UK Government

iDeeksha

BUREAU OF ENERGY EFFICIENCY
Government of India, Ministry of Power

ASPIRE Programme

Accelerating Smart Power & Renewable Energy in India

SUMMARY REPORT

DOMESTIC STUDY TRIP OF
GUJARAT ALKALIES AND CHEMICALS LTD., DAHEJ, GUJARAT

28th February 2024

Hosted by:
Gujarat Alkalies and Chemicals Limited, Dahej, Gujarat

GACL
Promoting Green Technology

iDeeksha

Industrial Decarbonisation and Energy Efficiency
Knowledge Sharing Platform

Contents

Abbreviations

ASPIRE	Accelerating Smart Power and Renewable Energy in India
BEE	Bureau of Energy Efficiency
CEU	Caustic Evaporation Unit
CAGR	Compound Annual Growth Rate
FCDO	Foreign, Commonwealth and Development Office
GESI	Gender Equality Social Inclusion
GACL	Gujarat Alkalies and Chemicals Limited
IEED	Industrial Energy Efficiency and Decarbonisation
MW	Mega Watt
MTPD	Metric Tons per Day
NMEEE	National Mission for Enhanced Energy Efficiency
PAT	Perform Achieve and Trade
SEC	Specific Energy Consumption
TPD	Tonnes per Day

BACKGROUND

The chlor-alkali industry constitutes approximately **1%** of the global chemicals industry, with a turnover of ~INR **5.7 trillion** (~GBP **55 billion**). The Indian chlor-alkali industry commands a **~6%** share of the global market and has made significant advancements in the last three years[1]. In India, this sector contributes **~70%** of basic chemicals, encompassing caustic soda, chlorine, soda ash, and essential elements such as hydrogen, hydrochloric acid etc. within the broader chemicals industry landscape. The caustic soda/ chlorine segment features a diverse array of **~30** companies, experiencing substantial investments in recent years. Installed capacity for caustic soda (and concomitantly that for chlorine, which is co-produced in an unalterable ratio) has grown at a compound annual growth rate (CAGR) of **~8%** from **3.37 million** tonnes per annum in FY 2016 to **4.54 million** tonnes per annum in FY 2020[2].

Chlor-alkali sector is categorised as one of most energy intensive industries in India. Energy consumption of the sector is expected to increase by **~45%** to **5 million** ToE resulting in **~16 million** tonnes of CO_2 emissions by FY 2030-31. The process for conversion of common salt into caustic soda lye, chlorine, and hydrogen gas involves utilisation of electric energy, while thermal energy is employed in brine preparation and the transformation of lye into flakes. In many units, the hydrogen produced serves as fuel for lye concentration and caustic flake production. This energy-intensive process incurs substantial costs, with energy accounting for **50-60%** of the total production cost, contingent on power expenses. The sector is bifurcated into captive power plant (CPP)-based facilities and non-CPP based facilities (grid-connected plants).

Given that the chlor-alkali sector holds substantial energy efficiency potential, it is under the ambit of Bureau of Energy Efficiency's (BEE) Perform Achieve and Trade (PAT) scheme. The threshold limit for any chlor-alkali unit to be notified as a designated consumer (DC) under the PAT scheme is **12,000** MToE4[3]. Currently, **29** industries are notified as DCs under the PAT scheme.

In view of this, a study trip to Gujarat Alkalies and Chemicals Limited (GACL), Dahej, Gujarat was organised on 28th February 2024 under the Accelerating Smart Power and Renewable Energy in India (ASPIRE) programme[4]. The study trip was jointly organised by the Foreign, Commonwealth and Development Office (FCDO), Government of UK and the Bureau of Energy Efficiency (BEE), Government of India with the support of Gujarat Alkalies and Chemicals Limited (GACL). The purpose of the study trip was to demonstrate and disseminate the various best practices and innovative industrial energy efficiency and decarbonisation (IEED) technologies adopted by GACL Dahej Complex to enhance its energy efficiency and enable decarbonise of its operations.

1 https://www.indianchemicalsnews.com/chemical/nextgen-summit-2023-chlor-alkali-to-dominate-investments-with-in-chemical-industry-18438
2 https://ama-india.org/wp-content/uploads/2020/10/Chlor-alkali-industry-in-India-status.pdf
3 https://beeindia.gov.in/sites/default/files/Chlor-Alkali-1-44.pdf
4 Accelerating Smart Power and Renewable Energy (ASPIRE) is a bilateral technical assistance programme being implemented by the Foreign, Commonwealth and Development Office (FCDO), Government of UK in association with the Ministry of Power and Ministry of New and Renewable Energy, Government of India. KPMG is the implementation advisor to FCDO in relation to the ASPIRE programme and Idam Infrastructure Advisory Private Limited (India) is a key consortium member.

Objective of the Study Trip

To demonstrate new and innovative IEED technologies implemented by GACL, Dahej Complex

To enable industries in chlor-alkali sector, to reduce their overall specific energy consumption (SEC) and adhere to the compliance requirements under BEE's Perform Achieve Trade (PAT) scheme

To foster an ambitious, mutually beneficial, and outcome-focused relationship between industry stakeholders

Highlights

Active participation from **~25+** (including **15+% women** participants) stakeholders including senior officials and executives from central and state government agencies, industrial organisations, research institutions, and technology providers

Name of key sections of the plant that were covered -

- Electrolysis cell division
- Floating solar plant
- Solar PV rooftop plant
- Back pressure turbine power generating unit

OVERVIEW OF GUJARAT ALKALIES AND CHEMICALS LIMITED

GACL Plant, Dahej, Gujarat, India

Founded by the Government of Gujarat, GACL is a forward-thinking enterprise that has emerged as one of India's leading players in the chlor-alkali industry. Operating across two complexes situated in Dahej and Vadodara, GACL is strategically expanding its operations beyond caustic soda to reinforce its dominance in the chlor-alkali domain and other associated downstream products like Chlorine and Hydrogen derivatives, leveraging state-of-the-art technologies.

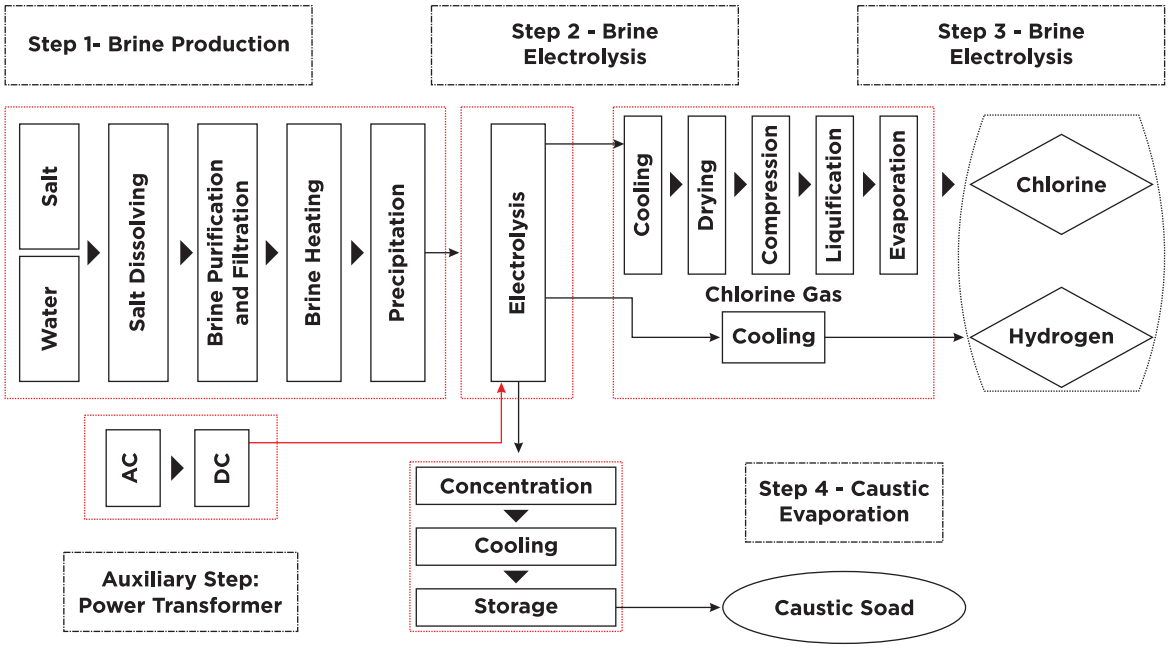
With a focus on energy efficiency and self-sufficiency, GACL has inaugurated a **90** MW combined cycle captive power plant at its Dahej facility. Furthermore, it possesses renewable energy assets, including **171.45** MW wind farms and **36** MW solar power installations. GACL places a strong emphasis on environmental responsibility, encapsulating a resolute "Green Attitude".

Committed to delivering superior customer satisfaction and adhering to global standards, GACL holds certifications for its management systems according to ISO 9001:2015, ISO 14001:2015, ISO 45001:2018, and ISO 50001:2018. The company has garnered recognition across various segments, notably being designated as a "Top performer consumer for the chlor-alkali sector of PAT cycle II under National Mission for Enhanced Energy Efficiency (NMEEE)".

STUDY TRIP TO GUJARAT ALKALIES AND CHEMICALS LIMITED

GACL stands as a pioneer in India's chlor-alkali industry. In alignment with its strategic expansion goals, GACL has significantly enhanced the capacity of its caustic soda lye plant at the Dahej complex, increasing it from **785** Metric Tons Per Day (MTPD) to **1,310** MTPD. As a vital component of this expansion initiative, a new **700** MTPD caustic evaporation unit (CEU) has been developed to fulfil the demand for caustic soda lye production at a concentration of **48%** weight/ weight (w/w).

During the study trip, participants explored several areas of the plant, encompassing the electrolysis division, solar rooftop PV, floating solar plant, back pressure turbine power generating unit etc. The participants were provided with invaluable insights into the critical areas and processes of the plant, detailed as follows:



Source: Manufacturing process of caustic soda (researchgate.net)

Brine Preparation and Purification

Raw salt is mixed with treated water, resulting in the creation of a saturated brine solution containing **300-330** grams of salt per litre. The saturated brine undergoes a rigorous purification process to reduce impurity concentrations, including calcium, magnesium, barium, strontium, and metals, to levels conducive for the electrolytic process. Impurities such as magnesium, calcium, strontium, and sulphate are removed, and any trace levels of remaining impurities are further eliminated to meet the stringent quality standards required for purified brine.

Electrolysis: Production of Caustic Soda, Chlorine, and Hydrogen

In this stage, heated purified brine (65-70°C) is introduced into the alkaline electrolyser or cell house for electrolysis. Within the cell house, the brine primarily decomposes into caustic soda, chlorine, and hydrogen, while side reactions yield by-products such as oxygen and chlorate.

Caustic Soda Concentration

Following electrolysis, the resulting caustic soda possesses a concentration of 32%. This solution is then subjected to concentration processes, with options including elevation to 48% via multiple-effect evaporators or further refinement to 98% from the 48% solution. Notably, Indian chlor-alkali plants typically leverage three-stage falling film evaporators due to their superior heat transfer and reduced fouling tendency. The resulting 48% caustic soda can either be directly sold or processed into solid flakes within a specialised flaking unit.

Chlorine Handling

Chlorine gas, a by-product of the electrolysis process, undergoes intricate handling procedures. Initially, it is partially dissolved in return brine solution, with any remaining gas being released. The released chlorine, saturated and containing impurities, undergoes a cooling and drying process employing concentrated sulfuric acid to mitigate corrosion and minimise hydrate formation. Further processing reduces water content before compression, ensuring safe temperatures are maintained.

Hydrogen Gas Management

Finally, hydrogen gas, another by-product of caustic soda production, serves various purposes, including steam generation (15%) and Hydrochloric acid production (64%). Any excess hydrogen, once bottled for specific market requirements, is ultimately vented into the atmosphere. The proportion of vented hydrogen may vary across plants but typically averages around 14%.

Key IEED Measures Implemented by GACL

Snapshots from participants briefing session before the study trip

- **GACL** has established a **90** MW combined cycle captive power plant (CPP) within its Dahej complex. Additionally, the company has implemented **171.45** MW of wind farms and **36** MW of solar power plants. GACL has also commissioned a **0.7** MW floating solar project on its raw water reservoir.

- GACL operates a **700** tonnes per day (TPD) caustic evaporation unit featuring state-of-the-art plate type heat exchangers, energy-efficient steam consumption methods, and holds the title of the nation's largest capacity. This advancement has significantly lowered operating costs, reduced energy consumption, and optimised space usage.

- GACL has implemented following IEED best practices:

    - **Individual cell voltage monitoring** enables real-time voltage monitoring, immediate problem detection, optimisation of cell performance, data logging and analysis, and seamless integration with control systems

    - **Chlorine (Cl_2) tonner temperature monitoring & tracking** ensures safe handling during filling with radio frequency identification (RFID) tracking

    - **Hydrogen (H2) pipeline supply** enables direct supply at 50 bar (G) reducing logistics and enhancing reliability

    - **Flameproof IIC static earthing relay:** enhances H2 bottling safety with modern earthing systems

    - **Radio remote units (RRC) for crane safety:** improves equipment reliability and worker safety

    - Heating, ventilation, and air conditioning (HVAC) air handling unit (AHU) System upgrade

    - **Energy saving equipment installations:** light emitting diode (LED) lights, efficient motors, variable frequency drive (VFD) drives, and relays enables energy savings and reduces carbon emissions

    - **Standard operating procedure (SOP):** provides criteria for energy-efficient cell systems and membranes

    - **Installation of wastewater treatment plant:** installed **3,300** kilo litres per day (KLD) wastewater treatment plant to ensure environmental preservation

FEEDBACK FROM THE PARTICIPANTS

- Participants were highly satisfied with the outcomes of the study trip.
- Participants appreciated GACL's innovative initiative of installing floating solar panels on the raw water reservoir, showcasing their commitment to renewable energy solutions.
- Visit to the 'Electrolysis Cell House' section of the plant, which provided valuable insights, was highly appreciated by the participants.
- Explanations/ clarifications provided by GACL team during the visit were very informative and insightful as per the feedback from the participants.
- Many participants expressed a desire for similar study trips in the future, emphasising the value gained from firsthand experience in a real industrial setting.
- Participants commended GACL for their efficient management of operations, evident in the successful implementation of large-scale projects.
- While appreciating GACL's overall management, some participants suggested areas for improvement, particularly in digitalisation efforts.

CONCLUSION

Group photograph of participants from the study trip

The response to the study trip has been positive with significant participation from senior officials from BEE, senior leadership of leading Indian chlor-alkali industries, and technology providers from India. The study trip seems to have achieved its goal of giving national organisations a stage to witness the operations of new and innovative IEED measures implemented and the challenges faced in the implementation of the same. It is expected that this study trip will have a demonstrable and long-lasting on-field impact in due course of time. Further, to keep up the momentum, the following activities are envisaged under ASPIRE to enable wider adoption of IEED measures and technologies by Indian chlor-alkali industries to achieve their net-zero targets.

- Provide support including B2B interactions/webinars to large energy-intensive industries (including chlor-alkali sector) to support in identifying technologies & solutions, and technology suppliers for enhanced adoption of IEED interventions.
- Create more discussion forums to facilitate the exchange of knowledge and information.

Annexure

Attendance Sheet

S. No	Name	Designation	Organisation
1	Mr. Mayank Shukla	Deputy General Manager	Grasim Industries – Aditya Birla Chemicals
2	Mr. K V Suresh	Head – Energy Cell	UPL Limited
3	Mr. Amit Dutta	Manager	Grasim, Karwar
4	Ms. Herambha Gayathri	Dy. Manager - Electrical	Grasim, Karwar
5	Mr. Paresh Vasava	Sr General Manager	Reliance Industries Limited, Dahej
6	Mr. Hardik Jasani	General Manager	Reliance Industries Limited, Dahej
7	Mr. Hanif Manknojiya	Sr Manager	Reliance Industries Limited, Dahej
8	Mr. Rakesh Sharma	AGM	Nirma Limited, Bhavnagar
9	Mr. Vivek Sharma	AGM (power plant and utility)	Epigral Limited
10	Mr. Laxman Ranoliya	DGM	Epigral Limited
11	Mr. Jitendra	AGM	Epigral Limited
12	Mr. RK Ranjan	DGM	Grasim India Limited
13	Mr. Pallan Das	Manager	Grasim India Limited
14	Mr. Santhosh Kumar G	GM	Grasim India Limited
15	Mr. Abhijit Shukla	Manager	Grasim India Limited
16	Mr. Sunil K. Khandare	Director	Bureau of Energy Efficiency
17	Mr. Aditya Moghe	Project Engineer	Bureau of Energy Efficiency
18	Mr. K. K. Chakarvarti	Sr. Advisor, IDEEKSHA	Idam Infra (ASPIRE Team)
19	Mr. Anurag Sirola	Manager	KPMG India (ASPIRE Team)
20	Mr. Ashish Sharma	Senior Consultant	KPMG India (ASPIRE Team)
21	Mr. Dipak Khandare	Associate Director – Industrial Decarbonisation	Idam Infra (ASPIRE Team)
22	Ms. Dhaarna Rawat	Consultant	Idam Infra (ASPIRE Team)
23	Dr. Asmita Marathe	Manager	Idam Infra (ASPIRE Team)
24	Ms. Krusha Dave	Executive	GACL

S. No	Name	Designation	Organisation
25	Ms. Banshari Purohit	Executive	GACL
26	Ms. Ritu Shah	Executive	GACL

FOR MORE INFORMATION PLEASE CONTACT

Archana Chauhan
Head, Energy Sector Reform
British High Commission
archana.chauhan@fcdo.gov.uk

Vikas Gaba
Partner and National Lead Power & Utilities
KPMG in India
vikasgaba@kpmg.com