ACHIEVING ENERGY AND

RESOURCE EFFICIENCY IN

CHEMICAL INDUSTRIES

A Sectoral Roadmap for Micro Small and Medium Enterprises

Prepared by

THE ENERGY AND RESOURCES INSTITUTE

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We also take this opportunity to express our deep appreciation for the excellent support and baseline information provided by the individual entrepreneurs of chemical manufacturing units of various clusters.

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Abbreviations

BEE	Bureau of Energy Efficiency
BOP	Best Operating Practices
CAGR	Compounded Annual Growth Rate
DIC	District Industries Centre
DPR	Detailed Project Report
EE	Energy Efficiency
EESL	Energy Efficiency Services Limited
EMC	Energy Management Centre
ESCO	Energy Service Company
FI	Financial Institution
GHG	Greenhouse Gases
GJ	Giga Joule
HSD	High Speed Diesel
LSP	Local Service Provider
MSME	Micro Small and Medium Enterprises
MSME-DI	MSME-Development Institutes
mt	million tonne
NG	Natural gas
SDA	State Designated Agency
SEC	Specific Energy Consumption
SIDBI	Small Industries Development Bank of India
SPV	solar photovoltaic
SPV-CDP	Special purpose vehicle for cluster development programmes
toe	tonne of oil equivalent
tpd	tonne per day

Achieving Energy & Resource Efficiency: A Roadmap for Chemical Industries

The roadmap provides the rationale for energy and resource efficiency improvements and further outlines the potential for improvements through deployment of efficient technologies and practices in the chemical sector.

The roadmap provides energy and resource efficiency goals, sectoral scenario and energy and resource saving potential in chemical industries in MSME sector. It identifies key barriers at sector level, which must be addressed to achieve optimum efficiency levels in chemical sector. Based on the type of interventions proposed, the roadmap proposes two distinct strategies i.e. policy level and cluster level for move towards energy efficiency for the sector. It is envisaged that achievement of milestones through implementation of the roadmap will contribute towards sustainability of the chemical sector as well as energy security of the country.

CLUSTER LEVEL STRATEGIES

- Energy efficiency institutional framework
- Capacity building
- Market &financing

POLICY LEVEL STRATEGIES

- Regulation for technology & infrastructure development
- Human resources
- Research, development & innovation

2022 – Initiation

Cluster level energy management cell
Identification & Development
Technology up gradation fund
Development of DPR

Common facility centers &
Infrastructure development
Identification & development of DPR

2024 – Implementation

Technology up gradation fund
Technology & financial assistance

Cluster level EM Cells
Established &Functional
Skill development
Identification & Development

2025 – Infrastructure

Common facility centers
Standard testing and infrastructure facilities, access to manufacturing process, technology and raw materials

2027 – Monitoring & Review

Technology up gradation fund
review, optimize, relaunch

Monitoring
(Skill development Common facility)
Review & optimize

Introduction

The Micro, Small and Medium Enterprises (MSME) sector contributes significantly in the inclusive industrial development of the country. MSMEs produces a wide range of products catering to the needs of both domestic and international markets. MSMEs are complementary to large industries as ancillary units. MSME sector contributes for 30.27% of all India GDP1. The estimated number of MSMEs in the manufacturing sector is about 196.65 lakh units located both in rural and urban areas in India (National Sample Survey, 73rd round). The sector provides employment opportunities to about 360 lakh people.

Most of the manufacturing industries in the MSME sector are traditional and deploy technologies that are predominantly inefficient and resource intensive. The MSME sector has a significant impact not only on the economy but also on the environment. The energy efficiency path of the MSME sector is quite challenging due to its fragmented nature. Further, the absence of data and information on energy consumption and technologies at national level limits the design of appropriate policy instruments for the sustainable growth of energy intensive MSME sectors.

The Bureau of Energy Efficiency has initiated a programme with an objective to improve both sustainability and competitiveness of the MSME sector. This includes detailed energy mapping of select energy intensive MSME sub-sectors. The chemical sector is one of the sectors covered under this study. A sector-specific roadmap was prepared for promoting adoption of energy and resource efficiency measures in chemical sector.

[1] Annual report 2020-21, Ministry of Micro, Small and Medium Enterprises

Overview of Chemical Sector

This section discusses about overview of chemical industries in MSME sector, key growth drivers of the market and major challenges. It also provides the geographical coverage and primary stakeholders of chemical industries in MSME sector.

Overview of chemical industries

At global level, Indian chemical industry ranks 6th position with about 3% contribution to the global chemical industry. India is one of the largest global dye suppliers with a global production share of about 16%. Chemical sector accounts[2] for 18% of total output of manufacturing sector. It contributes 14-15% of total exports and 8-9% of the total imports in the country. The chemical sector provides employment to about 20 lakh people. The diverse segments of Indian chemical sector produce[3] more than 80,000 products. The chemical industries in MSME sector may be grouped into dyes and pigments, API and pharma intermediates, pesticides, and specialty & other chemicals. A large number of chemical products are directly used in glass, paper, textile, jute, plastic, leather industries, etc. Chemicals such as detergents, pesticides, paints, cosmetics, perfumes, etc. are widely used in domestic sector. Gujarat is the largest producers of chemicals in India with a share of 51% of chemicals production and 35% of pharmaceuticals production.

Growth drivers

The chemical industry witnessed a production growth[4] of 23.62% during 2021-22 compared to 2020-21. During the same period, the growth of dyes & pigments was 51.07% and of pesticides & insects 23.62% in comparison with other segments in the sector. The demand for chemical products in India is expected to grow at 9% during 2020-25. The major drivers of growth of Indian chemical sector are directly linked with higher domestic demands from industrial end-use sectors such as textile, buildings, leather, automobile, etc. Further, the growth in middle class population and increasing urbanisation would create more demands for personal care, agro chemicals, food, paints and coatings resulting in higher per capita consumption of chemicals. The other growth drivers of Indian chemical sector include emerging manufacturing hubs, growth of end-user industries, foreign investment, abundant resources (raw materials, low cost of labourer, human skills, etc.). Modern agriculture practices would require higher consumption of chemicals like insecticides, fungicides, pesticides, etc.

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[2] https://www.ibef.org/

[3] Indian Brand Equity Foundation

[4] Indian Chemical News

Geographical coverage

The chemical industries exist generally in locations wherein the availability of basic raw materials, infrastructure, energy and manpower are available at competitive prices. The chemical industries are located mostly as clusters. A major share of chemical industries is found in the state of Gujarat. The important chemical clusters in Gujarat include Ahmedabad, Ankleshwar, Nandaseri, Valsad and Vapi (Figure 1). Among these, the Ahmedabad chemical cluster is the largest hub for chemical industries producing dyes & pigments, inorganics, organics, pesticides etc.

Figure 1: Location of chemical clusters

Other important chemical clusters in India are Ernakulum (Kerala), Ghaziabad (Uttar Pradesh), Jamshedpur (Jharkhand), Karnal (Haryana) and Thane (Maharashtra) as shown in figure 2. Among these, the Ahmedabad chemical cluster is the largest hub for chemical industries producing dyes & pigments, inorganics, organics, pesticides etc.

Sector level stakeholders

The institutional framework in chemical industries comprises industry associations, research and development (R&D) institutes and governmental bodies. The major institutions providing services to chemical industries in MSME sector are provided below.

Industry associations

The industry associations and apex bodies in the chemical sector are available at the national level and/or cluster level. The associations are actively involved in awareness generation on energy efficiency through newsletter and dissemination programmers and also involved in redressal of grievances, infrastructural development, and operational issues. The national level industry associations in chemical sector include (1) Chemical Industries Association (2) Dyestuffs Manufacturers Association of India, (3) Federation of Pesticides Manufacturers Association (SSI), (4), Indian Chemical Council, (5) Indian Chemical Manufacturers Association (6) Indian Specialty Chemical Manufacturers Association, (7) Indian Small Scale Paint Association (8) Pesticides Manufacturers & Formulators Association of India. The prominent cluster level industry associations in chemical sector are provided in table 1.

Table 1: Industry associations in chemical sector

Cluster	Name of industry association	Contact details
Ahmedabad	Vatva Industries Association	Centre of Excellence Building, Plot No. 511, Phase-IV, GIDC Estate, Vatva, Ahmedabad – 382 445, Gujarat Email: info@vatvaassociation.org Website: www.vatvaassociation.org Contact person: Mr Ankit S Patel (President)
	Naroda Industries Association	184-A/1, GIDC Estate Phase-1, Sheth Shantilal Kapasia Hall, Naroda GIDC, Ahmedabad –

Cluster	Name of industry association	Contact details
		382330 Website: http://narodaassociation.org Contact person: Mr Ajay S Patel (Secretary)
	Gujarat Dyestuffs Manufacturers Association	KARMA, 8th floor, Opp. Mahalaxmi Muni. Market, Paldi, Ahmedabad - 380 007, Gujarat Email: info@gdma.org Website: http://www.gdma.org/ Contact person: Mr Yodesh D Parikh (President)
Ankleshwar	Ankleshwar Industry Association	618/619, GIDC Industrial estate Ankleshwar – 393002, Dist. Baruch, Gujarat Phone: 02646 222 000
	Panoli Industry Association	L-913/10, Panoli, GIDC, Dist. Bharuch, Gujarat Tel : (02646) 272275
Ernakulam	Indian Small Scale Paint Association (Kerala region)	47, Maradu, Kochi – 682304, Kerala Phone: 098470 45223
Ghaziabad	Industrial Area Manufacturers Association	E-43, Site-1, Loha Mandi, Bulandshahr Road Industrial Area, Ghaziabad, Uttar Pradesh 201009 Phone: 0120 416 9203
Jamshedpur	Jharkhand Small Industries Association	Udyog Bhavan, Industrial Area, Kokar, Ranchi – 834001 Email: jsiaranchi2009@gmail.com Contact person: Mr Philip Mathew (President)
	Adityapur Small Industries Association	M-5, 7th, Phase Asia Bhavan Adityapur Industrial Area, Tata Kandra Road Jamshedpur-831001 Contact Person: Shri S.N. Thakur (President), Mr Santosh Khetan (Vice President) Contact no: 9234603805, 9334817741
	Singhbhum Chamber of Commerce & Industry (Jamshedpur)	Chamber Bhawan, Bistupur, Jamshedpur- 831001 Jharkhand Email: scci1950@gmail.com Contact person: Shri Ashok Bhalotia (President), Nitesh Dhoot (Vice President) Contact no: 9431111981, 9431117719
Karnal	Haryana Chamber of Commerce & Industries	HSSIDC, Karnal Website: www.hcci.in Contact person: Mr R.L Sharma
	Karnal Paint and Chemicals Association	Plot No 252, HSIIDC, Sector-3, Karnal Email: kpmakarnal@gmail.com Contact person: Mr Kamaljeet Khanna
Nandesari	Nandaseri Industries Association (Vadodara)	Plot C37Q & X4W, Nandesari Vadodara-391340, Gujarat Phone: 0265 284 0390
Thane	Thane Small Scale Industries Association	TSSIA House, Plot No. P-26, Road No. 16/T Wagle Industrial Estate Thane (W)- 400604, Maharashtra Email: tssia.thane@gmail.com

Cluster	Name of industry association	Contact details
		Website: www. tssia.org Contact person: Ms Sujata Soparkar- Vice President
	Chamber of Small Industry Association	TSSIA House Plot No. P-26, Road No. 16/T, Wagle Industrial Estate Thane (W)- 400604, Maharashtra E-mail: cosia.cosia@gmail.com Website: www.cosia.org.in Contact person: Mr Ninad Jaywant – Hon. Gen. Secretary
	Indian Small Scale Paint Association	104, Shubham Centre No.1B, Cardinal Gracias Road Chakala, Andheri (E) Mumbai - 400 099 Email: office@isspa.org Website: http://www.isspa.org
Vapi	Vapi Industrial Association	Plot No. 135, VIA House, GIDC, Vapi – 369195, Gujarat Email Id: info@viavapi.org Phone No.: (0260) 2430950, (0260) 2431950
Valsad	Valsad Industries Association	C1B-918, 2nd Phase G.I.D.C Gundlav-396035, Gujarat Phone: 073838 36666
	Sarigam Industry Association	Shed No. C1/614, GIDC Sarigam-396155, Gujarat

Research and development institutions

The important R&D institutions in chemical sector are (1) National Chemical Laboratory (NCL) and (2) National Institute of Pharmaceutical Education and Research (NIPER). NCL is one of the establishments under Council of Scientific and Industrial Research (CSIR). It undertakes science and knowledge based research, development and consulting. NCL forges research partnership with industry to develop need based solution. NIPER is a national level institute in pharmaceutical sciences. It undertakes collaboration with industries to meet the global challenges.

Government bodies

The government bodies associated with chemical industries include MSME-Development institutes, state designated agencies (SDAs) on behalf of Bureau of energy efficiency (SDA-BEE), district industries centre (DIC), National small industries corporation (NSIC), state and central pollution control boards and Gujarat gas limited.

Table 2: Government bodies in chemical sector

Name of organisation	Key roles
Micro, Small & Medium Enterprises Development Institute (MSME-DI)	Development of Micro, Small & Medium Enterprises sector through counselling, consultancy, training, different awareness programme, market promoting programme among MSMEs
District Industries Centre (DIC)	MSME-DIs field offices of the Ministry of Micro, Small & Medium Enterprises provide a wide range of extension/ support services to the MSMEs in their respective state of operation.

Name of organisation	Key roles
State Designated Agency (SDA)	It is the state designated agency (SDA) for Bureau of Energy Efficiency (BEE). The key roles of SDA include development of renewable policy, sustainable energy programmes, and promote energy efficient technologies.

Key challenges in chemical sector

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 3.

Table 3: 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 • Reluctance of entrepreneurs on technology upgradation • 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 • Poor disbursement of loans on EE projects by banks • 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 quality, productivity and energy performance • Investment by individual units on development of skilled manpower • Lack of in-house innovation on EE projects • Less exposure on new and EE equipment leading to inefficient operation
Policies	Non-existence/ availability of sector-specific programmes	• Limited technology upgradation by MSMEs
Infrastructure & others	Non-availability of cleaner fuels at cluster level.	• Inefficient use of energy hence high impact on environment

Energy Consumption and Benchmarks

This section provides energy benchmarking of chemical industries at cluster and sectoral level. An assessment of energy performance i.e. specific energy consumption (SEC) across different chemical clusters in India was undertaken using primary and secondary data collected through energy audits and interactions with stakeholders. The SEC levels of chemical industry vary widely and depend on product, technology, raw material, scale of operation, operating practices, etc.

Energy benchmarking of chemical industries

The products manufactured in chemical industries in MSME sector fall broadly under the following categories namely (1) dyes and pigments, (2) API and pharma intermediates, and (3) other chemicals. A cluster-wise analysis of production, energy consumption, energy benchmark and GHG emissions are provided below.

Jamshedpur chemical cluster (Jharkhand)

The products, production profile, energy consumption profile, specific energy consumption and GHG emissions from Jamshedpur chemical cluster are summarized below.

Products and production profile

The Jamshedpur chemical cluster comprises 80 MSME units of which about 72 are in operation. The cluster produces specialty and other chemicals such as bleaching powder, sodium hypo-chloride, deep galvanizing flux & rubber oil, natural rubber, reclaimed rubber, battery acid, liquid paints, thinner & varnish, dry & liquid alum, cement paint powder, etc. The total production of the cluster is estimated to be 99,950 tonne per year.

Energy consumption profile

The chemical industries in Jamshedpur cluster use mainly electricity in production processes. A few units in the cluster use coal and biomass for process heating requirements. HSD is used for backup power generation. The total energy consumption of the cluster is estimated to be 1,056 tonne of oil equivalent (toe). Thermal energy accounts for 87% and electrical energy 13% of total energy consumption (Figure 2). Biomass accounts for about 76% of total energy consumption in the cluster, while the share of coal is about 11% (Figure 3). The total GHG emissions of the cluster are estimated to be 1,588 tonne CO_2 per year. About 65% of GHG emissions are attributed to grid electricity (Figure 4).

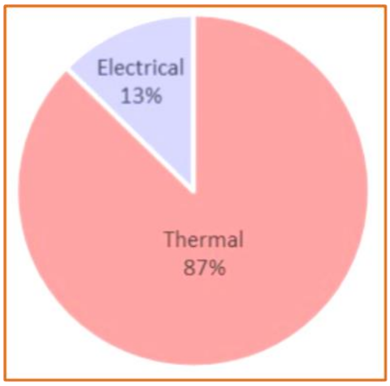

Figure 2: Thermal vs electrical

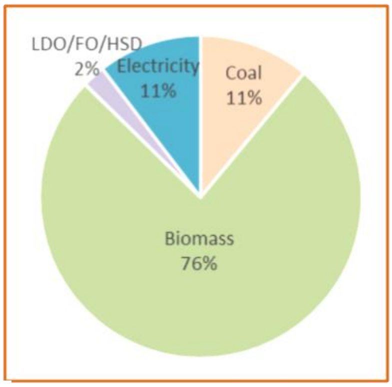

Figure 3: Energy share

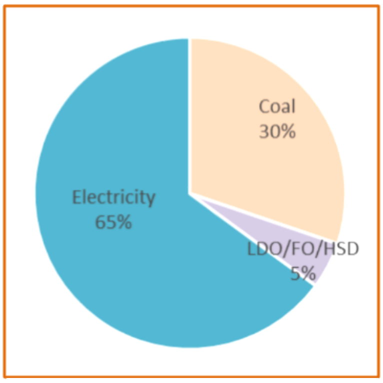

Figure 4: Emission share

The cluster level energy consumption and GHG emissions of the cluster are shown in table 4.

Table 4: Energy consumption and GHG emissions in Jamshedpur chemical cluster

Energy type (Unit)	Energy consumption	Equivalent toe	GHG emissions (t-CO_2)
Coal (tonne per year)	259	117	471
Biomass (tonne per year)	2,160	805	-
LDO/FO/HSD (kL per year)	28	24	76
Electricity (million kWh)	1.3	110	1,012
Total		1,056	1,558

Specific energy consumption

The average specific energy consumption (SEC) of Jamshedpur chemical cluster is estimated to be 0.44 GJ per tonne. (~0.011 toe per tonne).

Thane chemical cluster (Maharashtra)

The products, production profile, energy consumption profile, specific energy consumption (SEC) and GHG emissions from Thane chemical cluster are summarized below.

Products and production profile

The Thane chemical cluster comprises 325 MSME units of which about 293 are in operation. The cluster produces specialty and other chemicals such as bulk drugs, solvent distillation, resin, anti-oxidant, additive chemicals, cosmetics chemicals, etc. The total production of the cluster is estimated to be 532,198 tonne per year.

Energy consumption profile

The chemical industries in Thane cluster use LDO, NG and biomass 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 36,590 toe. Thermal energy accounts for 73% and electrical energy 27% of total energy consumption (Figure 5). Biomass accounts for about 34% of total energy consumption in the cluster, while the share of grid electricity is about 23% (Figure 6). The total GHG emissions of the cluster are estimated to be 118,365 tonne of CO2 per year. About 65% of GHG emissions are attributed to grid electricity (Figure 7). The cluster level energy consumption and GHG emissions are shown in table 5.

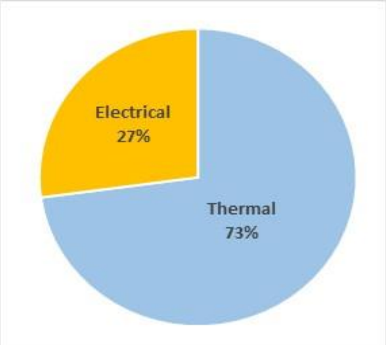

Figure 5: Thermal vs electrical

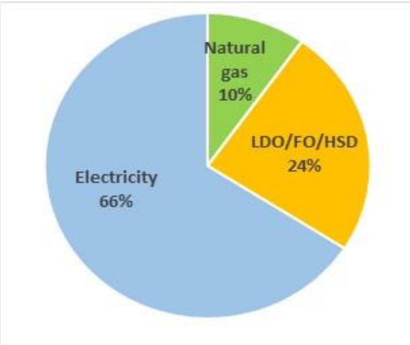

Figure 6: Energy share

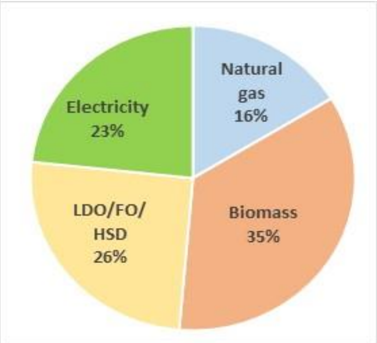

Figure 7: Emission share

Table 5: Energy consumption and GHG emissions of Thane chemical cluster

Energy type (Unit)	Energy consumption	Equivalent toe	GHG emissions (t-CO_2)
Natural gas (million SCM per year)	8	7,012	13,813
Biomass (tonne per year)	33,048	12,314	0
LDO/FO/HSD (kL per year)	10,081	8,889	27,622
Electricity (million kWh)	97.4	8,375	76,931
Total		36,590	118,365

Specific energy consumption

The average specific energy consumption (SEC) of dye & pigments is estimated to be 10 GJ per tonne (~0.24 toe per tonne), API/pharma is estimated to be 2 GJ per tonne (~0.05 toe per tonne) and of other chemicals is 3.21 GJ per tonne (0.08 toe per tonne) in Thane chemical cluster (Figure 8).

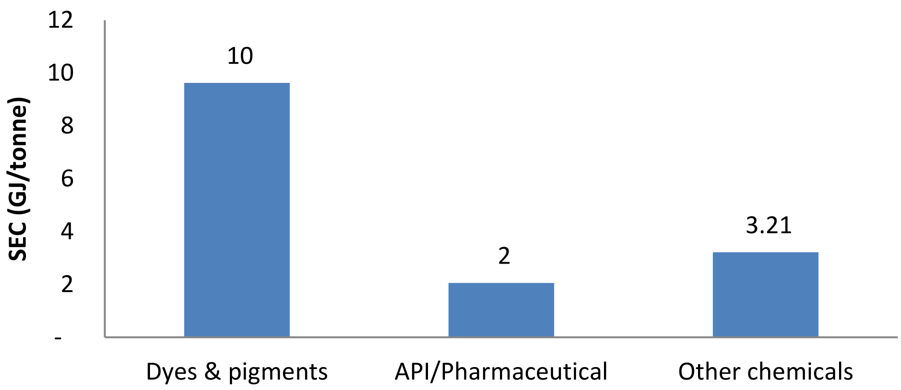

Figure 8: SEC levels of Thane chemical cluster

Karnal chemical cluster (Haryana)

The products, production profile, energy consumption profile, specific energy consumption (SEC) and GHG emissions from Karnal chemical cluster are summarized below.

Products and production profile

The Karnal chemical cluster comprises 107 MSME units of which about 91 are in operation. The cluster produces API/pharma intermediates and specialty & other chemicals such as tablet, capsule, syrup, ayurvedic medicine, surfactants, soaps, detergents, sanitizers, intermediate paints, resins. The total production of the cluster is estimated to be 104,528 tonne per year.

Energy consumption profile

The chemical industries in Karnal cluster uses LDO and coal 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 4,947 toe. Thermal energy accounts for 82% and electrical energy 18% of total energy consumption (Figure 9). Coal accounts for about 64% of total energy consumption followed by LDO (21%) in the cluster (Figure 10). The total GHG emissions of the cluster is estimated to be 22,832 tonne CO_2 per year. The cluster level energy consumption and GHG emissions are shown in table 6. About 56% of GHG emissions are attributed to use of coal (Figure 11).

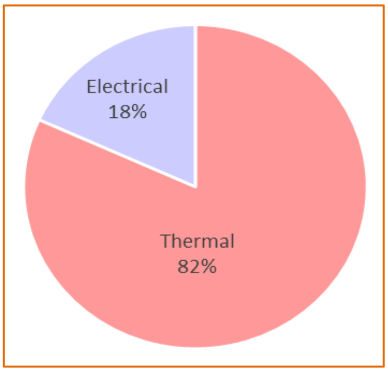

Figure 9: Thermal vs electrical

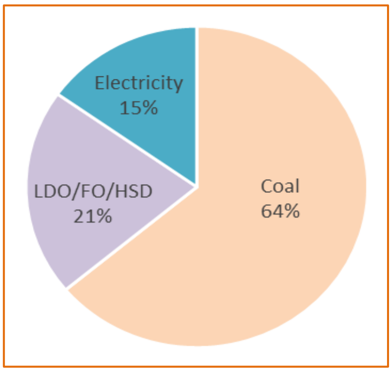

Figure 10: Energy share

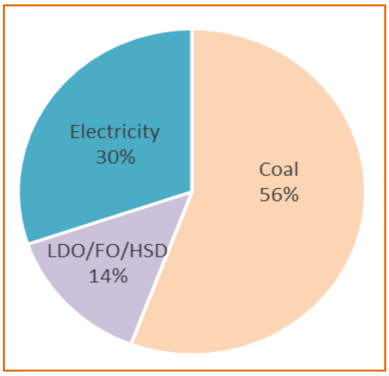

Figure 11: Emission share

Table 6: Energy consumption and GHG emissions of Karnal chemical cluster

Energy type (Unit)	Energy consumption	Equivalent toe	GHG emissions ($t\text{-}CO_2$)
Coal (tonne per year)	7,007	3,163	12,724
LDO/FO/HSD (kL per year)	1,054	1,033	3,209
Electricity (million kWh)	8.7	751	6,899
Total		4,947	22,832

Specific energy consumption

The average specific energy consumption of API/pharma industries is estimated to be 1.1 GJ per tonne (~0.03 toe per tonne) and of other chemicals is 2.1 GJ per tonne (0.05 toe per tonne) in Karnal chemical cluster (Figure 12).

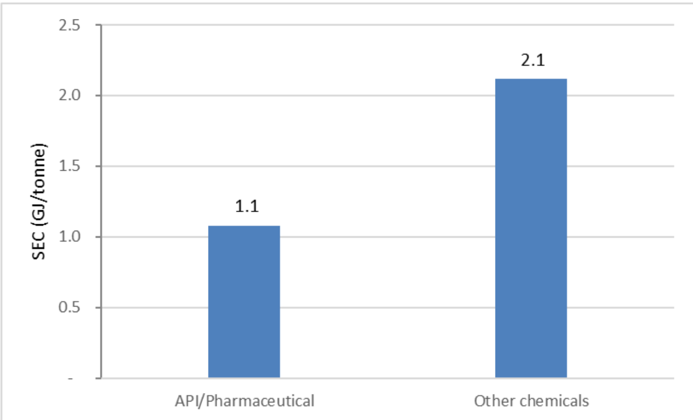

Figure 12: SEC levels of Karnal chemical cluster

Ahmedabad (Vatva, Naroda and Odhav) chemical cluster (Gujarat)

The products, production profile, energy consumption profile, specific energy consumption (SEC) and GHG emissions from Ahmedabad chemical cluster are summarized below.

Products and production profile

There are about 750 chemical industries in Ahmedabad cluster. The cluster comprises three broad areas namely Vatva (600 units), Naroda (100 units) and Odhav (50 units). About 585 units were estimated to be in operation. The cluster produces dyes & intermediates, reactive dyes, acid dyes, cotton dyes, pigments, etc. The total production of the cluster is estimated to be 956,520 tonne per year.

Energy consumption profile

A majority of the industries in the cluster uses natural gas (NG) to meet energy requirements in the process along with grid electricity. A few units also use coal for the process; and HSD is used for backup power generation. The total energy consumption of the cluster is estimated to be 144,624 toe. Thermal energy accounts for 82% and electrical energy 18% of total energy consumption (figure 13). Natural gas accounts for about 73% of total energy consumption followed by electricity (18%) in the cluster (figure 14). The total GHG emissions of the cluster is estimated to be 485,159 tonne CO_2 per year. The cluster level energy consumption and GHG emissions are shown in table 7. About 50% of GHG emissions are attributed to use of electricity followed by natural gas (43%) as shown in figure 15.

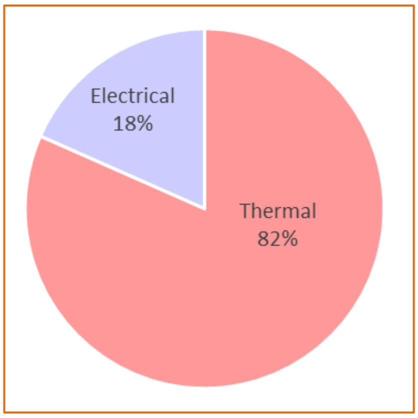

Figure 13: Thermal vs electrical

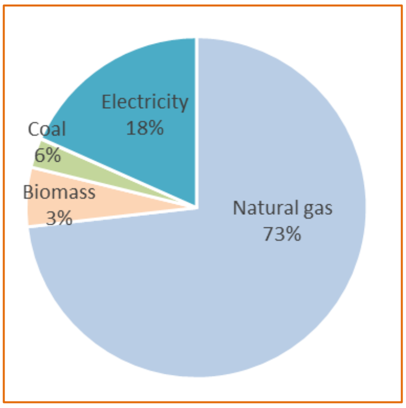

Figure 14: Energy share

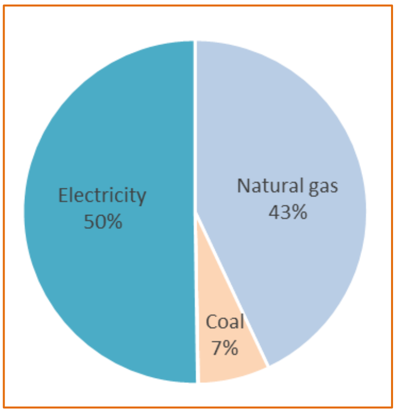

Figure 15: Emission share

Table 7: Energy consumption and GHG emissions of Ahmedabad chemical cluster

Energy type (Unit)	Energy consumption	Equivalent toe	GHG emissions (t-CO_2)
Natural gas (million SCM per year)	121	105,872	208,540
Coal (tonne per year)	18,000	8,125	32,688
Biomass (tonne per year)	10,800	4,024	-
Electricity (million kWh)	308	26,529	243,701
Total		144,624	485,159

Specific energy consumption

The average specific energy consumption of API/pharma industries is estimated to be 6.41 GJ per tonne (~0.15 toe per tonne) and of other chemicals is 1.9 GJ per tonne (0.05 toe per tonne) in Ahmedabad chemical cluster (figure 16).

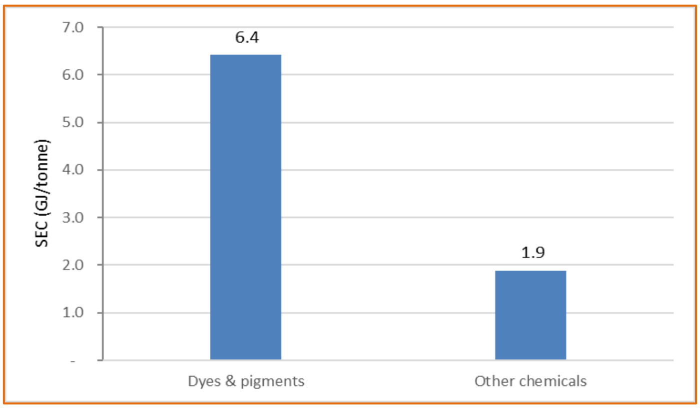

Figure 16: SEC levels of Ahmedabad chemical cluster

Vapi chemical cluster (Gujarat)

The products, production profile, energy consumption profile, specific energy consumption (SEC) and GHG emissions from Vapi chemical cluster are summarized below.

Products and production profile

There are about 308 chemical industries in Vapi cluster. About 277 units were estimated to be in operation. The cluster produces fine chemicals and intermediates for APIs, chemicals like aluminium phosphide, zinc phosphide, tanning agents, plastic additives, etc. The total production of the cluster is estimated to be 703,636 tonne per year.

Energy consumption profile

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 100,127 toe. Thermal energy accounts for 81% and electrical energy 19% of total energy consumption (figure 17). Natural gas accounts for about 73% of total energy consumption followed by electricity (18%) in the cluster (figure 18). The total GHG emissions of the cluster is estimated to be 327,164 tonne CO_2 per year. The cluster level energy consumption and GHG emissions are shown in table 8. Both electricity and NG share the GHG emissions equally (figure 19).

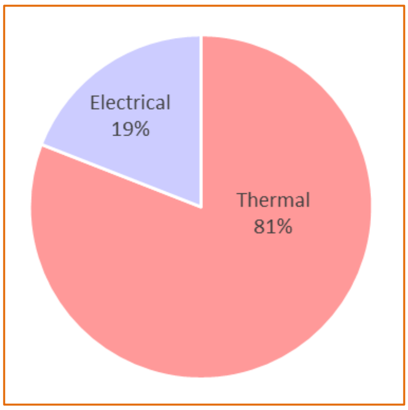

Figure 17: Thermal vs electrical

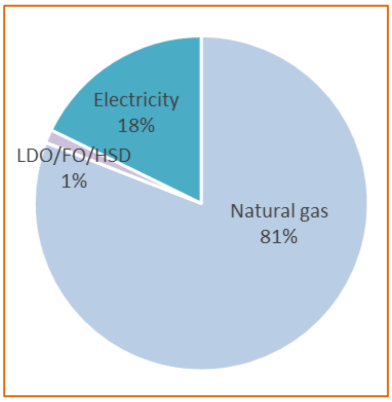

Figure 18: Energy share

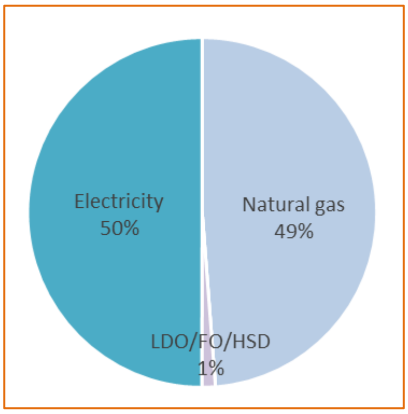

Figure 19: Emission share

Table 8: Energy consumption and GHG emissions of Vapi chemical cluster

Energy type (Unit)	Energy consumption	Equivalent toe	GHG emissions (t-CO_2)
Natural gas (million SCM per year)	93	81,032	159,611
LDO/FO/HSD (kL per year)	1,486	1,299	4,073
Electricity (million kWh)	207	17,797	163,480
Total		100,127	327,164

Specific energy consumption

The average specific energy consumption (SEC) of dye & pigments is estimated to be 6.6 GJ per tonne (0.16 toe per tonne), pesticides is estimated to be 5.1 GJ per tonne (0.12 toe per tonne), API/pharma is estimated to be 15.2 GJ per tonne (0.36 toe per tonne) and of other chemicals is 4.3 GJ per tonne (0.1 toe per tonne) in Vapi chemical cluster (figure 20).

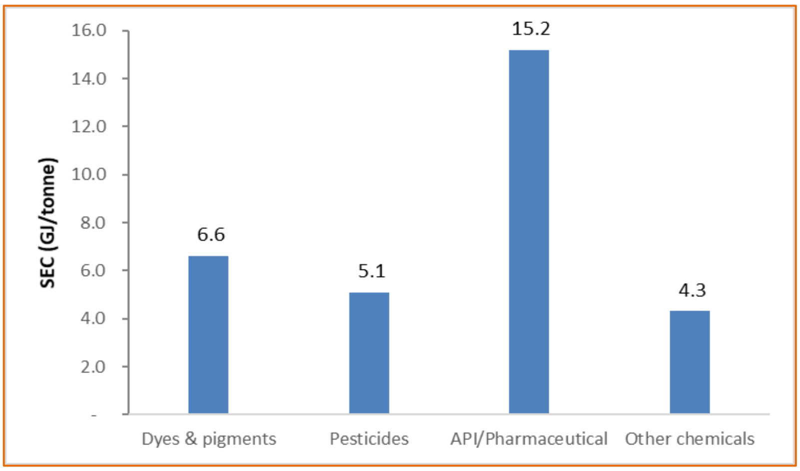

Figure 20: SEC levels of Vapi chemical cluster

Ankleshwar chemical cluster (Gujarat)

The products, production profile, energy consumption profile, specific energy consumption (SEC) and GHG emissions from Ankleshwar chemical cluster are summarized below.

Products and production profile

There are about 750 chemical industries in Ankleshwar cluster. About 600 units were estimated to be in operation. The cluster manufactures various types of chemicals, like dyes, pigments, insecticides, specialty chemicals, pharmaceuticals, and paints, etc. The total production of the cluster is estimated to be 315,512 tonne per year.

Energy consumption profile

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 26,637 toe. Thermal energy accounts for 56% and electrical energy 44% of total energy consumption (Figure 21). Natural gas accounts for about 56% of total energy consumption followed by electricity (43%) in the cluster (Figure 22). The total GHG emissions of the cluster is estimated to be 135,491 tonne CO_2 per year. The cluster level energy consumption and GHG emissions are shown in table 9. About 78% of GHG emissions are attributed to use of electricity followed by natural gas at 22% (figure 23).

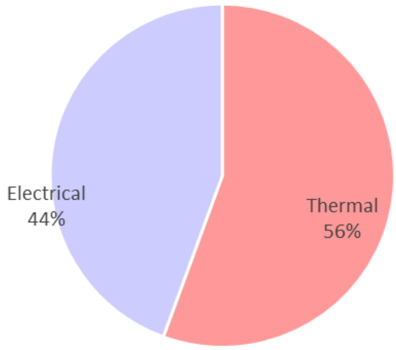

Figure 21: Thermal vs electrical

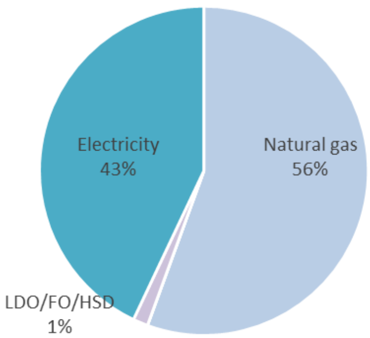

Figure 22: Energy share

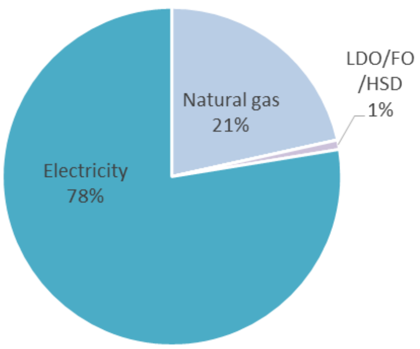

Figure 23: Emission share

Table 9: Energy consumption and GHG emissions of Ankleshwar chemical cluster

Energy type (Unit)	Energy consumption	Equivalent toe	GHG emissions (t-CO_2)
Natural gas (million SCM per year)	16.9	14,805	29,162
LDO/FO/HSD (kL per year)	447	391	1,225
Electricity (million kWh)	133	11,442	105,105
Total		26,637	135,491

Specific energy consumption

The average specific energy consumption (SEC) of dye & pigments is estimated to be 6 GJ per tonne (0.13 toe per tonne), pesticides production is estimated to be 3 GJ per tonne (0.07 toe per tonne), API/pharma production is estimated to be 16 GJ per tonne (0.37 toe per tonne) and of other chemicals is 1.27 GJ per tonne (0.03 toe per tonne) in Ankleshwar chemical cluster (Figure 24).

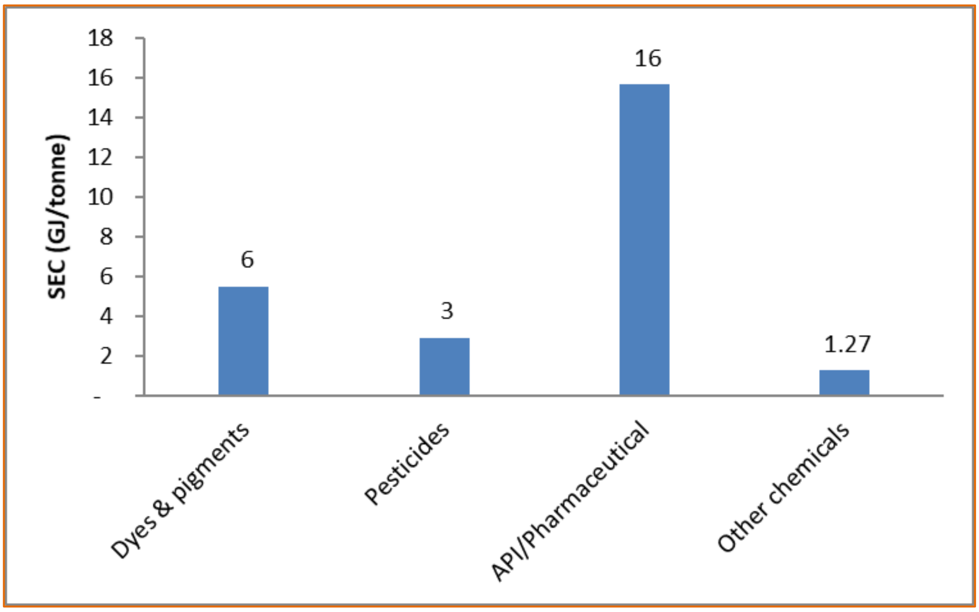

Figure 24: SEC levels of Ankleshwar chemical cluster

Valsad chemical cluster (Gujarat)

The products, production profile, energy consumption profile, specific energy consumption (SEC) and GHG emissions from Valsad chemical cluster are summarized below.

Products and production profile

There are about 42 chemical industries in Valsad cluster in operation. The cluster manufactures various types of chemicals, like dyes, pigments, pharma intermediates, and other chemicals. The total production of the cluster is estimated to be 62,410 tonne per year.

Energy consumption profile

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 6,644 toe. Thermal energy accounts for 72% and electrical energy 28% of total energy consumption (Figure 25). Natural gas accounts for about 72% of total energy consumption followed by electricity (28%) in the cluster (Figure 26). The total GHG emissions of the cluster is estimated to be 26,384 tonne CO2 per year. The cluster level energy consumption and GHG emissions are shown in table 10. About 64% of GHG emissions are attributed to use of electricity followed by natural gas at 36% (figure 27).

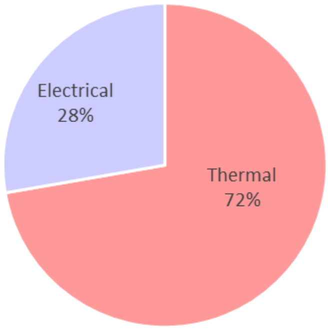

Figure 25: Thermal vs electrical

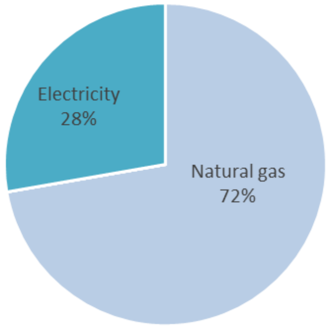

Figure 26: Energy share

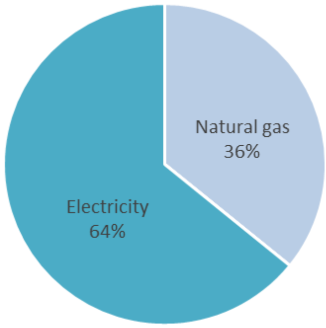

Figure 27: Emission share

Table 10: Energy consumption and GHG emissions of Valsad chemical cluster

Energy type (Unit)	Energy consumption	Equivalent toe	GHG emissions (t-CO2)
Natural gas (million SCM per year)	5	4,802	9,459
Electricity (million kWh)	21.4	1,842	16,925
Total		6,644	26,384

Specific energy consumption

The average specific energy consumption (SEC) of dye & pigments is estimated to be 6 GJ per tonne (0.14 toe per tonne), pesticides production is estimated to be 4 GJ per tonne (0.09 toe per tonne), API/pharma production is estimated to be 15 GJ per tonne (0.36 toe per tonne) and of other chemicals is 3.4 GJ per tonne (0.08 toe per tonne) in Valsad chemical cluster (Figure 28)

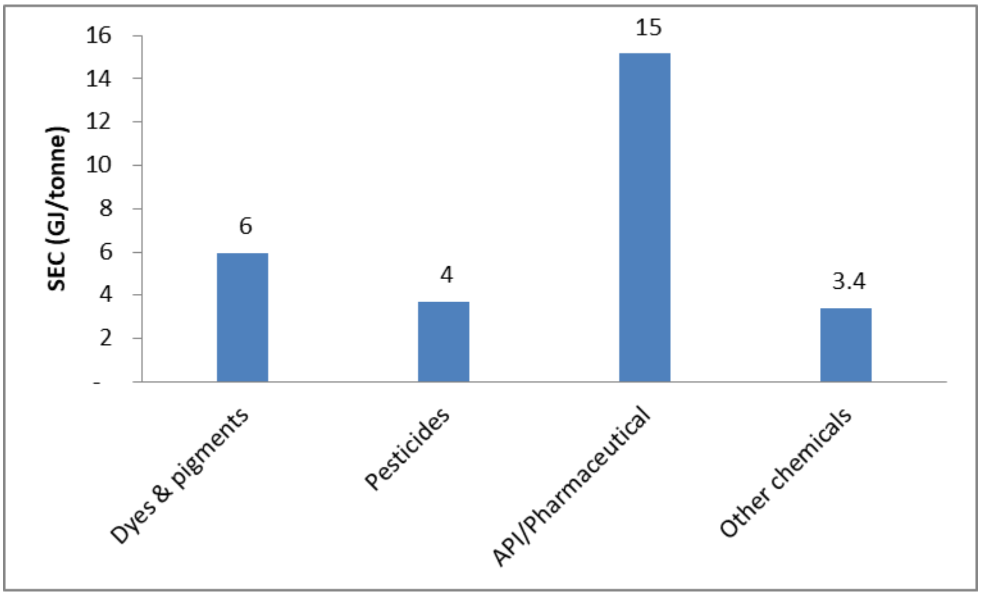

Figure 28: SEC levels of Valsad chemical cluster

Ernakulam chemical cluster (Kerala)

The products, production profile, energy consumption profile, specific energy consumption (SEC) and GHG emissions from Ernakulam chemical cluster are summarized below.

Products and production profile

There are about 100 paint manufacturing industries in Kerala of which 40 units are located in Ernakulam cluster. About 60 paint industries are small scale units and the balance 40 units are of micro scale category. The total production of the cluster is estimated to be 89,640 tonne per year.

Energy consumption profile

The cluster uses mainly electricity for process and utilities. About 10-20% of units use LDO for process heating. With stable electricity supply from grid, the units do not require backup support for power generation. The total energy consumption of the cluster is estimated to be 967 toe and the equivalent GHG emissions are of 6,283 tonne CO_2 per year. The cluster level energy consumption and GHG emissions are shown in table 11. Electricity accounts for about 56% of total GHG emissions in the cluster.

Table 11: Energy consumption and GHG emissions of Ernakulam chemical cluster

Energy type (Unit)	Energy consumption	Equivalent toe	GHG emissions (t-CO_2)
LDO/FO/HSD (kL per year)	484	427	1,326
Electricity (million kWh)	6.3	540	4,957
Total		967	6,283

Specific energy consumption

The average specific energy consumption (SEC) of other chemicals (paint) industries in the cluster is estimated to be 0.45 GJ per tonne.

Sectoral energy consumption

The total production of chemical industries in MSME sector considering major products such as dyes & pigments, pesticides, API/pharma and other chemicals is estimated to be 4.7 million tonne per year. The total energy consumption of chemical sector is estimated to be 493,277 toe and the corresponding GHG emissions are 1.83 million tonne are shown in table 12. Thermal energy accounts for about 78% of total energy consumption whereas the share of electricity is about 22% (Figure 29). Thermal energy and electricity account for almost equal share of GHG emissions (Figure 30).

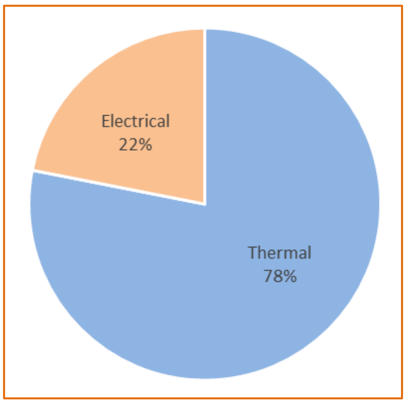

Figure 29: Sectoral energy consumption

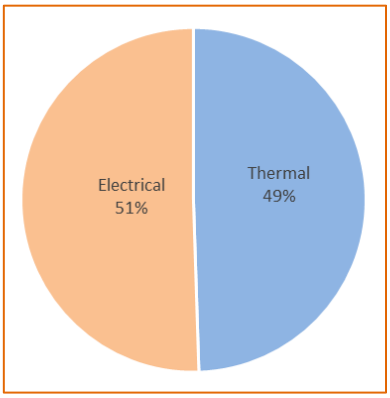

Figure 30: Sectoral GHG emissions

Table 12: Sectoral energy consumption and GHG emissions of chemical industry

Category	Energy consumption (toe)			GHG emissions (t-CO_2)
	Thermal	Electrical	Total	
Dyes & pigments	210,935	48,254	259,188	860,603
Pesticides	9,028	19,762	28,791	198,486
API/Pharma intermediates	41,828	42,153	83,982	455,956
Other chemicals	107,722	13,594	121,316	313,065
Total	369,513	123,764	493,277	18,28,110

Dyes and pigments industry is the largest consumer of energy among chemical sector (~52%). The share of energy consumption of API/pharma intermediates industries is about 17% (Figure 31 & 32).

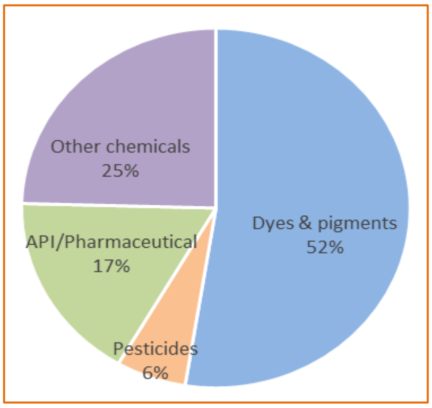

Figure 31: Break-up of sectoral energy consumption

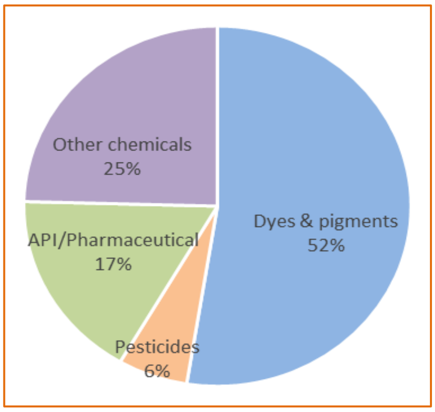

Figure 32: Break-up sectoral GHG emissions

The specific energy consumption of dyes & pigments across different clusters varies in the range of 5.4 GJ per tonne to 6.6 GJ per tonne (Figure 33). In case of pesticides, the SEC level in different clusters was 2.9 GJ per tonne to 3.7 GJ per tonne (Figure 34).

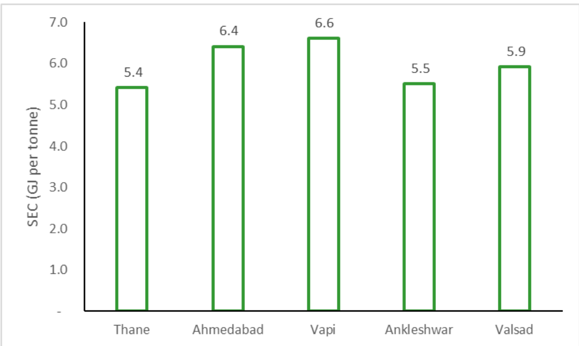

Figure 33: SEC of dyes & chemicals clusters

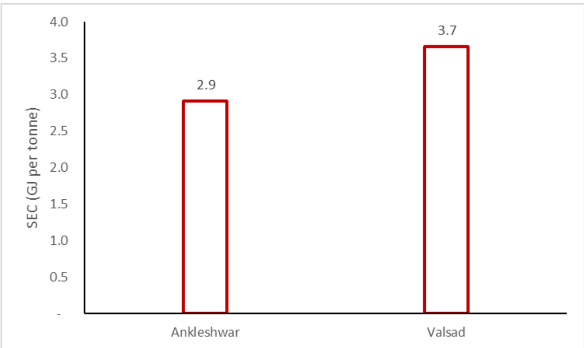

Figure 34: SEC of pesticides clusters

The variation in SEC level in pharma industries was found to vary widely from 1.1 GJ per tonne to 15.6 GJ per tonne, which may be attributed to product chemistry (Figure 35). The product categories under 'others' include a wide range of products, resulting in significant variations SEC levels from 0.4 GJ per tonne to 4.3 GJ per tonne, which may be attributed to product chemistry (Figure 36).

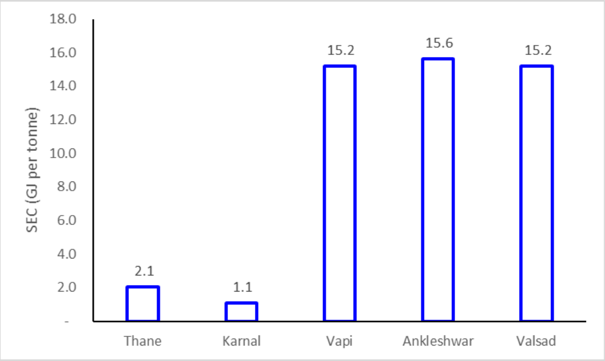

Figure 35: SEC of API/pharma clusters

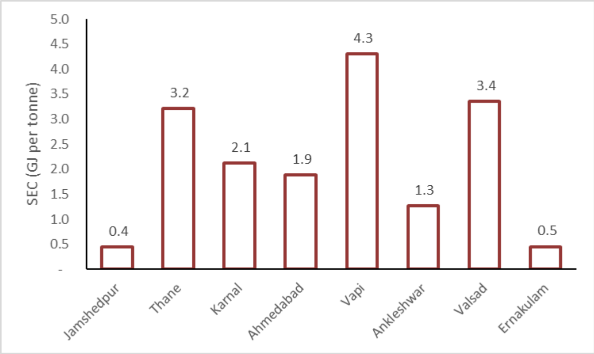

Figure 36: SEC of other chemical clusters

The average specific energy consumption (SEC) of dyes & pigments is estimated to be 6.4 GJ per tonne (0.14 toe per tonne), followed by API/pharma of 4.5 GJ per tonne (0.36 toe per tonne). The SECs of pesticides industries across the cluster is 3 GJ per tonne (0.09 toe per tonne), and of other chemicals is 2.8 GJ per tonne (0.08 toe per tonne) as shown in Figure 37.

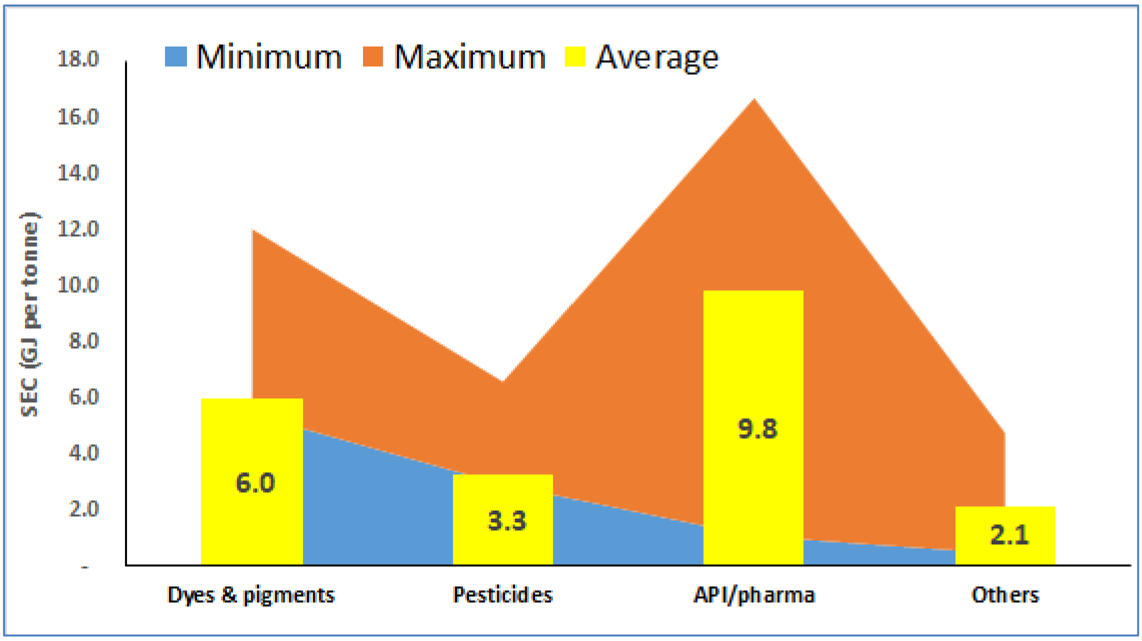

Figure 37: SEC levels of chemical sector

The present SEC levels can be improved by adopting best operating practices in different chemical industries (table 13).

Table 13: Target values and best operating practices in chemical industries

Parameter	Present value	Target value	Best operating practices
Boiler - wood based (Efficiency)	60%	70%	• Maintain proper air-fuel ratio • Maintain flue gas temperature around 250 °C • Ensure appropriate insulation to maintain surface temperature not more than 20 °C above ambient. • Optimise condensate recover for reuse in boiler • Preheat feed water using economiser
Boiler - natural gas based (Efficiency)	79%	85%	• Maintain proper air-fuel ratio • Maintain flue gas temperature around 250 °C • Ensure appropriate insulation to maintain surface temperature not more than 20 °C above ambient • Optimise condensate recover for reuse in boiler • Preheat feed water using economiser
Thermic fluid heater (oil/ NG fired)	70-74%	87%	• Install on-line automation system to maintain thermic fluid temperature (supply and return) as well as air-fuel ratio • Maintain flue gas temperature around 250 °C
Air compressor - Reciprocating (kW/cfm)	0.240	0.185	• Set air pressure based on end-use requirements • Plug air leakages • Use seamless airline network
Motors	85-88%	92%	• Avoid rewinding of motors • Ensure correct size of motors • Use of IE3 motors

SEC comparison with international benchmarks

The chemical clusters produce a wide range of products under different categories like dyes & pigments, API & pharma, pesticides and other chemicals. A comparison of SEC level for the wide range of products at international level is not readily available.

Energy efficiency potential in chemical sector

The Indian chemical industries in the MSME sector play an important role in catering to the customized product requirements of various end-users. Gujarat is the major state having chemical clusters manufacturing petrochemicals, agro-chemicals, dyes and pigments, APIs and pharma intermediates, etc. The cluster of chemical industries in other states primarily produces other chemicals such as paints, soaps, detergents, and assorted liquid chemicals for various applications apart from limited API and pharma intermediates. Thermal energy is predominant in chemical manufacturing in which fuel consumed for heating application in the process steps using steam from boilers, heated oil from thermic fluid heater and hot air from hot air generator, etc. accounts for about 75-80% and electrical energy is about 20-25% of total energy consumption.

An analysis of various categories of chemical industries in the MSME sector indicates several energy efficiency, technology upgradation and resource saving options can be adopted. The energy saving potential of dyes and pigments manufacturing segments is estimated to be about 13,220 toe per year. Table 14 shows major energy efficiency and technology upgradation options along with potential impacts in dyes and pigments industries.

Table 14: Summary of EE options and potential impacts in dyes and pigments industries

Energy and resource efficiency option	Energy saving potential	Replication potential	Replication potential in short-term (2024-25)	Replication potential in long-term (2030-31)	Energy saving (toe/ yr)	Monetary benefits (Rs lakh/yr)	Investments (Rs lakh)	Payback period (year)	GHG emissions (t CO2/yr)
Optimisation of steam generation and distribution system	15%	65%	Medium	High	4,113	283	229	0.8	843
Performance improvement of thermic fluid heater	10%	50%	Low	High	2,109	203	282	1.4	602
Replacement of tray dryer with fluidized bed dryer	15%	50%	Medium	High	3,797	11,816	7,835	0.7	38,531
Fuel switch over in thermic fluid from LDO to NG	10%	50%	Low	High	37	83	16	0.2	66
Technology upgradation: Electrification of thermic fluid heater	15%	50%	Low	Medium	3,164	4,499	6,738	1.5	4,191
Total					13,220	16,884	15,099		44,233

The overall energy saving potential in API/pharma intermediates industries is about 2,870 toe per year. Table 15 shows major energy efficiency and technology upgradation options along with potential impacts in API/pharma intermediates industries.

Table 15: Summary of EE options and potential impacts in API/pharma intermediates industries

Energy and resource efficiency option	Energy saving potential	Replication potential	Replication potential in short-term (2024-25)	Replication potential in long-term (2030-31)	Energy saving (toe/ yr)	Monetary benefits (Rs lakh/yr)	Investments (Rs lakh)	Payback period (year)	GHG emissions (t CO_2/yr)
Optimisation of steam generation and distribution system	15%	65%	Medium	High	816	1,885	1,122	0.6	3,597
Performance improvement of thermic fluid heater	10%	50%	Medium	High	418	1,230	712	0.6	3,097
Replacement of tray dryer with	15%	50%	Medium	High	753	5,409	3,586	0.7	17,638

Energy and resource efficiency option	Energy saving potential	Replication potential	Replication potential in short-term (2024-25)	Replication potential in long-term (2030-31)	Energy saving (toe/ yr)	Monetary benefits (Rs lakh/yr)	Investments (Rs lakh)	Payback period (year)	GHG emissions (t CO_2/yr)
fluidized bed dryer									
Fuel switch over in thermic fluid from LDO to NG	10%	50%	Medium	High	256	1,304	247	0.2	1,038
Technology upgradation: Electrification of thermic fluid heater	15%	50%	Low	Medium	627	2,059	3,084	1.5	1,919
Total					2,870	11,888	8,752		27,290

The overall energy saving potential in other chemicals including pesticides industries is about 6,024 toe per year. Table 16 shows major energy efficiency and technology upgradation options along with potential impacts in other chemicals including pesticides industries.

Table 16: Summary of EE options and potential impacts in other chemical industries

Energy and resource efficiency option	Energy saving potential	Replication potential	Replication potential in short-term (2024-25)	Replication potential in long-term (2030-31)	Energy saving (toe/ yr)	Monetary benefits (Rs lakh/yr)	Investments (Rs lakh)	Payback period (year)	GHG emissions (t CO2/yr)
Optimisation of steam generation and distribution system	15%	65%	Low	Medium	1,707	860	611	0.7	2,444
Performance improvement of thermic fluid heater	10%	50%	Low	Medium	876	488	421	0.9	2,064
Replacement of tray dryer with fluidized bed dryer	15%	50%	Low	Medium	1,839	11,767	7,802	0.7	38,369
Fuel switch over in thermic fluid from LDO to NG	10%	50%	Low	Medium	289	2,036	386	0.2	1,620
Technology upgradation: Electrification of thermic fluid heater	15%	50%	Low	Low	1,313	5,973	8,946	1.5	5,565
Total					6,024	21,124	18,166		50,063

The major cross-cutting options in chemical sector include (i) replacement of inefficient motors with energy efficient IE3 motors and (ii) installation of roof-top solar. The total energy saving is estimated to be 8,861 toe with an estimated GHG reduction potential of 81,385 tonne CO2 as shown in table 17.

Table 17: Summary of impacts of cross-cutting technologies

Energy and resource efficiency option	Energy saving potential	Replication potential in short-term (2024-25)	Replication potential in long-term (2030-31)	Energy saving (toe/ yr)	Monetary benefits (Rs lakh/yr)	Investments (Rs lakh)	Payback period (year)	GHG emissions (t CO2/yr)
Replacement of standard motors with IE3 motors	7%	Low	Medium	4,852	4,230	9,668	2.3	44,555
Installing roof-top solar	-	Medium	High	4,009	3,497	15,540	4.4	36,830
Total				8,861	7,726	25,208		81,385

Implementation of various energy efficiency and technology upgradation options including cross-cutting technologies in chemical sector will lead to an energy saving of 30,975 toe per year equivalent to a GHG reduction of 202,970 tonne CO_2 per year (table 18).

Table 18: Summary of EE options and potential impacts in other chemical industries

Energy and resource efficiency option	Energy saving (toe/yr)	Monetary benefits (Rs lakh/yr)	Investments (Rs lakh)	Payback period (year)	GHG emissions (t CO_2/yr)
Optimisation of steam generation and distribution system	6,636	3,028	1,962	0.6	6,883
Performance improvement of thermic fluid heater	3,403	1,921	1,415	0.7	5,763
Replacement of tray dryer with fluidized bed dryer	6,389	28,992	19,223	0.7	94,539
Fuel switch over in thermic fluid from LDO to NG	582	3,423	649	0.2	2,724
Technology upgradation: Electrification of thermic fluid heater	5,104	12,531	18,768	1.5	11,675
Cross-cutting technologies	8,861	7,726	25,208	3.3	81,385
Total	30,975	57,621	67,226	1.2	202,970

The energy saving potential in chemical sector ranges from 5.2% to 6.9% in different chemical segments as shown in figure 38.

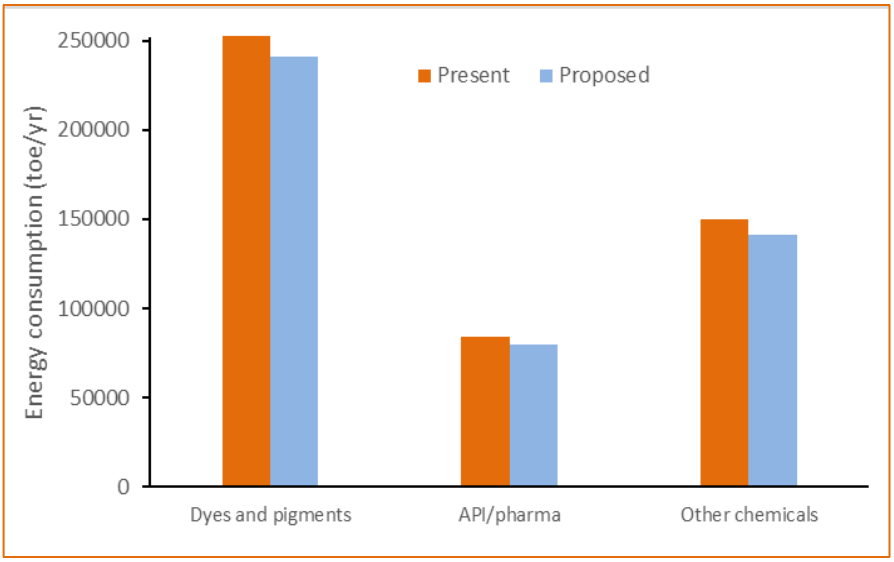

Figure 38: Energy saving potential in chemical sector

The total investment requirement for implementing energy efficiency and technology upgradation options including technologies is Rs 67,226 lakh with a simple payback of less than 1.2 years. The GHG reduction potential in the chemical sector is 202,970 tonne CO_2 per year. The share of energy saving, investments and GHG emission reduction in chemical industries in MSME sector are shown in figure 39.

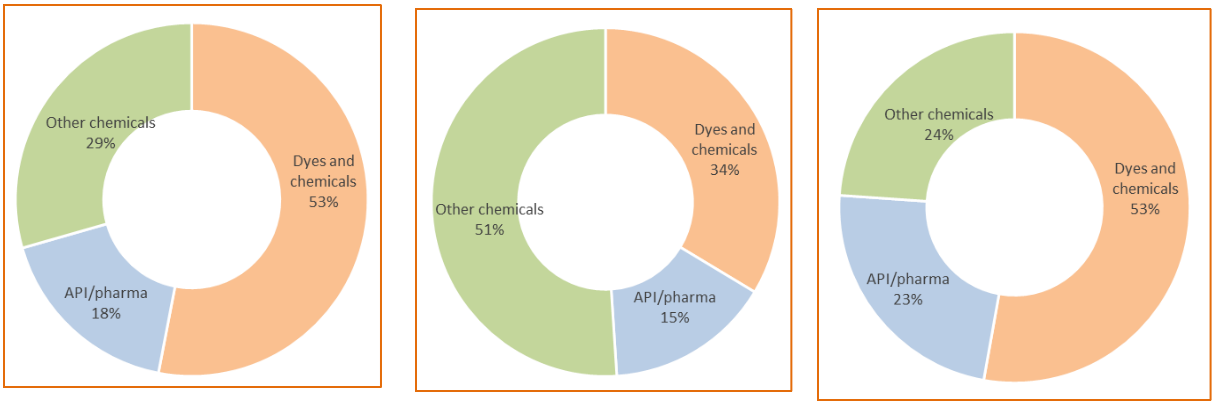

Figure 39: Share of energy, investments and GHG reduction in chemical sector

Impact analysis

The potential impacts on energy consumption and GHG emissions with adoption of energy efficiency and technology upgradation options in chemical industries in MSME sector are given below.

Dyes and pigments industries

The total energy saving potential in dyes and pigments industries by 2030-31 is estimated to be 42,319 toe assuming a CAGR of 9% in the sector. The corresponding GHG reduction potential is 140,514 tonne CO_2 per year. The potential impact of adoption of energy efficiency and technology upgradation options in dyes and pigments industries is shown in figure 40.

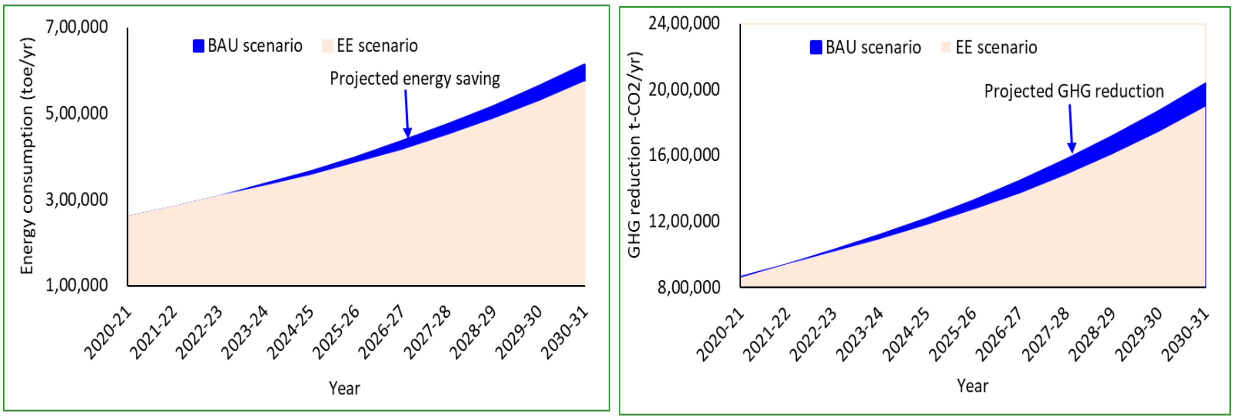

Figure 40: Energy saving and GHG reduction potential in dyes and pigments industry

API/pharma intermediates industries

The total energy saving potential in API/pharma intermediates industries by 2030-31 is estimated to be 10,366 toe assuming a CAGR of 9% in the sector. The corresponding GHG reduction potential is 56,278 tonne CO_2 per year. The potential impact of adoption of energy efficiency and technology upgradation options in API/pharma intermediates industries is shown in figure 41.

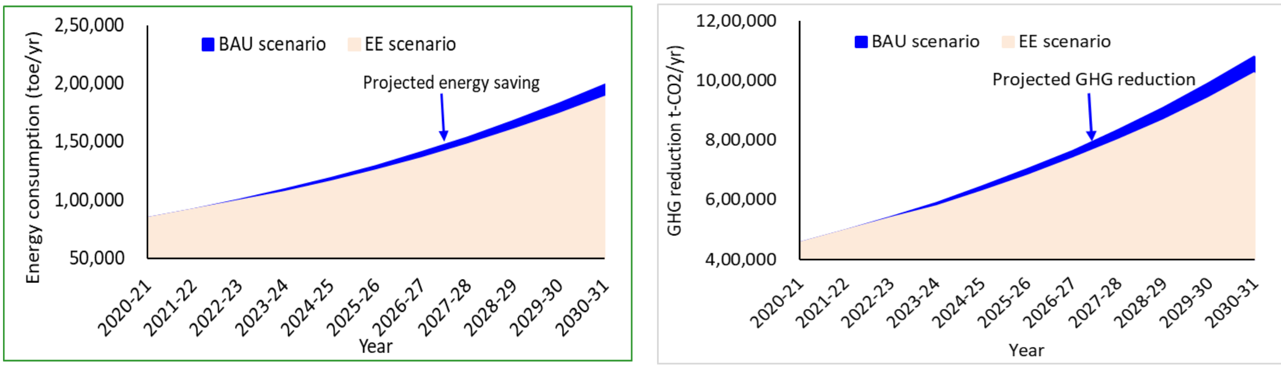

Figure 41: Energy saving and GHG reduction potential in API/pharmaceutical industry

Other chemical industries

The total energy saving potential in other chemical industries including pesticides by 2030-31 is estimated to be 20,644 toe assuming a CAGR of 9% in the sector. The corresponding GHG reduction potential is 70,354 tonne CO_2 per year. The potential impact of adoption of energy efficiency and technology upgradation options in other chemical industries is shown in figure 42.

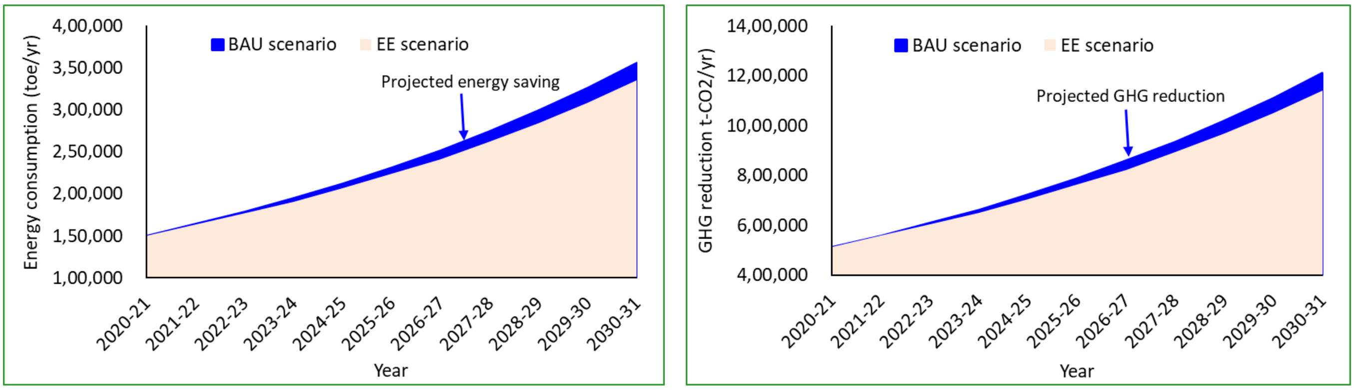

Figure 42: Energy saving and GHG reduction potential in other chemical industry

Sector level impacts

The total energy saving potential of chemical sector by 2030-31 is estimated to be 73,329 toe assuming a CAGR of 9% in the sector. The corresponding GHG reduction potential is 271,760 tonne CO_2 per year. The potential impact of adoption of energy efficiency and technology upgradation options in chemical sector is shown in figure 43.

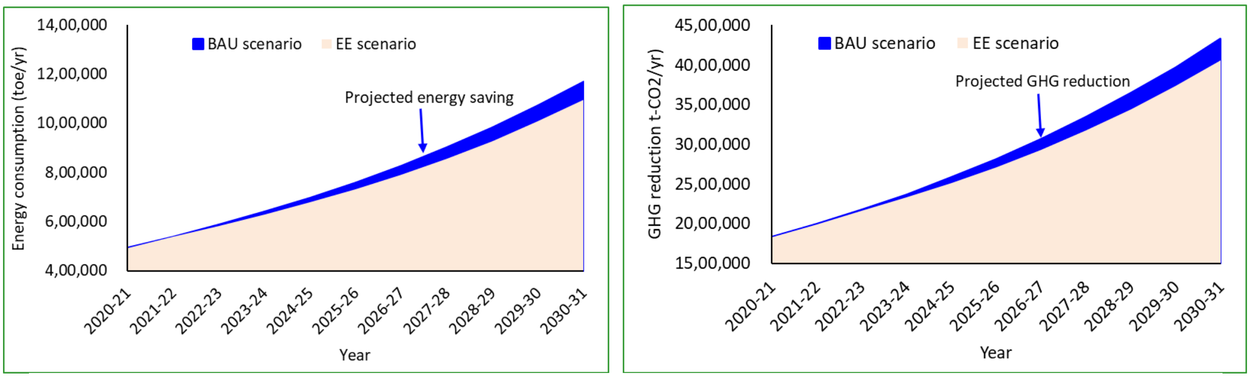

Figure 43: Energy saving and GHG reduction potential in chemical sector

It is evident from the sectoral analysis that there exists a significant energy saving and GHG reduction potential through adoption of energy efficiency measures and technology upgradation options in chemical sector.

Recommendations and Implementation Plan

Chemical manufacturing industry sector is one of the high energy consuming industry sub-sectors among Indian MSME sectors. The sector has shown sustained growth with increasing demands in various end-use sectors. A large share of chemical industries in different categories such as dyes & pigments, API/pharma intermediates and other chemicals continue to use inefficient technologies resulting in higher specific energy consumption.

An analysis of energy consumption of chemical industries show that there is a significant scope for enhancing efficiency levels as well as conserving resources in the chemical manufacturing industries in the MSME sector. In addition, skill development is also one of the vital measures towards sustainability of the sector. However, the challenges in terms of technology, financing, policies and infrastructure, etc. have slowed down their progress of modernization and energy performance improvements in chemical sector. The barriers in the chemical sector may be addressed through appropriate strategies along with suitable implementation plan along with way forward for the chemical sector. These recommendations are proposed with an aim towards improving the overall energy performance and competitiveness of the chemical sector.

Roadmap for energy efficiency improvements

The proposed strategies are collated into (i) cluster level strategies and (ii) policy level strategies outlining the specific interventions. The implementation plan provides the linkage between different organizations and agencies to be involved along with their roles (Figure 44).

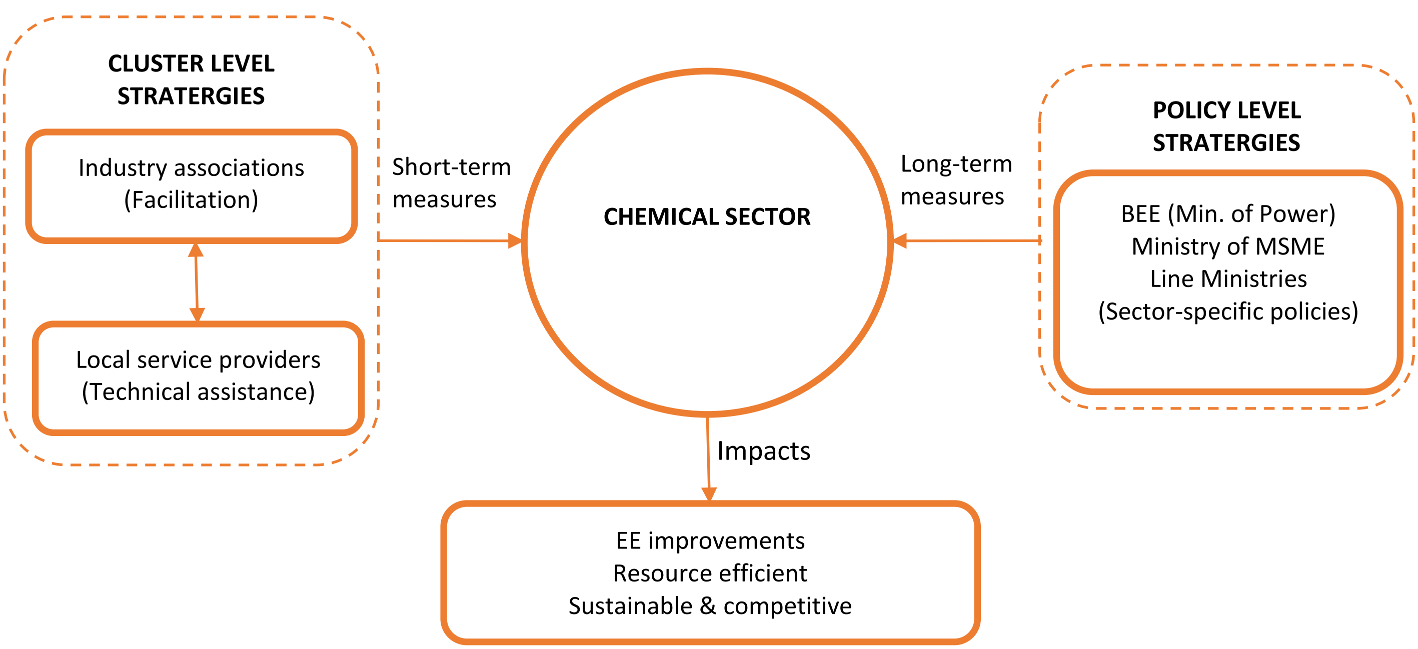

Figure 44: Proposed implementation plan

Cluster level strategies

There are several low cost technology-specific energy efficiency measures and technology upgradation options that have already been successfully demonstrated. The implementation of these options largely does not require facilitation through specific government policies but can be implemented directly at cluster level by local industry associations and/or apex bodies.

The sectoral analysis also indicates the need for improvement in the efficiency level of basic utilities and equipment such as pumps, electric motors, air compressors, insulation, etc. envisaging low investment and periodic replacement. The cluster-specific interventions can be promoted by 'cluster level energy management cell (EMC)' established and operated through key stakeholders such as industry associations, development institutes, special purpose vehicle for cluster development programmes (SPV-CDP), etc. The EMC will facilitate adoption of energy and resource conservation measures requiring minimum knowledge support of subject-matter experts and lower financial implications. The board scope of services of cluster level energy management cell (EMC) is depicted in Figure 45. The details of the recommended EMC covering financial assistant needed, functional aspect, main implementing agencies and time frame are provided in table 19.

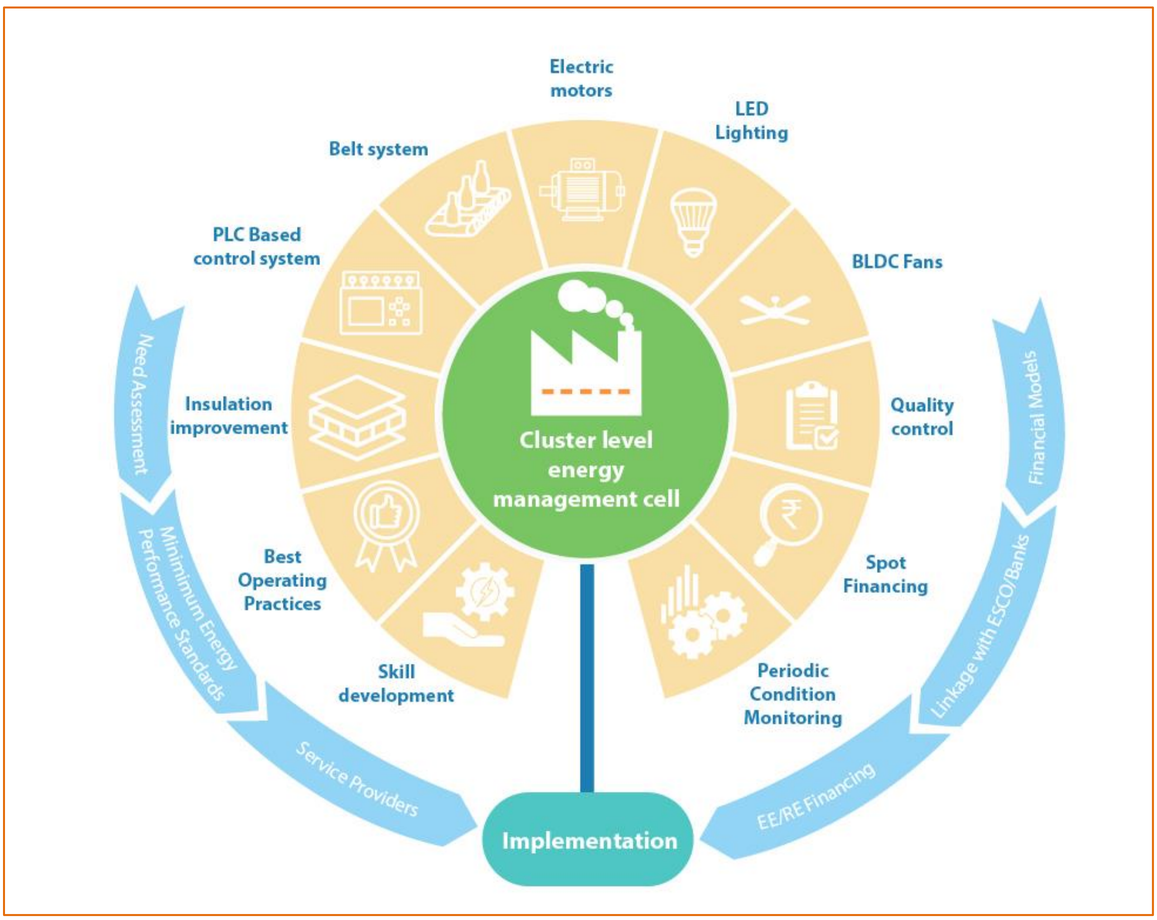

Figure 45: Roles of energy management centre

Table 19: Scopes of cluster level energy management cell

Recommendation/ interventions	Financial assistance	Objective	Key suggestions	Implementing agencies	Timeframe
Establishment of Energy Management Cell	Development of infrastructure: Rs. 25 lakh (max) per MSME cluster Total Budget: Rs. 3 crore	Facilitating the adoption of EE technologies/ equipment (self-sustainable model) to ensure minimum EE levels at competitive prices	1. Development of financial models for self-sustainable operation 2. Establishment of linkage with technology / equipment OEMs 3. Setting up minimum efficiency and quality levels for equipment/ system and spare parts. 4. Rate contract under bulk procurement model 5. Inventory management for spare parts 6. Establishment of linkages with banks/FIs for single-window financing	1. Bureau of Energy Efficiency and SDAs 1.1 Supporting establishment and coordination with cluster level "Energy Management Cell" 2. Industry associations/ apex bodies 2.1 Coordination and facilitation of programme 2.2 Periodic need assessment, review and customization 3 Ministry of Micro Small and medium enterprises 3.1 Development of basic infrastructure for local bodies 4. Energy Efficiency Services Limited (EESL) 4.1 Linkage with existing national level programme 5. SIDBI, FIs and banks 5.1 Single window financing	1. Identification and development of local bodies: 1st year 2. Development of energy management cell: 2nd year 2.1 Rate contract with OEMs: 2nd year onwards 2.2 Awareness & outreach: 2nd year onwards

Policy level strategies

The energy and resource efficient manufacturing sector not only requires change in the technology use, but also needs strengthening of infrastructure such as fuel supply network, skilled workforce and financing mechanism. Sustainable development of chemical sector using low carbon path demands mass production and high productivity. Thus, availability of cost-competitive raw materials, product testing facilities at doorsteps and product development & promotion also need strong policy level support.

The key stakeholders for implementing the policy level strategies include government agencies, infrastructure development agencies, development institutions, and financial institutions / ESCOs (Figure 46). The major policy level strategies include are (1) technology upgradation fund, and (2) common facility centres (CFCs) (Table 20).

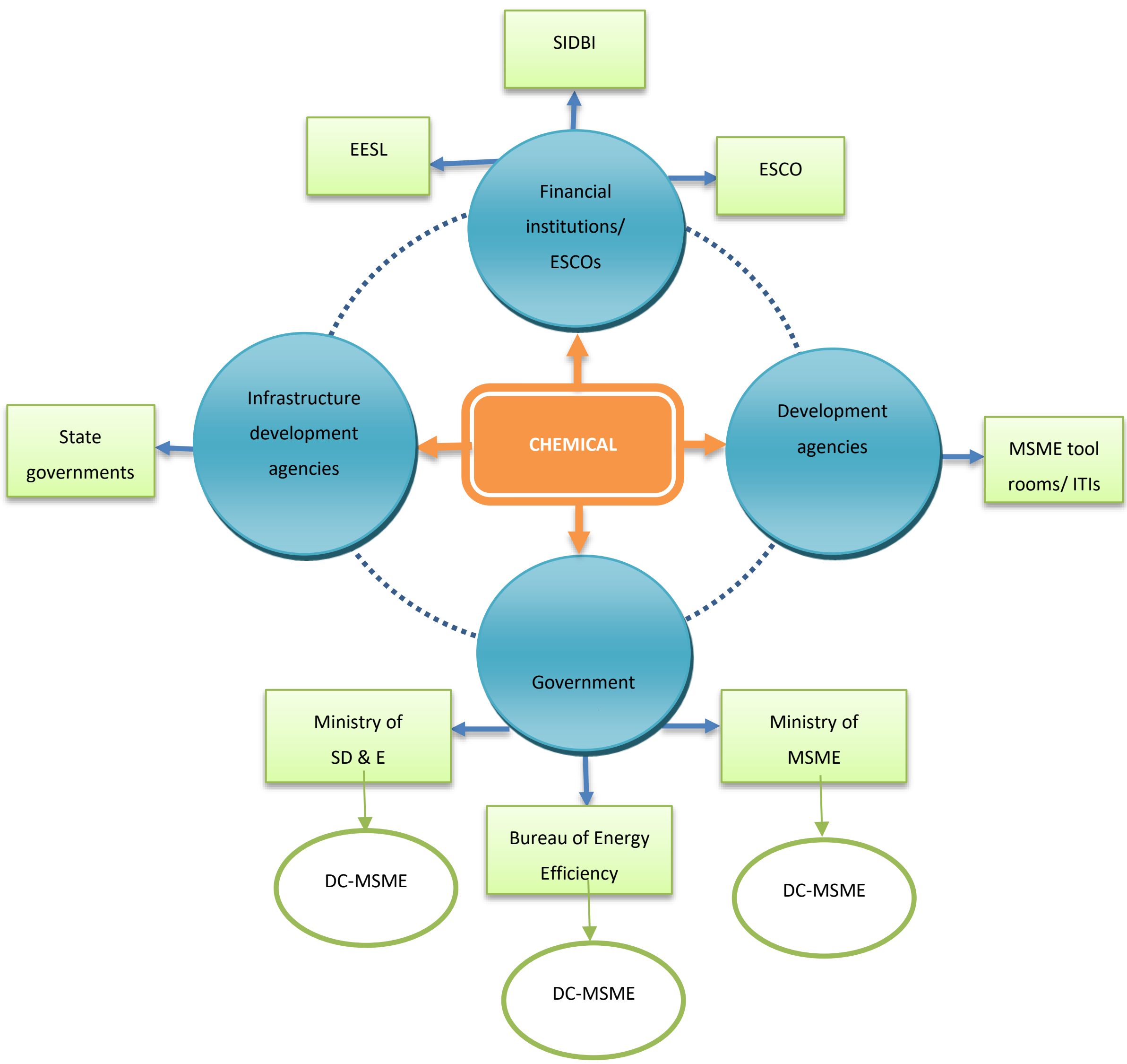

Figure 46: Key stakeholders for policy implementation

Table 20: Details of policy level strategies

Recommendation / interventions	Financial assistance	Objective	Key suggestions	Implementing agencies	Timeframe
Technology upgradation fund for chemical sector	1. Technology upgradation • Capital subsidy for energy efficiency and tech-up projects (@ 25% upfront subsidy): Rs 50 Crore	Enabling MSMEs to adopt energy efficient technologies in manufacturing processes	1 Energy efficient technologies in steam generation system 2 Energy efficient technologies in dryer system 3 Energy efficient technologies in cross-cutting technologies and utilities	1 Bureau of Energy Efficiency and SDAs 1.1 Facilitate preparation of technology specific DPRs 1.2 Technology adoption through PPP / ESCO mode 1.3 Develop/ strengthen technology providers and local service providers (LSPs) at cluster level 1.4 Create awareness among industries 2 Ministry of MSME/ DC-MSME/MSME- DI 2.1 Implementation of schemes in MSMEs 3 SIDBI/FIs/Banks 3.1 Provide financial assistance for technology adoption 3.2 Linkage with partial risk guarantee fund	1 Technology upgradation 1.1 Launch of scheme: 1st year 1.2 Implementation: 2nd – 5th year 1.3 Monitoring and verification (M&V)/ reassessment: 4th year 1.4 Amendment & relaunch: 6th year onward
Skill development centres	Establishment of skill development centres at cluster level • Needs assessment and preparation of detailed project reports (DPRs) • Establishment and operation of skill development centres/ facilities in the major clusters	Building capacities and strengthening skillsets of operators and supervisors	1 Skillset development and dissemination of best operating practices (BOP) through cluster level experts 2 Awareness generation through hands-on work exposure and training	1 Ministry of MSME/ DC-MSME/MSME- DI 1.1 Establishment of cluster level skill development centres 2 Ministry of Skill Development & Entrepreneurship 2.1 Skill certification programme focusing industry-relevant skill development courses	1 Skill development 1.1 Needs assessment study and DPR preparation: 1st - 2nd year 1.2 Establishment of centres: 2nd -3rd year 1.3 Imparting skill development programme: 3rd year onward

Recommendation / interventions	Financial assistance	Objective	Key suggestions	Implementing agencies	Timeframe
	Total budget: Rs 45 crore • Infrastructure: Rs 40 crore • Training support: Rs 5 crore				
Common facility centres	To be estimated[5] (Estimated cost for feasibility studies and DPRs: Rs 5 crore)	Extending support sustainability and growth of chemical industries in MSME sector by addressing common issues like high end technology, market access, financing, etc.	1 Address common issues such as availability of quality raw materials, access to manufacturing process, technology, etc. 2 Build capacities through formation of special purpose vehicle (SPV) 3 Providing easy access to standard testing and infrastructure facilities 4 Strengthening the existing infrastructure facilities	1 Ministry of MSME/DC-MSME/ MSME-DI 2 State governments 3 Cluster level associations	1. Pre-feasibility study & DPR preparation: 1st - 2nd year 2. Development of CFCs: 2nd – 3rd year 3. Operation of CFCs: 3rd - 4th year onward

[5] Detailed project reports for each cluster are required for total budget estimates

Way forward

The energy efficiency and technology upgradation options are intended to reduce the energy intensity, improve competitiveness and enhance sustainability in the chemical sector. There is a need to initiate innovative cluster level strategies and introduce sector-specific policies aiming to address key barriers in a holistic manner. This approach would ensure sustained pace of growth and development of the chemical sector. This document provides collated strategies and implementation plans which are expected to provide both short-term and long-term solutions for the chemical sector.

It is vital to establish collaborative approach on a common platform involving relevant stakeholders such as Bureau of Energy Efficiency, Ministry of Micro, Small and Medium Enterprises, Ministry of Skill Development & Entrepreneurship, Ministry of Commerce and Industry, banks & financial institutions, cluster level industry associations, sector specific apex bodies, etc. In this context, industry associations can play a major role in undertaking collaborative approaches and implement cluster-specific programmes. Cluster level initiatives will not only help in minimizing the transaction costs but also mitigate the risk of investment.

The implementation plan includes both cluster level strategies and policy level strategies. The cluster level strategies require proactive involvement of industry associations and other cluster level stakeholders for facilitating implementation of short term measures with minimum support from government bodies. The execution of policy level strategies requires long-term involvement of relevant ministries to address mitigation of sectoral barriers through a collaborative approach. Both the strategies would complement each other in improving energy efficiency and enhancing competitiveness of chemical industries in the Indian MSMEs sector.

Annexure-A: Production process and technology use in 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 and/or cooling as needed. On completion of chemical reaction, intermediate products or mother liquor is passed through next step of operation to produce cake or paste, which is subsequently dried, pulverized, blended, etc. before packaging of final products completed. A few common product specific manufacturing process such as (1) dyes and pigments, (2) API and pharma intermediates and (3) other chemicals industries covering paints, soap, detergent, inorganic chemicals in the MSME sector are discussed in this section. The section also provides details of the common technologies and equipment used across diverse chemical industries in MSME sector.

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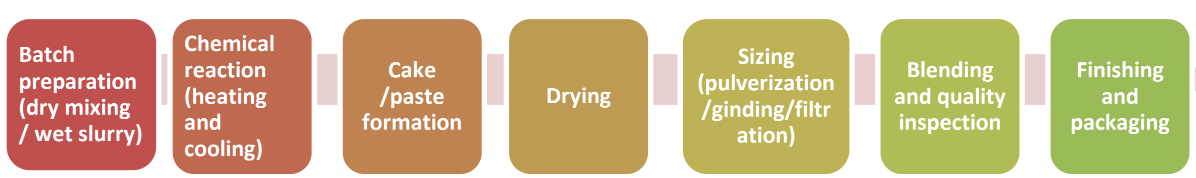
Production process for dyes and pigments

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



Process steps of chemicals manufacturing

Dissolving and 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. The overall batch cycle duration depends on the raw materials and desired output. The thermal energy requirement is met through a boiler or thermic fluid heater (TFH). The connected motors in the vessel are either belt or shaft driven using electrical energy.

Primary filtration

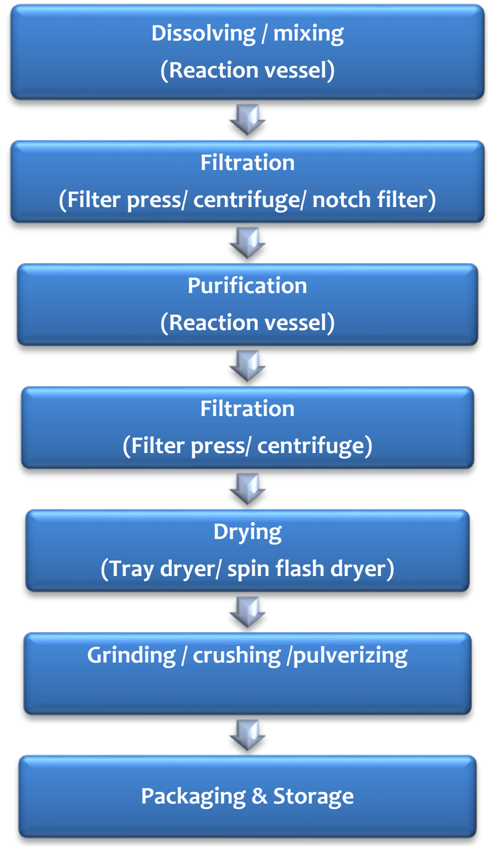
After mixing, the intermediate products i.e. liquid and/or suspended solid particles are separated from the slurry. The filtration is carried out using centrifuge or filter press.

Purification

Purification helps in improving or modifying the basic properties of the intermediate product as per the requirement of final product. For example, to neutralize 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 wet cake from secondary filtration process is transferred to following step for moisture reduction.



Dye and pigment process

Drying

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.

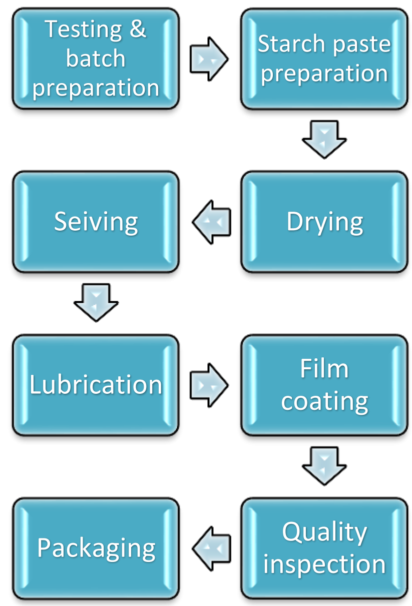
Pulverizing

The granules/ blocks of dried products are crushed in a pulverizer and further size reduction if needed is carried out in ball mill to produce desired particle size of the final product. The final product is checked for the quality and sent for packaging.

Production process for API/ pharmaceutical

The manufacturing process of the API/Pharmaceutical industries varies widely depending on the type of products. The generic process followed in API/Pharmaceutical production is discussed below.

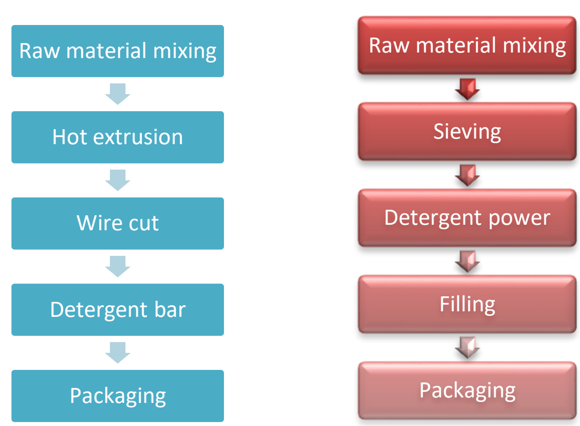
The raw materials for the tablets and capsules are procured in the form of chemical powders and/ or salts. These powders are tested and segregated in weighed proportions as per the desired composition of the tablets / capsules. This weighed mixture is then mixed to form a starch paste and then checked 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 capsules/ tablets. These raw tablets then undergo lubrication process to prevent sticking to one another and applied film coating on tablets surface prevents being affected by atmospheric moisture. These coated tablets/ capsules are then once again passed through quality check before final packaging.



API & pharmaceutical process

Production process for detergents

The manufacturing of detergent either in bars or powder is a simple process consisting mechanical mixing of batch materials such as soda ash, dolomite, calcite, sodium salts, etc., and additives in the right proportions. Generally, horizontal drum-type mixer is used for this process step. The mixture is hot extruded in the shape of detergent bar and wire cut into definite sizes for final packaging.

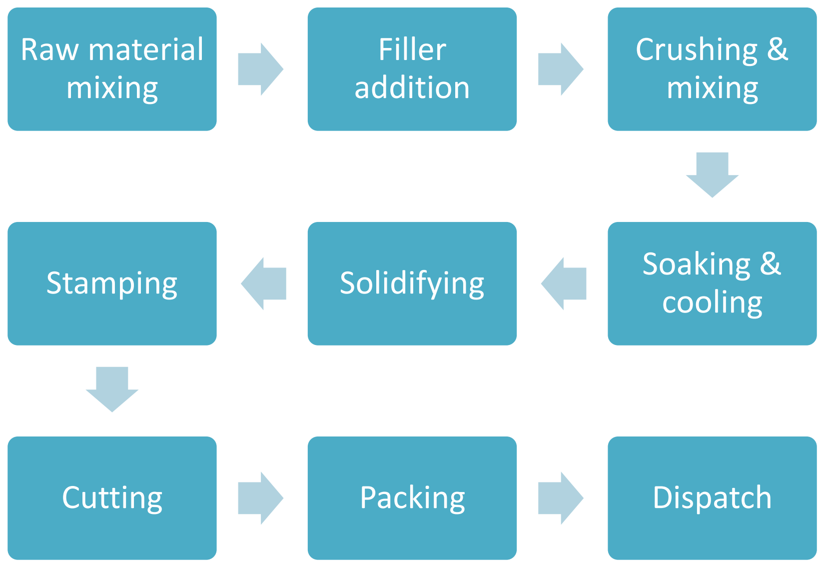


Process of detergent manufacturing

The detergent powder processing requires the mixture to be sieved through a vibratory sieve to separate out the chunks and/ or foreign particles if any and then filled into desired packet/ pouches through a filling machine and then packed for dispatch.

Production process for soap

The prime raw materials used in soap manufacturing include sodium silicate, caustic soda, non-edible oil, filler materials like China clay, dolomite, softener, and desired fragrance. Batch raw materials are thoroughly mixed in a crusher at a temperature of 70 – 80 °C converting batch mixture to semi-solid state. Depending upon the target product chemistry special ingredients like coconut oil or almond oil is added to the semi-solid state of mixture. Prepared semi-solid paste



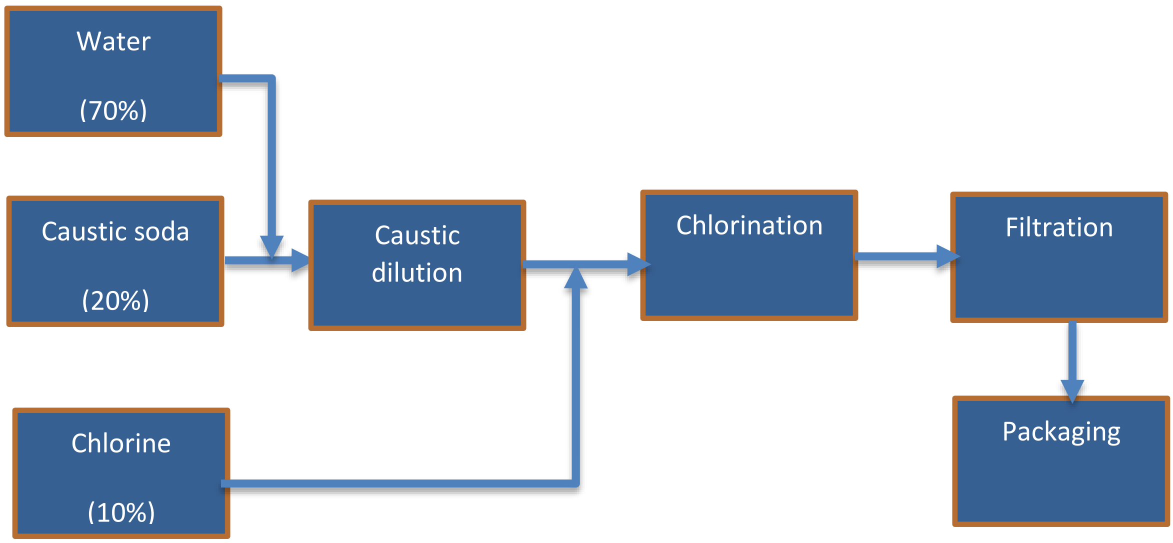
Process of soap manufacturing

mixture is poured into trays and allowed to soak while cooling down its own. This soaking process is carried out in a well-ventilated area under several wall-mounted fans to facilitate quicker cooling. Soaking helps in removing moisture from the soap so that it does not break at the time of stamping and pressing. Soaked soap pastes are stamped for final shape of the soap. The stamped soap bar is wire cut into desired sizes before packaging.

Production process for inorganic chemicals

Sodium hypochlorite (NaOCl) is one of the important inorganic chemicals that can be effectively used for surface purification, water disinfectants, bleaching, odour removal etc. Production of sodium hypochlorite is an exothermic reaction resulting increased batch mixture temperature at about 35 – 40 °C.

Being strong oxidizer, sodium hypochlorite reacts with flammable compounds its solution is a weak base and inflammable. It is produced by reacting caustic soda lye with chlorine followed with dilution using water. During manufacturing, initially caustic soda lye is charged in a plastic mixer tank followed with dosing of chlorine to initiate chemical reaction. Reaction takes about 5-7 hours to produce sodium hypochlorite. The final product is sampled for analyse to ensure appropriate chlorine percentage before packing in suitable plastic containers.



Production process for sodium hypochlorite

Technology use

Most of the equipment in the process and auxiliary utility system are similar in nature across different chemical industries in MSME sector. The brief details of the common equipment used in chemical industries are given below.

Reaction vessel

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 varying in the range of 1-20 kilo litre (kL). The capacities and number of vessels in a chemical unit are dependent on type of manufacturing process, production capacity and batch size. Reactor vessels are normally equipped with electrically driven mechanical agitator, direct/indirect jacket heating using steam, thermic fluid, cooling arrangement as needed to maintain the desired temperature.

Centrifuge

Water from the intermediate products in the form of slurry is removed with the help of either centrifuge. The capacity of the equipment depends on the plant manufacturing capacity.

Filter press

It is used to convert slurry to wet cake by forcing out water on application of compressed air and mechanical pressure through fixture and filter plates. 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/cm2 is used to remove liquids from pores in the filter cake. Upon reaching the desired residual moisture content, the cake deposited on the filter surfaces are removed. The residual moisture content in the wet cake is reduced by 50% to 60%.

Dryer

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 are used depending upon product chemistry. Some of the commonly used dryers are tray dryer, fluidized bed dryer, rotary vacuum dryer, and spin flash dryer, etc. The heating requirements in the dryer are supplied either by thermic fluid heater or hot air generator depending upon heating profile needed.

Steam boiler

The steam boilers used in chemical industries in MSME sector are mostly low and medium pressure (i.e. 3.5-10.5 kg/cm2) applications types. Most of the industries require low pressure steam (i.e. 3.5-5.5 kg/cm2) for jacket heating and direct steam purging into the reactor vessels. The steam generation capacity of these boilers range from 1-5 tonne per hour (tph) owing low steam demand in the process. In case of intermittent steam requirements in the process for specific products, plant uses smaller capacity boilers up to 750 kg per hour evaporation rate. Depending upon the availability and cost, the boilers may be operated using natural gas, biomass, coal, etc.

Thermic fluid heaters

The thermic fluid heaters (TFH) or thermos-packs are used to cater to the indirect heating requirements of manufacturing processes viz., jacket heating in reaction vessel, drying through heat exchanger where finer control of process temperature is essential. The thermos-packs are custom designed and heating capacity may vary from 100,000 kcal per hour to 600,000 kcal per hour to meet process requirements. The temperature of thermic fluid is about 180-200 °C. The TFH could be either fuel fired or electrically heated.

Hot air generators

The hot air generators (HAG) are used to generate hot air by indirect heating, which is normally used in tray drier system for moisture removal from wet cake. The typical capacities of HAGs may vary from 100,000 kcal per hour to 400,000 kcal per hour. HAGs are generally fuel fired (natural gas and biomass).

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/cm2 to 7 kg/cm2. Most of the chemical units use small capacities tank mounted, reciprocating type air compressors, while some of the progressive units use screw compressors.

Chiller system

Some of the chemical industries would require to maintain sub-zero temperature in the reaction vessels during chemical phase change and reaction cycle. The temperature of the reaction vessels is maintained by indirect cooling using chilled water supply from ammonia-type reciprocating chillers. Lower cooling demand in selective intermittent process of chemical manufacturing is met by ice blocks, which are supplied along with batch material into the reaction vessel for direct cooling instead of indirect cooling by chilled water.

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. 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. Ball mills are generally used for finer sizing

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 on its axis for mixing. The mixing process is generally an exothermic reaction and is carried out for 7 to 10 hours to attain adequate homogeneity. The chemical units have different capacities of mixer drums varying in the range of 100-400 litres. The capacities and number of vessels in a chemical unit are dependent on the type of manufacturing process, production capacity, and batch size.

Cooling tower

The cooling tower is used to reduce the temperature of incoming water based on wet bulb temperature and relative humidity of ambient conditions. The maximum possible drop in temperature of cooling water is limited to the wet bulb temperature of the ambient conditions. It could be either natural draught or forced draught operation. The performance of cooling tower can be compared with the rated output with the actual output like range, approach, effectiveness, heat rejection capacity in TR, evaporation loss and make up water flow rate etc. Most of the cooling towers are not equipped with automatic control system to regulate the fan operation. The seasonal variations in ambient temperatures and relative humidity clearly indicate that continuous monitoring of temperatures is required in cooling tower for effective operation with minimum power consumption.

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.

Fans and blowers

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.

Annexure-B: Technology compendium

The energy mapping study in chemical sector has identified a range of potential and feasible energy efficient technologies and energy conservation measures to improve energy performance. The various energy efficiency options such as technologies and retrofits, state of the art technologies and best operating practices are described below.

Energy efficient boiler system

Steam boilers in chemical sector consume significant thermal energy using various forms of fuels like natural gas, coal, biomass, etc. to meet process heat requirements in the plant. The energy consumption in boiler system depends on operating practices such as combustion air supply, manual combustion control, setting of high generation pressure than actual requirement, inadequate insulation, absence of waste recovery system and condensate recovery.

There is a significant potential to optimize the boiler system performance and reduce energy cost in chemical sector. The most common energy conservation measures include automation of FD and ID fans using VFD, excess air optimization within standard levels (2 to 7% depending on type of fuel), waste heat recovery using economiser or air preheater, insulation of steam distribution network to minimize surface heat loss through convection and radiation (surface temperature should be ambient temperature + 10 °C), steam generation pressure optimization, condensate recovery and installation of energy efficient boiler.

Energy savings potential (toe/year)	Monetary saving (Rs Lakh/year)	Investment (Rs Lakh)	Payback (year)	GHG reduction (tCO_2/year)
23	44	31	0.7	148

Energy efficient thermic fluid heater

Thermic fluid heater (TFH) is used for indirect heating in process areas viz. drying and jacket heating and accounts for major share in total energy consumption of a chemical unit. The overall performance of thermic fluid heaters depends on air fuel ratio, burner maintenance, use of waste heat recovery system and proper surface insulation, etc.

Energy efficiency of a TFH can be improved by automation of combustion air blower to avoid excess air supply to burner, use of energy efficient modulating burner, installation of waste heat recovery system (combustion air preheating), minimizing surface heat loss in distribution system and switching to clean gaseous fuel from solid or liquid fuel. Upgradation of TFH monitoring and control system by integration of online combustion analyser would help in real-time monitoring of O2/ CO in the exhaust and fine tuning of air fuel ratio to maintain excess air level within standard limits (2 to 7% depending on fuel used).

Energy savings potential (toe/year)	Monetary saving (Rs Lakh/year)	Investment (Rs Lakh)	Payback (year)	GHG reduction (tCO_2/year)
83	52	27	0.5	247

Energy efficient air compressor

Compressed air is one of the costliest utility in the industries. Most of the chemical units use fixed speed reciprocating or screw compressors to generate required air volume. In many installations, the use of compressed air requirements is intermittent and compressors operate on low /no-load conditions leading to increase in specific power consumption. Also, air leakages in distribution network, poor pipe sizing, and moisture carryover due to faulty air dryer results in additional power consumption of the compressed air system.

Energy conservation measures such as installation of VFD to avoid unload operation of screw compressors, adequate sizing of air distribution network, optimizing air generation pressure, use of energy efficient screw compressors with IE4 class electric motors, etc. will result in reducing overall energy consumption for compressed air generation.

Energy consumption (kWh/year)			Monetary saving (Rs Lakh/year)	Investment (Rs Lakh)	Payback (year)	GHG reduction (tCO_2/year)
Present	Proposed	Saving				
198,000	135,000	63,000	5.4	5	0.9	52

Performance improvement in cooling tower

Cooling tower (CT), a common utility in many chemical sector units, is used to remove heat in cooling water from process areas to atmosphere. Most cooling tower fans are operated at fixed speed irrespective of supply water temperature or ambient conditions and CT fan blades are made of aluminium material. Use of inefficient and oversized cooling water pumps along with poor operational practices such as throttling for capacity control also results in higher energy consumption of cooling tower system.

Replacement of aluminium blades with FRP blades, installation of thermostatic controller along with VFD for CT fan, use of high efficiency pumps with VFD for flow control can reduce daily energy consumption by 20 – 30% and result in energy cost savings in operation of cooling tower system.

Energy consumption (kWh/year)			Monetary saving (Rs Lakh/year)	Investment (Rs Lakh)	Payback (year)	GHG reduction (tCO_2/year)
Present	Proposed	Saving				
295,680	211,680	84,000	6.4	7.5	1.2	69

Premium efficiency motor

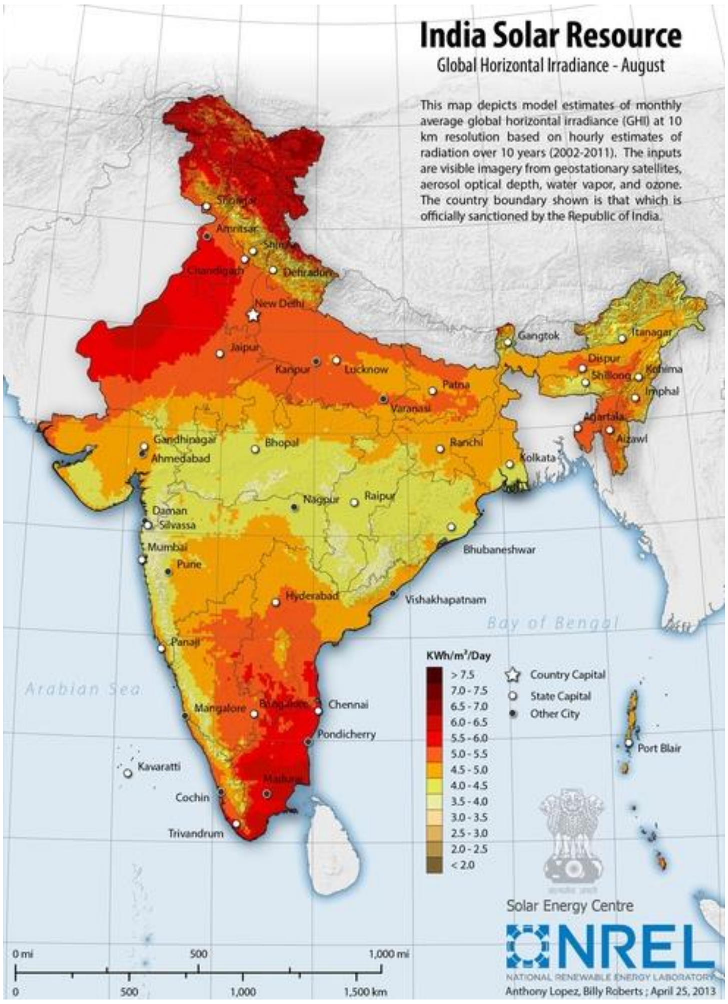
Electric motors are used mainly in reactors, mixers, centrifuges, and auxiliaries associated with the manufacturing process. The chemical industry uses air circulation fans & blowers in boilers, thermic fluid heaters and dryers with connected motors of standard efficiency class. Further, the motors are also rewound a number of times which reduces the overall efficiency of the motor driven system.

These inefficient motors can be replaced with premium efficiency class (IE3) motors. The salient features of high-efficiency motors include the following:

- Longer core lengths of low loss steel laminations to reduce flux densities and iron losses
- Maximum utilization of slots and generous conductor sizes in stator and rotor to reduce copper losses
- Careful selection of slot numbers and tooth/ slot geometry to reduce stray losses
- Generation of less heat leading to a reduction in the size of the cooling fan thereby lowering windage losses and waste power

Energy consumption (kWh/year)			Monetary saving (Rs Lakh/year)	Investment (Rs Lakh)	Payback (year)	GHG reduction (tCO_2/year)
Present	Proposed	Saving				
730,181	686,420	43,761	7.7	23.0	3.0	36

Solar photovoltaic system



Rooftop solar photovoltaic system is one of the options for sourcing green and low cost electricity in chemical industries. Rooftop solar panels utilize sunlight to generate electricity. Most of the chemical clusters are situated at ideal geographical locations receiving ample tropical sunlight.

One of the biggest advantages of installing rooftop solar panels in chemical industries is that it can be installed on any type of roof. Therefore the existing shed/roof can be effectively utilized and investment for additional land will not be required. The landed costs of electricity from solar PV system in comparison to industrial tariff rates are cheaper by 15-25%. The electricity utilization in chemical units is mainly in the raw material processing, reactor motors, mixing motors, grinding motors, centrifuges, pumps, fans, indoor and outdoor lighting and therefore rooftop panels can supply electricity to the units during day time. This would result in reduced grid electricity and backup power consumption, thereby saving on energy costs.

Potential energy generation (kWh/year)	Monetary saving (Rs Lakh/year)	Investment (Rs Lakh)	Payback (year)	GHG reduction (tCO_2/year)
177,357	11.9	51.5	4.3	145

Best operating practices

The best operating practices for chemical industries are given below.

Raw material processing

- Monitor material to liquor ratio to optimize water and energy consumption levels in reaction vessel.

- Monitor the temperature of reaction vessel and the system shall be switched off on completion of the reaction using control system.
- Use the correct and consistent quality of raw materials.
- The industry shall recover, treat, and re-use water used in various process sections.

Process and Utility Equipment

- Install boiler, TFH, HAG, etc., with the highest efficiency that meets the process requirements.
- Maintain correct air ratio in boiler, thermic fluid heater (TFH), and hot air generator (HAG) as specified as standard value by the OEM.
- Use automatic air-fuel ratio control system in the combustion system and integrate with control loop.
- Install blower having suitable capacity and correct air pressure. Avoid over-sized or under-sized blower. Install blower close to the combustion equipment to avoid transmission loss.
- Undertake thermal insulation work on different systems such as steam and condensate pipes, ducts, equipment (TFH and HAG), etc., which are used for transporting heat media either through steam or hot fluid according to the industrial standard practices for thermal insulation works and equivalent standards.
- Use dry steam from boiler in heating processes to enhance heat transfer. Close steam flow to the process when it is not in operation. Use appropriate steam separator or steam trap to maintain the required dryness fraction of steam.
- Ensure better resolution of measuring instruments for accurate measurements.
- Use suitable log sheet(s) for measurement and recording of key operating parameters.
- Clean the equipment periodically as per the instructions to get rid of soot, scale or dirt to avoid deterioration of heat transfer surfaces and performance.
- Repair, renovate, and maintain the WHR systems once in six months to avoid scale formation and ensure optimum performance.
- Use rotary dryer in place of tray dryer wherever feasible.
- Use improved streamlined pipe route (avoiding unnecessary bends and joints) for transporting heat media (water, thermic fluid, hot air, etc.) to minimize heat loss.
- The industry shall use compressed air only at required pressure to optimize energy consumption.
- The industry shall avoid idle running of motors to reduce energy consumption.

General

- Maximize the use of day lighting.
- Install natural ventilators.
- Arrest leakages from compressed air lines to reduce power consumption.
- Avoid spillage of fuels to reduce wastage.

Annexure-C: Strategies for decarbonisation and circular economy

Strategies for decarbonisation and circular economy

The chemical sector is one of the energy intensive sectors among MSME in India. The share of thermal energy is predominant in most of the chemical industries accounting in the range of 75-90% of the total energy consumption within the individual plant premises. The sector needs to explore suitable options to transit gradually towards decarbonisation. The chemical industries may explore the following.

1. Technology switch over from polluting coal / oil based to clean natural gas based technology
2. Adoption of best available technology (BAT) at global level
3. Electrification of fossil fuel based processes
4. Promoting deep decarbonisation through research and development
    a) Electrification route
    b) Hydrogen route

The deep decarbonisation of chemical sector would require involvement of stakeholders globally for developing commercial scale technologies and suitable policies.

Strategies for decarbonisation of chemical sector

The chemical industries use coal, oil, natural gas, biomass and electricity to meet the energy demand for the process. Natural gas is the major energy source accounting for about 45-50%; electricity accounts for 20 – 25% of total energy consumption in chemical sector. The energy intensity in chemical sector can be reduced with adoption of energy efficiency options. The chemical sector may explore the electrification and /or hydrogen based technology options for the following processes and technologies for decarbonisation of the sector.

1) Steam generation system to replace the consumption of fossil fuels
2) Drying process and hot air generator to replace the consumption of natural gas
3) Thermic fluid heaters to replace the consumption of furnace oil, NG, etc.

The industries can also minimize the consumption of non-renewable based grid electricity by installing renewable based systems.

Strategies for circular economy in chemical sector

The in-house waste generation in chemical industries is generally dependent on the manufacturing process and type of end product. The primary waste stream from most of the chemical industries is liquid discharge from process stream, which is transferred to common effluent treatment plant (CETP) after initial treatment within the plant premises. Post treatment of effluent in CETP, water is recovered, recycled and reused to minimize the dependency on raw water supply and /or subsoil water extraction. The reuse of treated waste water promotes sustainable consumption and production, which is in-line with circular economy. A suitable supply chain must be established for utilizing the waste generation in upstream or downstream industries. With steam used as the major heating source for processes in large number of chemical industries, the possibility of common steam generation at cluster level based on the proximity and utilization factor may be explored for power generation and process heating.

Annexure – D: Existing energy efficiency policies and programs

This section provides an overview of existing schemes and policies that are applicable for MSME sector in general and chemical sector in particular.

Existing schemes and policies

It has been well recognized that the MSME sector forms the bedrock of Indian entrepreneurship, and needs to be nurtured appropriately. There are several programs and schemes promoted by the Government of India under the Ministry of Micro Small and Medium Enterprises (MoMSME) as well as by other ministries and state governments. The general industrial policy of the Government of India, as well as the states, is applicable for the chemical sector as well. Some of the relevant schemes are summarized below.

Micro and Small Enterprises Cluster Development Programme

Implementation agency	The Ministry of Micro, Small and Medium Enterprises (MoMSME)
Description	The Ministry of Micro, Small and Medium Enterprises (MSME), Government of India (GoI) has adopted the cluster development approach as a key strategy for enhancing the productivity and competitiveness as well as capacity building of Micro and Small Enterprises (MSEs) and their collectives in the country. A cluster is a group of enterprises located within an identifiable and as far as practicable, contiguous area and producing same/similar products/services. The essential characteristics of enterprises in a cluster are (a) Similarity or complementarity in the methods of production, quality control and testing, energy consumption, pollution control, etc. (b) Similar level of technology and marketing strategies/practices (c) Channels for communication among the members of the cluster (d) Common challenges and opportunities.
Nature of assistance	Matching share basis and reimbursement
Period of implementation	Year 2007 – Present (on-going)

Credit Linked Capital Subsidy Scheme

The Credit Linked Capital Subsidy Scheme (CLCSS) was launched in the year 2000 by the MoMSME and is being implemented by Development Commissioner, Micro Small and Medium Enterprises (DC-MSME).

Implementation agency	Ministry of MSME
Description	The objective of the scheme is to facilitate technology upgradation in MSMEs by providing an upfront capital subsidy of 15% (on institutional finance of up to INR 1 crore availed by them) for induction of well-established and improved technology in the specified 51 industrial sub-sectors/products approved
Nature of assistance	15% upfront capital subsidy to MSMEs, including tiny, khadi, village, and coir industrial units, on institutional finance
Period of implementation	Year 2000 – Present (on-going)

The scheme covers several technologies for the chemical. The equipment covered under the CLCSS scheme in chemical sector is provided in below.

Sector	Equipment/Section/Utility	CLCSS coverage
Drugs and Pharmaceuticals	Dispensing	• Reverse laminar flow equipment.
	Weighing	• Automatic electronic balance 300 kg.; 150 kg and 1 kg.
	Mixing and granulation	• Rapid mixer granulator 200 L capacity
	Dry granulation	• Roller compactor
	Drying	• Fluidized bed dryer 200 L capacity
	Size reduction	• Oscillating granulator
	Coating suspension	• Colloid mill
	Compression	• 16 station rotary tablet machine • 27 station rotary tablet machine
	De-dusting of tablets	• On-line de-duster
	Capsule filling	• Semi-automatic capsule filling machine
	Capsule polishing	• Automatic polishing machine
	Printing of packaging cartons	• Semi-automatic
	Reaction	• Stainless steel reactor. • Glass lined reactor
	Filtration	• Filter press.
	Drying	• Stainless steel dryer with modern facilities spray/flash
	Centrifugation	• Centrifuge (Stainless steel or Rubber Lined)
	Pulverisation	• Latest technology pulverizes impact type.
Dyes & Intermediates	Filtration System	• Membrane filtration system
	Ice Flaker	• Flaker with silo and screw conveyer
	Reactors	• Closer vessels with planetary gears and high speed turbine stirrers
	Product Drying System	• Flash dryers or rotary vacuum dryers
	Incinerator	• Use of gasifier with slurry economizer
	Blenders	• Nauta mixers
Paints	Manufacturing	• Basket mill • Twin shaft disperser • Tinter dispensing system • Electronic balances • Automatic/semi-automatic • Filling machines • De-mineralized water plant • Transfer pumps
	Technology	• Powder coatings • Electrode position

Credit Guarantee Fund Trust for Micro and Small Enterprises

Implementation agency	Ministry of MSME and Small Industrial Development Bank of India (SIDBI)
Description	The trust fund is to implement the Credit Guarantee Scheme for providing collateral-free loans to individual MSE on payment of guarantee fee to the bank by the MSMEs. The corpus of CGTMSE is contributed by the Government of India and SIDBI.
Nature of assistance	Eligible borrower can avail fund and non-fund based credit facilities up to Rs 200 lakh The guarantee covers to the extent of 50-85% of the sanctioned amount of the credit facility. The extent of guarantee cover is 85% for micro enterprises for credit up to Rs 5 lakh. The extent of guarantee cover is 50% of the sanction amount of the credit facility for credit from Rs 10 lakh to Rs 100 lakh per MSME borrower for retail trade activity. The extent of guarantee cover is 80% (i) Micro and Small Enterprises operated and/or owned by women; and (ii) all credits/loans in the North East Region (NER) for credit facilities up to Rs 50 lakh. In case of default, Trust settles the claim up to 75% of the amount in default of the credit facility extended by the lending institution for credit facilities up to Rs 200 lakh.
Period of implementation	Year 2000 – Present (on-going)

Micro and Small Cluster Development Program

Implementation agency	Ministry of MSME
Description	The objective is to improve the competitiveness of MSME clusters (industries working in similar proximity, having similar products) by focusing on common issues such as access to technology, skills, quality, market access, access to capital, etc. It further focuses on capacity development, create/upgrade infrastructural facilities in industrial parks such as training centers, testing centers, effluent treatment plants, etc.
Nature of assistance	Common Facility Centers: Grant up to 70% of the cost of the project of a maximum INR 20 crore. Infrastructure Development: Grant up to 60% of the cost of project of maximum INR 10 crore for industrial estate & Rs 15 crore for flatted factory complex.
Period of implementation	Year 2007 – Present (on-going)

Interest Subvention Scheme for MSMEs 2018

Implementation agency	Ministry of MSME
Description	The objective is to encourage both manufacturing and service enterprises to increase productivity and provide incentives to MSMEs for on-boarding on GST platform.
Nature of assistance	The interest relief will be calculated at two percentage points per annum (2% p.a.), on the outstanding balance from time to time from the date of disbursal/ drawl or the date of notification of this scheme, whichever is later, on the incremental or fresh amount of working capital sanctioned or incremental or new term loan disbursed by eligible institutions.
Period of implementation	Year 2018 – Present (on-going)

Champions portal

Implementation agency	Ministry of MSME
Description	The champions portal is a technology-driven centralized control room, grievance management, and information platform. It aims at creation and harmonious application of modern processes for increasing the output and national strength. The portal promotes smaller units to transfer into bigger units by helping and handholding through problem solving and addressing grievances.
Nature of assistance	• Help the MSMEs in this difficult situation in terms of finance, raw materials, labour, permissions, etc. • Help the MSMEs capture new opportunities in manufacturing and services sectors. • Identify the sparks, i.e., the bright MSMEs who can withstand at present and become national and international champions.
Period of implementation	Year 2020 – Present (on-going)