सत्यमेव जयते
Ministry of Power
Government of India

Improving Energy Efficiency in

Chlor-Alkali Sector

(Achievements and Way Forward)

Perform Achieve & Trade

September 2018

BUREAU OF ENERGY EFFICIENCY

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Dr. Damm's

Director, IGEN

India shares 4% of global chlor Alkali production capacity. Electricity being the main fuel for this sector as well as raw material in a way, has led to increase in captive power plants in the sector. Though India is well ahead of many countries in phasing out mercury cell and using the latest energy efficient technologies in caustic soda production, it has more to do in the long run. As more and more plants are being dependent on the CPPs, the energy efficiency of CPPs has also become a point of concern. However, the current trend of adopting recent and advanced technology in the sector is anticipated to continue in future as well.

Germany has been playing a very active role in promoting energy efficiency in not only its own land, but also supporting the other countries to adopt the same. Germany has been supporting India in various fields since last 60 years, with an aim of promoting cooperation and involving public-private sectors of both sides in the areas of energy, environment and sustainable economic development. The Indo-German Energy Programme (IGEN), works as a partner of Bureau of Energy Efficiency (BEE) in supporting policies and programmes envisaged under the Energy Conservation Act, 2001.

It has been a privilege to work with BEE, the organization spearheading activities on energy efficiency in India. IGEN has been involved with BEE in the Perform Achieve and Trade since its inception, and hence it is blissful to know that the outcome of this scheme led to a huge savings in terms of CO_2 emission reduction and coal.

However, the real outcome of PAT scheme is not only the savings in terms of toe and CO_2, but it is the change in behavior towards energy efficiency. It is astonishing to see the amount of resources and concepts the industries have put together in achieving the target. Some state-of-the-art projects implemented in PAT cycle-I are cross cutting and could have significant potential across the sectors. Some of the positive outcomes of this scheme were the utilization of waste heat in generation of steam and power, adoption of cogeneration, use of alternate fuel and raw material, etc. This report analyses the outcome of PAT scheme in Chlor Alkali sector in multidimensional ways and forecasts the future savings along with innovative case studies having high replication potential. The estimate suggests the cumulative energy savings from the sector till 2030 to be 2.51 million TOE, which is quite impressive.

We are delighted to be a part of this historic journey where India has been a forerunner in implementing an exceptional scheme, customized to the benefit of the industries as well as the nation. I personally feel that the deepening of this scheme in Chlor Alkali sectors would prove a game changer in the times to come. This scheme has tremendous opportunities for regional synergies and its adaptation by other countries could lead to address the global climate issues.

Dr. Damm's
Director, IGEN

अभय बाकरे, आईआरएसईई
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Director General

सत्यमेव जयते

ENERGY IS LIFE
CONSERVE IT

ऊर्जा दक्षता ब्यूरो
(भारत सरकार, विद्युत मंत्रालय)
BUREAU OF ENERGY EFFICIENCY
(Government of India, Ministry of Power)

FOREWORD

As we are embarking an ambitious path to provide electricity to all and raise the level of energy availability to the population across the country with limited resources at disposal; efficient use of primary energy resources is absolutely necessary.

Bureau of Energy Efficiency, under the Ministry of Power has been spearheading the promotion of energy efficiency in various aspects of the country's energy landscape, through programs such as Standards & Labelling for appliances, Energy Conservation Building Code (ECBC) for buildings and Demand Side Management (DSM) program for Agriculture and Municipality sectors.

One such flagship program for energy intensive industries namely Perform, Achieve and Trade (PAT) was launched under the National Mission for Enhanced Energy Efficiency (NMEEE). This scheme has demonstrated its value in its first cycle, in which 478 Designated Consumers have achieved 8.67 MTOE of energy savings against the target of 6.68 MTOE, exceeding by about 30 %.

With an objective to have further insight on the actions taken and other notable effects taken by these designated units in achieving the excellent results, a study has been taken up by BEE in partnership with GIZ. The report gives an in-depth analysis of the achievements, projections and success stories across various sectors covered in the first cycle of PAT scheme.

With the continued guidance of Ministry of Power, the Bureau of Energy Efficiency expresses its gratitude towards all the industries, associations and other stakeholders for their significant contribution to achieve the task of saving energy and adoption of energy efficiency measures. BEE intends to convey our congratulations to all who joined us on our collective endeavour of improving energy efficiency in the country.

Abhay Bakre.
(Abhay Bakre)

New Delhi: 19.09.2018

स्वहित एवं राष्ट्रहित में ऊर्जा बचाएँ Save Energy for Benefit of Self and Nation

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1.0 Executive Summary

In a bid to combat increasing energy consumption and related carbon emissions, the Government of India released the National Action Plan on Climate Change (NAPCC) in 2008 to promote and enable sustainable development of the country by promoting a low carbon and high resilience development path. Under the NAPCC, eight national missions were framed to focus on various aspects related to water, solar energy, sustainable habitat, agricultural, energy efficiency, ecosystems, etc. Perform Achieve and Trade scheme (PAT) is a component of the National Mission for Enhanced Energy Efficiency (NMEEE) which is one of the eight missions under the NAPCC.

PAT is a regulatory instrument to reduce specific energy consumption (SEC) in energy intensive industries, with an associated market-based mechanism to enhance cost effectiveness through certification of excess energy savings, which could be traded. Energy Savings Certificate (ESCerts) are issued to the industries which reduce their SEC beyond their target. Those companies which fail to achieve their target are required to purchase ESCerts for compliance, or are liable to be penalised. Trading of ESCerts are conducted on existing power exchanges.

PAT Cycle - I, which was operationalized in April 2012, included 478 units, known as "Designated Consumers" (DCs), from eight energy-intensive sectors viz. Aluminium, Cement, Chlor- Alkali, Fertilizer, Iron &Steel, Pulp & Paper, Thermal Power Plant and Textile were included. The annual energy consumption of these DCs in eight sectors was around 164 million TOE. The overall SEC reduction target in the eight sectors was about 4.05% with an expected energy saving of 6.68 million TOE by the end of 2014-15.

With the completion of the PAT Cycle - I in 2015, the reported overall achievement was 8.67 million TOE, exceeding the target for cycle – I by almost 30%. The total energy saving of 8.67 million TOE is equivalent to saving of about 20 million tonnes of coal and avoided emissions of about 31 million tonnes of CO_2. In terms of monetary value, saving in energy consumption corresponds to Rs. 95,000 million.

PAT Cycle - I has witnessed an exceptional performance from all the sectors in terms of reducing their energy consumption. The DCs have made commendable efforts to achieve energy efficiency targets by adopting various improvement measures in technology, operational and maintenance practices, and application of management techniques.

Chlor Alkali sector is the one of the lowest consumers of energy in PAT Cycle - I, with an annual energy consumption of 0.88 million TOE by the DCs. The summary of the achievement by the chlor alkali sector in PAT Cycle - I is presented in Table 1.

Parameter	Units	Values
Number of DCs in the sector	nos	22
Total energy consumption of DCs in the sector	million TOE	0.88
Total energy saving target for Chlor Alkali sector in PAT Cycle - I		0.054
Total energy Savings achieved by Chlor Alkali sector in PAT Cycle - I		0.09
Energy savings achieved in excess of the target		0.036
Reduction in GHG Emissions in Cycle – I	million T CO_2	0.62
Cumulative energy savings with impact of PAT till 2030 over BAU	million TOE	2.51

Table 1: Chlor Alkali sectoral achievement in PAT Cycle – I and projections till 2030

The focus of chlor alkali sectoral report is on the energy savings resulting from PAT scheme as compared to the business as usual scenario (BAU). The report also includes the impact of PAT on GDP of the country, sector specific data analysis, process trends, sectoral benchmarking of specific energy consumption, success stories implemented in plants, and list of key technologies which can be implemented in the sector. Analysis has been presented until the year 2030.

2.0 Chlor Alkali sector in India

Chlor Alkali is considered to be one of the oldest industrial sectors, which plays a key role in supplying chemicals to other manufacturing sectors such as textiles, pulp & paper, alumina, soaps & detergents, pharma, etc. As on 2012, India constituted to 4% of global chlor alkali capacity, with installed capacity and production of 3.1 Million MTPA and 2.6 Million MTPA respectively.

The main products in the chlor alkali industry comprises of caustic soda, chlorine, hydrogen and soda ash. The manufacturing process of caustic soda is considered an energy intensive process and the recent years has witnessed the sector upgrade the technology from mercury cell technology, which consumes around 3200 kWh/MT of caustic soda, to membrane cell technology, thereby reducing the energy demands by at least 20%.

Highlights Of Chlor Alkali Industry In

SECTOR HIGHLIGHTS......

- India contributes to 4% share of global Chlor alkali capacity
- Phase out of mercury cell technology by 2012 for caustic soda production
- Adoption of latest generation energy efficient electrolysers and membranes
- Increase in electricity consumption through CPPs up to 74% in 2014-15
- Increase in demand from aluminium industry and textile industry becoming the key drivers for chlor alkali market
- India's per capita consumption of chlorine is 1.85 kgs
- Specific water consumption reduced to less than 1kL/MT caustic produced

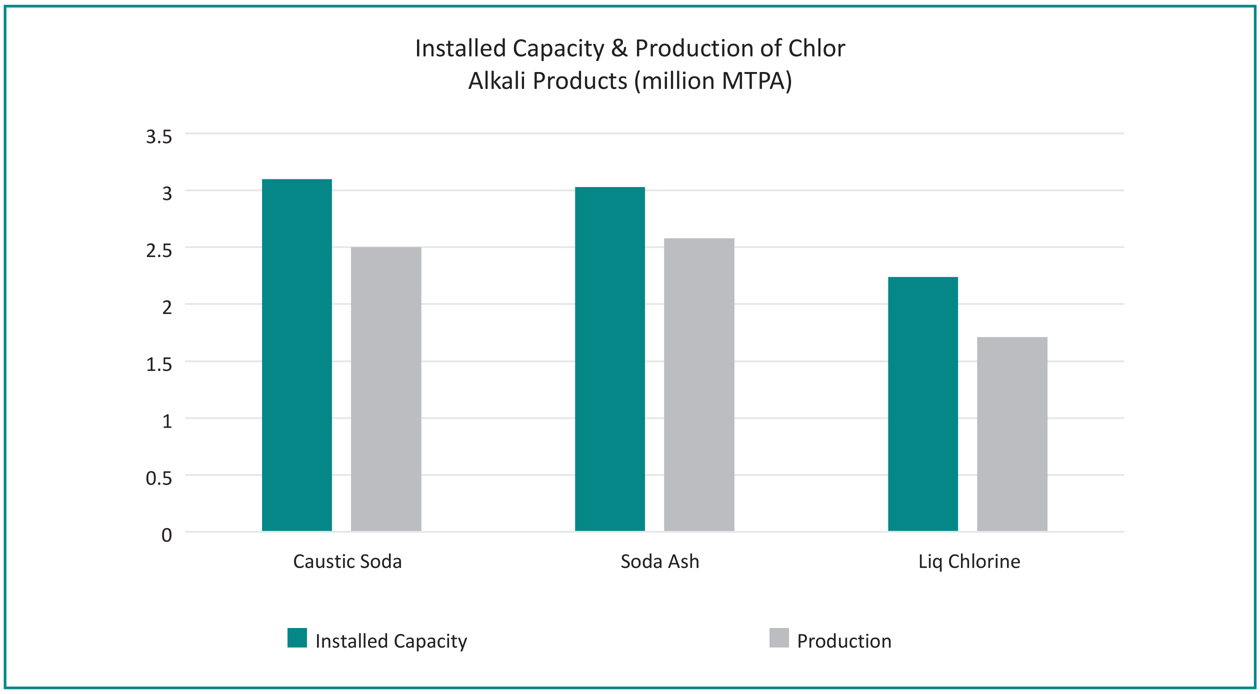


Figure 1: Installation capacity & production of alkali product as on 2015-16, Ministry of Chemicals & Fertilizers

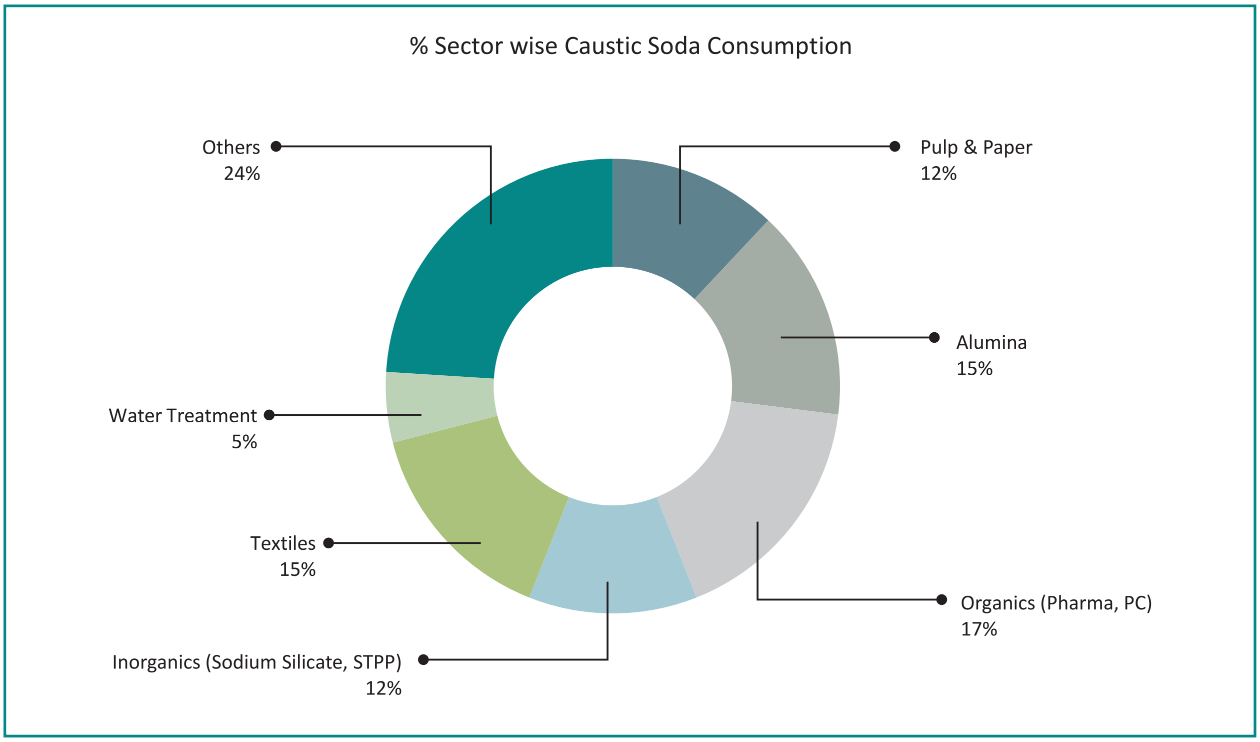


Figure 2: Sector-wise consumption of caustic soda in India

2.1 Sectoral Contribution to Country's Economic Value

Chlor alkali sector being one of the oldest industrial sectors in India and has contributed significantly to the nation's economic growth through exports, supply to various downstream companies (textile, alumina, soaps, detergents, water treatment, etc.). The increase in demand for consumer goods has played a tremendous role in contributing to the goods and services in monetary terms. The year-on-year percentage growth of caustic soda, chlorine and the corresponding equivalent production is tabulated in Table 2[1]. The projections for the production of chlor alkali products from FY15 to FY30 is estimated at a growth rate of 2.45%.

	Caustic Soda (1000' MT)	Chlorine (1000' MT)	Total Eq Production of Caustic Soda (1000' MT)	% growth
(As on 2015-16)	3102	2289	3243	-
FY 11	2334	1638	2435	4.43
FY 12	2409	1658	2511	3.10
FY 13	2376	1673	2479	-1.27
FY 14	2392	1697	2496	0.70
FY 15	2443	1720	2549	2.11
FY 20	2759	1893	2875	2.45
FY 25	3114	2142	3246	
FY 30	3515	2423	3664	

Table 2: Percentage growth of production year-on-year basis, Ministry of Chemicals & Fertilizers

The above table does not consider the equivalent production of caustic soda from hydrogen which is considered in PAT. The calculated energy intensity considers the energy consumption of both CPP and non-CPP based plants in the sector.

1 Chemical and Petrochemical statistics at a glance: 2016/ Ministry of Chemicals and Fertilizers

Financial Year	Total Energy Consumption of India	Gross Domestic Product	Energy Intensity
	million TOE	Billion USD	toe/ million USD
2008	427	1,187	360
2009	453	1,324	342
2010	512	1,657	309
Average Baseline	464	1,389	334
2015	659	2,102[2]	313
2020	1018[3]	3,018	337
2025	1211[4]	4,233	286
2030	1440[7]	5,937[6]	243

Table 3: India's energy intensity

The Energy Intensity of the sector is given in Table 4. Energy Consumption of DCs of Chlor alkali sector covered in PAT Cycle – I is 0.88 million TOE. The contribution of DCs to overall energy intensity of India's GDP is 0.19% for baseline year. The Chlor alkali sector has achieved 0.09 million TOE savings under PAT cycle – I. The contribution of this energy savings to overall energy intensity of India's GDP is 0.01% for assessment year.

Financial Year	Total Production	Total Energy Consumption*	Gross Domestic Product (GDP)	Energy Intensity
	000' MT	million TOE	Billion USD	MTOE/ million USD
Average Baseline	1992.59	0.88	1,389	0.42
2015	2891.62	1.08	2,102	0.34
2020	3731.23	1.33	3,018	0.28
2025	4814.63	1.63	4,233	0.29
2030	6212.60	2.00	5,937	0.20

Table 4: Chlor Alkali sectoral energy intensity

Chlor Alkali sector GDP intensity contribution in baseline year and assessment year was 0.19% and 0.12% respectively

2 GDP from World Bank GDP for India – Upto 2015

3 India Energy Outlook, Year 2015 – IEA

4 Estimated by calculating CAGR for 2020 and 2040 in India Energy Outlook, Year 2015 – IEA

6 GDP values calculated based on CAGR value of 7.5% till 2020 and 7% between 2020 and 2030. Same assumptions have been considered in India Energy Outlook, Year 2015 – IEA

3.0 Process, Technologies and Energy consumption trend of the sector

The primary product of the chlor alkali industry is caustic soda, with chlorine and hydrogen generated as byproducts in the ratio of 1.00:0.89:0.025. Caustic soda can be produced using either of the three electrochemical cell technologies: (1) Diaphragm cell (2) Mercury cell (3) Membrane cell. The mercury cell technology has been phased out owing to its high electricity consumption and environmental pollution.

Membrane cell

The membrane cell technology is the latest development of clean and energy efficient method of production of caustic soda.

Brine solution is fed into the anode half of the system, and chlorine is separated from the brine, wherein the electric current passed through the anode helps to produce chlorine gas. The caustic solution is dispersed along the cathode through the permeable membrane, and 30-35% caustic soda and hydrogen is exited from the cathode shell.

The power consumption of utilizing membrane cell technology is significantly lesser, i.e, 2400 – 2500 kWh/MT caustic soda, thereby implicating the increase in production for the amount of power consumed by mercury cell technology.

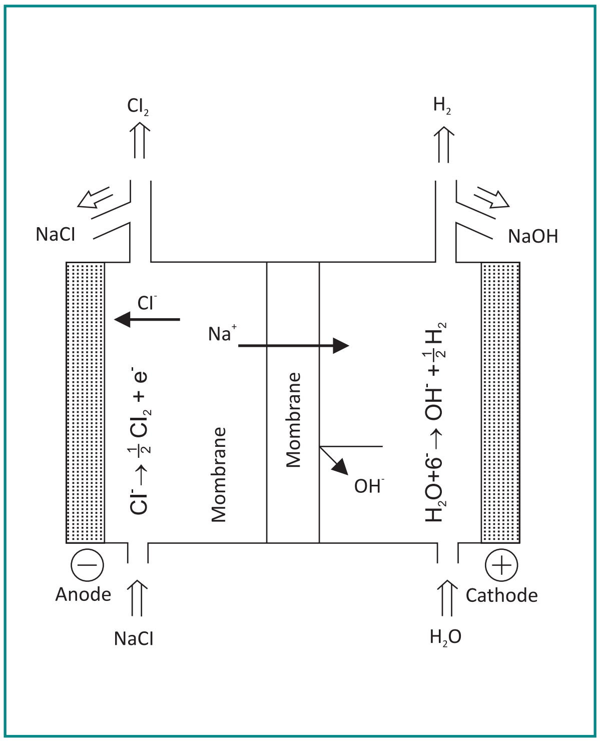


Figure 3 Schematic of membrane cell technology

The main disadvantage of this technology is the need to replace membranes at regular intervals, unless otherwise could increase the overall specific energy consumption of the production.

4.0 Methodology adopted for the project

The activities were initiated with the collection of sector specific data from Bureau of Energy Efficiency (BEE). In addition, data was also collected through secondary research. Data analysis was conducted to assess the impact of PAT Cycle – I on energy intensity in the BAU v/s PAT scenario, GDP of the country, trend analysis for energy efficiency, quantification of energy saving in terms of TOE, coal saving reduction. Feedback was also collected from DCs on benefits and the challenges experienced through the PAT scheme.

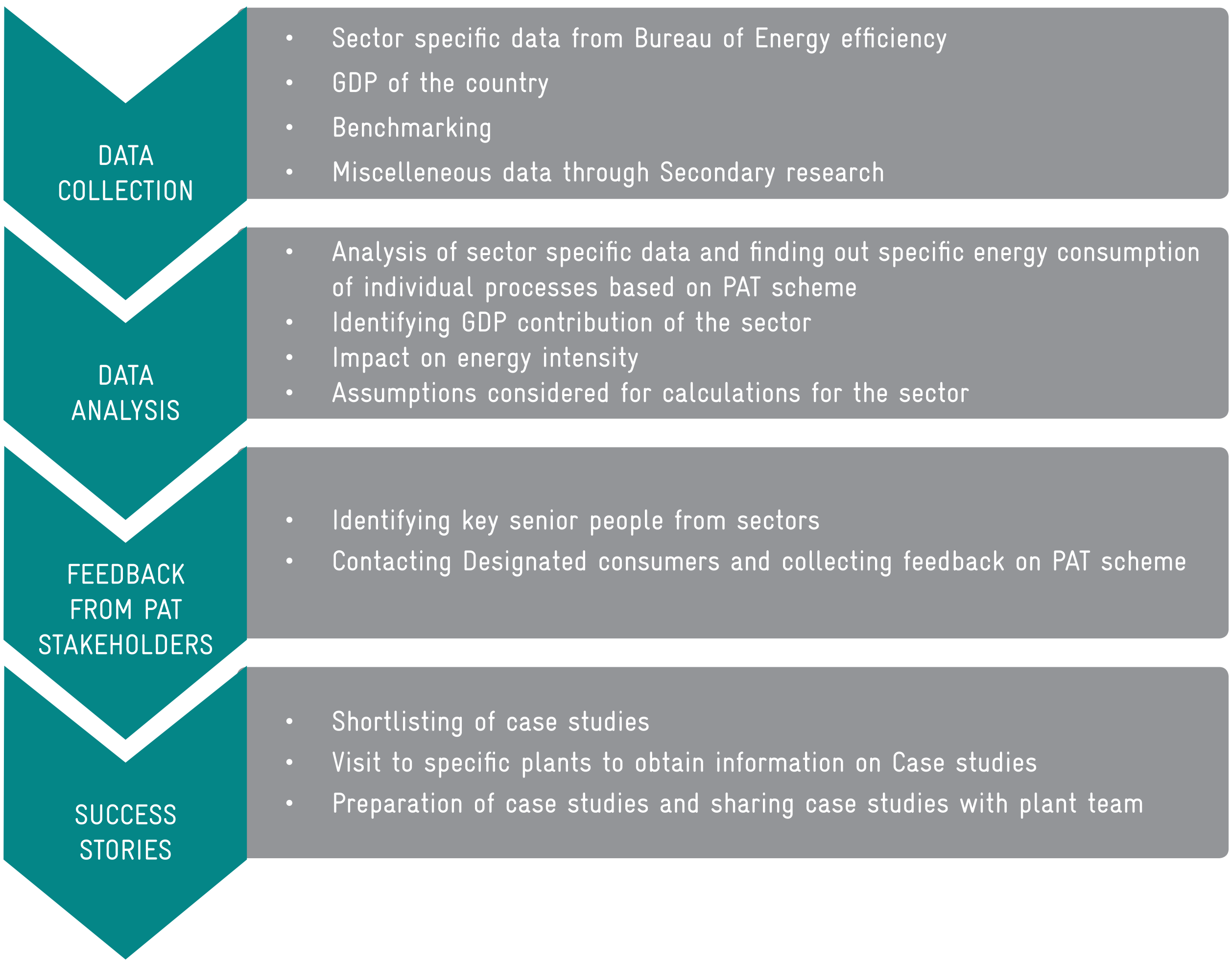


Figure 4: Methodology followed for Impact assessment of PAT Cycle - 1

5.0 PAT Cycle-I and its impact on Chlor Alkali sector

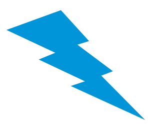
PAT is a regulatory instrument to reduce specific energy consumption (SEC) in energy intensive industries, with an associated market-based mechanism to enhance cost effectiveness through certification of excess energy savings, which could be traded. Energy Savings Certificate (ESCerts) are issued to the industries which reduces their SEC beyond the target, whereas, those who fails to achieve their target are entitled to purchase the certificate for compliance, or liable to be penalised. The platform for trading are the existing power exchanges.

PAT Cycle – I started from 2012, with its baseline from Financial years 2007 – 08 to 2009 – 10. During the 1st Cycle of PAT, the average value of specific energy consumption by the unit during baseline year i.e. 2007-08, 2008-09 & 2009-10 were taken into consideration and the specific targets were established for the plants. Under PAT scheme, those industries with a minimum energy consumption of 12,000 MTOE and above were enlisted as a Designated Consumer (DC).

A total of 22 chlor alkali plants were listed as DCs, mandated to reduce their energy consumption as per the target given to those DCs. The total reported energy consumption of these designated consumers was about 0.88 million TOE. These DCs were given target of 0.054 million TOE energy consumption reduction, which was only around 0.8% of the total national energy saving target assessed under PAT Cycle – I.

5.1 Impact of PAT Cycle-I

Chlor Alkali sector has achieved 0.09 million TOE in comparison to the target of 0.054 million TOE. This achievement has estimated GHG emission reduction of 0.62 million tonnes of CO_2 equivalent.


Energy Savings
0.093 mMTOE


0.21 million
tonnes of coal


0.62 million
tonnes of CO_2
equivalent


Savings
1.02 billion INR


Reported
Investment
3.94 billion INR

The savings are attributed to a number of measures adopted by the DCs. While some of the DCs implemented short term measures with minimal investment, others opted for medium and long-term measures requiring considerable investment. The investment figure was reported by 68% of the DCs. The emissions reduction due to PAT Cycle – I and contribution of these emissions are mentioned in Table 5. The emission reduction of fossil fuels is considered for reduction in GHG emissions.

Parameter	Value
Reduction of CO_2 emission due to implementation of PAT Cycle - I(All sectors)	31 million Tonnes of CO_2 equivalent
Reduction of CO_2 emission due to implementation of PAT Cycle - I in Chlor Alkali sector	0.62 million Tonnes of CO_2 equivalent
Contribution to CO_2 emission reduction in overall PAT Cycle-I	2%

Table 5: Reduction in CO_2 emissions from the PAT cycle

5.2 Energy Scenario at Business as usual (BAU) Vs PAT

The section describes the impact of PAT and comparison with BAU scenario. A summary of the performance of the sector and its projection for 2030 is mentioned in Table 6.

Particulars	Unit	Value
Number of plants in the sector	Nos.	22
Baseline Energy Consumption in PAT Cycle - I	million TOE	0.88
Energy reduction target for the sector	million TOE	0.054
Energy Savings achieved in PAT Cycle - I	million TOE	0.09
Reduction in GHG Emissions in Cycle – I	million T CO_2	0.62
Cumulative energy savings with impact of PAT till 2030 over BAU	million TOE	2.51

Table 6: Achievements of Chlor Alkali sector in PAT Cycle - I

The energy saving of 8.67 million TOE declared for PAT Cycle - I has been calculated based on notified production for the baseline period, whereas the actual energy saving obtained will be higher while considering the subsequent production of individual sectors for subsequent years. The methodology of calculation involves SEC consumption of individual years and the achieved energy savings till 2030.

The reduction in specific energy consumption in the baseline year from 2007 – 08, 2008 – 09 and 2009 – 10, has been calculated and considered as Business as Usual scenario (BAU). Specific energy consumption is used to project the reduction in specific energy consumption by the sector till 2030. The PAT Cycle - I witnessed an energy consumption reduction target of 6.14%.

Figure 5 & 6 in this section show specific energy consumption and energy consumption for Business as usual and impact of PAT, projected to 2030. The reduction from baseline to assessment year of PAT is the reduction in specific energy consumption for PAT Cycle – I. Since the achievement of specific energy consumption targets is considered to be achieved after PAT Cycle – II, the specific energy reduction is lesser than PAT Cycle – I. Figure 5, Figure 6, and Figure 7 show the projection till 2030 for specific energy consumption, energy consumption for the sector.

Considering the reduction in specific energy consumption during the baseline year and the assessment year, the comparison is made to analyze the energy consumption with PAT and the BAU scenario. A graphical representation of market transformation of chlor-alkali industry due to implementation of PAT scheme is shown below:

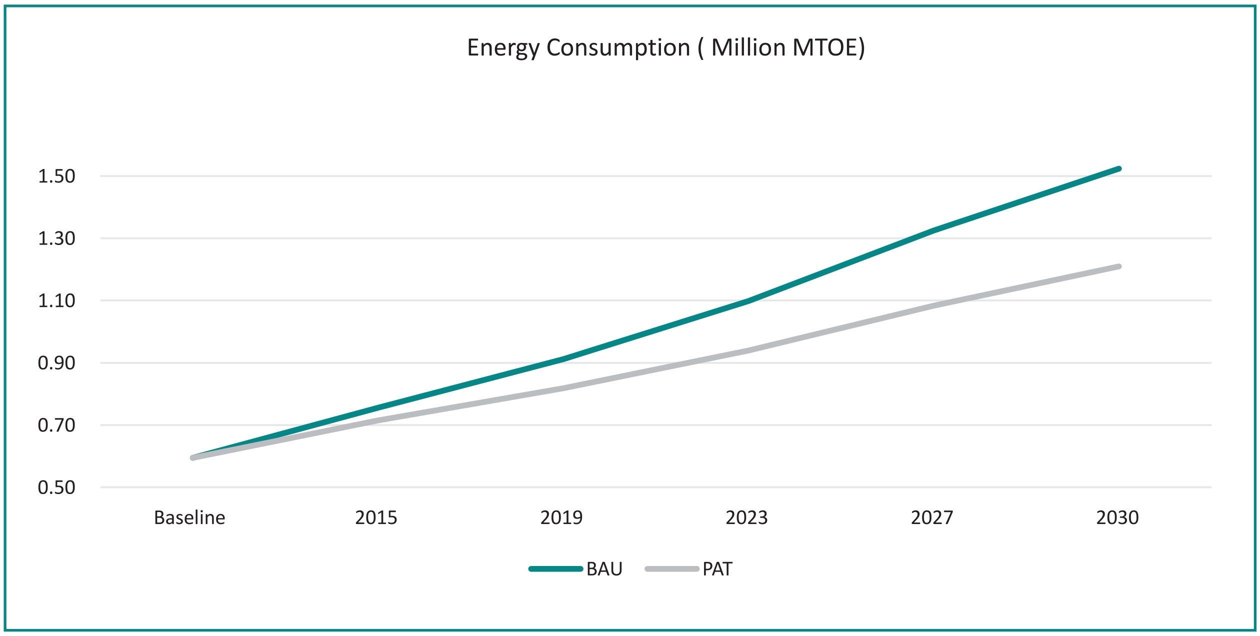


Figure 5 Energy Consumption Business as usual (BAU) vs with PAT

The actual energy consumption of the Chlor Alkali sector in baseline year was 0.88 million TOE. The figure 0.59 million TOE in baseline year (as indicated in the graph) has been taken by considering the CPP based plants equivalent to Non-CPPs, and accordingly the projected till 2030. This method of analysis provides better relativity when comparing CPP and non-CPP plants in the chlor alkali sector

1.21 million TOE energy consumption is estimated for chlor alkali sector in 2030 through the implementation of PAT scheme as compared to 1.52 million TOE energy consumption in BAU scenario

Similar comparison for the average specific energy consumption (MTOE/Product) as well as the GHG emissions for the sector is also illustrated below:

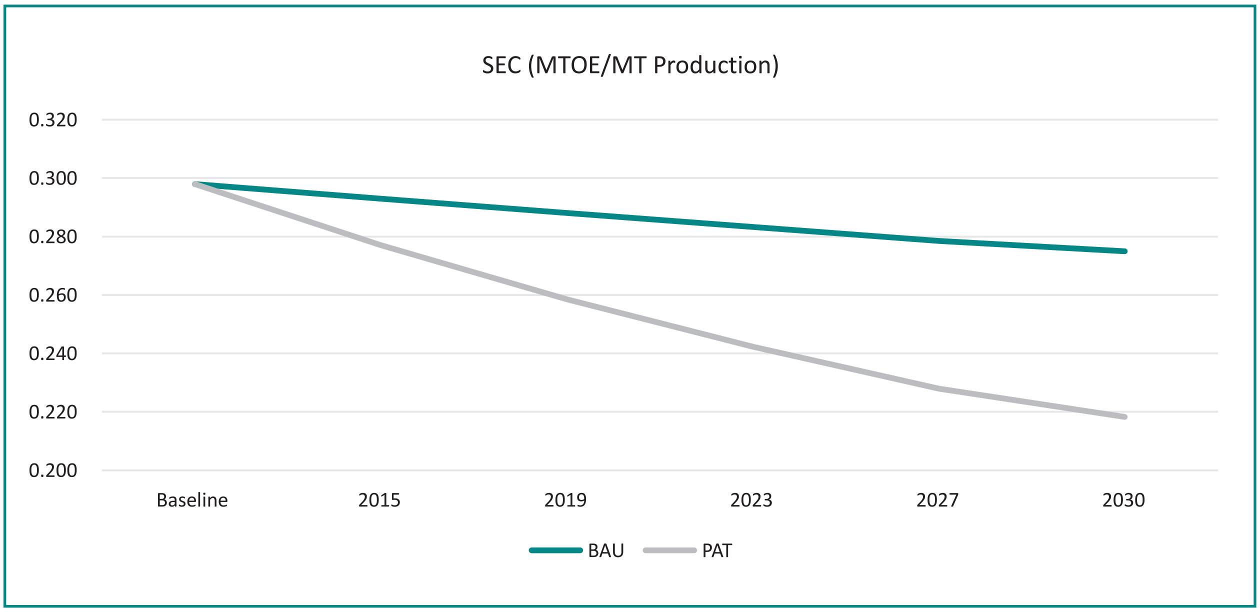


Figure 6: Specific energy consumption BAU vs PAT

It can be inferred from the graph that the implementation of the PAT scheme can improve the SEC of the sector by almost 20% when compared to the BAU of the sector. The projection also implicates that almost 2.6 million TOE of energy consumption can be reduced cumulatively till 2030.

Figure 7: A view of Chlor Alkali plant

Year	GDP	Business as usual	With PAT
	Billion USD	Energy Intensity	Energy Intensity
		TOE/million USD	TOE/million USD
Baseline	1,389	0.42	0.42
2015	2,102	0.36	0.34
2020	3,018	0.31	0.28
2025	4,233	0.28	0.24
2030	5,937	0.26	0.20

Table 7: Energy intensity with PAT and BAU for chlor alkali sector

Assumptions considered for BAU Vs PAT calculation till 2030

Specific Energy Consumption

- The SEC of the sector has been calculated by considering the total production of the sector and the total energy consumption in the sector, and hence may not represent the actual SEC of any particular sub-sector/ product/ process.

Business as usual scenario:

- The plant would have undertaken activities on energy efficiency on its own, even without the intervention of PAT scheme.
- The reduction in specific energy consumption in the baseline year from 2007 – 08, 2008 – 09 and 2009 – 10, has been calculated and the same reduction is projected till the year 2030 to get the BAU scenario.

With PAT scenario:

- The actual energy saving achieved in the PAT Cycle – I is taken for the assessment year 2014 – 15.
- For evaluating impact of PAT, all CPP based plants are considered equivalent to Non-CPP plants.
- The target for the subsequent PAT cycles is calculated based on the current trend of reduction in target between PAT Cycle – I and II.
- The target will go on decreasing in the subsequent cycles owing to the diminishing potential in the plant as they go on implementing projects on energy efficiency.
- Various breakthrough technological advancement might provide further reduction potential in the sector.

6.0 Benchmarking in Chlor Alkali Industry

As per the data published by the Ministry of Chemicals and Fertilizers in 2016, the trend of the production of caustic soda, chlorine and soda ash is illustrated in the graph below.

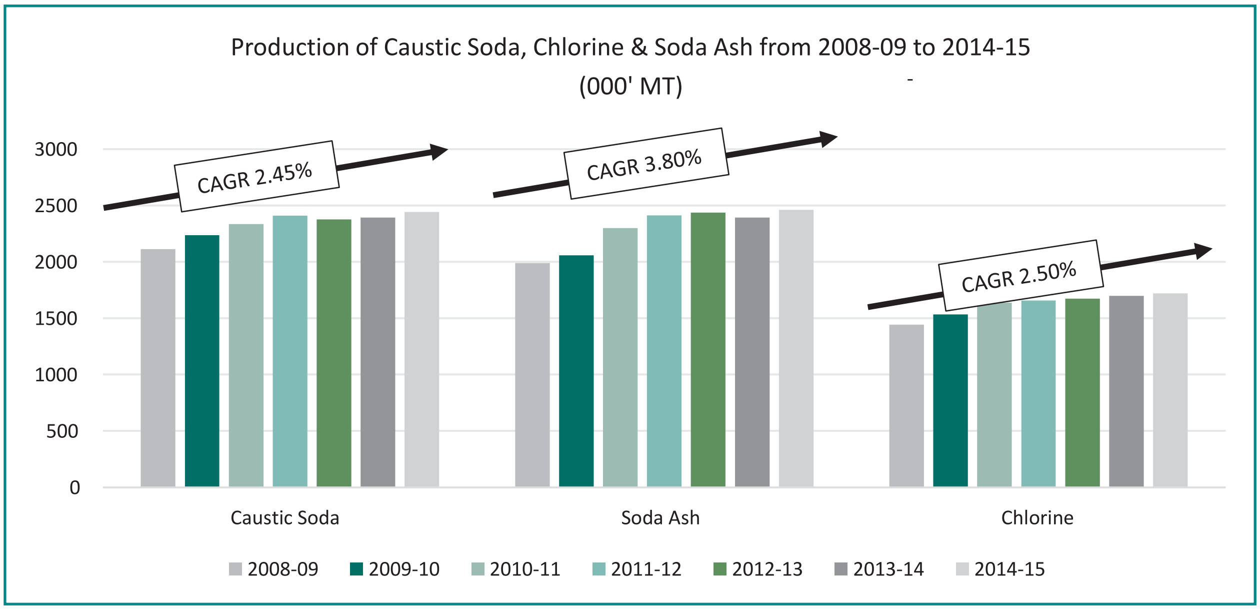


Figure 8: CAGR of production of caustic soda, chlorine and soda ash

It was observed that the overall increase in production grew at a CAGR of ~3% annually from 2008-09 to 2015-16. Similarly, the share of electrical usage from CPPs have increased, thereby reducing the dependency on grid. The below illustration indicates that the import of electricity from grid decreased by almost 35% in 2015-16 when compared to 2009-10.

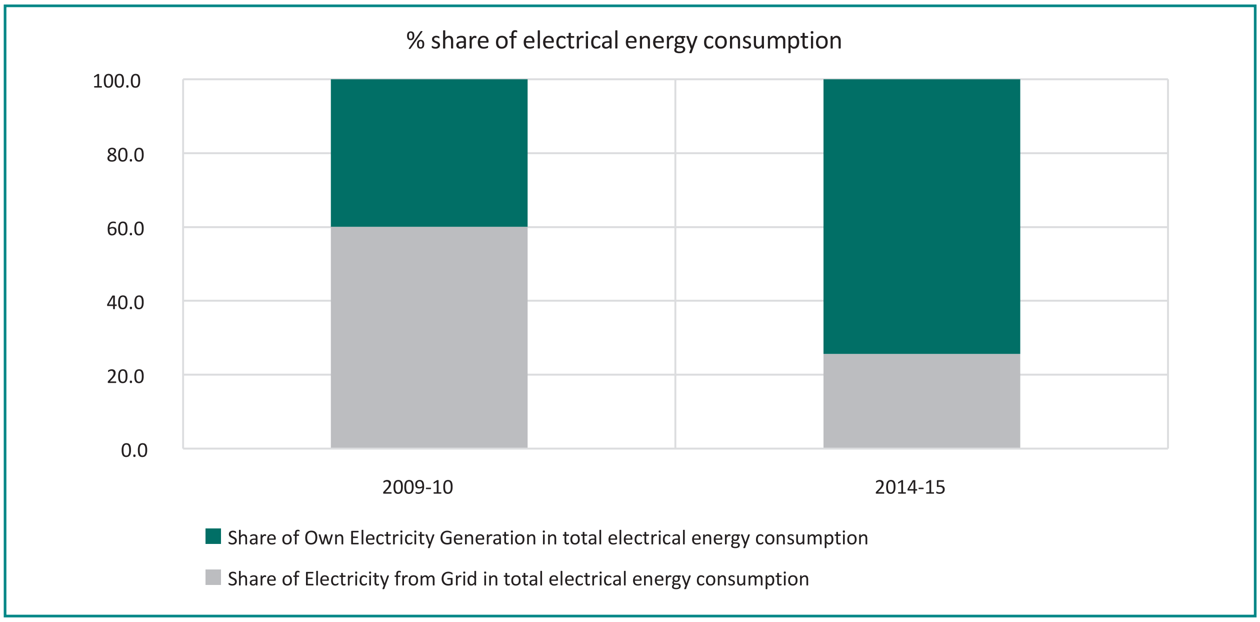


Figure 9: Percentage share of own electricity generation and grid imports

The below table indicates the best benchmarks for the chlor alkali industry[7]. Also, the comparison of various cell technology based on their respective specific energy consumption in kWh/MT caustic soda is given in the graph below:

Parameter	Units	Values
Total water requirement	m^3/MT NaOH	5.9
Process water	m^3/MT NaOH	2-2.25
Cooling water	m^3/MT NaOH	2.5-2.9
Brine purification	kWh/MT NaOH	2.5
Energy required for flaking	kWh/MT NaOH	95
Energy required for chlorine liquefaction	kWh/MT NaOH	120-200
Energy required @ 6 kA/m2 for electrolysis	kWh/MT NaOH	2,060

Table 8: Best benchmark numbers in chlor alkali sector

The chlor alkali industry has witnessed a shift in technological aspects, i.e., from the upgradation of mercury cell technology to the latest generation of membrane cell zero gap technologies. With the development of the ODC technology, it is expected to reduce the specific energy requirement of the process to as low as 1550 kWh/MT caustic soda. Comparing this technology with that of early mercury cell technology, the specific energy requirement is reduced to more than half of its predecessor technologies.

A comparison of various technologies for specific energy requirements to manufacturing caustic soda is illustrated in the figure below:

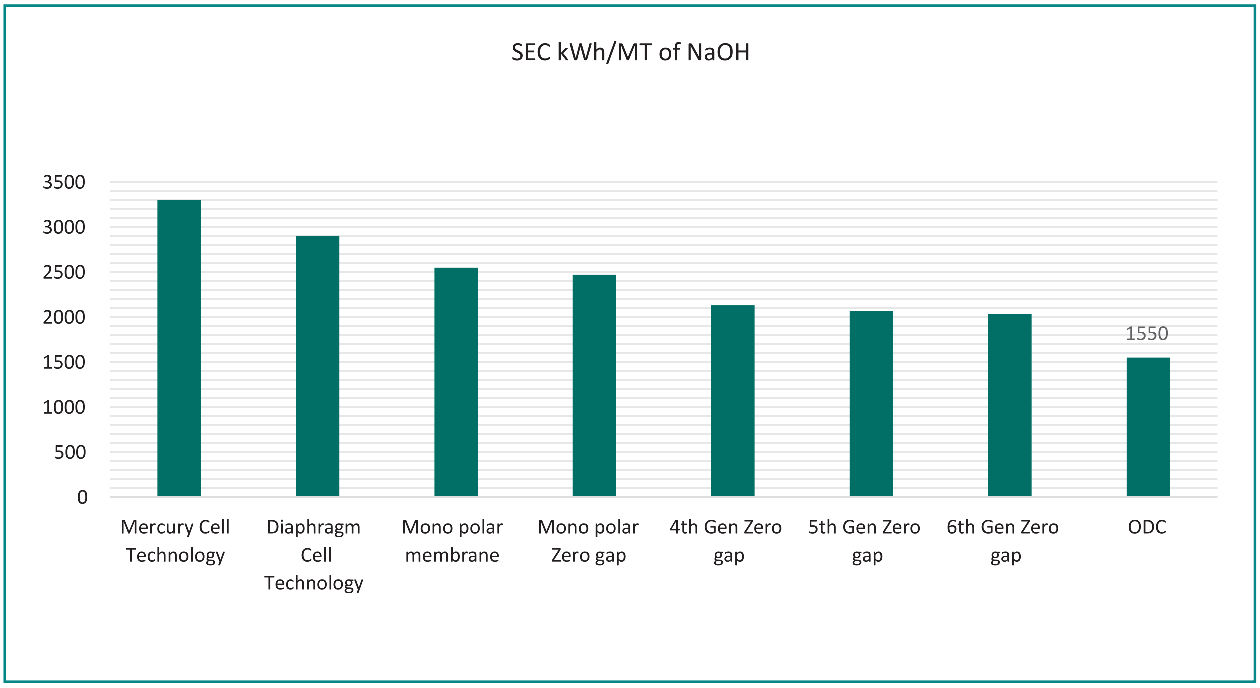


Figure 10: Benchmark of various cell technologies for NaOH production

7 Good Practices Manual – Chlor Alkali Sector/ National Productivity Council

7.0 List of major energy saving opportunities in the sector

The implementation of the PAT scheme has mandated various industrial sectors to focus more on energy efficiency and strive to reduce the overall energy consumption. With more PAT cycles rolling out for the forthcoming years, the industries look towards various energy efficient technologies in order to achieve the respective targets. The list of energy efficient technologies with the corresponding specific energy reduction and investment for implementing the technology is tabulated below. The projects are listed based on readiness level, co – benefits obtained by installing the system and based on expected payback range by implementing the project.

Technology Readiness Level (TRL):	Co-Benefits: PQCDSME	Payback Horizon (PB)
TRL 1 – Research (Basic or Advanced)	Productivity (P)	PB 1 – less than 1 year
TRL 2- Proof of concept	Quality (Q)	PB 3 – 1 year to 3 years
TRL 3- Demonstration(Pilot)	Cost(C)	PB 5 – 3 to under 5 years
TRL 4- First of a Kind	Delivery (D)	PB 8 – 5 to under 8 years
TRL 5- Fully Commercial	Safety (S)	PB 12 – 8 to under 12 years
	Moral (M)	PB >12 – over 12 years
	Ethics, Environment (E)	

S No	Technology	Co-Benefits	Readiness Level	Payback
1	Zero gap electrolyzer	P, C, E	TRL – 5	PB 12
2	Oxygen Depolarized Cathode	P, C, E	TRL – 2	PB 12
3	Low energy consumption in chlor-alkali cells using oxygen reduction electrodes	P, C, E	TRL – 5	PB 3
4	Install adaptive control system and minimize variation in feed temperature	P, C	TRL – 5	PB 5
5	Replace steam ejector with water ring vacuum pump for brine dichlorination	P, C, E	TRL – 5	PB 1
6	DSM for compressed air system	C, E	TRL – 5	PB 3
7	Install thermos-compressor and utilize flash steam from process	P, C	TRL – 5	PB 5
8	Install commercial co-generation system for chlor – alkali industry	P, C, E	TRL – 5	PB 5
9	Replace old compressors with EE compressors	C, E	TRL – 5	PB 3

Table 9: List of key technologies in the sector

8.0 Success stories – Case Studies in Chlor Alkali sector

8.1 Replacement Of Old Rectiformer's With Thyrister Based Rectiformers

Introduction

The project was implemented at DCW Limited, Sahupuram, Tamil Nadu. The main process in chloro-alkali plant is electrolysis of NaCl. The process is conducted on a brine (an aqueous solution of NaCl), in which case sodium hydroxide (lye/caustic soda), hydrogen, and chlorine results, which are commodity chemicals required by industry. In order to achieve electrolysis, direct current (DC) supply is provided to electrodes by rectifier unit. This provides the energy necessary to create or discharge the ions in the electrolyte. The electrolysis process has a high energy consumption.

There are 4 no of rectifier unit. Each rectifier unit consists of Transformer, Rectifier blocks, Control panels, DC links, and copper bus bars up to DC links.

The transformer was erected in 1959 and rectifier blocks in 1967 (02 no's) and 1973 (02 no's). The rectifier transformers served for 35 years and were reaching the end of their service. The insulation of the windings has become brittle due to ageing. The tap changer mechanisms became obsolete and poses many challenges to conduct overhauling work in old tap changer and without this mechanism the rectifier cannot be put in to service.

The rectifier blocks were diode-based rectifier, whose efficiency of the ranged from 93% to 96%, which is low. Some of the vital spares like current regulator, diverter resistances, etc., was consumed already due to failures in the past.

Description of the project

In order to improve the efficiency of operation and breakdown free operation, diode-based rectifier was replaced by thyristor-based rectifier.

AC 800PEC controller of thyristor provides high processing power with very short cycle times. It has been specially designed for power electronic applications in harsh industrial environments. Also, drive has been designed to provide highest possible EMI immunity. All peripheral devices including the thyristors' firing boards are linked via fiber optic connections directly with the main CPU. System communication is via fiber optic links only and is immune to electromagnetic interference even in high magnetic field areas.

The intelligent control logic avoids a primary under-voltage shut down by a ride through of several hundred milliseconds, basing its control on a Phase Locked Loop (PLL). This increases the uptime of the system in case of a primary

under-voltage and avoids the costly shut-downs that can result from even the smallest drop in incoming supply voltage, when conventional control systems are employed.

The efficiency for diode rectifier varies from 93% to 96% whereas thyristor-based rectifier unit has got 98 % to 98.4% depending upon load.

Hence, considering full load of 04* 18 KA and 50,000 tonnes of lye per annum at 3125 units per ton. The expected savings in energy, by replacing 4 nos. thysistor-based rectifier units are approx. (50,000 * 3125) – (50,000 * 3125 * (0.93 /0.98)) = 7,972,000 units per annum.

- Existing
  - o 04 nos of 18 kA * 315 V diode rectifier
- Replaced
  - o 04 nos of 20 kA * 345 V thyristorised high current rectifier units.

(Considering the future expansion of production, the rating of each thyristor based rectifier unit has been chosen as 20 kA * 345 V)

- Along with 04 nos of 11 kV / 570 V, 8.08 MVA Rectifier Transformer.
- Entire project finance is done on Capex model.
- The project was implemented in the year 1997.

Benefits

Parameter	Values
Energy Savings	7.97 million units per annum
MTOE equivalent savings	492 TOE
PAT benefits	Nil
Investment	Rs 90 million
Payback(months)	60 Months
GHG reduction	4000 Tons of CO_2 equivalent of GHG reduced
Replication Potential	60% of plants in the sector can opt for this technology
	Reduction in TOE anticipated for the sector is 9000 TOE
	Investment potential for implementing this project in the sector is Rs 1500 million

Additional Benefits

1. Quick start-up and stoppage
2. Very minimum maintenance
3. Flexibility of operation to cut off any number of cells
4. Common control desk for load adjustments of all rectifiers
5. Elimination of starting surges resulting in stable operation

Challenges faced during Implementation

- Shutdown required
- Specific problems faced by plant
- Change in operational practices

Contact details for the project	
Plant Name	DCW Limited
Person to be contacted	T Chandru
Designation	Senior General Manager
Contact number	04639-285439
Email – ID	tchandru@shpm.dcwltd.com
Address for communication	Sahupuram P.O. 628229 , Thoothukudi District, Tamilnadu

8.2 Install a Back-Pressure steam turbine to generate steam and power

Introduction

The project was implemented at DCW Limited, Sahupuram, Tamil Nadu. Plant has 2 x 25 MW Turbine equipped with 125 x 2 MT/hr AFBC Boiler. The steam generated from boiler is fed to turbine for electricity generation and steam extracted from turbine is used for process requirement. Plant require steam for various process like Caustic Soda (NaOH), PVC Plant, beneficiated ilmenite, and synthetic iron oxide manufacturing facility.

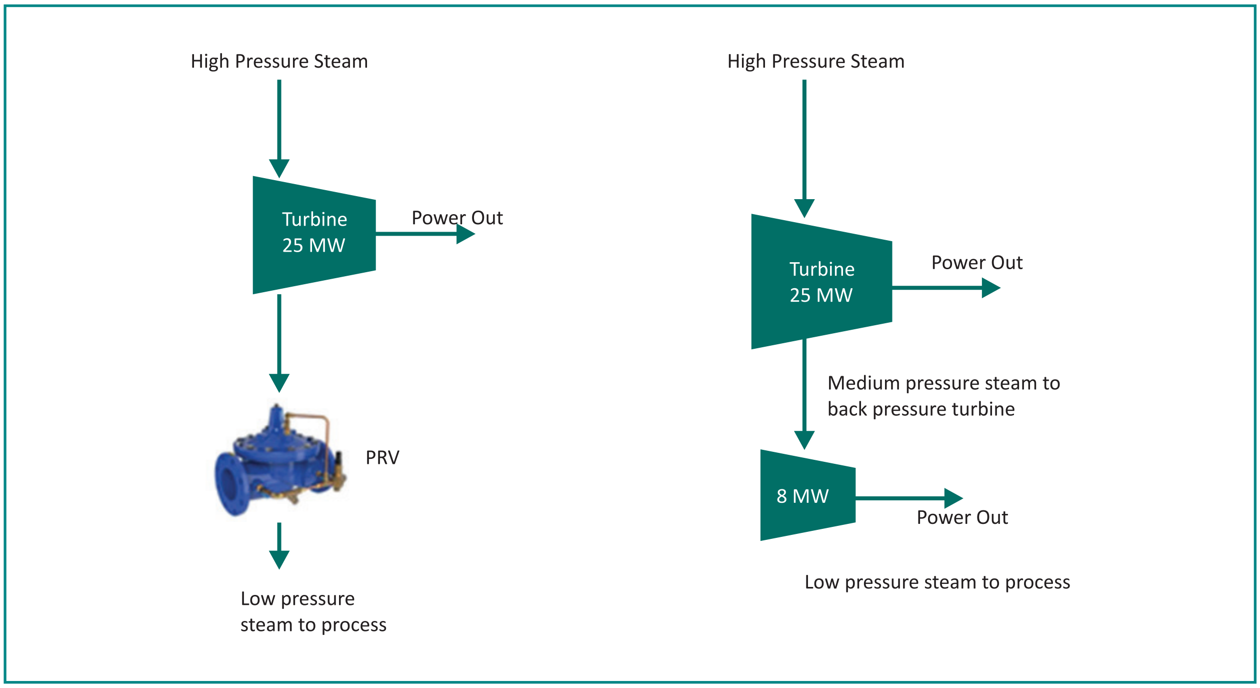
But due to limitations of steam requirement for the iron oxide plant, the installed capacity of 2 x 25 MW could not be attained. Therefore, to overcome the challenges of effective steam utilization, the plant team installed a bottom up cycle steam turbine of 8.27 MW capacity to convert all low-pressure steam to power. The turbine was commissioned on 2010 incurring an investment of Rs. 20 Crores, without the requirement for additional boilers. This has absolved issues pertaining to both maintaining power consumption and simultaneously catering process steam requirements.

Description of the project

The back-pressure injection turbine utilizes Medium pressure steam and low pressure steam in a single turbine. MP Steam of 12.29 Bar @ 285^{0}C and LP steam of 4.61 Bar @ 200^{0}C is injected into the steam turbine.

This then-newly commissioned turbine of 8.27 MW is full consdensing turbine, thereby maximizing power generation with MP and LP steams, reaching operating efficiencies as high as 97%. This system is also equipped with the latest protection and control system to operate remotely.

Before	After
The process steam pressure is regulated by operating the main turbine(25MW) under pressure control mode	The process steam pressure is supplied by extraction of back pressure injection turbine which utilizes extracted steam from main turbine of 25 MW.
Due to variation in process steam requirement , the installed capacity of 2 x 25 MW could not be attained	Able to achive the installed capacity of 2 x 25 MW and also achieved 8 MW additional generation from Back Pressure Turbine



Benefits

- Increased plant utilization with no additional infrastructure
- Reduction of Auxiliary Power Consumption to 8.2%
- Plant heat rate reduced by 12% from 3607 kCal/kWh
- Reduced overhead costs due to increased plant utilization factor

Parameters	Value
Energy savings	Rs 156.8 million
MTOE equivalent savings	17640 MTOE per annum
Investment	Rs 200 million
Payback(months)	16 Months
GHG reduction	1,50,000 tons of CO_2 equivalent of GHG reduced
Replication Potential	30 % of plants in the sector can opt for this technology
	Reduction in TOE anticipated for the sector is 300000 TOE
	Investment potential for implementing this project in the sector will be around Rs 3500 million

Additional Benefits

1. Direct coupling of generator without gear box reduction; improving transmission efficiency.
2. STGs are equipped with latest microprocessor base multifunction protection relays with redundancy for important fault to safeguard STGs from external fault.
3. Turbine operated by pressure control mode making best utilization of surplus steam for power generation on continuous basis.

Contact details for the project	
Plant Name	DCW Limited
Person to be contacted	T Chandru
Designation	Senior General Manager
Contact number	04639-285439
Email – ID	tchandru@shpm.dcwltd.com
Address for communication	Sahupuram P.O. 628229 , Thoothukudi District , Tamilnadu

9.0 List of Technology suppliers

S No	Company Name	Technology	Website link
1	Asahi Technologies	Manufacturer of inorganic chemicals and other downstream chemical products such as propylene oxides and glycols	http://www.asahi-kasei.co.jp/asahi/en/
2	Dupont India	Dupont Teflon, Dupont Tyvek, Titanium technologies, Sorona, Sentry glass, Kevlar, Surlyn, Nomex, Tynex filaments	http://www.dupont.co.in/
3	Hind Rectifiers Ltd	Power Semiconductor Devices, Rectifier Assemblies, Industrial Rectifier System, Power Electronic Equipment	http://www.hirect.com/
4	Uhde India	EPC for implementation of chemical and industrial plants	http://www.tkisindia.com/
5	Triveni Engineering & Industries Limited	Manufacturers of back pressure turbines	https://www.trivenigroup.com/
6	ABB	Manufacturer of electrical equipment such as motors, VFDs, IGBT based rectiformers, etc.	https://www.abb.com/

Table 10: List of key technology suppliers in Chlor Alkali sector

Abbreviations

Bureau of Energy Efficiency

Ministry of Power, Government of India
4th Floor, Sewa Bhawan, R. K. Puram, New Delhi – 110066 (INDIA)
T: +91 11 26766700 I F: +91 11 26178352
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