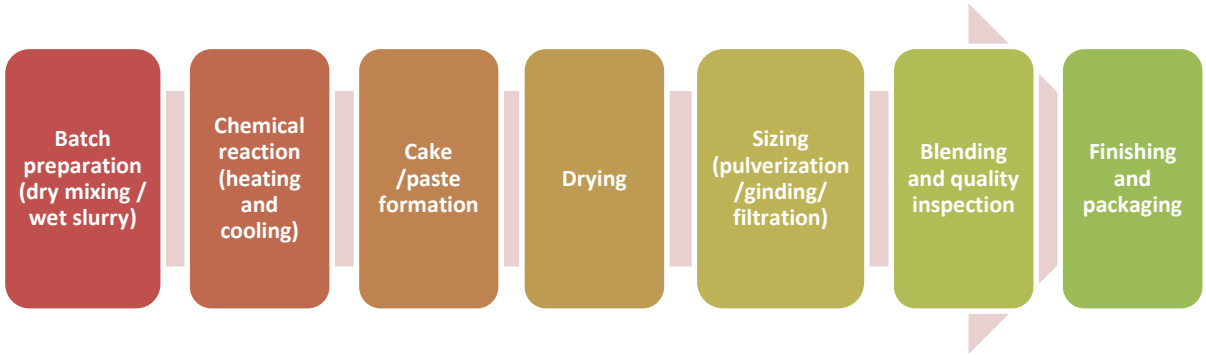

Figure 4.1a: Process steps of chemicals manufacturing

Dissolving/Mixing: The raw materials of a batch product are transferred to a specific reaction vessel that is compatible to provide necessary support during entire reaction phase. Reactor vessels are normally equipped with electrically driven mechanical agitator, direct/indirect jacket heating ,cooling using steam, thermic fluid to maintain the desired temperature. Raw materials, by proportion by weights, are poured into reaction vessel. The mixture is continuously stirred as per the specific requirement of the product and the temperature is maintained using jacket heating/ cooling arrangement. The overall processing time in the reaction vessel varies from 8 hours to 72 hours depending on the desired output in terms of temperature or intermediate product concentration. The process uses both thermal energy and electricity. The thermal energy requirement is met through a steam boiler or thermic fluid heater (TFH).

Primary Filtration: After mixing, the intermediate products i.e. liquid and/or suspended solid particles are separated from the slurry. The filtration is carried out using centrifuge or filter press. This process takes about 1–2 hours for completion.

Purification: Purification helps in improving or modifying the basic properties of the intermediate product as per the requirement of final product. For example, to neutralise the alkaline natured intermediate product, sulphuric acid is added in the intermediate product and the desired temperature is maintained using jacket cooling/ heating. The product is continuously stirred using an agitator system.

Secondary filtration: In secondary filtration process, the intermediate product is separated from the slurry using a centrifuge or filter press. The secondary filtration process takes about 1-2 hours for completion.

Drying: The drying process is generally applicable for organic chemical products in which the final product is of powder form. The cakes from filtration process are loaded into tray/ spin flash dryers for removal of moisture and drying using hot air. Drying is thermal energy intensive and most time-consuming process and takes about 20–36 hours per batch. The hot air is supplied by natural gas or wood-fired hot air generator.

Grinding/crushing (Pulverization): The granules/ blocks of dried products are crushed or ground in a pulverizer, as per the desired particle size of the final product. The process takes about 3–5 hours per batch. Later on this final product is checked for the quality and sent for packaging.

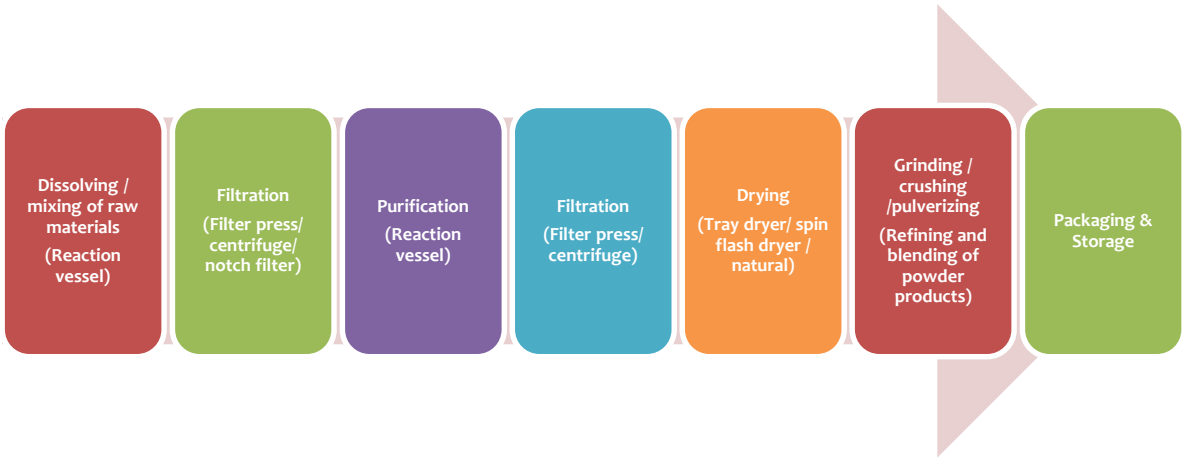

Figure4.1b: Process flow in typical dyes and pigment manufacturing units

4.1.1 API/Pharmaceutical

The manufacturing process of the API/Pharmaceutical industries varies widely depending on the type of products. The process followed and technologies used in API/Pharmaceutical production are discussed below.

The raw materials for the API/pharmaceuticals are procured in the form of chemical powders and/ or salts. These powders are tested and segregated in weighed proportions as per the desired composition of the products. This weighed mixture is then mixed to form a starch paste and then checked for desired quality. Once the specified composition is achieved, the starch paste is set to dry in an electric dryer. The dried mixture then undergoes sieving process to remove uneven chunks from the batch and form the desired sized product. These raw products then undergo lubrication process to prevent sticking to one another. Further these products are sent for film coating to prevent being affected by atmospheric moisture. These coated products are then once again passed through quality check for medical standards and composition before being

forwarded for packaging. The final product is then packed by packaging machines and then dispatched. The basic process steps of API/pharmaceuticals manufacturing are given in Figure 4.1.1.

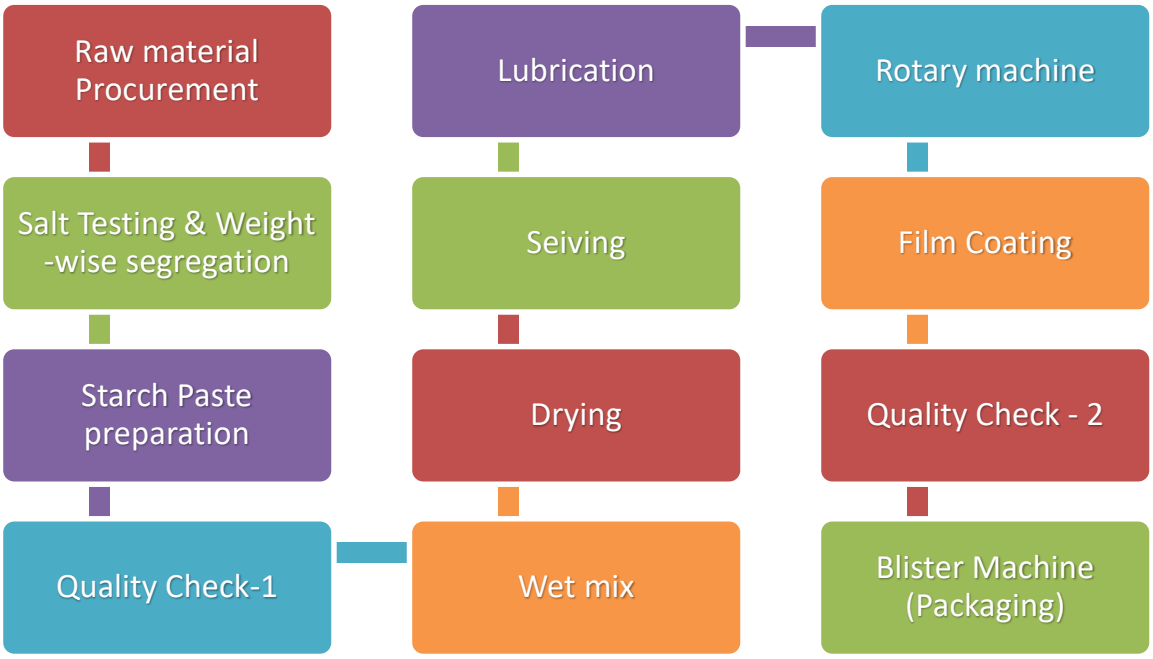

Figure 4.1.1: Production process of API/Pharmaceuticals manufacturing

4.1.2 Manufacturing Process for other chemicals

The chemical industries prepare a large number of other products like detergent powder, soaps, solvent distillation, acid preparation, anti-oxidants, rubber, sodium hypochlorite etc. All these products are categorised under other chemicals. The manufacturing process of the other chemicals varies widely depending on the type of products. The general process followed in other chemicals are discussed below.

The manufacturing process begins with preparation of raw materials. The raw materials in required proportions are taken and mixed together. Mixing may be done manually or by using mixers. After mixing, the product is sent for filtration to remove or to separate chunks from the product. After filtration, depending on the need they are sent for cooling/chilling and then the final product obtained is quality checked and sent for packaging. The basic process of manufacturing is given in Figure 4.1.2.

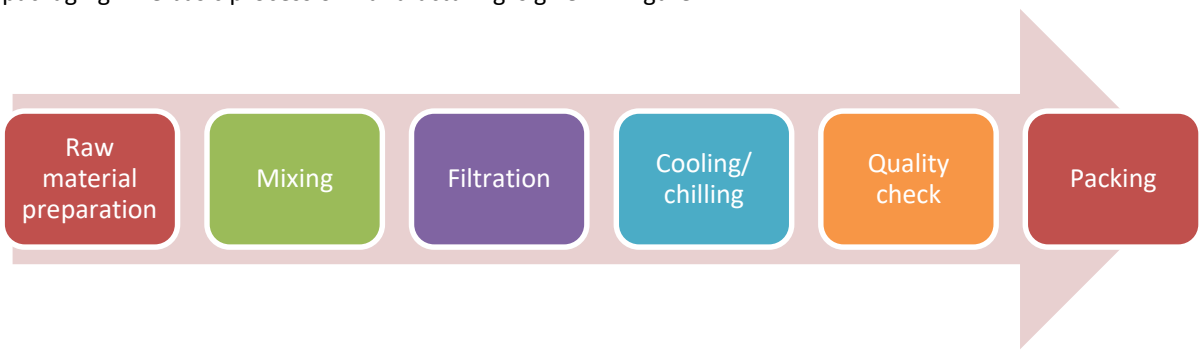

Figure 4.1.2: Production process of other chemicals

4.2 Major technologies and equipment

A variety of chemical products like paints, acid, bleaching powder, pigments, rubber oil are manufactured in Vapi cluster. However, the technology use and type of process equipment used in manufacturing of these chemicals are different. The major technologies and equipment used in process areas and utility sections are provided in Table 4.2.

Table 4.2: Major technolgies/equipment used in chemical industries

Manufacturing process	▪ Mixer drum ▪ Ball Mill ▪ Reaction vessels/kattles ▪ Distillation Columns ▪ Centrifuge ▪ Press Filters ▪ Dryers
Auxiliaries/utilities	▪ Steam boilers ▪ Pumps ▪ Blowers/Fans ▪ Air compressors ▪ Thermic fluid heaters ▪ Chilling systems ▪ Cooling towers ▪ DG Sets

4.2.1 Details of process equipment

The brief details of the equipment used in the manufacturing processes are provided below.

4.2.1.1 Mixer Drum

The mixer drum carries grinding stones inside, which help to break down the coagulation of raw materials while the drum is being rolled/ rotated for mixing. The mixing process is an exothermic reaction and is carried out for 7 to 10 hours to attain adequate homogeneity. The chemical units have different capacities of mixer drum varying in the range of 100-400 litre . The capacities and number of vessels in a chemical unit are dependent on type of manufacturing process, production capacity and batch size.

4.2.1.2 Ball Mill

A ball mill consists of a hollow cylindrical shell rotating about its axis. The axis of the shell may be either horizontal or at a small angle to the horizontal. It is partially filled with balls. The grinding media are the balls, which may be made of steel (chrome steel), stainless steel, ceramic, or rubber. The inner surface of the cylindrical shell is usually lined with an abrasion-resistant material such as manganese steel or rubber lining. Less wear takes place in rubber lined mills. The length of the mill is approximately equal to its diameter.

4.2.1.3 Reaction Vessels/Kettles

The chemical reactions take place in kettles, primarily made of stainless steel or rubber lined ceramic material. The chemical units have different capacities of reaction vessels. The capacities and number of vessels in a chemical unit are dependent on type of manufacturing process, production capacity and batch size.

4.2.1.4 Distillation Columns

The distillation columns are used for separating components of a solution. As the components of a solution has different degree of volatilities, such components can be separated and collected one by one using a distillation column. It is a combination of two physical processes vaporization and condensation. More volatile components gets separated first and less volatile components gets separated later.

4.2.1.5 Centrifuge

The intermediate products in the form of slurry (suspended solid particles) are separated from the slurry using centrifuge. Different basket sizes of centrifuge e.g. 24/36/48 inch are used in the cluster.

4.2.1.6 Press Filters

In a press filter, the solid particles and liquid chemicals are separated by pressing the slurry in filter plates using hydraulic force. The separation occurs in chambers formed between the recessed faces of filter plates, which are clamped together in a rugged steel frame. Compressed air at about 5–7 kg/cm^2 is used to remove liquids from pores in the filter cake. Upon reaching the desired residual moisture content, the filter is opened and the cake is removed. The filter press helps in reducing the moisture content by 50% to 60%.

4.2.1.7 Dryers

The moisture-laden solid cakes are kept in the dryer chamber and heated to the required temperature to remove the moisture. A wide range of dryers is used namely tray dryer, fluidized bed dryer, rotary vacuum dryer, and spin flash dryer. Steam boilers, thermic fluid heaters, and hot air generators are used for providing heating requirements in the dryer.

4.2.2 Details of auxiliaries equipment

The brief details of auxiliaries/utilities used in the chemical industries are provided below.

4.2.1.8 Steam boilers

The steam boilers, as per Indian Boilers Regulations (IBR), are mainly used for low and medium pressure (i.e. 3.5-10.5 kg/cm^2) applications in the chemical units. The coal is the major fuel used in boilers to generate the steam.. Most of the chemical processes require low pressure steam (i.e. 3.5-5.5 kg/cm^2) for jacket heating and direct purging into the reactor vessels. The capacities of IBR type boilers range from 1-5 tonne per hour (tph). The non-IBR boilers (up to 750 kg per hour evaporation rate) are also used in the chemical units to meet intermittent steam requirements. These boilers are of single pass, once through type and primarily use natural gas or liquid fuels as energy source.

4.2.1.9 Pumps

The pumps are one of the major energy consuming equipment in chemical industries and the pumps are installed for boiler feed water pumps, process circulation pumps and plant water supply pumps. Majority of the pumps installed are of local make or old and pumps are found to be highly inefficient.

4.2.1.10 Blowers/Fans

The bowers or fan are used for different purposes in the chemical units like exhaust blower, FD fan ID fan etc. The capacity of blowers varies according to its purpose of use and capacity of the system.

4.2.1.11 Air compressors

The air compressors are used to meet compressed air requirements of processes and pneumatic instrumentation in the chemical units. The end use compressed air pressure varies from 5 kg/cm^2 to 7 kg/cm^2. Most of the chemical units use small capacities tank mounted, reciprocating type air compressors, while some of the progressive units use screw compressors.

4.2.1.12 Thermic fluid heaters

The thermic fluid heaters (TFH) or thermos-packs are used to cater to the indirect heating requirements of manufacturing processes viz., dryer and jacket heating. The natural gas is mainly used as fuel in TFH. The capacities of thermos-packs vary from 100,000 kcal per hour to 500,000 kcal per hour based on process requirements. The temperature of thermic fluid is about 180-200 °C.

4.2.1.13 Chilling systems

Some of the chemical units require to maintain the temperature of processes below 0^{o}C. To meet this process cooling requirements, ammonia type reciprocating chillers are mainly used in these units. The capacity of ammonia based chillers varies from 15 TR to 110 TR. A few chemical units employing intermittent processes use ice blocks instead of chillers for the cooling process.

4.2.1.14 Cooling towers

Cooling towers are used to cool down hot water coming from process, boilers, chillers etc. It is a heat rejection equipment where the heat from water rejected to atmosphere by means of evaporation process. A cooling tower normally includes a fan for air supply to increase the evaporation rate and a pump for water circulation from process to the cooling tower inlet.

4.2.1.15 DG Sets

DG sets are being used as backup power generator and operates only when power failure occurs. HSD is the common fuel for the DG sets. For power backup, 125 to 500 kVA DG sets are installed in majority of the units.

Chapter 5

5.0 Energy consumption profile and conservation measures

5.1 Details of energy use

The chemical industries in Vapi cluster use both thermal energy and electricity in the manufacturing processes. Energy accounts for a sizeable portion of manufacturing costs of the chemical units of Vapi cluster. The levels of energy consumption in these units are dependent on the type of products and the process followed. Types of energy sources used in the cluster mainly include natural gas and electricity, HSD is used for backup power generation.

5.1.1 Thermal energy

Thermal energy is used to meet the heating requirements of the processes followed in chemical industry. The details of thermal energy use in the cluster are provided in 5.1.1.

Table 5.1.1: Details of fuels used for thermal energy requirements

Energy type	Source	Calorific value	Landed cost
Natural Gas	Gujarat Gas Limited	8750 kCal/kg	Rs 61/SCM
HSD	Retail outlets	10,580 kCal/kg	Rs 77-80/lit

5.1.2 Electricity

Electricity is used in electric motors to operate equipment such as pumps, blowers, ball mills, drum mixers and other motor driven equipment. Most of the micro category chemical units use LT connection, whereas the small and medium category units use HT connection. Electricity is supplied by Dakshin Gujarat Vij Company Limited (DGVCL). The applicable tariff of various such categories is given in Table 5.1.2.

Table 5.1.2: Electricity tariff plans in Vapi chemical cluster

Category	Contract demand	Demand Charges	Energy Resource	Energy Charges
HTP-1 (Supply Voltage: 11 kV)	For the first 500 kVA of billing demand	Rs. 150/- per kVA	Dakshin Gujarat Vij Company Ltd. (DGVCL)	(a) Up to 500 kVA of billing demand, 400 Paise per unit (b) For billing demand above 500 kVA and up to 2,500 kVA, 420 Paise per Unit
	For next 500 kVA of billing demand	Rs. 260/- per kVA		
	For billing demand in excess of 1,000 kVA	Rs. 475/- per kVA		

Category	Contract demand	Demand Charges	Energy Resource	Energy Charges
				(c) For billing demand above 2,500 kVA, 430 Paise per Unit
LTMD (Supply Voltage: 0.415 kV kV)	For the first 40 kW of billing demand	Rs. 90 per kW	Dakshin Gujarat Vij Company Ltd. (DGVCL)	For total units consumed during the month : Rs. 4.60 per unit For total reactive units consumed during the month : Rs. 0.1 per kVARh
	For the next 20 kW of billing demand	Rs. 130 per kW		
	For billing demand in excess of 60 kW	Rs. 195 per kW		
	For billing demand in excess over the contract demand	Rs. 265 per kW		

5.2 Energy consumption pattern

The energy consumption pattern of the chemical units varies based on product type, technology employed and production capacities. The unit level energy consumption of typical production capacities and cumulative cluster level energy consumption of the Vapi chemical industries are summarised below.

5.2.1 Unit level

The energy consumption of typical chemical units in Vapi chemical cluster varies very widely from 320 to 470 toe per year for dyes & pigments manufacturing units, from 51 to 455 toe per year for API/pharmaceuticals manufacturing units and 152 to 370 toe per year for units manufacturing other chemicals. Most of the units are completely running on the electricity and natural gas and use HSD for backup power generation. But the consumption of thermal energy in these units is high which makes the overall part of thermal energy 76% in total energy consumption. Therefore, natural gas can be considered as main source of energy.

Table 5.2.1: Unit level energy consumption

Category	Thermal energy (toe/year)	Electricity (toe/year)	Total energy consumption (toe/year)
Dyes & pigments	334	74	408
API/Pharmaceutical	126	123	249
Other chemicals	218	43	261

Here it is to be noted that the bandwitdths of annual energy consumption are very wide. Such wide bandwidths are caused by the following factors:

a. Wide variation in production and capacity of the units
b. Variation of energy intensity of products manufactured under same category
c. Technology/equipment used for production
d. Variation in ratio of electrical and thermal energy consumption

5.2.2 Cluster level

The cluster uses natural gas (NG) to meet energy requirements in the process along with grid electricity. HSD is used for backup power generation. The total energy consumption of the cluster is estimated to be 92,645toe. Thermal energy accounts for 76% and electrical energy 24% of total energy consumption. Natural gas accounts for about 76% of total energy consumption followed by electricity (22%) in the cluster. The total GHG emissions of the cluster is estimated to be 3,28,959 tonne CO_2 per year. The cluster level energy consumption is shown in Table 5.2.2. Both electricity and NG share the GHG emissions.

Table 5.2.2: Cluster level energy consumption

Energy type (Unit)	Energy consumption	Equivalent toe
Natural gas (million SCM per year)	93	81,032
LDO/FO/HSD (kL per year)	1,486	1,299
Electricity (million kWh)	207	17,797
Total	-	100,127

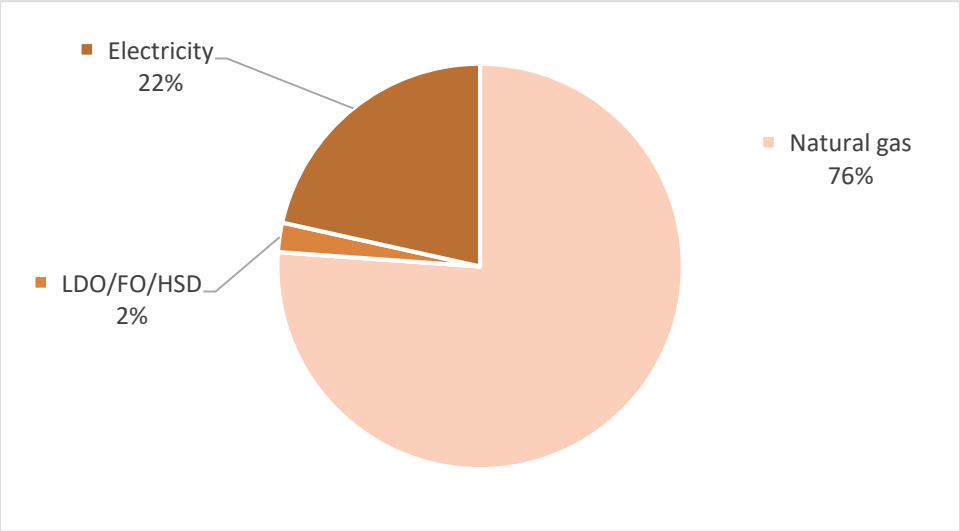

Figure 5.2.2: Cluster level energy consumption

5.3 Other resources

Apart from thermal energy and electricity, the chemical industries in the Vapi cluster consume other resources such as raw water and treated water in the manufacturing process.

5.4 Energy conservation opportunities

The chemical units in Vapi cluster mostly use locally fabricated technologies, especially for thermal and process equipment. These technologies/equipment are invariable energy in-efficient and polluting. The electrical motors are rewound multiple times that leads to inefficiencies in many of the motor driven systems. Accordingly, the chemical units in the cluster offer significant scope for energy saving. A list of different energy conservation measures applicable for Vapi chemical units is provided in Table 5.4.

Table 5.4: Major energy conservation opportunities in cluster

Equipment/section/utility	Energy conservation measures
Steam generation and distribution system	– Installation of VFD for FD fan/blower of the boiler – Rectifying & Installation of economiser to heat boiler feed water – Waste heat recovery to preheat boiler feed water – Insulation of boiler feed water tank and pipeline network
Thermic fluid heater	– Replacement of existing TFH with a new energy efficient TFH – Optimisation of air-to-fuel ratio and installation of waste heat recovery system
Hot air generator and spray dryer	– Temperature based control system of Spray Dryer (FD Fan, ID Fan, Material Feed Pump) – PLC-based control system for spray dryer operation
Compressed air system	– Optimisation of generation pressure of air Air compressor system – Installation of VFD for air Air compressor – Installation of compressed air header and reduce set discharge pressure – Adaption of energy efficient, screw air compressor
Reaction vessels and process	– Installation of the programmable timer for reactor vessels to avoid idle running – Installation of heat exchanger in chilled water circuit – Installation of the programmable timer in Ball mill to avoid idle running
Electrical distribution system	– Automatic power factor correction system – Transformer tap setting change to maintain supply voltage close to 415 – 420 V.
Electric motors	– Replacement of rewound, old inefficient electrical motors with IE3 efficiency class motors
Pumps	– Replacement of inefficient water pumps – Installation of VFD for water pumps
Cooling Tower	– Installation of thermostat controller and VFD to automate cooling tower fan operation
Other areas	– Installation of solar rooftop PV system

Chapter 6

6.0 Major challenges in the cluster

The cumulative energy consumption of Vapi chemical cluster is quite significant. The analysis of energy consumption by various sub-processes indicate the use of inefficient technologies and equipment by the cluster units. There exists a significant scope for energy saving in the cluster. However, the cluster needs to address a number of challenges for large scale adoption of energy and resource conservation measures. The key challenges in chemical industries operating in MSME sector can be broadly grouped into technical, financial, skillsets, policy related and infrastructure. The specific challenges and impacts are depicted in Table 6.0.

Table 6.0: Key challenges in chemical sector

Key challenge	Specific challenge	Impact
Technical	Lack of awareness on efficient technology options	• Use of outdated technologies • Higher capital costs for efficient technologies • Longer period for adoption of energy efficient technologies
	MSME is not the priority sector for technology providers	• Reluctance of entrepreneurs on technology upgradation
	Limited knowledge of entrepreneurs and focus on low hanging fruits	• Apprehension in loss of production
Financial	Higher transaction costs for financing low value loans by banks	• MSMEs are not able to reap the benefits from technology promotion schemes of banks • Lack of technology adoption on a wide scale among MSMEs
	Mandatory collateral requirements for financing and low credit rating of MSMEs	• Poor disbursement of loans on EE projects by banks
	Lack of updation to banks on EE technologies/ equipment	• Low prospects for large scale adoption of new and modern technologies at cluster level
Skillsets	Non-availability of sub-sector specific training institutes at cluster level for skillset improvements	• Variations in production, productivity, energy performance and quality • Apprehension towards development of new processes and products • Investment by individual units on development of skilled manpower • Lack of in-house innovation on EE projects
	Lack of in-house technical capabilities	• Less exposure on new and EE equipment leading to inefficient operation

Key challenge	Specific challenge	Impact
Policies	Non-existence/ availability of sector- specific programs or schemes	• Limited implementation by MSMEs due to high investment required for up gradation of process equipment in targeted sector
Infrastructure & others	Fragmented and geographically dispersed nature of units	• Difficulties in accessing common infrastructure facilities e.g. common facility centers etc.

Chapter 7

7.0 SWOT Analysis

The chemical industries in Vapi face a number of challenges pertaining to regulations on production capacities and exports that can affect the adoption of energy efficiency measures by the cluster units. Over the past few years, there has not been any capacity expansion in the chemical units of the cluster. Most of the industries are over 20 years old so the technology used by them is not upgraded. The MSME units also face challenges due to the higher cost of coal as compared to neighbouring state which results the industries to shut down due to unable to stand in the competitive market. Vapi chemical cluster has many regional advantages like the availability of raw material that help the cluster remain at the forefront of the Indian chemical industry. There is a need for the chemical units to become efficient and maintain a better profit margin which would require adoption of energy efficient technologies and increasing the capacity of production by adoption of automation in their processes. A SWOT (Strength, Weakness, Opportunities, and Threats) analysis of the chemical manufacturing units in the Vapi cluster was performed to understand the cluster situation. The SWOT analysis of the Vapi chemical cluster is given below.

Table 7.0: SWOT Analysis

Strength	Weaknesses
• Large number of self-reliant & independent chemical units in Vapi • Active industry associations • Adequate supply of electricity. • Locally available raw materials • Locally available technology suppliers and fabricators • Common effluent treatment plant • Entrepreneurship zeal in local community	• Polluting nature of chemical industries leading to closure of several units • Escalating raw material prices • Use of conventional technologies leading to inefficient production processes • Short product life cycle
Opportunities	**Threats**
• High energy cost for individual unit • Significant potential for energy saving • Potential for expansion and automation of processes • Strong domestic and international market • High scope for expansion in the cluster	• Competition due to low cost imported products/material • Soaring prices of energy sources • Shortage of manpower • Recent entry of substitute products in the market

Chapter 8

8.0 Conclusions

Vapi chemical cluster with more than 250 operational chemical units is an important industry cluster under MSME sector in the country. The chemical units of dyes & pigments, API/pharmaceuticals and some chemical allied products use both thermal energy and electricity to meet their energy demands. The analysis of Vapi chemical cluster shows that thermal energy account for a major share of energy consumption. The energy intensities of these units are also quite high as compared to large units, which may be attributed to the use of inefficient technologies and equipment in both process and utilities. This also results in increased energy costs. Further the higher cost of energy as compared to neighbouring state increases the production cost which results the industries to shut down due to unable to stand in the competitive market.

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

In order to stand in the competitive market of China, the unit also needs to increase its production capacity with the adoption of automation system. This will enable the units to increase its production and decreasing the per unit production cost.

The technical assistance with the support of the project would help the chemical industries in Vapi cluster to (i) identify potential process/ utility areas for energy saving, appropriate EE technologies, energy saving potential through detailed energy audits of cluster units (ii) adopt EE technologies through increased awareness and by strengthening linkages with EE technology providers. (iii) identify the units which has the capacity to increase production by adopting automation.

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