सत्यमेव जयते
Ministry of Power
Government of India

Enhancing Energy Efficiency

Through

Industry Partnership

(Outcome & Way Forward)

Perform Achieve & Trade

September 2018

BUREAU OF ENERGY EFFICIENCY

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DEUTSCHE ZUSAMMENARBEIT

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विद्युत एवं नवीन और नवीकरणीय ऊर्जा
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भारत सरकार
Minister of State (Independent Charge)
for Power and New & Renewable Energy
Government of India

सत्यमेव जयते

Message

Energy is the key driver of economic growth and development. We need to and are developing at a rapid pace and, therefore, the energy demand is going to increase in the coming years. At the same time, we are conscious of the need to ensure that we leave behind a healthy planet for our succeeding generations, and therefore, we are also determined to reduce the energy intensity of our economy.

Energy Efficiency can contribute significantly to help meet the commitments made by India under the Nationally Determined Contributions where India has agreed to reduce its emission intensity by 33-35% by 2030 from 2005 levels. The potential for enhancing energy efficiency in energy intensive sectors is enormous. Hence, the Perform, Achieve and Trade (PAT) scheme, which is the flagship programme under the National Mission for Enhanced Energy Efficiency, was launched to reduce specific energy consumption covering 478 energy intensive units in eight industrial sectors.

The Outcome and Evaluation Study for the first PAT Cycle reveals that the scheme has had a tremendous impact and has exceeded its allocated target by around 30% to achieve a reduction of 8.67 million tonnes of oil equivalent (MTOE). It is also heartening to learn that this has resulted in emission reduction of 31 million tonnes of CO_2, savings of Rs. 95 billion and encouraged investment of around Rs. 261 billion. It has also led to creation of a pool of professionals in the field of energy efficiency and has fostered a new ethos for promoting large scale adoption of energy efficient technologies and practices. Some new sectors have been added subsequently and currently as many as 846 units from 13 such sectors are under this scheme.

I would like to congratulate all the participating industries for making this initiative a grand success. I am confident that you will continue to cooperate with all stakeholders in contributing to meet our National commitments on climate change in future too.

(R. K. Singh)

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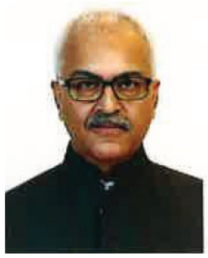
September 14, 2018



Message

Energy is the primary engine of growth and efficient use of energy is the cornerstone of sustainable development. As the manifestation of the global climate shift is everywhere and such a shift is attributed to the use or rather misuse of energy resources, efficient use of energy is not a choice but a necessity for the very sustainability of our planet.

Ministry of Power and Bureau of Energy Efficiency have taken significant steps for conserving energy resources through its various flagship programmes such as Perform, Achieve and Trade (PAT, Standards and Labelling (S&L), Energy Conservation Building Code (ECBC), Demand Side Management etc. which cover industries, appliances, buildings, agriculture and municipal bodies respectively.

After the tremendous success of first cycle of PAT scheme, a need was felt to evaluate the outcome of the scheme in terms of energy savings achieved and other impacts across the sectors to understand the performance better. It gives me immense pleasure to inform that PAT cycle that ended in 2015-16 has resulted in mitigating India's carbon emissions significantly and has contributed towards sustained economic development.

This report provides comprehensive information about various sectors including their current energy consumption, projections, greenhouse gas emission reductions, global and national bench-marking, major energy saving opportunities and success stories. The report has been prepared on the basis of inputs received from industries and in consultation with associations and other major stakeholders.

I congratulate the entire team of officials from Ministry of Power, Bureau of Energy Efficiency and partner organisations like GIZ and representatives from various Industries.

With best wishes.

14/9/18

(A.K. Bhalla)

अपर सचिव
ADDITIONAL SECRETARY

भारत सरकार
GOVERNMENT OF INDIA
विद्युत मंत्रालय
MINISTRY OF POWER
श्रम शक्ति भवन, रफी मार्ग
SHRAM SHAKTI BHAWAN, RAFI MARG
नई दिल्ली - 110001
NEW DELHI - 110001

Message

In our times of global uncertainty, one thing is certain that the world needs energy in increasing quantities to support economic and social progress, to build a better quality of life, particularly in developing countries like India. Providing this energy around the globe also comes with responsibility and commitment to use our resources efficiently. It's our responsibility to protect both people and the environment in larger interest of the nation and the world, pursuing a growth path that leads to sustainable development.

I am happy to share that Bureau of Energy Efficiency (BEE), under Ministry of Power, has been the driving force behind the implementation of energy conservation measures across various sectors of India and thus contributing significantly to mitigating carbon emissions.

Industry is the one of the main energy intensive sector which contributes primarily to the economic development, thus their action towards improving energy efficiency plays an important role in reducing energy intensity of the country. The Perform, Achieve and Trade (PAT) Scheme has demonstrated substantial energy savings benefits in eight key sectors of the industry.

BEE along with Industrial units, Associations and other key stakeholders have contributed tremendously to the success of the scheme and I hope the same will continue so that India becomes an efficient, progressive and low carbon economy.

This report captures the efforts of the industries that have contributed to the success of the scheme. It also provides projections, success stories and recommendations for further enhancing the efficiency levels which would be of great use for future course of the scheme.

I congratulate all the designated consumers for their exemplary efforts in enhancing energy efficiency and for spreading the message of energy conservation. I further congratulate BEE and GiZ for the effective execution of this study which will provide a valuable analysis for all the stakeholders.

With Best Wishes

(S. N. Sahai)

RIGHT TO INFORMATION

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सत्यमेव जयते

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MESSAGE

Nature has its own way of balancing the human autocratic act of utilizing the fossil fuel resources. "Better late than never" human being are now doing every bit to ensure the conservation of natural resources and utilizing them efficiently. In this regard, Ministry of Power has entrusted the Bureau of Energy Efficiency (BEE) with implementation of the Energy Conservation Act. 2001. BEE in turn has been shouldering various programs/scheme and Perform Achieve and Trade scheme has been one of them.

I am glad to see that BEE has come up with a compendium in partnership with GIZ that highlights outcomes, achievements, best practices resulting from the efforts put in during last 7-8 years and the way forward.

This report has been able to showcase that our industries have not only lead their respective sectors but even gone ahead to attain best by deploying state of the art technologies. The summary has also projections complying with the NDC commitment till 2030.

I congratulate all the designated consumers towards their achievements and wish them best of wishes for future endeavour. I would request them to motivate others to accelerate their efforts towards national cause of energy efficiency.

(Raj Pal)

RIGHT TO INFORMATION

Dr. Winfried Damm

Head of Energy, GIZ India

In this era of economic liberation, industrialization has been conceived as the key to better living. Industrialization not only involves technological innovations, it also involves economic and social transformation of the human society. However, with industrialization comes opportunities as well as challenges. The challenges include coping with higher temperatures, more extreme weather conditions, changing human life styles and changing philosophies. Due to these challenges, it becomes essential that industrialization considers climate change and its consequences.

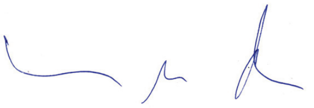
Germany has been playing a very active role in not only addressing these issues pertaining to its own land, but also supporting the other countries to move towards sustainable living with lesser carbon footprints. Germany has been supporting India in various fields since last 60 years, with an aim of 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 analysis the outcome of PAT scheme in multidimensional ways and forecasts the future savings. Separate booklets indicating sector wise analysis have been made along with showcasing innovative case studies having high replication potential.

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 and widening of this scheme across sectors including SME 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.

I congratulate Sh. Abhay Bakre, and the entire PAT team contributing to the success of this scheme.



Dr. Winfried Damm

अभय बाकरे, आईआरएसईई
महानिदेशक
ABHAY BAKRE, IRSEE
Director General

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

सत्यमेव जयते

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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10	Shri N. Sankar	Director (Generation)	TANGEDCO
11	Shri Praful Pathak	Reg. Manager	MSEB

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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, sustainable agricultural, enhancing energy efficiency, ecosystems, Green India, and strategic knowledge of climate change. 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 6.686 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 adopt various measures, to improve their technology, operational and maintenance practices, and by applying management techniques in order to achieve their target.

These savings from PAT cycle-I has been projected till the years 2030, by taking suitable assumptions as applicable. The expected cumulative energy savings from the eight sectors under PAT cycle-I, till the year 2030 and brief achievement of PAT is mentioned in the Table 1.

Parameter	Units	Values
Number of DCs in the sector	nos	478
Total energy consumption of DCs in the sector	million TOE	164.97
Total energy saving target for DCs in PAT Cycle I		6.68
Total energy savings achieved in PAT Cycle I		8.67
Avoided emissions in PAT Cycle – I	million T CO_2 equivalent	31
Estimated Cumulative energy savings with impact of PAT till 2030 over BAU[1]	million TOE	165.23

Table 1: Achievement in PAT Cycle I and projections till 2030

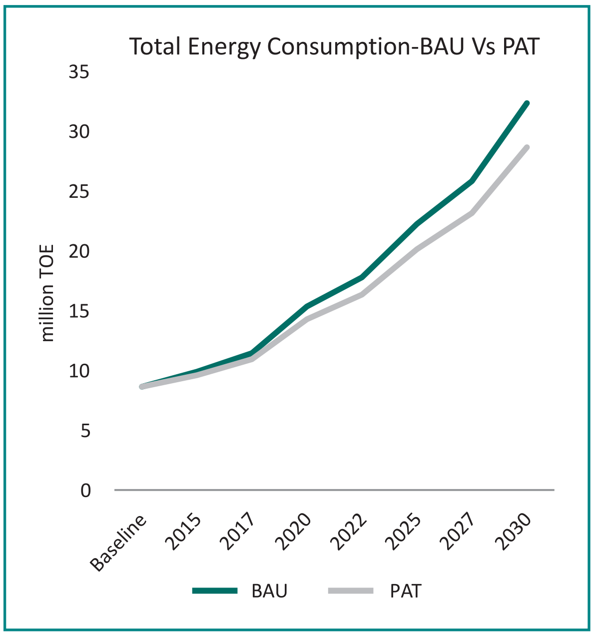
The energy saving in PAT cycle-I is equivalent to:

31 million home's energy use for one year

13 million cars taken off the road for 1 year

Aluminium

The Indian Aluminium sector contributes to 3% of global Aluminium production capacity. With a minimum energy consumption threshold of 7500 TOE, 10 Aluminium plants in India were notified as Designated Consumers under PAT cycle-I. Against a total saving target of 0.456 million TOE, the sector achieved 0.730 million TOE of energy savings, thereby saving 3.10 million tonnes of CO_2. The energy consumption till the year 2030, under scenarios with PAT and business as usual, has been projected for this sector as shown below:

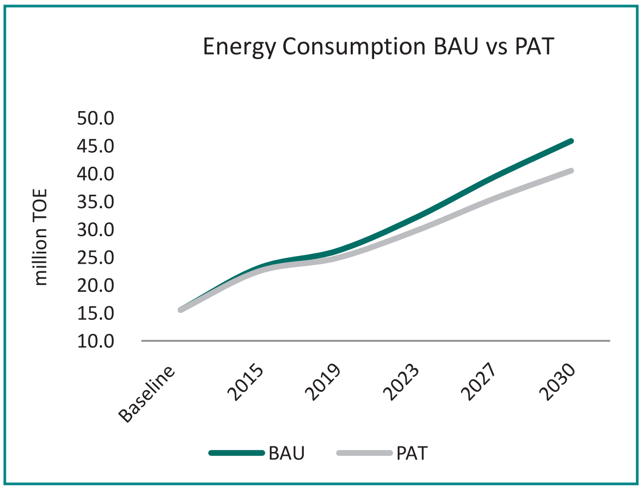


Through subsequent PAT cycles by 2030 the cumulative energy savings possible in Aluminium Sector is 27.89 million TOE

1 Difference of energy consumption between PAT and Business as Usual scenario (BAU)
2 Difference of GHG reductions between PAT and Business as Usual scenario (BAU)

Cement

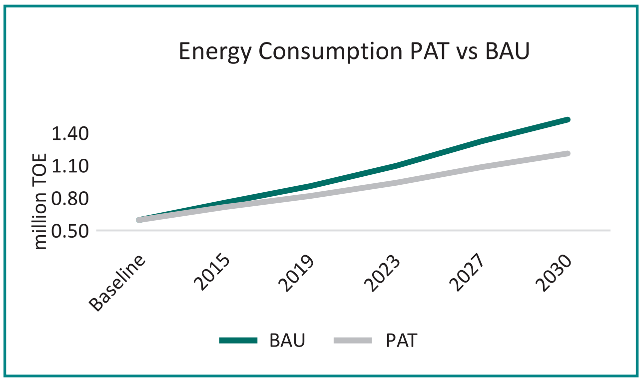
India is the second largest producer of cement in the world. With a minimum energy consumption threshold of 30,000 TOE, 85 Cement plants in India were notified as Designated Consumers under PAT cycle-I. Against a total saving target of 0.815 million TOE, the sector achieved 1.480 million TOE of energy savings, thereby saving 4.34 million tonnes of CO_2. The energy consumption till the year 2030, under scenarios with PAT and business as usual, has been projected for this sector as shown below:



Through subsequent PAT cycles by 2030 the cumulative energy savings possible in Cement Sector is 34.46 million TOE

Chlor-Alkali

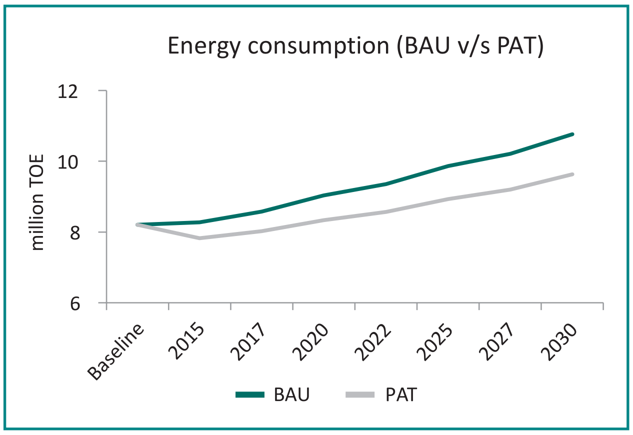
India contributes to 4% share of global Chlor alkali capacity. With a minimum energy consumption threshold of 12,000 TOE, 22 Chlor-Alkali plants in India were notified as Designated Consumers under PAT cycle-I. Against a total saving target of 0.054 million TOE, the sector achieved 0.093 million TOE of energy savings, thereby saving 0.62 million tonnes of CO_2. The energy consumption till the year 2030, under scenarios with PAT and business as usual, has been projected for this sector as shown below:



Through subsequent PAT cycles by 2030 the cumulative energy savings possible in Chlor Alkali Sector is 2.51 million TOE

Fertilizer

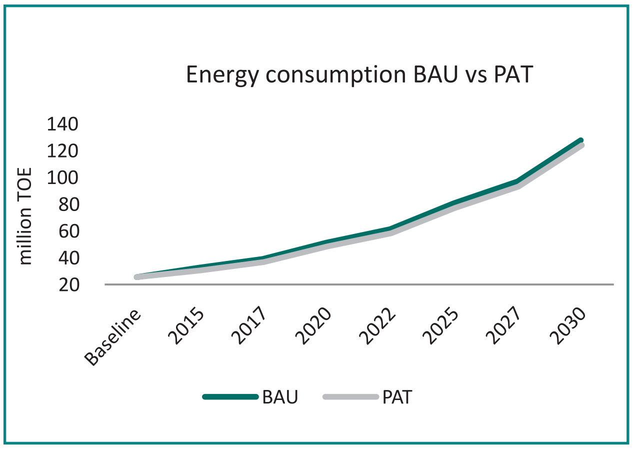
India contributes to 16.81% share of global Fertilizer production. With a minimum energy consumption threshold of 30,000 TOE, 29 Fertilizer plants in India were notified as Designated Consumers under PAT cycle-I. Against a total saving target of 0.477 million TOE, the sector achieved 0.78 million TOE of energy savings, thereby saving 0.93 million tonnes of CO_2. The energy consumption till the year 2030, under scenarios with PAT and business as usual, has been projected for this sector as shown below:

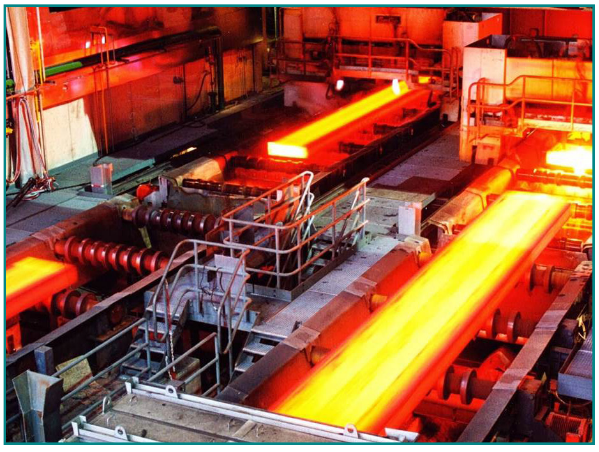


Through subsequent PAT cycles by 2030 the cumulative energy savings possible in Fertilizer Sector is 12.95 million TOE

Iron and Steel

India is the third largest manufacturer of steel in the world. With a minimum energy consumption threshold of 30,000 TOE, 67 iron and Steel plants in India were notified as Designated Consumers under PAT cycle-I. Against a total saving target of 1.486 million TOE, the sector achieved 2.10 million TOE of energy savings, thereby saving 6.51 million tonnes of CO_2. The energy consumption till the year 2030, under scenarios with PAT and business as usual, has been projected for this sector as shown below:

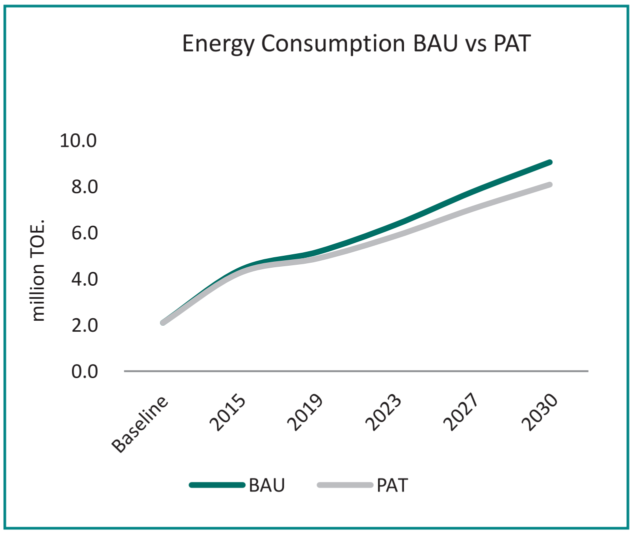




Through subsequent PAT cycles by 2030 the cumulative energy savings possible in Iron and Steel sector is 29.88 million TOE

Pulp and Paper

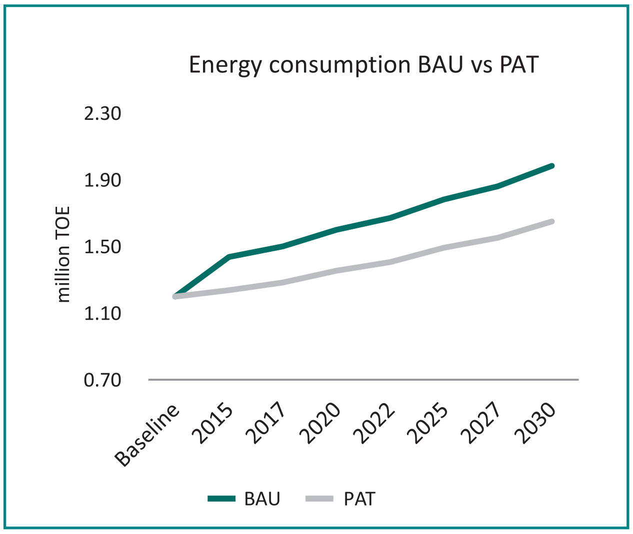
Indian Paper industry accounts for 3.7% of world's paper production. With a minimum energy consumption threshold of 30,000 TOE, 31 pulp and paper plants in India were notified as Designated Consumers under PAT cycle-I. Against a total saving target of 0.119 million TOE, the sector achieved 0.289 million TOE of energy savings, thereby saving 1.24 million tonnes of CO_2. The energy consumption till the year 2030, under scenarios with PAT and business as usual, has been projected for this sector as shown below:



Through subsequent PAT cycles by 2030 the cumulative energy savings possible in Paper Sector is 7.81 million TOE

Textile

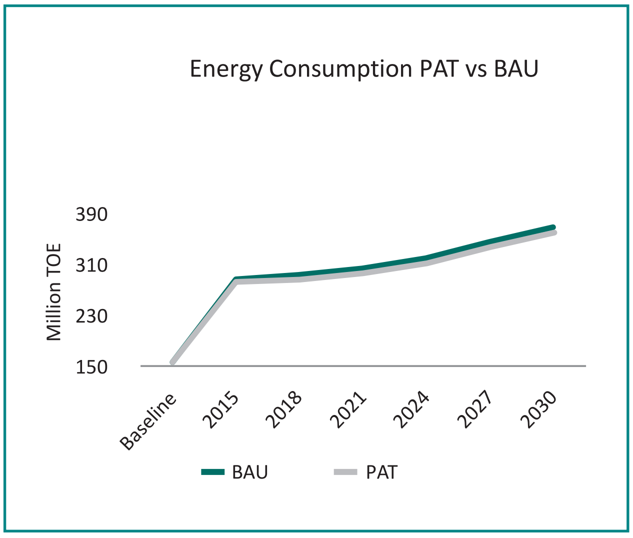
India is the third largest exporter of textiles in the world. With a minimum energy consumption threshold of 3,000 TOE, 90 textile plants in India were notified as Designated Consumers under PAT cycle-I. Against a total saving target of 0.066 million TOE, the sector achieved 0.129 million TOE of energy savings, thereby saving 0.62 million tonnes of CO_2. The energy consumption till the year 2030, under scenarios with PAT and business as usual, has been projected for this sector as shown below:



Through subsequent PAT cycles by 2030 the annual energy savings possible in Textile Sector is 4.28 million TOE

Thermal Power Plants

India is ranked 5th globally, in overall power generation capacity and 3rd in overall generation. With a minimum energy consumption threshold of 30,000 TOE, 144 Thermal Power Plants in India were notified as Designated Consumers under PAT cycle-I. Against a total saving target of 3.21 million TOE, the sector achieved 3.06 million TOE of energy savings, thereby saving 13.64 million tonnes of CO_2. However, the achievement of 3.06 million TOE relates to only 120 DCs who carried out the Monitoring & Verification (M&V) exercise and submitted the same to BEE. The target of these 120 DCs corresponds to 2.58 million TOE. The energy consumption till the year 2030, under scenarios with PAT and business as usual, has been projected for this sector as shown below:



Through subsequent PAT cycles by 2030 the cumulative energy savings possible in Thermal power plant Sector is 45.45 million TOE

2.0 Indian Energy scenario

India's primary energy consumption is 3rd largest[5] in the world after China and USA, and is growing at a CAGR of 5.3% over the past decade. About 85% of energy demands are met by coal and oil in the country. While natural gas and hydro power has experienced a gradual decline, India's share of renewable energy is pacing at a CAGR of 17% annually from FY 2007 till 2017. The year 2017 has witnessed 4.35% increase in overall energy consumption in India, while the global energy requirements increased by 1.91%.

2.1 India's primary energy mix

India's mix of primary energy consumption in 2017 was 753 million TOE, as shown in Figure 1. India's net import of fuel is 354.3 million TOE of primary energy, which is 47% of energy consumption due to primary sources. IEA has estimated the primary energy consumption of India to be 1440 million TOE by 2030. The estimated energy mix for 2030 is mentioned in the Figure 2.

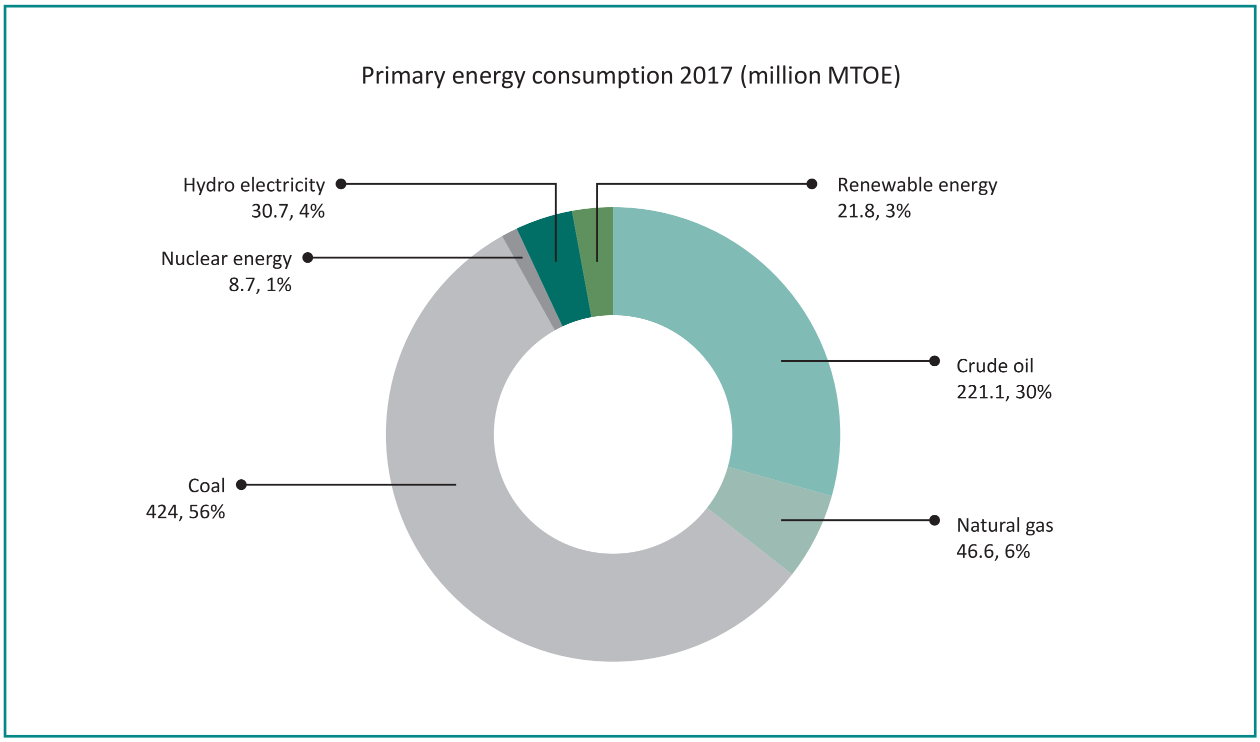


Figure 1: Consumption of Primary energy sources[1] 2017

5 BP statistical review – June 2018

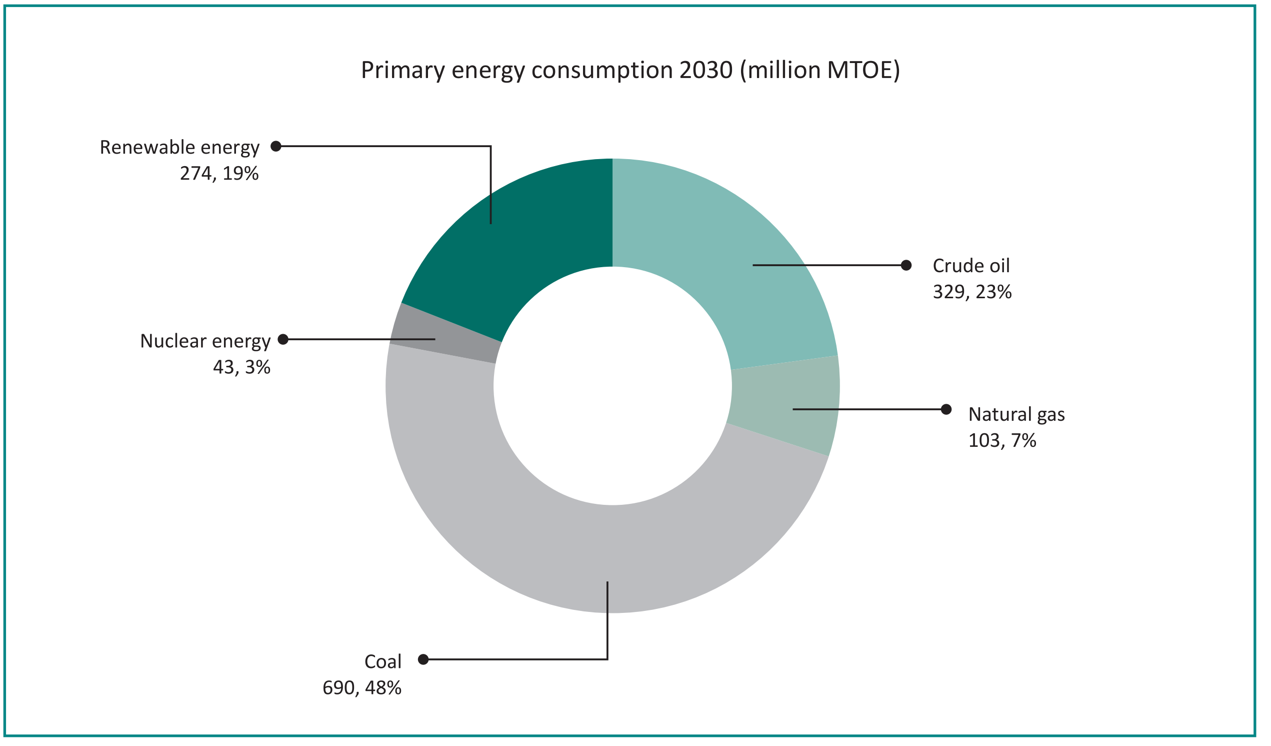


Figure 2: Primary energy consumption 2030

In 2030 renewable energy share is estimated to be 274 million TOE, which would be 19% of the total energy mix compared to 3% in 2017. Correspondingly in 2030, nuclear energy share is expected to be 3% in comparison to current share of 1.16%. Overall in 2030 dependency on imported coal is expected to reduce due to overall increase in energy efficiency. The share of hydroelectric energy on overall consumption is estimated as 1.53% and the current contribution is 4%.

In IEA estimate of 2030 energy mix hydroelectric power has been considered under renewable energy whereas in BP statistical review, 2017, hydroelectric power is not considered as renewable energy.[6]

2.2 Electricity generation in India

India's energy consumption increased from 441 million TOE in 2000 to around 753 million TOE in 2017. India's energy consumption is projected to increase to 1440 million TOE[7] by 2030. This trend is central to India's developmental goals, considering industrial, infrastructural, enhanced modes of transportation and meeting the primary objective of providing electricity for all.

6 Key data in this section has been taken from BP statistical review and calculations have been made accordingly.
7 IEA – India Energy Outlook 2017

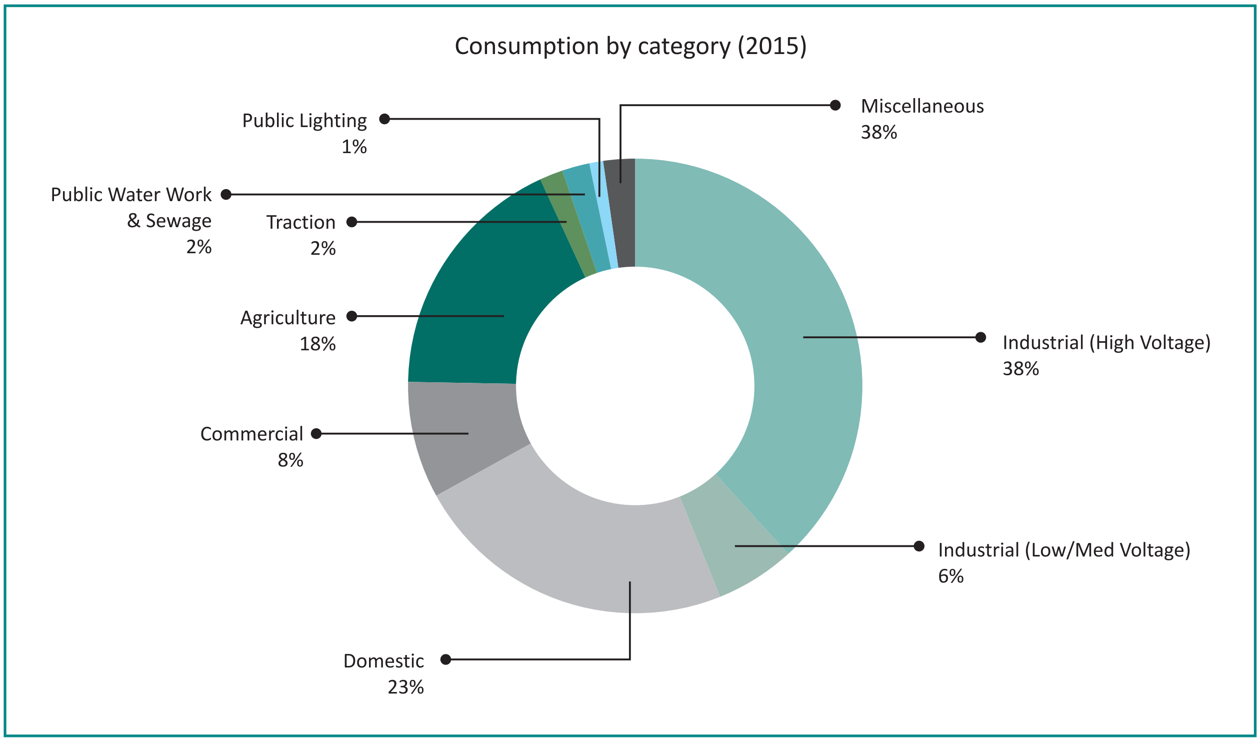


Figure 3: Electrical consumption in 2015

The Figure 3 indicates the percentage share of consumption of electricity by various categories namely industrial, residential, commercial, agricultural, etc. Over the years, energy is witnessed as an essential indicator of sustainable economic development of the nation. Therefore, it is essential to look into the aspects of both the energy consumption as well as the GDP of the nation in order to understand energy intensity. Energy intensity, acts as an indicator to illustrate economic progress associated with energy Consumption.

2.3 Country's Energy Intensity

India is ranked third on primary energy consumption, however, the per capita energy consumption of India is 627 kgoe[8], which is 67% lesser than the global per capita primary energy consumption. In terms of CAGR between 2007 and 2017, India's energy consumption has increased at 5.3%, while the GDP has increased at 8%. By 2030, India's energy consumption is projected to be 1440 million TOE, and the GDP is projected to be USD 5937 Billion. The Figure 4 illustrates India's primary energy consumption[8] and the GDP[9] from 2007 to 2017. The Figure 5 illustrates India's energy intensity in MTOE/Million USD from 2007–17.

8 World Bank
9 GDP – World Bank

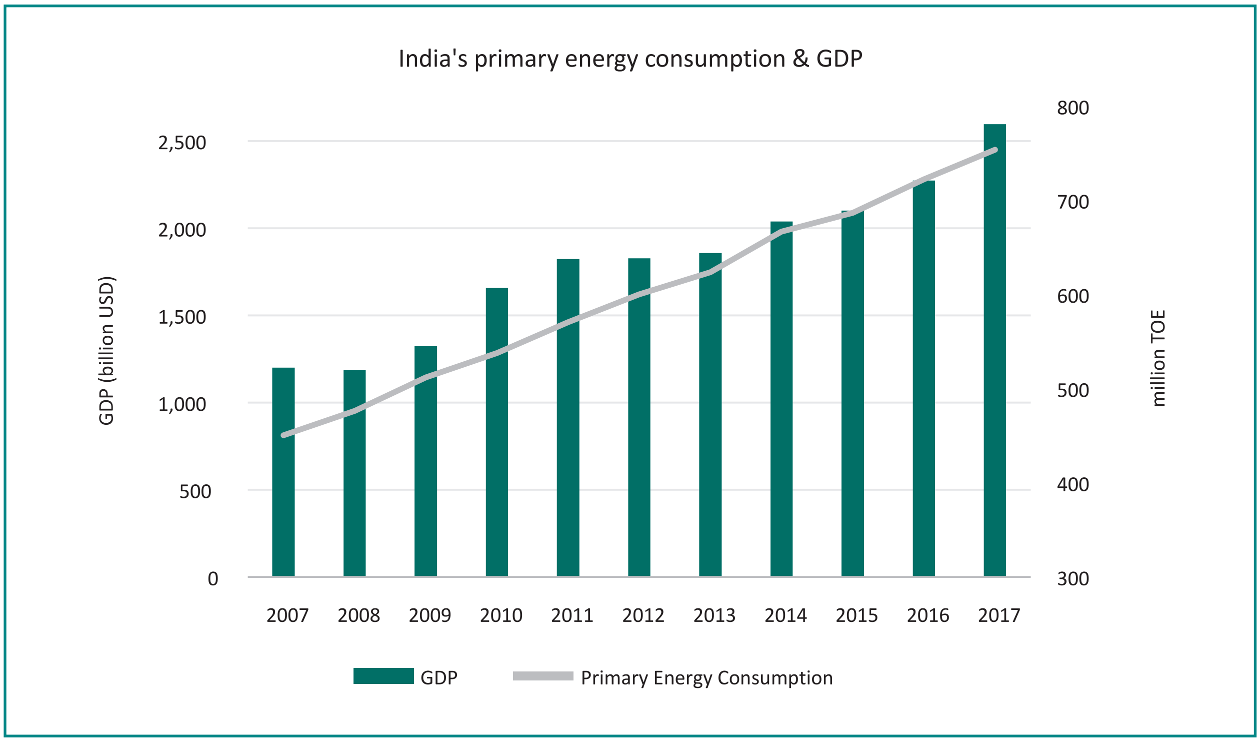


Figure 4: India's primary energy consumption & GDP

It can be inferred from Figure 5 that the energy intensity has been its lowest in 2017 at 290 MTOE/Million USD, and has been reducing at a rate of 2.5% annually over the past decade.

This has become possible through various policy interventions, promoting renewable energy, energy efficiency, adoption of energy efficient technologies, resource conservation, etc.

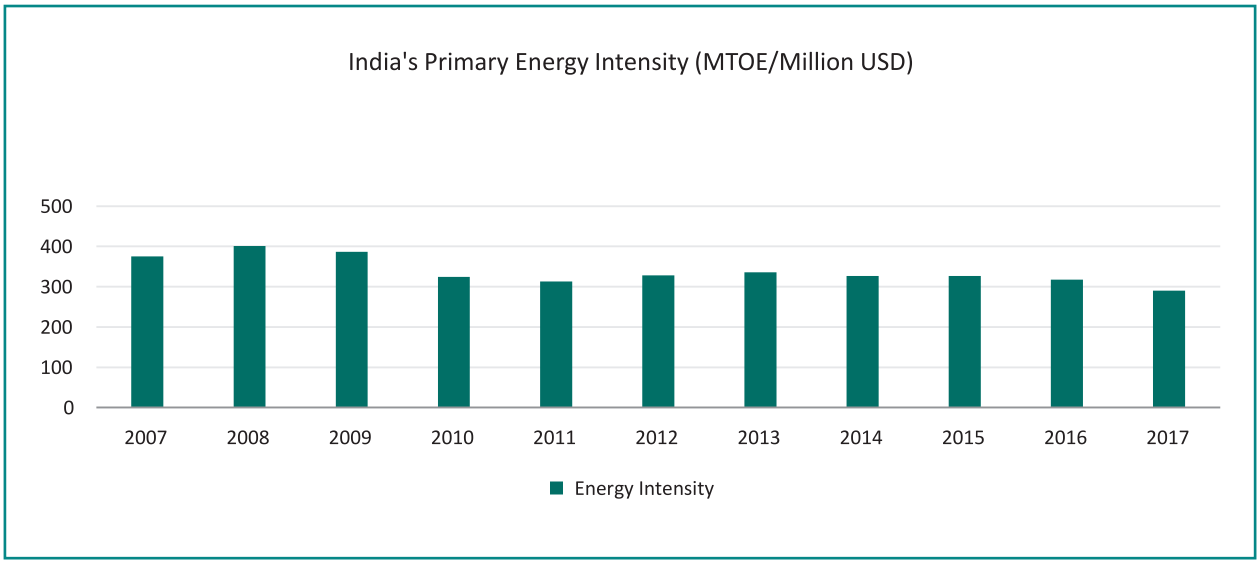


Figure 5: India's Primary Energy Intensity

2.4 Energy security

Energy security is the association of national security and the availability of natural resources for energy consumption. International Energy Agency defines energy security as "the uninterrupted availability of energy sources at an affordable price". In developed economies the affordability of natural resources is cheaper and more sustainable due to higher share of renewable energy, self-sufficiency of fuel, more energy efficient & environment friendly technologies and high availability of skilled labour.

Key Indicator	Approach
Changes in energy mix	Improving energy mix – More renewable energy and increasing self – sufficiency. Possible comparison of energy mix of developed countries.
Abundance in supply of natural gas	Higher production of natural gas by Hydraulic fracture technology producing more natural gas.
Over supplied oil and gas	Oil and gas prices have fallen over the past few years. Many oil importing countries have included bold reforms in pricing reforms and are in good position for attempting larger energy policy reforms
Maturity of renewable energy technologies	Sharp decline in prices for wind and solar technologies in recent years has changed perspective of energy
Climate change concerns	Introduction of latest technologies in energy efficiency and environmental impact

Table 2: Key Indicators and corresponding global approach for energy efficiency[10]

India is expected to be one of the fastest growing economies in 2018 – 19 at 7.4%[11]. With this increasing demand in economy the energy security plays a key role, requiring an accelerated need for exploiting natural resources, renewable energy installations, energy and environment friendly technologies and improving skilled labour.

NITI Aayog has recently launched the India Energy Portal (IEP) which houses its flagship initiative of India Energy Security Scenarios (IESS) 2047. The key concern seen is to reduce import dependence by 2047 and be more self-sufficient in fuel requirements. The draft National Energy Policy by NITI Aayog operates with the objectives of access to energy at affordable prices, improved security and independent in energy, greater sustainability and economic growth. The key indicators identified in National energy policy and corresponding global development to be considered in the framework are shown in Table 2.

2.5 Highlights and projections of energy scenario in India

- India's energy requirements are witnessing a shift to renewable energy sources, with an ambitious target of 175 GW by 2022.[12]
- Capacity additions of other sources include 50 GW from thermal power, while 22 GW of thermal power capacity is planned for retirement.[13]
- India's carbon emissions growing at a CAGR 4.14%, while the global average growth rate is 1.29% for FY16-17.

2.5.1 Coal

- 4.5% increase in coal consumption against the global average of 0.69% for FY16-17.
- 75% of India's coal demands is met

10 Niti Aayog – National energy policy
11 International Monetary Fund
12 Ministry of New and Renewable Energy http://pib.nic.in/newsite/PrintRelease.aspx?relid=133220
13 National Electricity plan

domestically, while the rest is imported from various countries such as Indonesia, South Africa, etc.

- As on 2015, almost 85% (approx. 550 million Tonnes) of domestic coal utilized by power sector (both IPP and CPP)

2.5.2 Oil & Natural Gas

- India's share of energy consumption from oil & gas has reduced significantly by 3% over the past decade, although the overall energy demand has increased by almost 8 million TOE in FY16-17.
- The global demand for oil and gas has increased by 147 million TOE in FY16-17, and India contributes to 5% of this demand.
- As on 2016, 50% of India's oil demand arises from Transport/Retail sector, while the demand for Natural Gas is driven by power (22%) and fertilizer industry (33%).

2.5.3 Electricity Generation

- India shares almost 6% global electricity requirements, growing at a CAGR of 6.5%, compared to the global growth rate of 4.85%.
- India's installed capacity stands at 344 GW as on March, 2018; while the electricity demand is projected to be 2404 BU by 2030.
- As on 2015, from conventional sources, 80% of India's electricity demand is met by coal-based fuels.
- As on 2016, with gaining prominence of renewable energy, 7% of India's electricity demand is catered by renewable energy.

2.5.4 Renewable energy

- India shares about 4.5% of global energy consumption from renewable energy sources in 2017.
- India's renewable energy contribution increased by 3 million TOE, and global energy consumption from renewable energy sources is recorded as 69 million TOE
- As on 2016, wind energy constitutes to 56.8% of India's grid installed renewable power capacity, comparing to 18.6% of solar power.
- India's potential for solar power installation is estimated to be 750 GW, considering the availability of waste land in India.

2.6 PAT's contribution to Country's economic value

The sectoral growth in Indian economy is measured by Index of industrial production (IIP). The level of IIP is a reference number, showing the growth of sectors from 1993 – 94 to current period, with 100 being the base value considered in 1993 – 94.

Industry	Weightage	2015 – 16	2016 – 17
Coal	10.8	4.3	3.2
Crude oil	9	-1.4	-2.5
Natural gas	6.9	-4.7	-1.0
Refinery products	28.0	4.9	4.9
Fertilizers	2.6	7.0	0.2
Steel	17.9	-1.3	10.7
Cement	5.4	4.6	-1.2
Electricity	19.9	5.7	5.8
Overall Index	100	4.8	3.9

Table 3: Eight core Industries in India

The Ministry of commerce in 2011 – 12 has declared eight core industries in India, which comprise of 40.27% weight of items in the overall index. Around 40% of the weightage is given to manufacturing industries in the country. The weight of these industries is given in Table 3. The growth rate of these eight core industries have been one of the key factors for the country. The 8 core industries also include major energy usage or consumers in the country. On one side concentrating on these 8 core sectors also needs reforms to reduce the energy consumption of these core industries to be competitive in the world.

Thermal power plant, Iron & Steel and Cement in PAT consume around 88% of the total energy consumption of all the sectors in PAT Cycle – I. These 3 major sectors and beyond fall under the eight core sectors of the country. Later PAT Cycles have included DISCOMs and Refinery, almost including all of the eight core sectors.

Energy and emission intensities are ratios of energy consumption and emission over GDP of the country. Energy and emission intensities are key factors in determining the sustainable growth of a country or a sector. In this section overall country has been focussed and the impact of PAT on the overall GDP of the country has been described.

India specific GDP values and energy intensity, projections till 2030 are mentioned in Table 4. The energy consumption for eight sectors under PAT Cycle-I has been taken for baseline years (2007-2010), and assessment year (2015). The projections for energy consumption for these sectors are based on their estimated growth till 2030 and accordingly the energy intensity has been projected, which is shown in Table 5.

Year	Total Energy Consumption of India[14]	Gross Domestic Product (GDP)	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[15]	464	1,389	334
2015	659	2,102[17]	313
2020	1018[18]	3,018	337
2025	1211[19]	4,233	286
2030	1440[7]	5,937[21]	243

Table 4: India's energy intensity

14 Energy consumption values are taken from Energy Statistics 2017 report
15 Equivalent Production of Iron and Steel Industries in PAT
16 BP Statistical Review of World Energy 2018
17 GDP from World Bank GDP for India – Upto 2015
18 India Energy Outlook, Year 2015 - IEA
19 Estimated by calculating CAGR for 2020 and 2040 in India Energy Outlook, Year 2015 – IEA
20 India's GHG emissions profile – Results of 5 climate modelling Studies : Mckinsey India model
21 GDP values calculated based on GDP growth rate of 7.5% till 2020 and 7% between 2020 and 2030. Same assumptions have been considered in India Energy Outlook, Year 2015 – IEA

Year	India Energy Consumption	GDP	BAU	PAT
			Energy Intensity	Energy Intensity
	million TOE	Billion USD	TOE/million USD	TOE/million USD
2008	427	1,187	BAU and PAT scenario is compared based on baseline and assessment year and is reflected only from assessment year	
2009	453	1,324		
2010	512	1,657		
Average Baseline	464	1,389	156.66	156.66
2015	659	2,102	176.63	172.71
2020	1018	3,018	132.83	130.39
2025	1211	4,233	111.20	108.50
2030	1440	5,937	98.65	95.95

Table 5: PAT DCs energy intensity

PAT Cycle I contributes 46.98% and 55.18% of energy intensity in baseline and assessment year.

The energy intensity by 2030 with PAT will be 95.95 TOE/million USD

3.0 Methodology adopted for the project

3.1 PROJECT OBJECTIVE

The outcome evaluation study of PAT scheme was conducted with the objective to assess the overall impact of implementation of the PAT scheme and also for the eight industrial sectors (individually) on the fronts of energy consumptions, carbon emissions, and contribution to national efforts for GHG mitigation.

To further complement the accomplishments of PAT, various success stories highlighting the high potential energy efficiency measures were also documented from each industrial sector, relevant to technological upgradations, benefits and challenges faced by the sectors.

3.2 METHODOLOGY

The outcome evaluation of PAT Cycle 1 was undertaken in two steps –

1. Assessing the sector wise Impact through analysis of the baseline year and assessment year data
2. Assessing the overall impact - Based on the analysis and outcome of the study for each sector, the overall impact was assessed.

Sector Wise Analysis: For undertaking the assessment of impact by the PAT scheme, the sector wise analysis was undertaken. The necessary inputs from stakeholders such as technical experts, associations and designated consumers were also incorporated during the various stages of the study. The stakeholders were consulted through targeted interviews, workshops and discussions and their inputs have contributed significantly to the study. As part of the analysis the following aspects were studied for each sector under the first cycle of PAT scheme:

1. Analysis of achievements of DCs under PAT Cycle 1 – Energy Saving achieved, emission reduction mitigation, comparison of energy saving targeted and achieved by the sector
2. Comparison of energy consumption in the sectors under two scenarios - Business as Usual (BAU) and PAT Scenario. The impact was projected under two scenarios till 2030 to estimate the yearly and cumulated energy savings that can be additionally achieved by implementation of subsequent cycle of PAT scheme. Necessary assumption on increase in production and energy efficiency improvements were taken after discussion with various stakeholders
3. Analysis of energy efficiency levels – product & section wise, capacity utilization, and possible improvements such as utilization of Waste Heat Recovery (WHR), renewable energy, utilization of alternative fuel and raw material, etc. were also undertaken for individual sectors.
4. Benchmarking analysis for specific energy consumption for each sector – Nationally and internationally was undertaken to highlight the potential available for energy efficiency improvements
5. Identifying the key technologies and measures for energy efficiency improvement that can be implemented by DCs in each sector
6. Documentation of success stories of DCs for implementation of high potential and innovative energy saving measures which can be upscaled and implemented across the sector were also undertaken. Details on the rationale for implementation, methodology adopted, challenges faced and cost savings and investments details were captured in success stories.

The outcome of the sector analysis, the eight individual sector assessment reports based on achievements under PAT Cycle -1, a combined

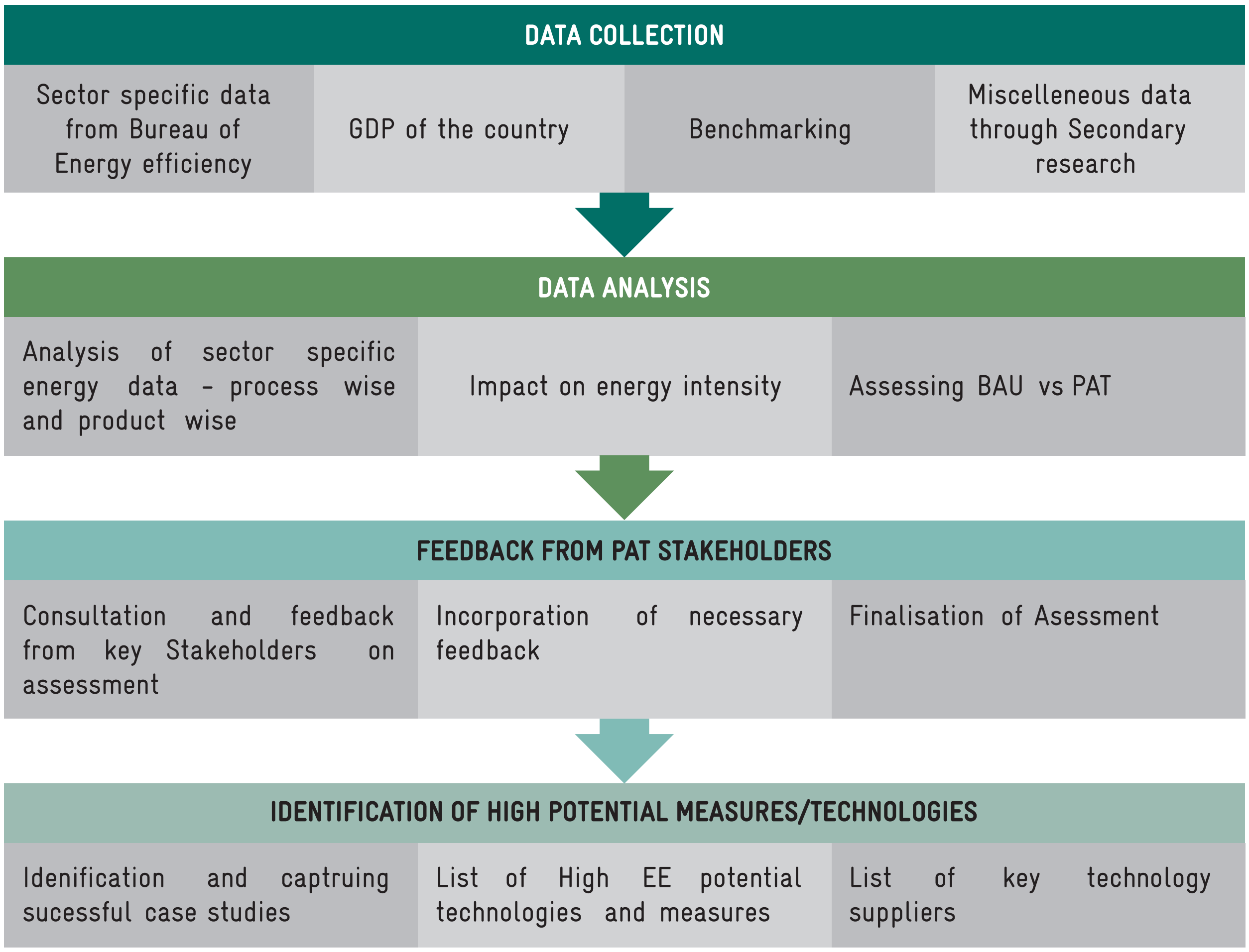


Figure 6: Methodology adopted for the project

report on cycle 1 evaluation was undertaken.

Overall impact assessment report - The impact of eight individual sectors under Cycle 1 were combined to assess the overall impact of the scheme. The common challenges and barriers were also included in the report. One of the major activities undertaken was also to collect the feedback of DCs and other stakeholders on the PAT scheme. More than 75 DCs provided their feedback through an online survey (25 questions) covering various aspects of PAT scheme such as baseline, monitoring & verification, mandatory energy audits, contribution in achieving competitiveness, collaboration, etc. was developed.

The key stakeholders consulted during varuous stages of the project acivities were officials from BEE, Designated Consumers (DCs) across various PAT sectors, Industrial Associations, SDAs, and Energy Consultants.

4.0 Introduction to PAT scheme

In order to accelerate energy efficiency and to improve the energy security in the country by implementing energy efficient and environmental friendly technologies, government of India has introduced National Mission for Enhanced Energy Efficiency (NMEEE), which is one of the eight missions coming under National Action Plan on Climate Change by the Government of India. NMEEE's main objective is to promote innovative policy, regulatory and financial mechanism as well as business models that promote market for energy efficiency in a time bound manner. NMEEE has rolled out four initiatives to enhance energy efficiency in India. Perform Achieve and Trade (PAT), Market Transformation for Energy Efficiency (MTEE), Energy Efficiency Financing Platform (EEFP) and Framework for Energy Efficient Economic Development (FEEED).

The Energy Conservation Act, 2001 has identified 15 large Energy Intensive Industries for energy efficiency improvements in India. Section 14 (e) and 14 (g) of the Act empower the Central Government on the recommendations of Bureau of Energy Efficiency (BEE), to prescribe energy consumption norms and standards for energy intensive industries.

Policy Maker & Administrator	Ministry of Power (MoP)
Nodal Agency	Bureau of Energy Efficiency (BEE)
Implementer	Designated consumer (DC)
State Administrator	State Designated Agency (SDA)
Adjudicator	State Electricity Regulatory Commission (SERC)
Verifier	Empanelled Accredited Energy Auditors
Trading Regulator, Registry	State Electricity Regulatory Commission (SERC), CERC/ POSOCO, Power exchanges - IEX and PXIL
Trading Platform	Power exchange - IEX

Figure 7 Stakeholders involved in PAT

PAT is one of the innovative and unique market-based mechanism in the world for energy efficiency. It is a step taken by the Government of India to ease the pressure exerted by the industries on energy resources. There are other mechanisms in world for energy savings in the industry like 10000 Enterprise Program in China, White Certificates program in Europe, but the PAT mechanism is designed by considering various aspects of the energy across the different sectors considering specific energy consumption reduction and normalizations independently for different sectors.

Normalization factors have been introduced in each sector for an apple to apple comparisons of different plants. The key normalization factors involved in almost all the sectors were quality of fuel, capacity utilization and mix of final product. These normalization factors were determined with the help of expert opinion from Technical experts of each individual members.

PAT is market-based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded. PAT was derived from the Energy Conservation Act 2001. In EC act 2001, the Central Government of India has the power to notify energy intensive industries, as listed out in the schedule to the act, as designated consumers (DCs).

PAT scheme is the flagship scheme of NMEEE with the primary objective of helping DCs to achieve their accountability under the EC act, 2001. PAT scheme also provides DCs with necessary incentives to over-achieve the targets given to them.

Stakeholders

Stakeholders were identified to ensure maximum coverage in all the relevant sectors. This coverage includes industry, industry associations, state designated agencies (SDAs), Energy exchanges and regulatory bodies. Stakeholders also consist of key decision-making bodies like BEE, EESL, IEX, SDAs and industry associations. A selected number of DCs were also identified as stakeholders to gain appreciation from that particular sector.

BEE: The Government of India set up Bureau of Energy Efficiency (BEE) (Website: http://www.bee-india.nic.in) on 1st March 2002 under the provisions of the Energy Conservation Act, 2001. The mission of the Bureau of Energy Efficiency is to assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing energy intensity of the Indian economy. This will be achieved with active participation of all stakeholders, resulting in accelerated and sustained adoption of energy efficiency in all sectors.

The major functions of BEE include:

- Regulate activities focusing on DCs
- Develop specific energy norms
- Certifying energy managers and energy auditors
- Defining the procedure and frequency of mandatory energy audits
- Develop reporting format on action taken on recommendation of energy auditors
- Providing financial assistance for promoting efficient use of energy and its conversation

Designated consumer: The government has notified energy intensive industries and establishments as designated consumers (DCs). These DCs have to meet the specific energy consumption reduction targets given by BEE.

SDA: Under clause (d) of section 15 of Energy Conservation Act 2001, the State Governments/UT administrations have designated State Designated Agencies (SDA) to coordinate, regulate and enforce the provisions of the Act in their respective States. The SDAs, working in close coordination with BEE are required to undertake duties and responsibilities to effectively implement the Act and supplement the efforts of the Central Government at the state level. The role of SDAs is to unlock the latent potential at the grass root level and holds the key to achieve EE proliferation.

All over India, SDAs have been set up in 32 states and UTs which include Renewable Energy Development Agencies, Electrical Inspectorates, Distribution Companies, Power Departments etc.

CERC: Central Electricity Regulatory Commission (CERC) serves as the regulator for development of ESCert market. It defines the framework for ESCert trading, in Power exchanges, under PAT scheme. ESCert trading is done in IEX (Indian Energy Exchange), a power trading platform.

DCs who fail to meet their respective targets will face cost complications such as penalty or purchase of energy saving certificates. Ministry of Power, through Bureau of Energy Efficiency

(BEE), will issue ESCert for 1 metric tonne of energy saving achieved by the DC. These ESCerts can be traded among DCs at Power Exchange. ESCerts can also be banked for a maximum of one compliance cycle, after which it expires. Monitoring and verification of energy savings is done by Accredited Energy Auditors (AEA) in the assessment year of the respective PAT cycle.

PAT cycle- I baseline period was 2007-2010 and assessment period was 2014-2015. After the completion of first PAT cycle -I, the Bureau undertook two activities i.e. widening and deepening activity so as to include more number of DC's under PAT framework within same sector as well as identifying other sector which can be included under PAT framework. The deepening and widening process are an iterative process; through this process the Bureau will define the new threshold annual energy consumption (minimum prescribed annual energy consumption) for each sector.

In PAT cycle – II, three more sectors were added to the existing 8 sectors. Discoms, Railways and Refineries were added in this cycle. The total number of DCs notified in this cycle was 621. from 11 sectors. The total energy reduction taget for this cycle was 8.869 million TOE

The duration of PAT cycle 3, is from 2017-18 to 2019-20 with 116 new DCs. These DCs are to reduce 1.01 million MTOE by the end of the cycle period. These DCs are from 6 sectors viz. Thermal Power plant, Cement, Aluminium, Pulp and Paper, Iron and Steel and Textile. PAT scheme is operating on rolling basis, i.e., new DCs from existing or new sectors are included in PAT scheme in an annual basis.

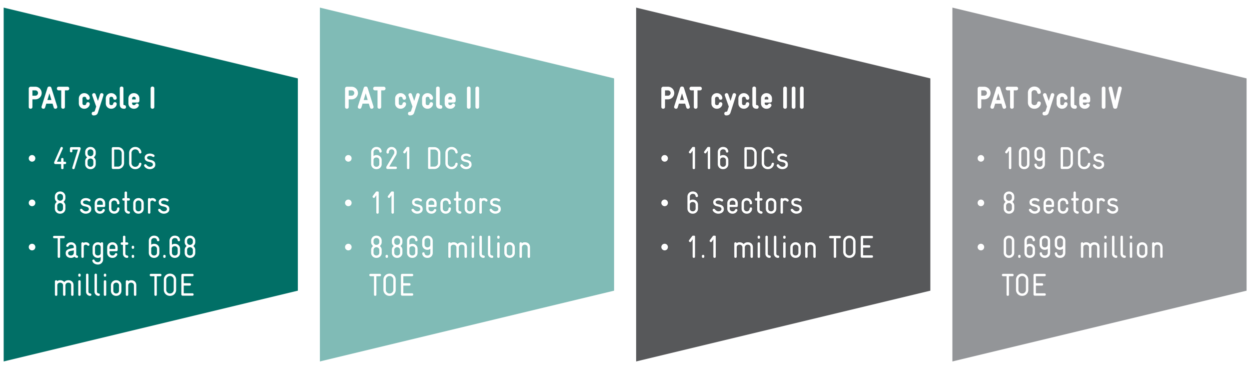


Figure 8: Designated consumers in PAT Cycles

PAT Cycle - 4 consists of 8 sectors-Petrochemical, Cement, Pulp and Paper, Iron and Steel, Textile, Thermal Power plant, Hotels and Chlor-Alkali. 109 DCs have been notified under this cycle, the cycle period being 2018-19 to 2020-21. In this cycle, 2 new sectors are added- Petrochemicals and Hotels. The target energy consumption reduction for this cycle is 0.699 million MTOE.

The Government of India expects to reduce Energy Intensity, GHG emissions and other environmental pollutants, also reduce energy costs and improve competitiveness. The PAT scheme intention is to ensure energy savings that will not only benefit the industries but also would contribute to an extent to ensuring energy security of the country and thus easing the pressure on energy infrastructure.

4.1 PAT Cycle I

In cycle I, 478 energy intensive units have been identified as DCs, to whom targets were given. These DCs were mandated to reduce their SEC from FY2012 to FY2015. The following industries were selected in PAT cycle- I: Aluminium, Cement, Chlor- Alkali, Fertilizer, Iron and Steel, Pulp and Paper, Textiles and Thermal Power plants.

Name of Sector	Minimum Annual Energy Consumption (TOE)	No. of DCs
Cement	30,000	85
Pulp and Paper	30,000	31
Aluminium	7,500	10
Chlor-Alkali	12,000	22
Fertilizer	30,000	29
Iron and Steel	30,000	67
Textile	3,000	90
Thermal Power plant	30,000	144

Table 6: Minimum annual energy consumption to be declared as a DC

The Industries under these eight sectors, who would become a Designated Consumer (DC), should have annual energy consumption more than the minimum value specified by the Bureau. If the industry has more than the specified minimum annual energy consumption, in that particular sector, it qualifies as a DC and has to participate in PAT mechanism. Each of eight sectors has the different minimum annual energy consumption threshold.

Sector	Threshold Limit for Qualifying as DC (MTOE)	No of DC	Annual Energy Consumption (million MTOE)	Energy Reduction Target for PAT-1 (million MTOE)
Cement	30,000	85	15.01	0.815
Pulp & Paper	30,000	31	2.09	0.119
Aluminium	7,500	10	7.71	0.456
Chlor-Alkali	12,000	22	0.88	0.054
Fertilizer	30,000	29	8.2	0.478
Iron & Steel	30,000	67	25.32	1.486
Textile	3,000	90	1.2	0.066
Thermal Power Plant	30,000	144	104.56	3.211
Total		**478**	**164.97**	**6.685**

Table 7: Energy consumption and Energy reduction target (PAT cycle -1)[22]

22 From Pathways for accelerated Transformation in Industry Sector- a BEE publication

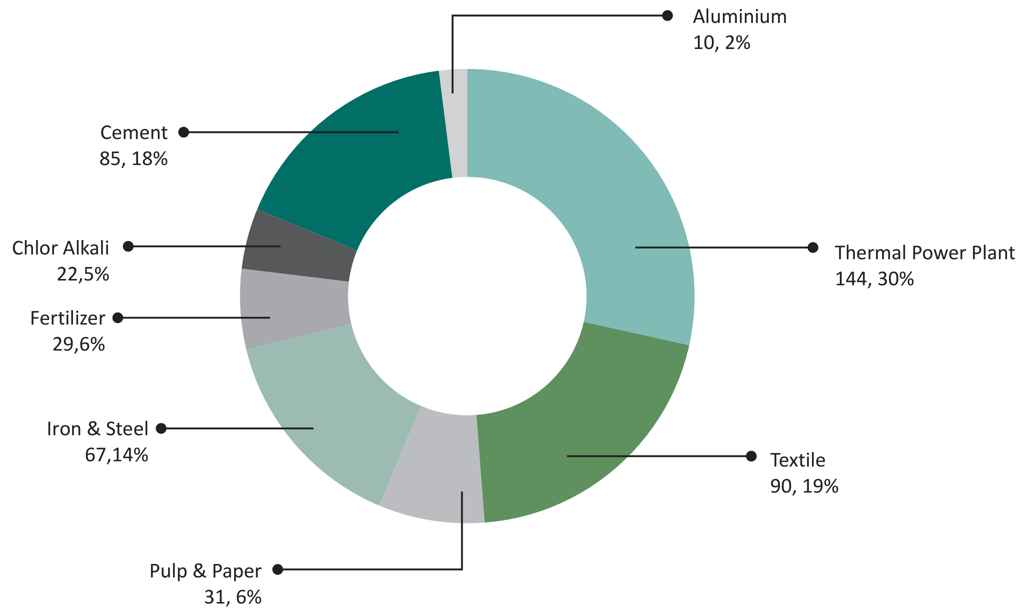


Figure 9: Sector wise breakup of total number of DCs in PAT cycle-1

The percentage share of the energy saving targets is illustrated in the Figure 10. It can be inferred that Power sector, Iron & Steel sector and Cement sector, being the most energy intensive sectors, constitute up to 82% (5.51 Million MTOE) of the total energy saving target. In the latter PAT cycles additional sectors were added- Railways, Electricity DISCOMS, Refineries and Commercial buildings.

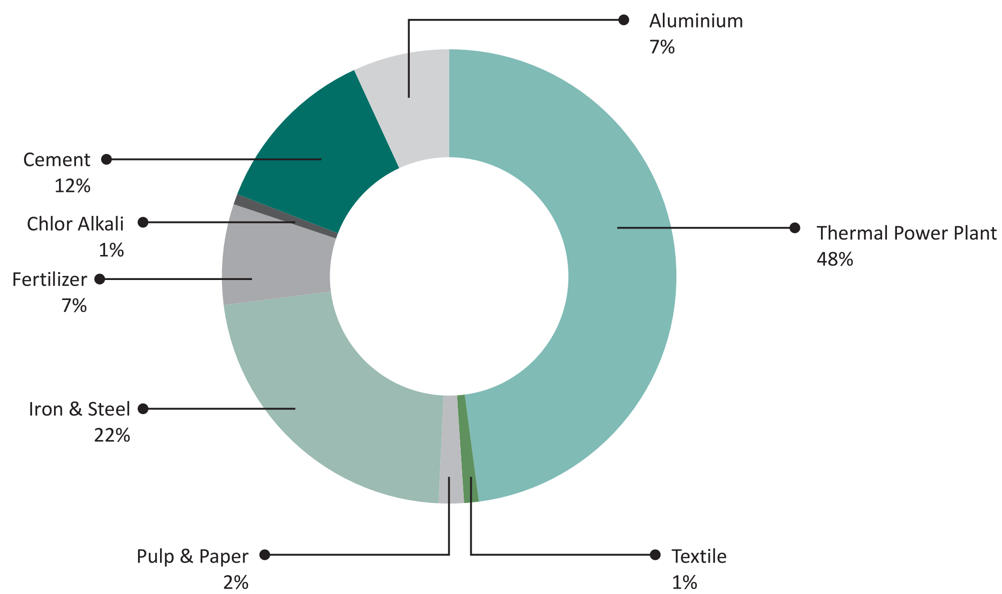


Figure 10: Share of sectors in total saving targets under PAT cycle -1

5.0 Outcome of PAT Cycle – I

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 fail 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 – 1 has shown tremendous impact by exceeding its allocated target of 6.68 million TOE by around 30% and achieving a reduction of 8.67 million TOE. Table 8 shows the sectoral energy savings achieved in PAT cycle-I

Sl. No.	Sector	Notified DCs	Energy Saving Target (million TOE)	Energy Saving Achieved (million TOE)	Achievement over the target (%)
1	Aluminium	10	0.456	0.73	60
2	Cement	85	0.815	1.48	82
3	Chlor-Alkali	22	0.054	0.09	72
4	Fertilizer	29	0.478	0.78	64
5	Iron and Steel	67	1.486	2.10	41
6	Pulp and Paper	31	0.119	0.29	143
7	Textile	90	0.066	0.13	95
8	Thermal Power Plant	144	3.211	3.06	-5
	Total	**478**	**6.685**	**8.67**	

Table 8: Energy savings achieved in PAT Cycle I

144 DCs from Thermal Power Sector were given a total target of 3.21 million TOE in PAT cycle 1. The overall achievement of this sector in PAT-I was 3.06 million TOE. According to this, the sector underachieved its overall target by around 5%. However, the achievement of 3.06 million TOE relates to only 120 DCs who carried out the Monitoring & Verification (M&V) exercise and submitted the same to BEE. These 120 DCs were given an energy reduction target of 2.58 million TOE. Under such a circumstance, the DCs have overachieved their target by 19%.

5.1 Impact of PAT Cycle-I

PAT Cycle - I has achieved 8.67 million TOE in comparison to the target of 6.685 million TOE. This achievement has estimated GHG emission reduction of 31 million tonnes of CO_2 equivalent.

19. Ministry of steel Annual report 2017-18

Figure 11 Savings achieved by PAT

The savings are attributed to a number of measures adopted by the DCs. Where 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 55% of the DCs amounting to 261 billion INR.

5.2 Reduction in Green House Gas emissions

The GHG reduction in each sector is calculated based on input fuel mix for the sector. The reduction in Green House gas emission for each sector is shown in the Table 9. The total CO_2 emissions averted due to PAT is 31 million Tonnes of CO_2 equivalent.

Sl. No.	Sector	Notified DCs	Reduction in emission (million Tonnes of CO_2 equivalent)
1	Aluminium	10	3.10
2	Cement	85	4.34
3	Chlor-Alkali	22	0.62
4	Fertilizer	29	0.93
5	Iron and Steel	67	6.51
6	Pulp and Paper	31	1.24
7	Textile	90	0.62
8	Thermal Power Plant	144	13.64
	Total	**478**	**31.00**

Table 9: Reduction in CO_2 equivalent emissions due to PAT Cycle - 1

5.3 Market transformation of PAT Cycle – 1

PAT Cycle – I has accelerated the market towards energy efficiency in the country. The impact of PAT Cycle –I has resulted in implementation of several energy saving opportunities across different sectors. The key points of market transformation due to PAT is mentioned in this section.

5.3.1 Investment in PAT Cycle – I

The cost abatement curve for sectors under PAT cycle-I is mentioned in Figure 12. The cost abatement curve is a curve for Investment made by the sector with respect to the energy savings obtained. Several energy conservation measures have been implemented by the industries, which has resulted in 8.67 million TOE reduction in energy consumption. The weighted average investment (based on energy savings) for Thermal power plant, Iron and Steel and Cement is Rs. 18,084/TOE. The weighted average cost for all the sectors is Rs. 30,135/TOE.

The total investment in PAT Cycle – I has been Rs. 261 billion against the energy savings of 8.67 million TOE. The overall investment per toe in textile

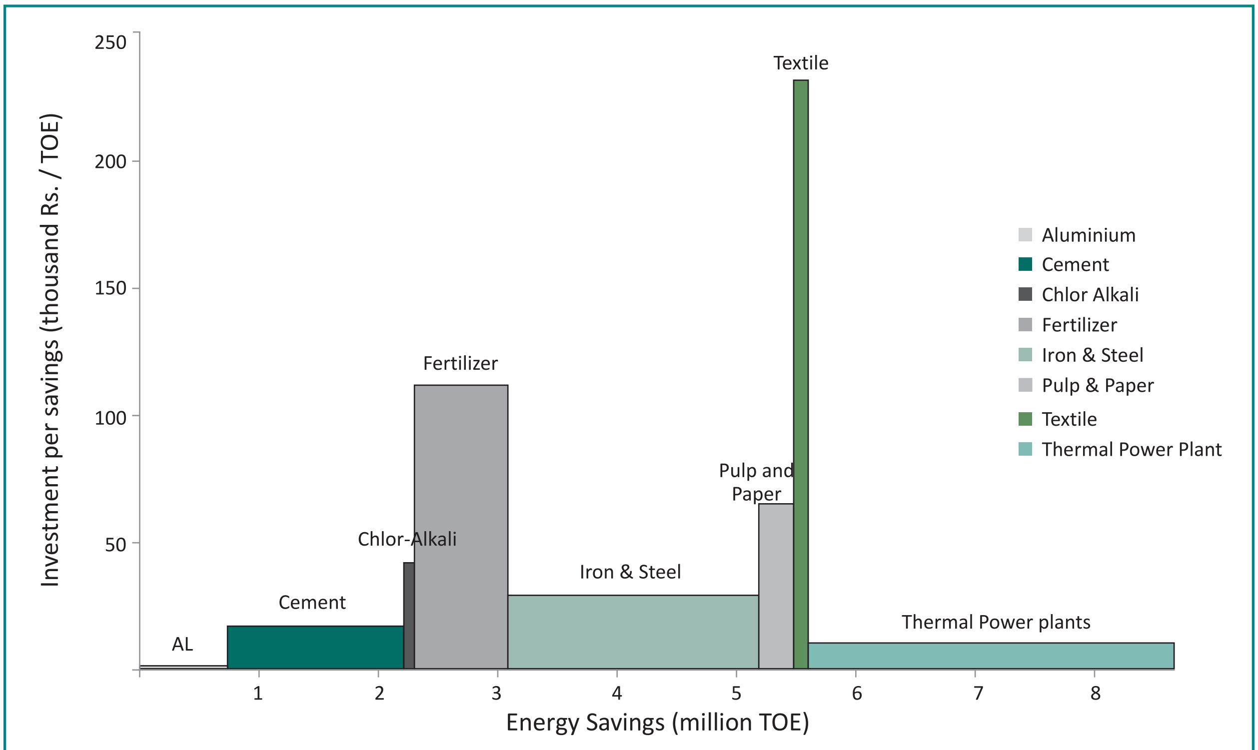


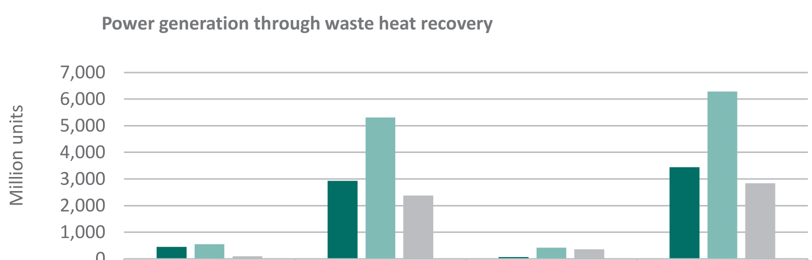
Figure 12: Cost abatement curve for different sectors

sector is too high as compared to other sectors. This is mainly due to one plant, whose investment accounts for around 86% of the total investment of this sector. Without considering the investment of this plant, the investment per TOE for entire textile sector comes to be around Rs. 29000.

5.3.2 Waste heat recovery and AFR utilisation

The transformation of market for energy saving opportunities in PAT Cycle – I, has given a drive for installation of waste heat recovery in the plant to utilize natural resources more efficiently. This has also boosted the utilization for AFR in Cement plants.

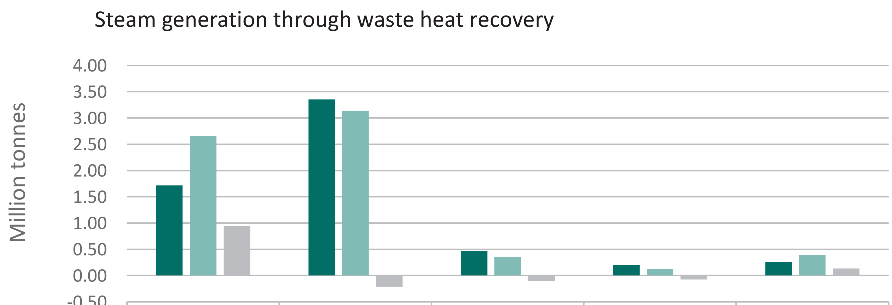
The data for increased waste heat recovery generation or utilisation of waste heat for thermal applications has been captured for Iron and Steel and Cement sector.



	Coke Oven Plants	Sponge Iron Kilns	Top Recovery Turbine	Total Power generation from WHR
Waste Heat recovery generation in Baseline year	446	2,932	69	3,447
WHR generation in assessment year	545	5,314	424	6,283
Additional WHR generation in Assessment year	100	2,382	355	2,837

Figure 13: Power generation through waste heat recovery

Iron and steel sector has several waste heat recovery opportunities for achieving better energy efficiency. Waste heat recovery opportunities are available in coke oven batteries to rolling mills. The waste heat installed in the integrated steel plant is mentioned in the Figure 13 and Figure 14 and is mentioned separately for integrated steel plants and plants of lesser capacity with DRI or Mini blast furnace technologies. Installed capacity of Top recovery turbine increased by 30 MW and waste heat recovery of sponge iron kiln increased by 80 MW.



	Coke Oven plants	Coal based HBI/DRI	Calcining plants	Plate mills	Compact strip mills
Waste Heat recovery generation in Baseline year	1.72	3.35	0.47	0.20	0.25
WHR generation in assessment year	2.66	3.14	0.36	0.12	0.39
Additional WHR generation in Assessment year wrt Baseline	0.94	-0.21	-0.11	-0.08	0.13

Figure 14: Steam generation through waste heat recovery

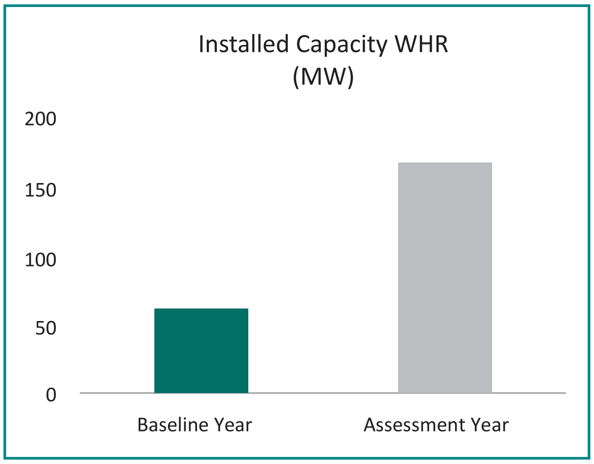


Figure 15: Installed capacity of Waste heat recovery in baseline and assessment year

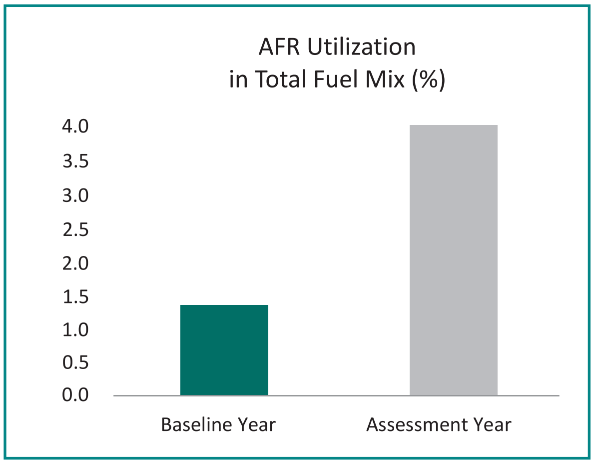


Figure 16: Share AFR in Total fuel mix for Cement sector

The waste heat generation in cement sector has seen significant improvement. This has resulted in increase in installed waste heat recovery by 105 MW in assessment year compared to baseline, as shown in figure 15. PAT has been one of the key drivers in these industries to achieve energy savings. The AFR utilisation in the baseline year was 1.4%, which has increased to 4% in the assessment year as shown in figure 16 .

5.3.3. Creating Business Opportunities for Energy Professionals and Technology Suppliers

BEE has created a pool of certified energy professionals through National Certification Examination for Energy Managers and Energy Auditors. These certified energy auditors are accredited and empanelled with BEE to carry out various works on audit, Monitoring and Verifications. PAT has created a huge opportunity for these professionals in engaging themselves in activities related to this scheme. The business for these professionals was estimated to be around Rs. 500 million in PAT cycle-I[23], which is further expected to increase in future cycles of PAT.

With the investment of Rs. 261 billion, huge market was created for the technology suppliers. This also led to technology transfer of cutting-edge technologies across the sectors. The cost of energy efficient technologies witnessed significant reduction due to increase in demand. Many innovative technologies were implemented, showcasing huge replication potential in respective sectors. The continuous demand for energy efficiency has led to Research and Development activities being taken aggressively by the technology suppliers.

5.4 Energy Scenario at Business as usual (BAU) Vs. PAT

The energy scenario and BAU for each sector is calculated till 2030 and is shown in Table 10. The cumulative energy savings for all sectors due to intervention of PAT is 165.23 million TOE.

Sl. No.	Sector	Cumulative reduction in energy consumption (million TOE)
1	Aluminium	27.89
2	Cement	34.46
3	Chlor-Alkali	2.51
4	Fertilizer	12.95
5	Iron and Steel	29.88
6	Pulp and Paper	7.81
7	Textile	4.28
8	Thermal Power Plant	45.45
	Total	**165.23**

Table 10: Cumulative reduction in energy consumption due to PAT

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.

23 The overall baseline verification for PAT cycle-1 was done in approx. 40 crore, and average cost of each M&V was Rs. 0.25 million, and 419 DCs carried out the M&V exercise.

Sector		Baseline	2015	2017	2020	2022	2025	2027	2030
Aluminium	BAU	8.64	9.89	11.44	15.34	17.78	22.23	25.82	32.34
	PAT	8.64	9.60	10.93	14.27	16.34	20.12	23.15	28.66
Cement	BAU	15.53	23.05	23.56	27.46	30.42	35.46	39.28	45.84
	PAT	15.53	22.45	22.69	26.02	28.53	32.83	36.04	41.61
Chlor Alkali	BAU	0.59	0.75	0.83	0.95	1.05	1.20	1.32	1.52
	PAT	0.59	0.71	0.76	0.85	0.91	1.01	1.08	1.21
Fertiliser	BAU	8.20	8.28	8.57	9.03	9.36	9.86	10.21	10.77
	PAT	8.20	7.82	8.02	8.33	8.56	8.93	9.20	9.63
Iron and Steel	BAU	25.32	31.39	37.80	49.94	60.13	79.45	95.67	126.41
	PAT	25.32	30.57	36.71	48.37	58.25	77.15	93.12	123.88
Pulp and Paper	BAU	2.09	4.38	4.66	5.43	6.01	7.01	7.76	9.05
	PAT	2.09	4.26	4.47	5.10	5.58	6.41	7.02	8.08
Textile	BAU	1.20	1.44	1.50	1.60	1.67	1.78	1.86	1.98
	PAT	1.20	1.24	1.28	1.36	1.41	1.49	1.55	1.65
Thermal Power plant	BAU	156.05	265.17	282.98	291.16	297.82	313.74	322.36	357.82
	PAT	156.05	261.93	278.24	289.24	295.37	311.36	319.86	354.98
Total	BAU	217.62	344.34	371.34	400.92	424.25	470.74	504.28	585.73
	PAT	217.62	338.58	363.11	393.54	414.95	459.30	491.03	569.70

Table 11: Sectoral energy consumption projection up to 2030(units in million TOE)

The sector wise consumption of energy for each sector is projected either by the targets placed for the sector or based on CAGR of the sector for past few years. The projection of energy consumption of different sector is mentioned in Table 11.

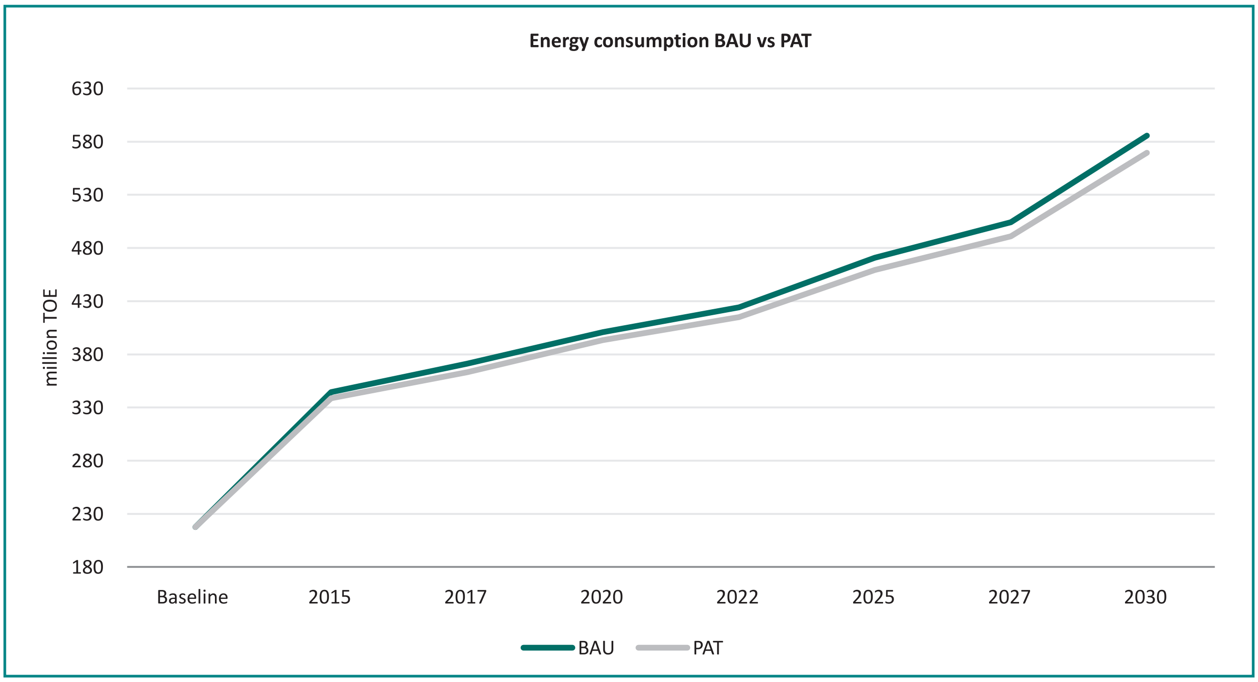


Figure 17: Energy consumption BAU vs. PAT

The energy consumption of the sectors under PAT cycle I is expected to be approximately 569.70 million TOE with PAT in the year 2030, in comparison to energy consumption of 585.73 million TOE with Business as usual scenario i.e., without PAT. The energy consumption is increasing for each sector due to expected increase in production over the years till 2030. For BAU the average rate of reduction of SEC in the baseline years 2007-2010, is considered till the yeas 2030, while under the PAT scenario the targets are considered till 2030, which is expected to decrease in the subsequent cycles. The projections are for two scenarios, i.e., BAU Vs PAT in the country, for the eight sectors under PAT cycle-I, is compared in Figure 17.

The total energy consumption for the eight sectors under PAT cycle I, in the year 2030, in Business as Usual scenario is estimated to be 585.73 million tonnes, which may reduce to 569.70 million tonnes considering the impact of PAT.

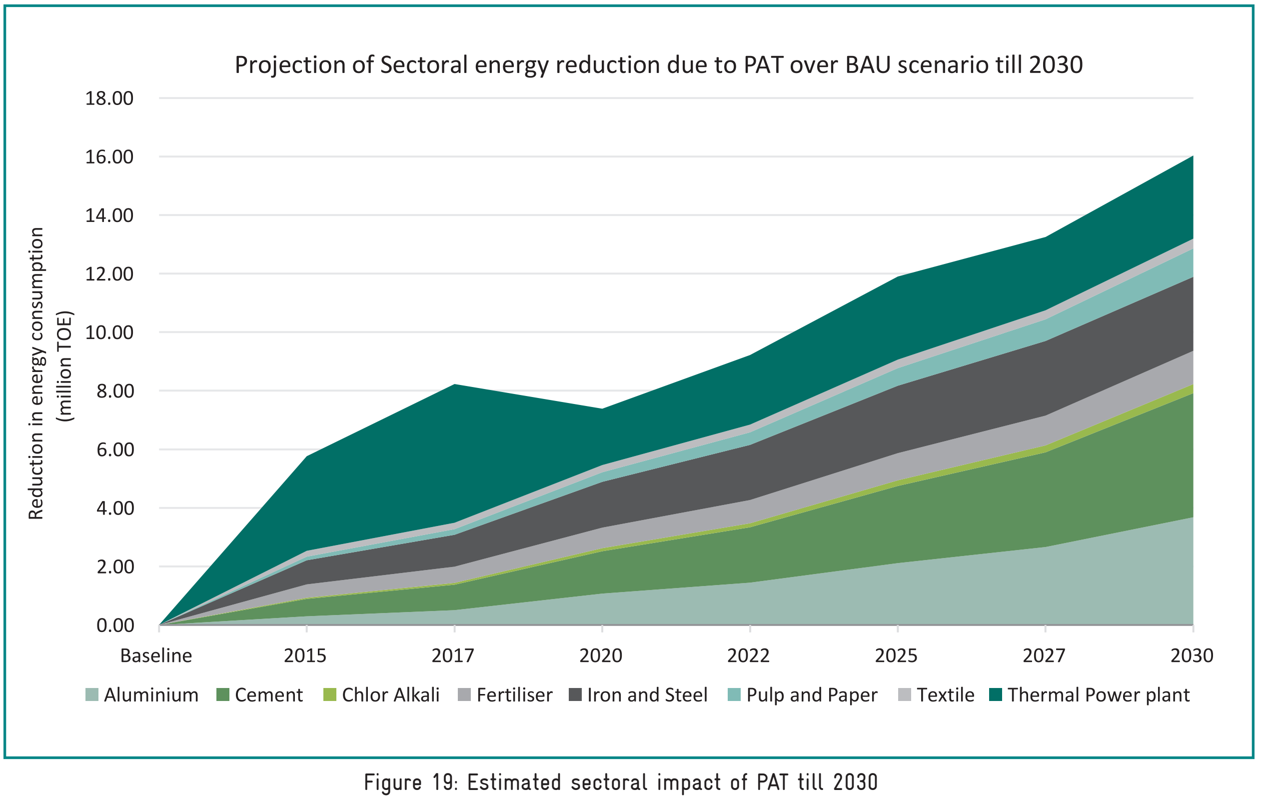


Figure 19: Estimated sectoral impact of PAT till 2030

The total impact of PAT with individual sectors is mentioned in the Figure 19. The total cumulative energy savings due to PAT for all the sectors in comparison to a business as usual scenario is 165.23 million TOE.

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 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.
- It has been assumed that the plants meet the target allotted to them till the years 2030.
- The target for the subsequent PAT cycles is calculated based on the current trend of reduction in target between PAT Cycle I and II.
- It has been considered that 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.
- It has also been considered that some breakthrough technological advancement might provide further reduction potential in the sector.
- It has been considered that 90% of the energy intensive plants in these sectors will come under PAT directly, whereas small production units which comes under SMEs may be covered under voluntary PAT scheme for SMEs, a scheme under consideration by Govt. of India, wherever applicable.

6.0 Sectoral data analysis and Benchmarking

6.1 Thermal Power plant

Sector specific data analysis

The overall trend of various categories of power plants indicating the unit heat rate, APC and the net heat rate for the assessment year is tabulated in Table 12, for PAT Cycle 1.

Category	Gross Unit Heat Rate		APC		Net Heat Rate	
	National Best	Average	National Best	Average	National Best	Average
MW	kCal/kWh	kCal/kWh	%	%	kCal/kWh	kCal/kWh
<100	2606	3082	8.38	11.18	2908	3470
100 – 150	2450	2718	6.92	11.48	2687	3070
150 – 300	2274	2554	5.86	7.36	2496	2757
300 – 600	2244	2386	5.34	6.66	2419	2556
Gas	1837	2161	1.43	3.47	1881	2239

Table 12: Specific Energy Consumption & APC % (National Average vs. National Best)

In order to analyze the sectoral profile of the power industry, the units of the thermal power plants are categorized into five different segments, based according to the size of the installed capacity namely, (1) <100 MW (2)100 – 149 MW (3) 150-300 MW (4) 300 – 600 MW (5) >600 MW.

Based on the data received from BEE, analysis was carried out by compiling and analyzing data for 78 TPPs and 34 Gas Turbine modules (CCGT), which is equivalent to 75% of the power plants shortlisted in PAT cycle-I.

Category	No. of Units	Installed Capacity	Operating Load		Gross Generation		PLF	
		AY	BY	AY	BY	AY	BY	AY
		MW	MW	MW	MU	MU	%	%
<100	46	2,717	2,280	1,719	17,263	11,543	67.23%	62.11%
100 - 149	65	7,755	5,189	5,525	28,742	26,290	50.15%	44.46%
150 - 300	183	39,690	33,489	34,094	219,351	192,855	65.65%	56.33%
300 - 600	56	27,180	19,603	24,575	66,210	78,576	43.19%	33.00%
>600*	3	1,980	-	617	-	14,340	-	82.67%
TPP Total (A)	**331**	**77,112**	**60,562**	**66,529**	**331,566**	**323,604**	**58.13%**	**47.91%**
Gas (B)	68	10,558	7,831	6,512	63,361	32,134	68.51%	34.74%
Sector Total (A+B)	**399**	**87,670**	**68,392**	**73,041**	**394,927**	**355,738**	**59.58%**	**46.32%**
***The first 660 MW unit in India was commissioned in 2010, and hence, units with capacity of 660MW and beyond were not available in baseline period of PAT Cycle-I**								

Table 13 Installed capacity and operating load for BY and AY

From the above table, the percentage variation trend for operating capacity and the gross units generation was estimated with respect to Assessment Year (AY) and Baseline Year (BY) and is tabulated Table 14. It can be inferred that the total operating capacity of thermal power plant increased by 9.85%, but the gross generation was reduced by 2.4%. This is an indicative of reduced plant load factor due to increase in larger capacity units, resulting in increase in average heat rate of the sector.

Category	% Increase	
	Op. Load	Gross Generation
	%	%
<100	-24.63	-33.13
100 - 149	6.47	-8.53
150 - 300	1.81	-12.08
300 - 600	25.36	18.68
>600	–	–
TPP Total	**9.85**	**-2.4**
Gas	-16.84	-49.28
Sector Total	**6.8**	**-9.92**

Table 14: Percentage increase or decrease of operating capacity and gross generation

Similar comparisons were constructed to analyze the trend of average unit heat rate and the net heat of the corresponding categories. Based on the analysis, the trend of the same was also evaluated. The unit heat rate of all the categories, with the exception of 300 – 600 MW units, have decreased by at least 2% (on weighted average) for the thermal power plants. The unit heat rate of 300 – 600 MW segment and the gas turbine modules increased by at least 2%. Majority of the units operate with gross unit heat rates deviating by up to 10% with respect to the design heat rate, wherein the plant load factor and decreasing gross generation have been detrimental to the gross unit heat rate.

Category	Gross Unit Heat Rate (Wt. Avg)				
	Design	BY	AY	Range BY	Range AY
	kCal/kWh	kCal/kWh	kCal/kWh	kCal/kWh	kCal/kWh
<100	3,476	3,205	3,082	2,606 – 3,886	2,606 – 3,940
100 – 149	2,802	2,967	2,718	2,321 – 3,886	2,213 – 2,678
150 – 300	2,306	2,603	2,554	2,275 – 3,182	2,273 – 3,138
300 – 600	2,263	2,326	2,386	2,226 – 2,976	2,244 – 2,835
>600	2,207	–	2,284	–	2,272 – 2,293
Gas	1,956	2,114	2,161	1,807 – 4,503	1,837 – 4,780

Table 15: Unit Heat Rate comparison of assessment and baseline year

The following table is the evaluation of the % increase or decrease of unit heat rate and the deviations of the heat rate in the assessment year and baseline year, with respect to design.

Category	% Increase	Deviation w.r.t. Design	
		BY	AY
	%	%	%
<100	-3.85	-7.78	-11.34
100 - 149	-8.41	5.9	-3.0
150 - 300	-1.90	10.31	8.21
300 - 600	2.55	2.8	5.42
>600	–	–	–
Gas	**2.25**	**8.1**	**10.53**

Table 16: Percentage increase or decrease of unit heat rate

Similar to the unit heat rate comparison, the APC of the power plant units of various categories were also evaluated and is tabulated in Table 17. The APC% for 150-300 MW units have significantly reduce by almost 10%, while the other categories have shown increase.

Category	Auxiliary Power Consumption % (Wt. Avg)				% Increase
	BY	AY	Range BY	Range AY	APC
	%	%	%	%	%
<100	10.40	11.18	7.98 - 14.26	8.38 - 15.39	7.5
100 - 149	11.06	11.32	7.38 - 19.76	6.92 - 21.78	3.8
150 - 300	8.85	7.36	4.53 - 14.26	5.86 - 14.54	-16.84
300 - 600	6.37	6.66	4.50 - 10.78	5.34 - 8.82	4.55
>600	-	5.34	-	5.34	-
Gas	2.59	3.47	1.68 - 10.42	1.43 - 9.67	33.98

Table 17: APC comparison of assessment and baseline year

The decreasing net heat rates of the thermal power sector from 2768 kCal/kWh in the baseline period to 2712 kCal/kWh in the assessment year is the result of the implementation of the PAT scheme, wherein the wt. average net heat rates of various categories can be observed in Table 18.

Category	Net Heat Rate (Wt. Avg)				% Increase
	BY	AY	Range BY	Range AY	Avg Net HR
	kCal/kWh	kCal/kWh	kCal/kWh	kCal/kWh	%
<100	3,577	3,470	2,870 – 4,532	2,908 – 4,300	-3.01
100 - 149	3,336	3,070	2,506 – 4,559	2,687 – 4,861	-7.97
150 - 300	2,856	2,757	2,492 – 3,661	2,496 – 3,506	-3.48
300 - 600	2,484	2,556	2,413 – 3,277	2,419 – 3,014	2.87
>600	--	2,413	-	2,400 – 2,422	-
Gas	2,170	2,239	1,843 – 4,613	1,881 – 5,072	3.17

Table 18: Net heat rate comparison of assessment and baseline year

Supplementing the analysis illustrated above, comparisons were made to analyze the number of cold/warm/hot boiler startup during baseline and assessment year. It can inferred from Figure 20 that, for the overall thermal power sector, the number of cold/warm startup have increased by almost one-third and the number of hot startups have reduced by 23%. It is imperative to understand that, particularly the 150-300 MW category has experienced a majority of these cold/warm startups, increasing almost two-fold in the assessment year.

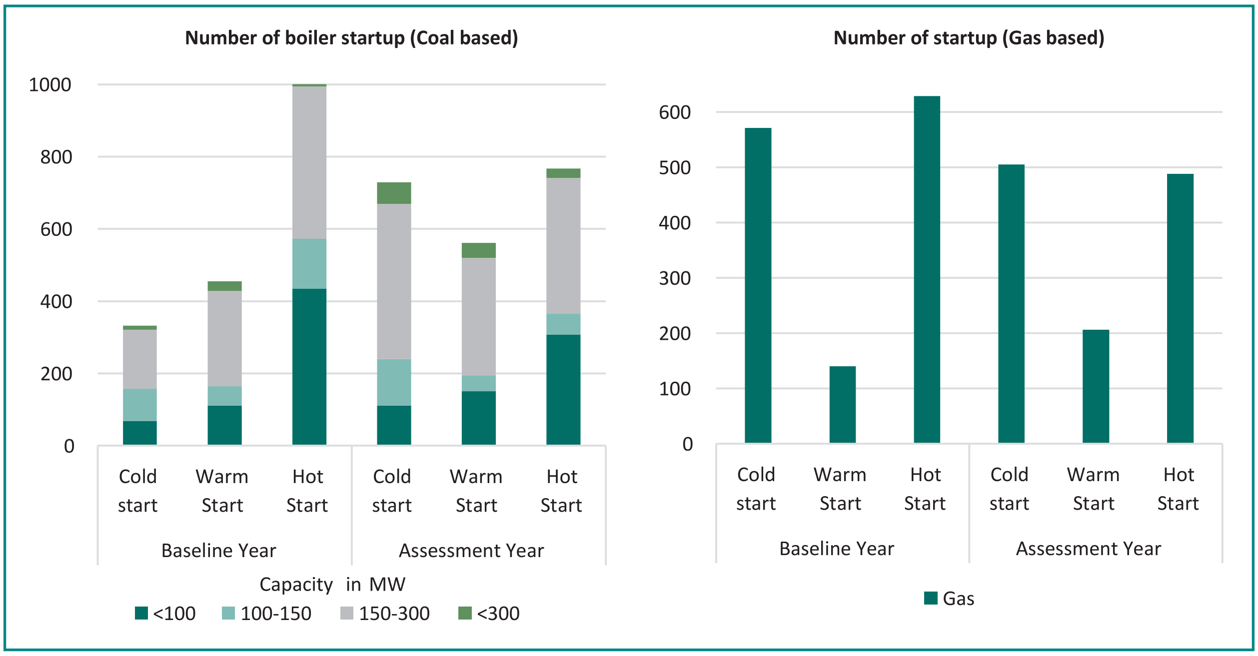


Figure 20: Comparison of no. of boiler startups for BY and AY in PAT Cycle 1

The variation in the number of cold/warm/hot startups can be attributed to various factors:

- Decreasing PLF of the power sector/Load scheduling
- Resource unavailability (fuel, water, etc.)
- Environmental compliances
- Surplus electricity resulting in lower peak demands, hence, decreased hot startups in AY

All of the aforementioned factors are not only indicative of the sector's operational efficiency, but also reflect on the primary energy consumed by the sector. The percentage share of the primary energy consumption of the sector for the baseline and the assessment year is shown in Figure 21.

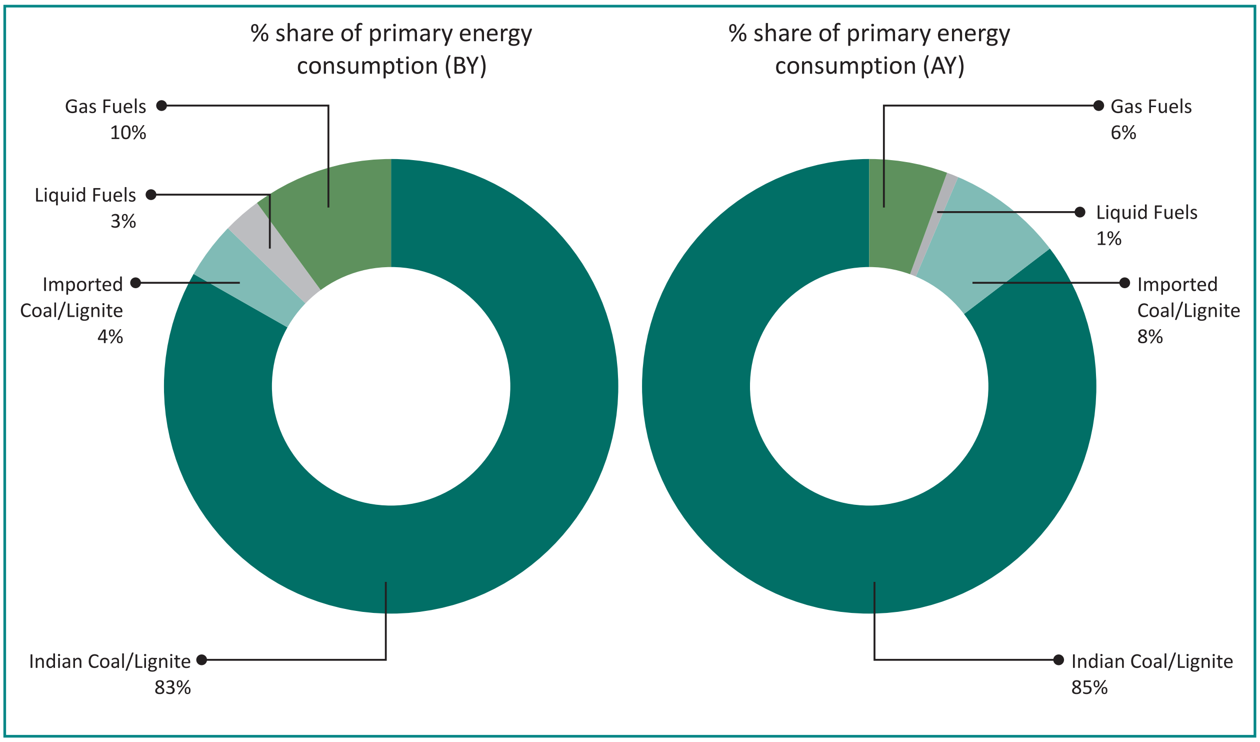


Figure 21: Percentage share of primary energy consumption in BY and AY in PAT Cycle 1

The percentage share of the primary energy consumption of the sector for the baseline and the assessment year is shown in Figure 22. The figure evidently indicates the decrease in the consumption of liquid and gas fuels, while the consumption of imported coal has doubled between the baseline and assessment year. Based on the trends of primary fuel consumption, the following conclusions were drawn.

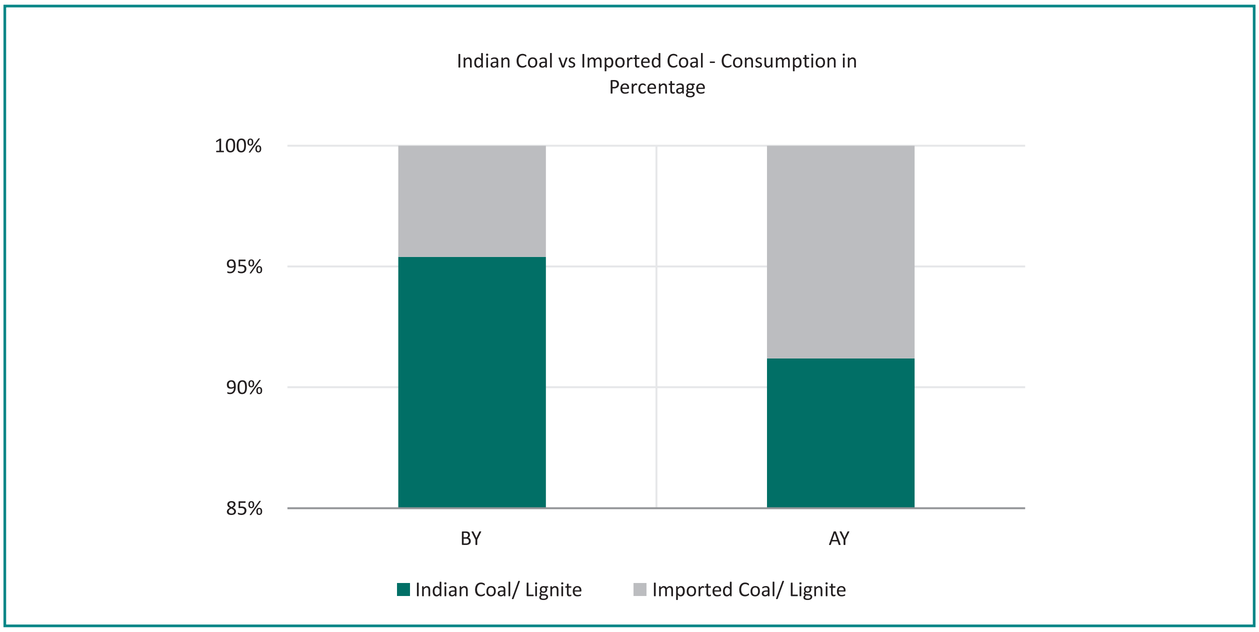


Figure 22: Comparison of consumption of Indian coal and imported coal

- **Demand & Supply gap of coal:** With India's coal reserves being able to cater to only 75% of coal requirements, and the demand for coal increasing at a CAGR of 6% every year, the imports of coal have increased substantially in order to avoid fuel shortages.
- **Fuel quality of coal:** India's domestic coal is characterized as a fuel with low GCV, high ash content and high moisture content, and the alternative to blend domestic coal with imported coal provides impetus to the generating stations to operate more efficiently. The increase in imported coal consumption has increased by 4.2% as shown in Figure 22
- **Increase in installed capacity:** With the commissioning of larger power plants, and increase in the operating load of medium capacity (300-500 MW) power plants, has resulted in increased demand for coal
- **Unavailability of gas:** The utilization of NG fuel has witnessed a 4% decline between the baseline and the assessment year, majorly attributing to the low availability of gas fuel.
- **Shutdown of diesel based plants:** Owing to various environmental compliances and high cost of generation, various diesel based plants are also being shut down, therefore resulting in reduced consumption of liquid based fuels.

6.2 Iron and Steel

Sector specific data analysis

The major Iron and steel production in the country is from integrated steel plants. The capacity utilization of the DCs from integrated steel plants and various section of sponge Iron plant is mentioned in Table 19. The capacity utilization is marginally varied in the case of integrated steel plants and was higher in the baseline period in comparison to assessment period, whereas the Sponge Iron and mini blast furnace steel plants can be improved in the near future for enhancing energy efficiency.

S No	Sections of Steel plants	Capacity Utilization Baseline period (%)	Capacity Utilization Assessment period (%)
1	Integrated Steel Plant	89.88	77.27
2	Sponge Iron	67.86	69.22
3	Steel Melting Shop	13.47	15.89
4	Ferro Chrome	67.14	73.56
5	Ferro Manganese	15.90	36.57
6	Silico Manganese	27.95	48.29
7	Pig Iron	59.33	56.07
8	Ferro Silicon	69.14	53.20
9	Rolling Mill	45.04	42.67

Table 19: Capacity Utilization of Steel Plants

The minimum specific energy consumption of individual sections of PAT designated consumers is mentioned for Integrated as well for plants less than 1 million Tonne per annum capacity is mentioned in Table 20. The capacity utilization as mentioned earlier has been low for Iron and Steel Industry for assessment period in comparison to baseline period. In spite of low capacity utilization target was exceeded by several plants. The minimum consumption of Integrated Iron and Steel plant is 5.96 GCal/tcs during the assessment period. The minimum consumption mentioned Table 20 does not include any normalization factors.

Section	Baseline year			Assessment year		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Material Handling (Sinter+Pelletisation +Coking)	0.729	1.571	2.604	1.091	1.520	2.287
Iron Making (Blast furnace+DRI+HBI+Corex)	3.237	3.670	4.559	3.279	3.771	6.003
Calcination	0.021	0.102	0.184	0.069	0.107	0.199
Steel melting and casting	0.093	0.567	1.905	0.235	0.530	1.515
Hot strip Rolling	0.285	0.270	0.594	0.195	0.235	0.565
Cold rolling	0.103	0.156	0.223	0.107	0.143	0.213
Others(Rest of the Rolling Section)	0.048	0.409	1.170	0.036	0.419	0.758
Compact strip mill	0.000	0.000	0.000	0.121	0.161	0.281
Boiler	-0.846	0.151	0.568	-0.715	-0.110	1.770
Oxygen plant	-0.010	0.064	0.258	0.025	0.051	0.734
Power plant	-0.001	0.315	2.793	0.041	0.282	4.058
Auxiliary Plant	0.020	0.196	0.379	0.065	0.169	2.087
Component losses	0.000	0.318	2.749	0.093	0.258	3.886
Total	6.331	7.261	9.537	5.960	7.171	9.126

Table 20: Specific energy consumption in integrated steel plants (in Gcal/tcs)

24 The values in negative indicate that there is no consumption of energy

The specific energy consumption of plants less than 1 million MTPA were analysed for baseline and assessment year of PAT cycle-I, and is mentioned in Table 21. The mini blast furnace has higher specific thermal energy in comparison to sponge Iron but onward process consume lesser in a mini blast furnace system, thereby reducing the overall specific energy consumption compared to sponge Iron.

Section	Parameter	Units	Baseline Period	Assessment Period
Sponge Iron	Thermal SEC	million kcal/Tonne of Product	3.56	3.92
	Electrical SEC	kWh/Tonne of product	57	59
Electric Arc Furnace	Electrical SEC	kWh/Tonne of product	216	199
Ferro Chrome	Electrical SEC	kWh/Tonne of product	3773	3643
Ferro Manganese	Electrical SEC	kWh/Tonne of product	3545	3600
Silico Manganese	Electrical SEC	kWh/Tonne of product	3563	4001
Mini Blast Furnace	Thermal SEC	million kcal/Tonne of Product	4.09	3.53

Table 21: Minimum Specific energy consumption of different sections in Steel plants (less than 1 million TPA)

Pelletisation plant is an excellent opportunity available in Indian steel plants to improve the quantity of agglomerates in the blast furnace. Plants have reported improved savings in energy consumption by increasing the use of agglomerates in the blast furnace or DRI kilns. In blast furnace overall 85% agglomerate (Sinter + Pelletisation) addition has been reported and DRI kilns around 100% agglomerate usage has been reported. 2 Integrated steel plants and 4 Sponge Iron plants/ Mini Blast furnace plants have Pellet plants in their facility. 1 Integrated steel plant and 1 Sponge Iron plants/Mini Blast furnace plants have installed Pellet plant between Baseline and Assessment period. Two integrated steel plants have also installed Thin slab casting in their facility which is in line with global standards in energy efficiency.

Benchmarking

The best specific energy consumption in the world achieved by a plant is 5.38 GCal/tcs. The best specific energy consumption of Indian plant is 5.67 GCal/tcs in the financial year 2016 – 17. India's and global best specific energy consumption for the sector is mentioned in Table 22.

Particulars	Units	Global Best	India Best	India Average
Specific energy consumption	GCal/tcs	5.38[25]	5.67[26]	7.171

Table 22: Specific energy consumption Global and India best

The best specific energy consumption for various process path is mentioned in Table 23. The minimum specific energy consumption mentioned is arrived by adding the best specific energy consumption in individual sections where best practices on energy saving are implemented and is not related to a single plant.

Process path	GCal/ton of steel
Blast furnace – Basic Oxygen Furnace – Thin Slab Casting	3.53
Smelt reduction – Basic Oxygen Furnace – Thin Slab Casting	4.25
Direct Reduced Iron – Electric Arc Furnace – Thin Slab Casting	4.06
Scrap – Electric Arc Furnace – Thin Slab Casting	0.62

Table 23: Best Specific Energy Consumption for Various Process Flow Path Based on World's Best Practices[27]

25 JFE Steel CSR report for 2016; http://www.jfe-holdings.co.jp/en/csr/pdf/csr2017e.pdf
26 Annual report 2017 – 18, Ministry of steel 2018
27 World Best Practice Energy Intensity Values for Selected Industrial Sectors, ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY 2008

- 0.9923 tonne pig iron required to produce 1tonne hot rolled steel (90% pig iron and 10% scrap)
- 1.05 tonne crude steel to make 1 tonne hot rolled steel

	Process parameter	Blast Furnace – Basic Oxygen Furnace	Smelt Reduction – Basic Oxygen Furnace	Direct Reduced Iron – Electric Arc Furnace	Scrap – Electric Arc Furnace
Units		GCal/t	GCal/t	GCal/t	GCal/t
Material Preparation	Sintering	0.45		0.45	
	Pelletizing		0.14	0.14	
	Coking	0.19			
Iron making	Blast Furnace	2.91			
	Smelt Reduction		4.13		
	Direct Reduced Iron			2.80	
Steelmaking	Basic Oxygen Furnace[28]	-0.10	-0.10		
	Electric Arc Furnace			0.62	0.57
	Refining	0.02			
Casting and Rolling	Continuous Casting	0.01	0.01	0.01	0.01
	Hot Rolling	0.44	0.44	0.44	0.44
Subtotal		3.94	4.66	4.47	1.03
Cold Rolling and Finishing	Cold Rolling	0.10	0.10		
	Finishing	0.26	0.26		
Total		4.30	5.02	4.47	1.03
Alternative: Casting and Rolling	Replace continuous casting and rolling with thin slab casting	0.05	0.05	0.05	0.05
Alternative Total		3.53	4.25	4.06	0.62

Table 24: Specific Energy Consumption for Best Practices in Iron and Steel Sector (Values are per metric ton of steel)

6.3 Cement

Sector specific data analysis

The Table 25 indicates the number of cement plants involved in PAT-I based on their major equivalent product. Total 85 nos. of cement plants involved in PAT-I with maximum share from plants making Pozzolana Portland Cement followed by Ordinary Portland Cement & Portland Slag Cement.

Major Equivalent Product	Ordinary Portland Cement (OPC)	Pozzolana Portland Cement (PPC)	Portland Slag Cement (PSC)	White Cement	Only Grinding Unit	Only Clinkerisation Unit	Wet Processing Unit
No of Plant	16	55	07	02	02	01	02

Table 25 No of Cement Plant in PAT-I based on Major Equivalent Product

28 Basic oxygen furnace operation is an exothermic process and does not use any additional energy

Some of the key findings of Proforma is listed below:

- Increase of Renewable Energy Share 13%
- Power Generation through WHRS increase from 62.7MW to 167.95 MW
- Capacity utilization of plant during baseline ~90% (except PSC plants) whereas during assessment year it is decreassed to ~70%
- OPC clinker factor increased by ~1%
- PPC clinker factor decreased by ~3%
- PSC clinker facto decreased by ~13%
- Specific Power Consumption Reduction for PPC ~9%, for PSC ~19% & for OPC 1%
- Specific Thermal Energy Consumption Reduction for PPC~4%, for OPC~2%

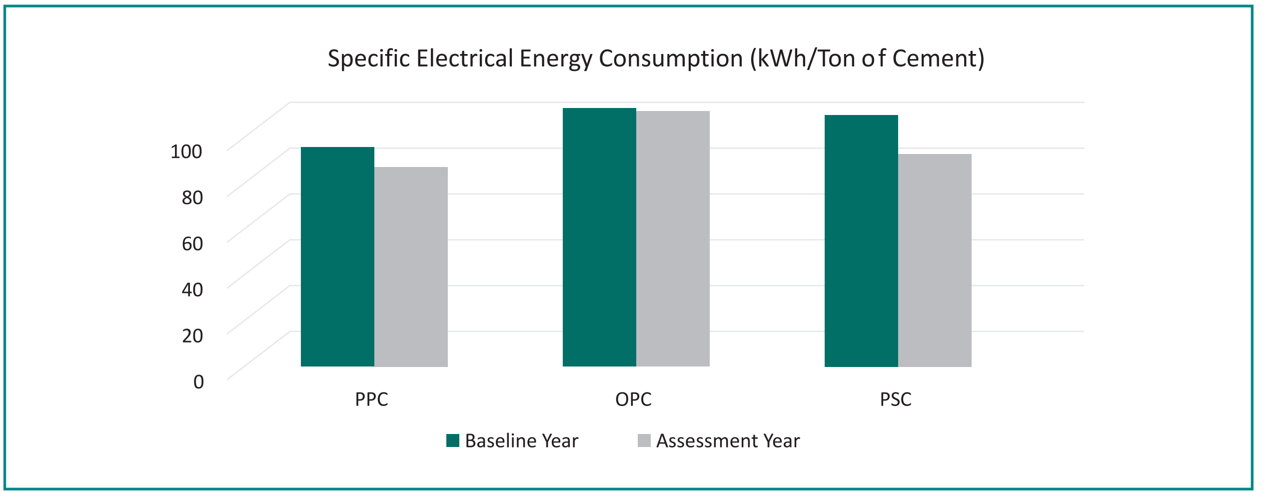


Figure 23: Specific Electrical Energy Consumption

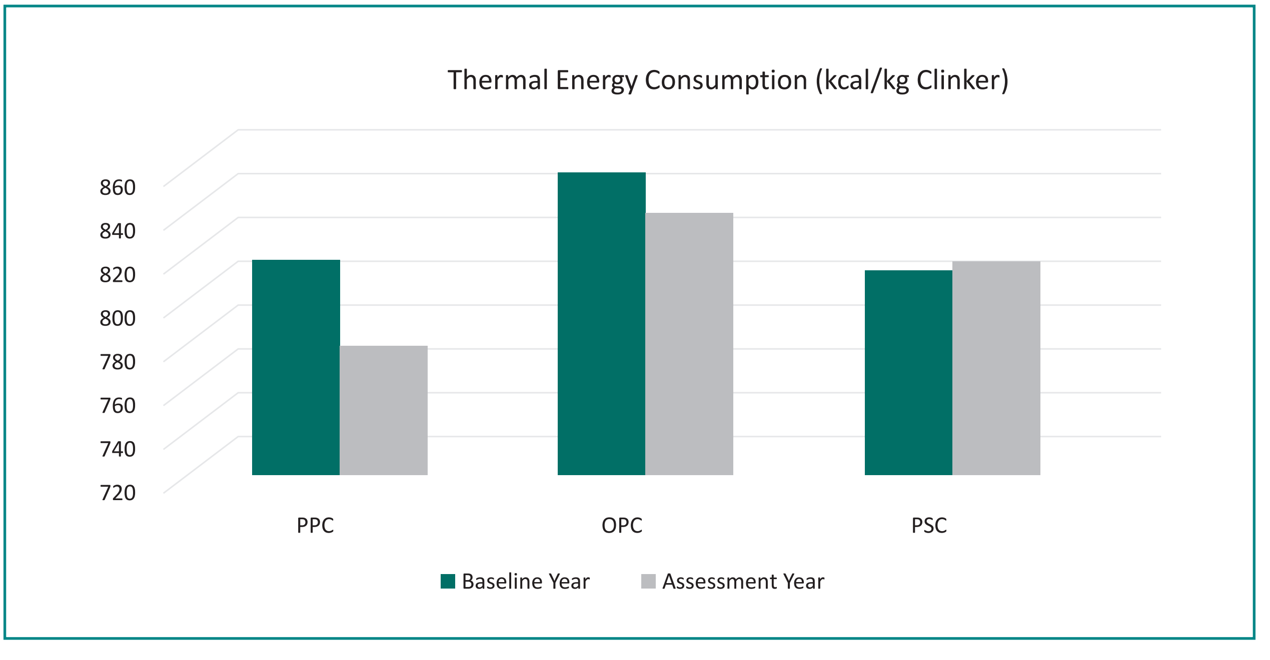


Figure 24: Thermal Energy Consumption

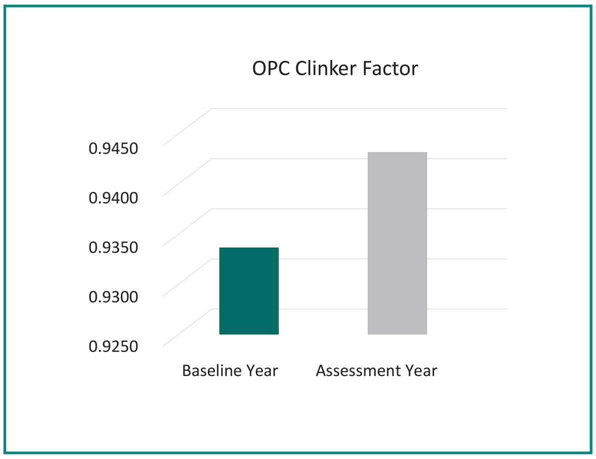


Figure 25: OPC Clinker Factor

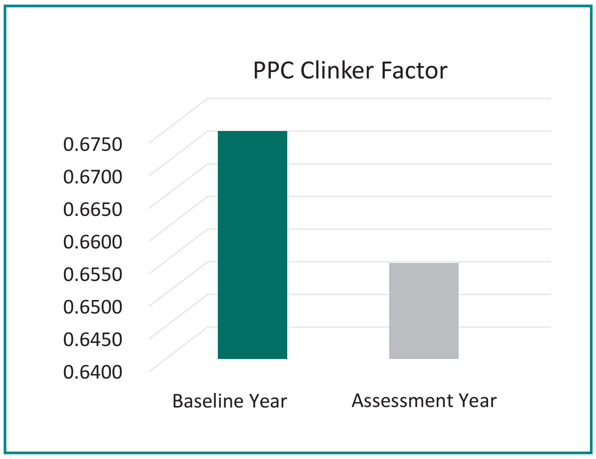


Figure 26: PPC Clinker Factor

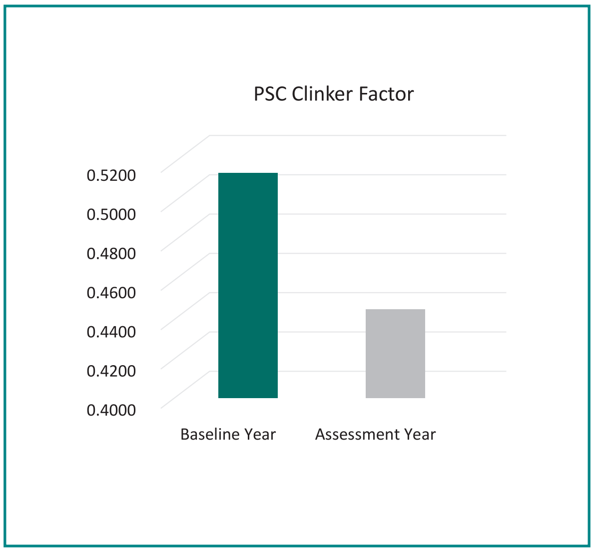


Figure 27: PSC Clinker Factor

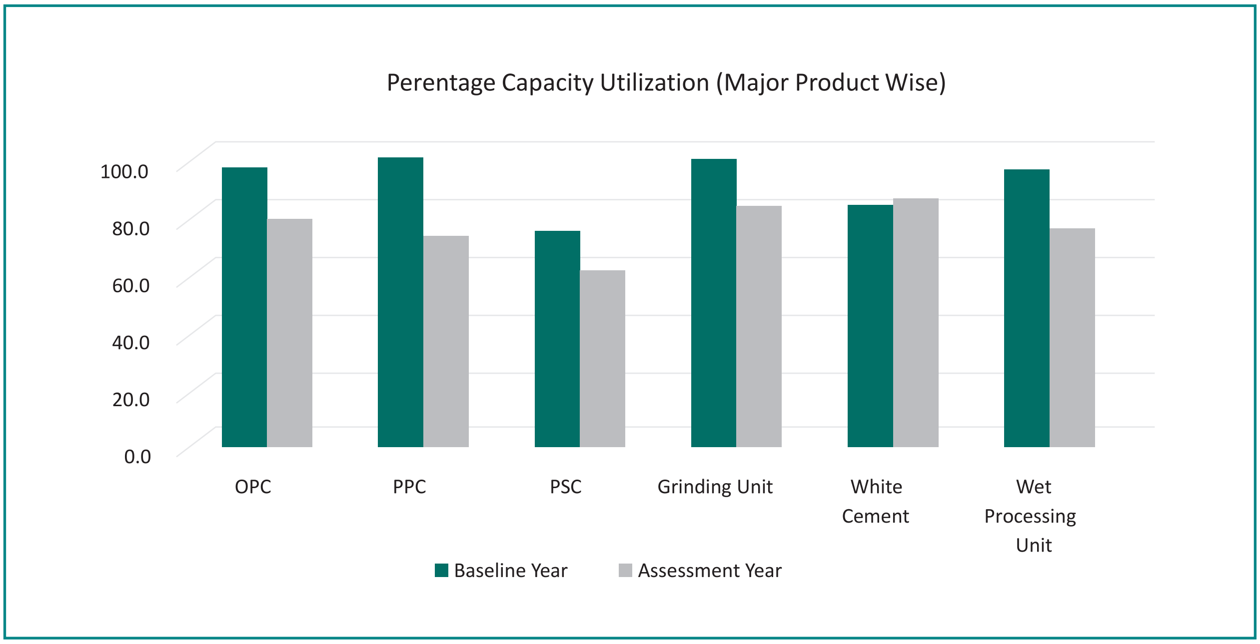


Figure 28: Percentage Capacity Utilization

Benchmarking

The Table 26 indicates the Electrical & Thermal energy consumption of cement sector Global & Indian trend.

Particulars	Units	Global Avg. [29]	India Best[30]	India Average
Specific Electrical Energy Consumption	kWh/tonne of cement	91	64	80
Specific Thermal Energy Consumption	GJ/tonne of clinker	3.5	2.83	3.1

Table 26: Specific Energy Consumption (Global & National)

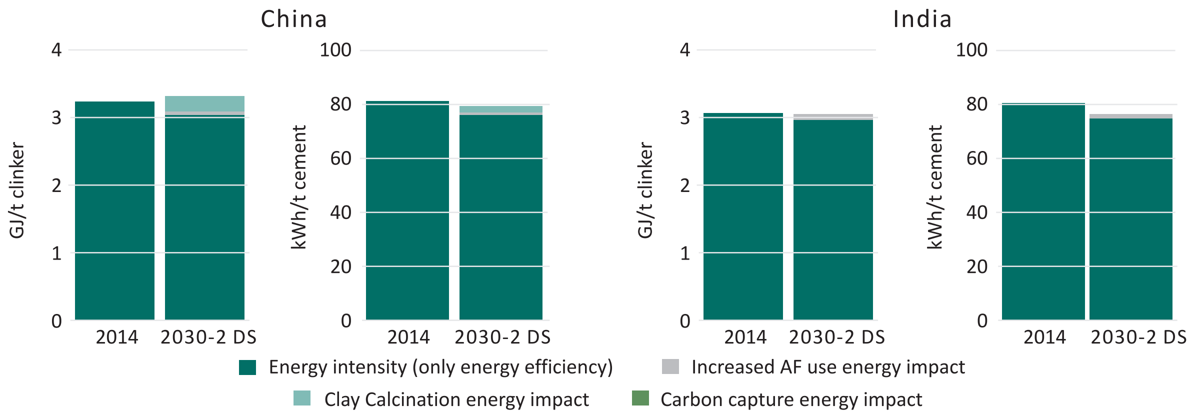
From Table 26 it is evident that Indian cement sector is one of the most energy efficient in the word and continuously adopting the latest technologies for energy conservation. Energy efficiency in the Indian cement industry is already high but still there is a scope for improvement in this area, providing continued use of energy efficient technologies in new plants and old plants.

Table 27 indicates the electrical specific energy consumption trends section wise of cement plant in India, whereas Figure 30 compares global energy intensity for cement.

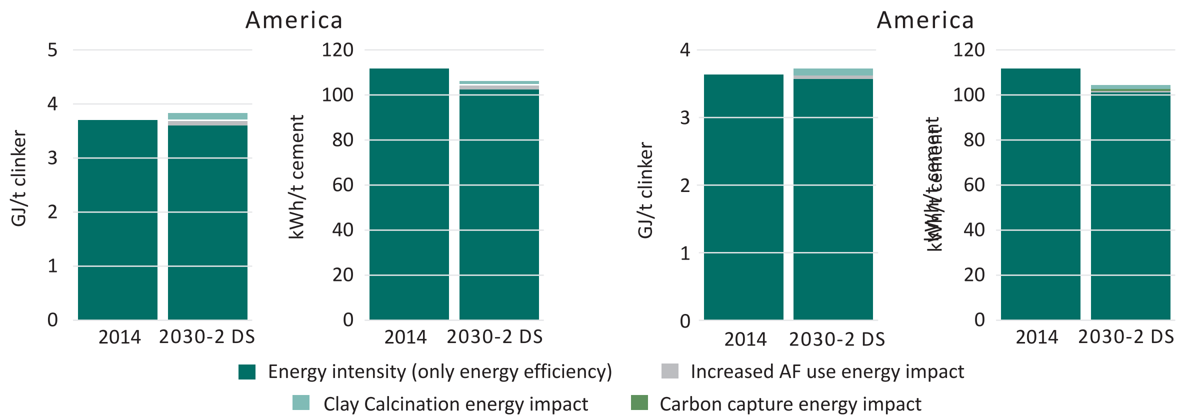
Particulars	Unit	Specific Power Consumption
Single Stage Crusher	kWh/Tonne of Material	0.7 – 1.8
Two Stage Crusher	kWh/Tonne of Material	0.65 – 2.3
Raw Mill - VRM	kWh/Tonne of Material	13 – 16
Raw Mill – Ball Mill	kWh/Tonne of Material	16 – 25
Pyro Section (5 stage Preheater)	kWh/Tonne of Clinker	16 - 32
Pyro Section (6 stage Preheater)	kWh/Tonne of Clinker	17 - 28
Cement Mill – Ball Mill	kWh/Tonne of Cement	27 – 40
Cement Mill - VRM	kWh/Tonne of Cement	21 - 36
Packing Plant	kWh/Tonne of Cement	0.65 – 1.9

Table 27: Section Wise Specific Energy Consumption Trend[31]

29 Technology Roadmap Low Carbon Transition in the Cement Industry by IEA & WBCSD
30 CII Database
31 CII Benchmarking Manual for Cement Industry in India Volume:2



Source: Base year data from CII, WBCSD and IEA (for the coming), Status Update Project from 2013 Low-Carbon Technology for the India Cement Industry, data submitted via personal communication by Sinoma Research Institute and China Cement Association (2016-17)



Source: Base year data from CSI, (2017), Global Cement Database on CO_2 and energy Information, www.wbcdcement.org/GNR; SNIC (for the coming), Low-Carbon Technology for the Brazillion Cement Industry.

Figure 29: Global Energy Intensity Comparison

6.4 Aluminium

Sector specific data analysis

The following section contains the details on the various aspects of energy efficiency in aluminium sectors based on the data submitted by the Designated Consumers under the PAT Scheme. The total numbers of Aluminium Plant in PAT Cycle 1 were 10 and summary of sub sectors is indicated in Table 28.

Sub Sector	Refinery	Smelter	Integerated	Cold Sheet
No. of Plants	4	4	1	1
CPP	0	4 (Total : 3692 MW)	1 (Total: 801 MW)	0

Table 28: Sector – Sub Sector Classification

Utilisation Factor

The average utilization factor for the calcined and hydrate alumina was lower for both baseline and assessment and the market conditions were the major reason for the lower utilization. However, the energy efficiency achievement would have been better if the capacity utilization was optimal. The average capacity utilization for refinery and smelter is shown in the Table 29 and Table 30:

Refinery	Baseline		Assessment	
	Hydrate Alumina	Calcined Alumina	Hydrate Alumina	Calcined Alumina
Plant 1	50	64	69.0	66.0
Plant 2	100	99	81.0	80.0
Plant 3	103	62	72.4	0.0
Plant 4	75	76	100.0	97.0

Table 29: Capacity Utilization of Refineries – Aluminium (all figures in %)

Smelter	Baseline		Assessment	
	Molten Aluminium	Cast House	Molten Aluminium	Cast House
Plant 1	93.67	113.00	78.37	64.56
Plant 2	102.94	52.23	104.70	49.64
Plant 3	94.51	95.50	70.60	71.10
Plant 4	56.01	48.04	100.83	93.46
Plant 5	112.00	85.61	118.75	109.68

Table 30: Capacity Utilization for Smelter – Aluminium (all figures in %)

Many of the plants have also shown substantial improvement in SEC for different products and improvement are in range of 24%-0.81% for calcined alumina and 29.32-4.30 % of hydrate alumina. The thermal specific energy consumption for alumina/refinery is mentioned in the Table 31:

Plant	Thermal SEC Baseline (million kCal/Tonne)		SEC Assessment (million kCal/Tonne)		Improvement (%)	
	Calcined Alumina	Hydrate Alumina	Calcined Alumina	Hydrate Alumina	Calcined Alumina	Hydrate Alumina
Plant 1	5.39	4.56	4.06	3.22	24.66	29.39
Plant 2	3.19	2.40	3.24	2.44	-1.50	-1.64
Plant 3	2.43	1.40	NA	1.34	NA	4.30
Plant 4	3.12	2.19	3.09	2.27	0.81	-3.43
Best Number			3.09	1.34		

Table 31: Thermal Specific Energy Consumption - Refinery

Similarly, for the smelter, there is good improvement in SEC for molten aluminium and is range of 9.25% -2.43%. The specific energy consumption for molten aluminium is mentioned in the Table 32.

Plant	SEC for Molten Aluminium Baseline		SEC for Molten Aluminium (Assessment)		Improvement	
	SEC (million kCal/Tonnes)	SEC (kWh/Tonne)	SEC (million kCal/Tonnes)	SEC (kWh/Tonne)	%	%
Plant 1	39.64	14541.00	42.08	14894.00	-6.16	-2.43
Plant 2	42.04	14549.65	37.11	14361.98	11.72	1.29
Plant 3	47.55	14573.47	44.62	14575.64	6.16	-0.01
Plant 4	43.74	15848.78	35.08	14383.00	19.80	9.25
Best Number			35.08	14575.64		

Table 32: Specific Energy Consumption - Smelter

In addition to the process, the improvement in energy efficiency for power plant is also critical for the sector as most of the smelters and integrated plants have installed Captive Power Plant (CPP) for meeting their power requirements.

The following Table 33 indicated the parameters for the captive power plants – Heat Rate and Unit Load Factor (ULF) at various smelters in Aluminium Sector

Plant	Baseline Year		Assessment Year	
	Heat Rate (kCal/kWh)	ULF (%)	Heat Rate (kCal/kWh)	ULF (%)
Plant 1	2747	78.65	2852.75	78.65
Plant 2	2899	89.6	2909	71.12
Plant 3	3275	76.22	3037	61.71
Plant 4	2730	43.09	2447	83.58
Plant 5	2909	98.18	2676	96.16

Table 33: CPP Heat Rates & ULF – Aluminium Sector

Benchmarking

The best specific energy consumption figures for different process paths are mentioned in the Table 34. The specific energy consumption values mentioned in Table 34, by considering the best practices implemented in that process are mentioned per tonne of product in order to compare with various processes. The following Table 34 and Table 35 indicate the benchmarking data for the Aluminium Sector:

Production	Global Best[10]	Global Average [32]	India Average [33]	India Best Numbers[11]	Unit
Alumina Refinery	0.20	0.267	0.33	0.23	TOE/Tonne of Alumina
Aluminium Smelting	13599	14145	14361	14558	kWh/Tonne of Molten Aluminium

Table 34: International Benchmarking – Aluminium Sector

Process	Section wise	Unit	India Best Numbers (Gcal/t)[11]	India Best Numbers (Gcal/t)[11]
Anode Manufacturing (Carbon)	Fuel	GCal/T	0.49	0.63
	Electricity	kWh/T	0.12	0.16
Ingot casting	Electricity	kWh/T	0.09	0.15

Table 35: Indian Benchmarking (For other areas)

From the above table it can be seen that there is significant potential for energy efficiency improvement for –refineries, anode manufacturing and aluminium smelting in India aluminium sector.

6.5 Fertilizer

Sector specific data analysis

The following section contains the details on the various aspects of energy efficiency in Fertilizer sector based on the data submitted by the designated consumers under the PAT Scheme. During PAT Cycle 1, only ammonia/urea producing plants were considered. There are 28 DCs producing ammonia/urea and 1 DC producing ammonia only. Total installed (Revamped) capacity of Urea product for 28 DCs is 19.2 million MT and ammonia product for one DC is 0.327 million MT.

32 Energy Statistics World Aluminium– International Aluminum Institute (2017)

33 Based on assessment year data PAT Cycle 1

34 World Best Practice Energy Intensity Values for Selected Industrial Sectors, Ernest Orlando Lawrence Berkeley National Laboratory, 2008

Product	No:- of units	Installed capacity (million MT)		Actual Production (million MT)	
		BY	AY	BY	AY
Urea	28	19.2	19.2	20.544	21.485
Ammonia	1	0.327	0.327	0.137	0.028

Table 36: Capacity and Production of the sector[35]

There is an increase of 4.5% in actual production of Urea, due to a number of reasons like revamps for capacity enhancement and energy reduction, increased capacity utilization, availability of raw feedstock and Government policy.

Another significant change in the sector is the use of Natural gas as feedstock instead of fuel oil and naphtha. This increased the efficiency of the plants by a good margin. Some of the plants were re-vamped to make use of Natural gas as the feedstock. The use of NG, as feedstock, increased by almost 1.3 times in the AY as compared to BY.

Feedstock used	Total Consumption		
	Unit	BY	AY
NG	Million SCM	10,954	14,146
Naphtha	MT	1,649,220	233,530
Fuel oil	MT	1,422,969	122,756

Table 37: Feedstock consumption during BY and AY[36]

The feedstock of 4 plants was switched over from fuel oil to Natural gas during the PAT cycle-I period. This revamping of the units to accommodate the use of NG as feedstock brought about a high reduction in SEC.

Parameter	Unit	Baseline year		Assessment year	
		Best	Average	Best	Average
Electrical SEC	MWh/MT	0.023	0.092	0.026	0.092
Thermal SEC	Gcal/MT	5.167	7.35	5.131	6.831
Overall SEC	Gcal/MT	5.171	7.354	5.135	6.836

Table 38: Average and Best SEC values in PAT cycle- I

The Table 38 gives a comparison of Specific energy consumption of Urea plants in PAT cycle – I between baseline and assessment year.

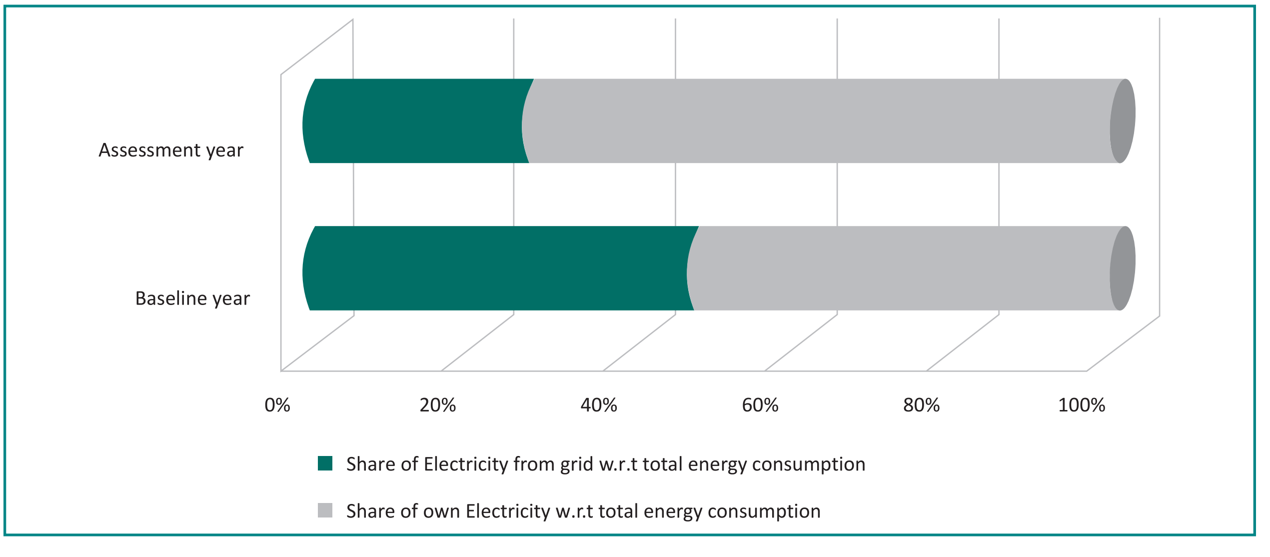


Figure 30: Share of electricity from grid for Fertilizer sector in BY and AY

35 Data from BEE
36 Data from BEE

The share of electricity generated in-house in total energy consumed increased by 39% between baseline year and assessment year.

Benchmarking

Benchmarking is an important tool to establish how one is performing and what avenues can be adopted to achieve the highest level in energy efficiency. Following section provides the comparison of India's Fertilizer sector performance with the best efficiency levels in the world. Fertilizer plants in India are among the most efficient plants in the world. The specific energy consumption (gate to gate) values mentioned Table 39 are by considering the best practices implemented in the sector.

Product	SEC (Gcal/MT)		
	India (average)	India (best)	World best
Urea	5.93	5.164	5.00
Ammonia	8.33	7.098	6.88[37]

Table 39: Benchmarking – Fertilizer Sector

A few Indian gas based plants having higher capacity (>3000 TPD/urea) based on natural gas feedstock, have specific energy consumption approaching international standards. Some older plants having of 40-50 years vintage having lower capacity around 1000 TPD/urea, may not be able to achieve lower energy standards. However, with the progressive installation of new gas based plants employing latest technology and phasing out of some older inefficient plants, there is potential for energy efficiency improvement in Indian Fertilizer sector. The most efficient plant in India, among PAT cycle- I DCs, has an SEC of 5.17 Gcal/MT of Urea. The average energy consumption of Indian plant is 5.93[38] Gcal/MT of Urea.

6.6 Pulp and Paper

Sector specific data analysis

Some of the key findings of Proforma is listed below:

- Specific Steam Consumption reduces by 4.6% w.r.t Baseline year
- Specific Electricity Consumption reduces by 5.7% w.r.t. Baseline year
- Percentage share of renewable energy increased by 8% wrt Baseline year
- Percentage share of electricity from grid decreased by 6% wrt Baseline year
- Percentage share of electricity through own genration increased by 6% wrt Baseline year
- Capacity utilization of paper mills remains same in basline as well as in assessment year
- Consumption of Imported Pulp increased by 34% wrt Baseline year
- Quantity of Exported Pulp increased by 13% wrt Basline year

37 Best Available Technology value taken from Global-Industrial-Energy-Efficiency-Benchmarking, UNIDO

38 Considering PAT cycle I – Fertilizer DCs

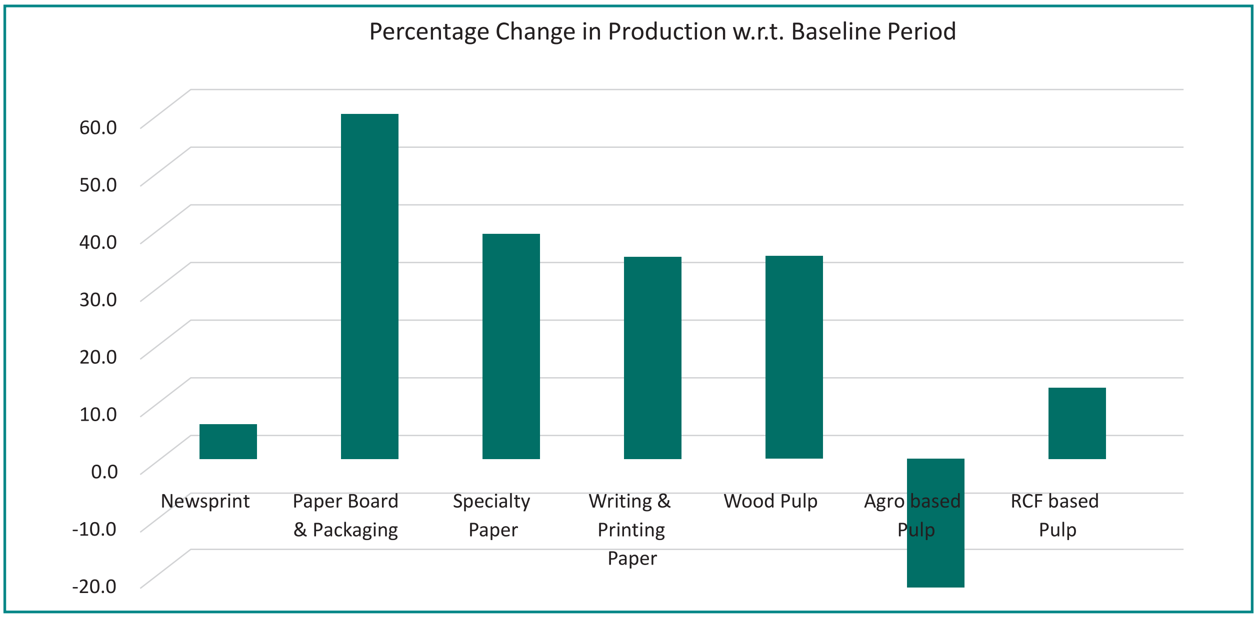


Figure 31: Percentage Change in Production w.r.t. Baseline period

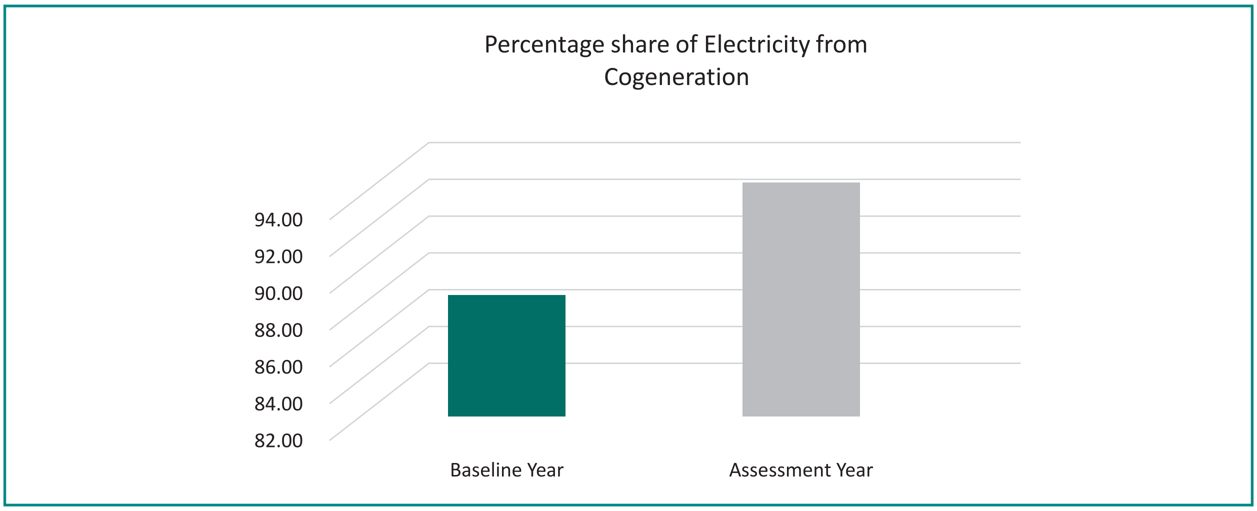


Figure 32: Percentage share of Electricity from Cogeneration

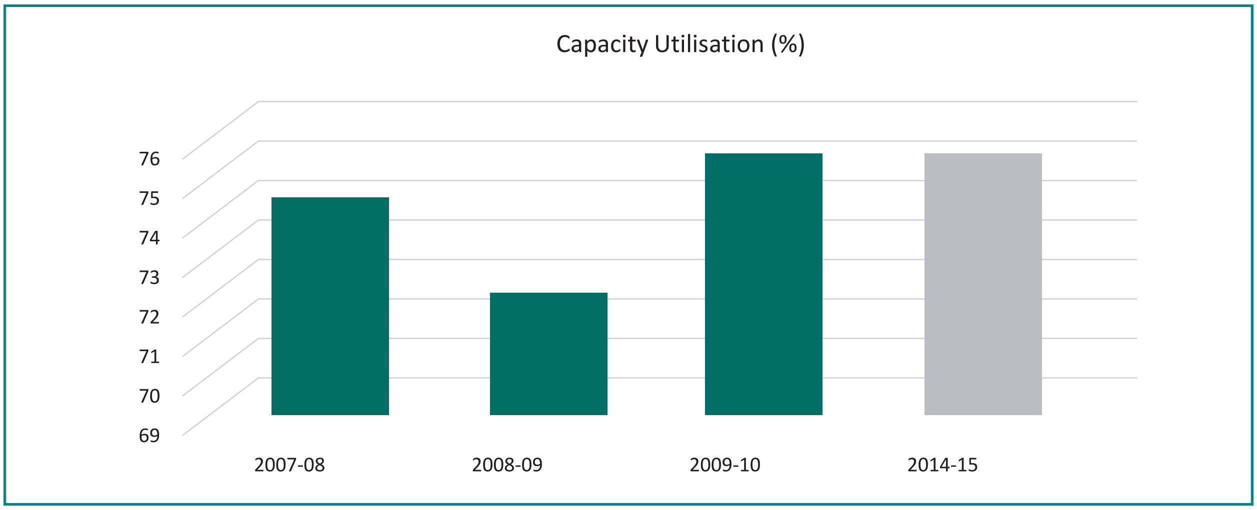


Figure 33: Capacity Utilization Paper Plants

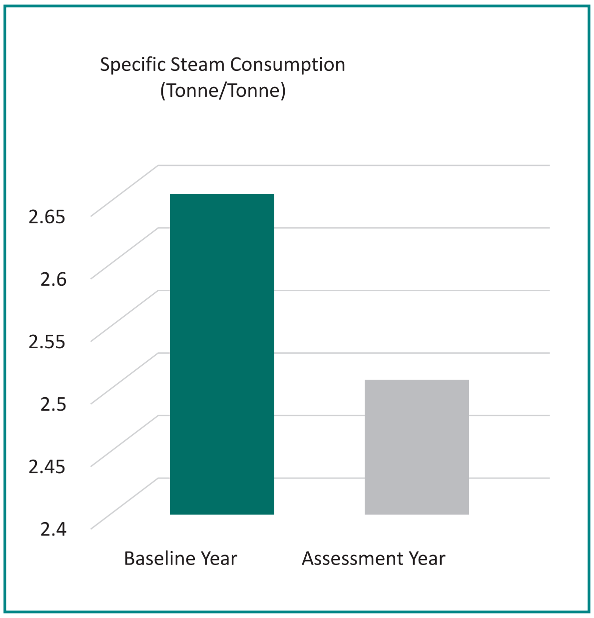


Figure 34: Specific Steam Consumption

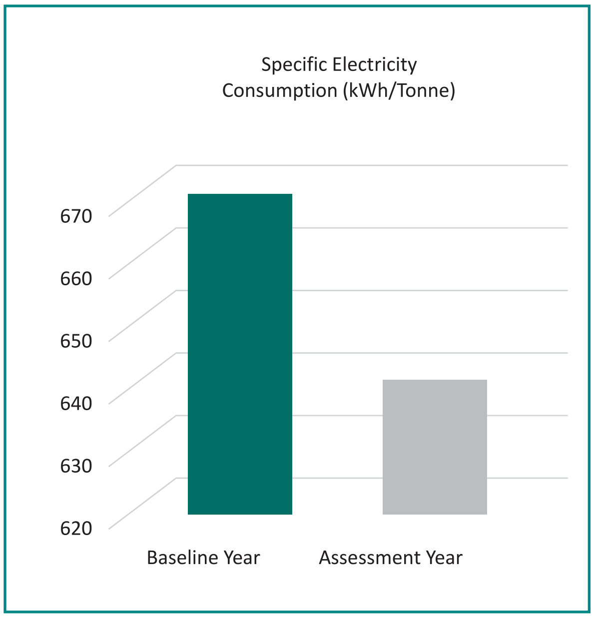


Figure 35: Specific Electricity Consumption

Benchmarking

Benchmarking is an important tool to establish how one is performing and what avenues can be adopted to achieve the highest level in energy efficiency. Following section provides the comparison of India's Aluminium sector performance with the best efficiency levels in the world. Table 26 indicates the Electrical & Thermal energy consumption of Paper sector (Raw Material Wise) Global & Indian trend.

Industry Group	Particulars	Units	Global Avg.	India Avg.	Industry Benchmark
Wood Based Mills	Specific Electrical Energy Consumption	kWh/tonne of paper	1000-1100	1400-1500	1200
	Specific Steam Consumption	Tonne of steam/ tonne of paper	7.0-9.0	12.0-13.0	9.0
Agro Based Mills	Specific Electrical Energy Consumption	kWh/tonne of paper	-	1200-1400	1000
	Specific Steam Consumption	Tonne of steam/ tonne of paper	-	12.0-14.0	10.0
Recycled Fiber Based Mills producing unbleached grades	Specific Electrical Energy Consumption	kWh/tonne of paper	500	450-550	400
	Specific Steam Consumption	Tonne of steam/ tonne of paper	2.5	4.0-5.0	3.5
Recycled Fiber Based Mills producing bleached grades	Specific Electrical Energy Consumption	kWh/tonne of paper	600-650	680-800	570
	Specific Steam Consumption	Tonne of steam/ tonne of paper	4-4.5	6.0-7.0	5.0

Table 40: Specific Energy Consumption (Global Vs India)[39]

The level of technology used in the three segments of industry (in terms of the raw material used: wood, agro and recycled fibre-based) varies. The agro and recycled paper mills still use conventional processes which are obsolete by international standards, and have not attempted to improve their methods. However, the wood-based mills have upgraded the technology used to improve paper quality and reduce pollution load. In order to solve many problems the industry faces, it is necessary to modernize the processes involved in paper manufacture; the technology currently in use lags behind that used in the rest of the world.

Steps aimed at filling the gaps in technology should be taken up in wood, agro- and recycled fibre-based paper mills through a structured technology support programme. The programme should aim to improve the competitiveness of industry by acquiring state-of-art technologies. This can be achieved by:

- Identifying and marketing appropriate technologies
- Contractual R&D activities leading to technology upgradation of the units.

The aspects that such a scheme should cover are:

- Raw material upgradation
- Resource conservation
- Product quality
- Process improvement
- Energy conservation
- Environmental compliance
- Research and development for adoption of technologies in Indian mills.

Specific Steam & Electricity Consumption section wise is mentioned in Table 41 Table 42 Table 43 based on the raw material uses.

Section	Power Consumption (kWh/Tonne Paper)	Steam Consumption (Tonne Steam/Tonne Paper)
Pulp Mill (Raw Material Preparation, Digester, Screening & Washing, Bleach Plant)	300-325	1.2-2.5
Recovery Section	250-300	3.0-3.5
Stock Preparation & Paper Machine	350-450	2.5-4.0
Effluent Treatment Plant	75-100	-
Power Generation Plant	150-200	-
Total	**1125-1300**	**3.7-6.5 ***

Table 41: Section wise Energy Consumption Trend (Wood Based)[40]

*Without considering the steam consumption in recovery section

Section	Power Consumption (kWh/Tonne Paper)	Steam Consumption (Tonne Steam/Tonne Paper)
Pulp Mill (Raw Material Preparation, Digester, Screening & Washing, Bleach Plant)	300-325	1.2-2.5
Recovery Section	75-100	1.0-1.7
Stock Preparation & Paper Machine	350-450	2.5-3.5
Effluent Treatment Plant	75-90	-
Power Generation Plant	125-200	-
Total	**925-1165**	**3.7-6.0***

Table 42: Section wise Energy Consumption Trend (Agro Based)[41]

40 Technology Gap Assessment of India Pulp & paper Sector & Technologies Available to Bridge the GAP to Achieve Targets Set Under PAT-2 Presentation by Dr B P Thapliyal - CPPRI

41 Technology Gap Assessment of India Pulp & paper Sector & Technologies Available to Bridge the GAP to Achieve Targets Set Under PAT-2 Presentation by Dr B P Thapliyal - CPPRI

*Without considering the steam consumption in recovery section

Section	Power Consumption (kWh/Tonne Paper)	Steam Consumption (Tonne Steam/Tonne Paper)
Pulper & Pulp Cleaning (HD Cleaner, Centricleaner, De-Inking & Bleaching)	300-350	0.5-0.7
Stock Preparation & Paper Machine	350-450	2.1-3.0
Effluent Treatment Plant	40-45	-
Power Generation Plant	100-110	-
Total	**790-950**	**2.6-3.7**

Table 43: Section wise Energy Consumption Trend (RCF Based)[42]

6.7 Textile

Sector specific data analysis

The following section contains the details on the various aspects of energy efficiency in Textile sector based on the data submitted by the designated consumers under the PAT Scheme. The total number of DCs in Textile sector for PAT Cycle I is 90. The capacity utilization of various sub sectors in Textile are mentioned in Table 44.

Sub Sector	Baseline	Assessment
Yarn spinning	103.87	101.20
Open end yarn	85.61	90.50
Dyed Fiber	80.50	70.9
Weaving@60 PPI	80.11	85.4
Cotton based Fabric	76.49	80.4

Table 44: Percentage Capacity utilisation in Textile sub sectors

The specific energy consumption of certain sections in Textile are mentioned in the Table 45 . The values are varying based on different blend of material used in the system. Some of the sub sectors had higher specific energy consumption due to lower capacity utilization, different product produced or increase in quality products.

Parameter	Unit	Baseline Year		Assessment year	
		Lowest	Average	Lowest	Average
Electrical UKG upto winding (Yarn-40s count)	kWh/kg	3.460	5.650	3.385	5.375
Electrical UKG (Open-end Yarn)	kWh/kg	0.426	1.255	0.392	1.349
Electrical UKG (Fiber Dyeing)	kWh/kg	0.230	0.437	0.122	0.461
Electrical UKG (Weaving)@ 60 PPI	kWh/kg	1.177	3.658	1.313	3.429
Thermal SEC (Weaving)@ 60 PPI	kcal/kg	221.320	1648.741	89.936	1231.110
Electrical UKG (Knitting)	kWh/kg	0.367	4.162	0.204	2.126
Electrical UKG (Cotton based fabric)	kWh/kg	0.437	1.455	0.637	1.499
Thermal SEC (Cotton based fabric)	kcal/kg	1736.312	7550.825	1818.000	7170.670
Electrical UKG (Polyester Cotton based fabric)	kWh/kg	0.643	1.385	0.616	1.714
Thermal SEC (Polyester Cotton based fabric)	kcal/kg	1718.954	9284.364	1908.280	8564.530
Electrical UKG (Lycra Fabric)	kWh/kg	1.371	1.543	1.144	1.211
Thermal SEC (Lycra Fabric)	kcal/kg	1736.379	5697.438	1619.780	4517.770
Electrical UKG (Wool based fabric)	kWh/kg	1.150	1.150	1.007	1.007
Thermal SEC (Wool based fabric)	kcal/kg	4300.914	4300.914	3630.360	3630.360

Table 45: Specific energy consumption of various sections in Textile

6.8 Chlor-alkali

Benchmarking

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 shown in Figure 36.

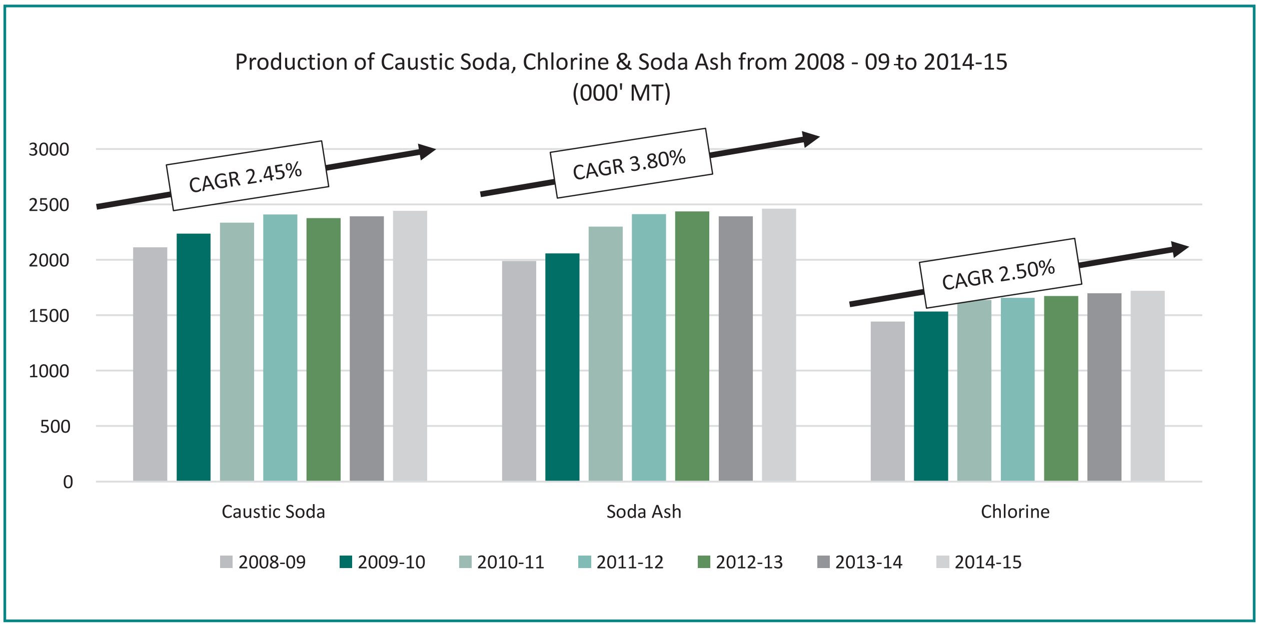


Figure 36: CAGR of production of caustic soda, chlorine and soda ash

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 illustration in Figure 36, indicates that the import of electricity from grid decreased by almost 35% in 2015-16 when compared to 2009-10.

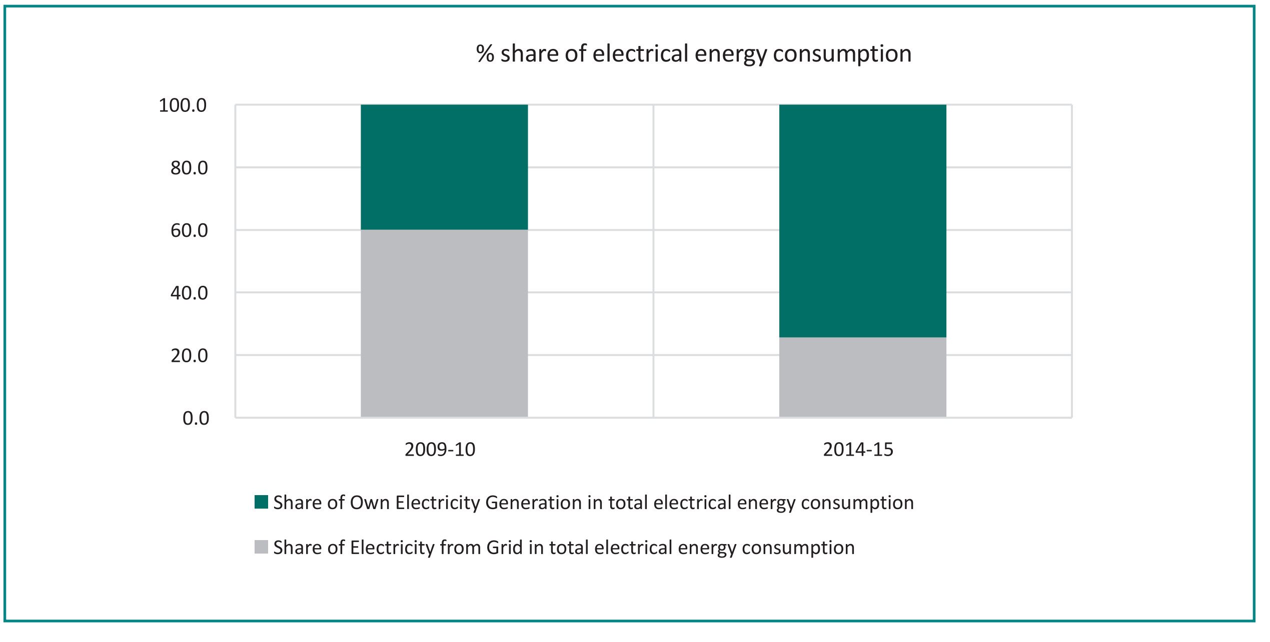


Figure 37: Percentage share of own electricity generation and grid imports

The Table 46 indicates the best benchmarks for the chlor alkali industry[43]. Also, the comparison of various cell technology based on their respective specific energy consumption in kWh/MT caustic soda is given in the graph shown in Figure 38:

Parameters	Units	Value
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 46: 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 Figure 38:

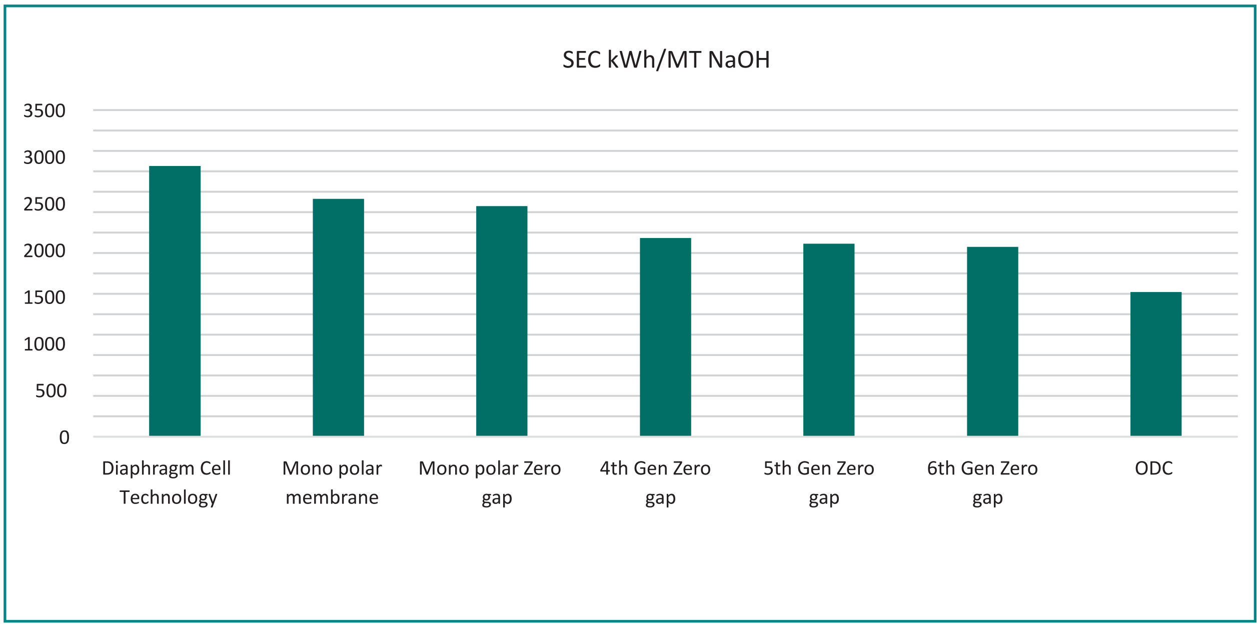


Figure 38: Benchmark of various cell technologies for NaOH production

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7.0 Technology Barrier and Issues faced during PAT

PAT Cycle 1 has been successful with energy saving achieved exceeding the energy saving target set during cycle 1. Even though the DCs were able to achieve significant savings there have been many barriers and challenges faced by the DCs which if addressed can result in much more savings and faster adoption of energy efficiency measures. The challenges and barriers faced by DCs can be grouped into following:

1. Technology Barriers
2. Financial Barriers
3. Market Barriers
4. Other barriers

Following are the some of the barriers faced by the DCs.

1. Technology Barriers:
    a. The major energy saving measures usually are from process side and it demands extended period of shutdown for implementation for example in the Cement sector waste heat recovery projects bed modification in fluidised bed boiler.
    b. The raw material quality also restricts the type of technology that can be implemented
    c. The DCs have lesser appetite for high risk or technologies which are at a very nascent stage.
    d. Lack of R&D in technology and process (indigenous) is also a restriction for attaining maximum benefits for achieving energy efficiency levels.
    e. Vintage of plants and technology is also a restriction for achieving high level of energy efficiency.
    f. Some of the other barriers that are faced by the DCs include lack of availability of space, production shutdown, lack of supplier base for particular technology, etc.
    g. In addition to that with stricter enforcement of environmental regulations, the DCs will have to implement various environmental impact reduction strategies which can have an impact on the overall energy consumption/efficiency of the plants.
    h. Standardisation in measurement of energy savings for particular energy conservation measures need to be more effective which can help DCs to take decisions on future energy saving project effectively.
    i. In addition to the above, the technology transfer among various international countries can be made more effective.
2. Financial Barriers:
    a. High energy saving projects require high capital expenditure. Some of the sector specific process improvement project implementation will have payback period of 4-5 years.
    b. Lack of financing for capital intensive Energy saving improvements is the main hurdle faced by the sector. The awareness on ESCO model of financing to attract more investment is not very high and not many plants have implemented projects on ESCO route which help reduce both the technology and financial barriers.
    c. The other major hindrance is the understanding of energy efficiency projects for financial appraisal among FIs and many efforts have been taken to reduce these gaps by creating more awareness among

FIs on EE projects.

d. Lack of project finance for Energy Efficiency projects is also a major hindrance for implementation of Energy Efficiency projects.

3. Market Barriers:

   a. Demand of products usually directs the manufacturing strategy for any company and fluctuation in the market can have significant impact on Energy Efficiency project implementation decision and also affects the capacity utilization of the DCs. If the Capacity utilization is lesser the energy efficiency levels also come down for example in power plant if capacity utilization is lower it would affect the Plant Heat Rate which would result in higher consumption of the energy.

   b. Competition from other markets also drives down the profitability of the company and thus create vacuum for funds for Energy Efficiency investment.

   c. High cost of imported technology can also be hindrance for the DCs for implementing the Energy Efficiency technologies.

4. Other barriers:

   a. Lack of financial incentives for high capital Energy Efficiency projects such as waste heat recovery, etc.

   b. The support and suggestions from the Auditors (energy) for identification of Energy Efficiency projects in process and key energy intensive areas.

   c. Lack of R&D and innovation (internal and external).

   d. Knowledge and Skills on PAT mechanism (Annual Energy Returns, normalization, etc.) among the energy managers.

   e. Availability of process wise benchmarking data for various sectors.

8.0 Trading of ESCerts

The success of PAT cycle-I resulted in 8.67 million TOE of energy savings. In lieu of these energy savings, over and above the target, the DCs were awarded with tradable Energy Saving Certificates (ESCerts). From the assessment of PAT – I, 309 DCs achieved in excess to their targets, thereby, adding to a total of 3.825 million positive ESCerts.

On the other hand, 110 DC could not achieve their target and were entitled to purchase a total of 1.425 million ESCerts. For PAT-I, out of 110 DCs who failed to achieve their target, 96 complied by purchasing ESCerts. A trading worth around 1 billion INR took place in 17 sessions with 1.29 million ESCerts being traded.

Sector	DCs Issued ESCerts	DCs entitled to purchase ESCerts
Aluminium	9	1
Cement	58	17
Chlor Alkali	18	3
Fertilizer	28	1
Iron and Steel	49	10
Pulp and paper	23	2
Textile	52	30
Thermal Power Plant	72	46
Grand total	309	110

Table 47: Status of DCs for procurement and entitled to purchase ESCerts

The trade price of the ESCerts was far less than the actual price of one tonne of oil equivalent, and the money invested for saving one tonne of oil equivalent. The low prices of ESCerts indicates that most of the energy savings has been accrued through least investment or by improving the operation and maintenance practices in the plant and ESCerts are a means to obtain additional revenues. The figure below explains three scenario which justifies the investment made for the savings.

Total Investment made	26100 Cr INR
Total Savings	8.67 mtoe
Investment per toe	30104 INR

Price of one toe (wt. avg fuel price)	10968 INR
ESCerts trade price (approx.avg price)	800 INR

Scenario 1		
Target	100	toe
Investment required	3010381	INR
Investment made	3010381	INR
Considering the saving to be valid for 5 years		
Saving in five years	500	
Monetary savings in five years	5484000	INR
Penality	0	

Net Profit = savings - investment

Scenario 2		
Target	100	toe
Investment required	3010381	INR
Considering no Investment made		
Saving in five years	0	
Monetary savings in five years	0	INR
Penality	1196800	INR
Purchased from market	80000	INR

Net Loss = ESCerts purchase price or penality price

Scenario 3		
Target	100	toe
Investment required	3010381	INR
Actually invested	5000000	INR
Toe saved	166	toe
Considering the saving to be valid for 5 years		
Saving in five years	830	
Monetary savings in five years	9108483	INR
Penality	0	
Additional revenue from sale of ESCerts	52874	INR

Net Profit = (Saving - investment) + ESCerts sale price

Basic: All calculations as per figures from PAT Cycle-I

Table 48: ESCerts trading for different trading

In scenario 1, the DC invests 3.01 million INR, just the amount needed to meet the target of 100 toe. The DC doesn't get any ESCerts and nor does they pay the penalty. However, the actual savings against the investment made till five years is 5.48 million INR, which is far more than the investment.

In scenario 2, the DC doesn't invest to achieve the target. The DC has to either pay the penalty of 1.197 million INR or purchase the ESCerts from the market at 0.08 million INR. Therefore, in five years, the DC gains nothing, but loses money in the way of penalty or trading.

In scenario 3, the DC invests 5.00 million INR, which is more than that required to meet the target. Obviously, the DC exceeds the target and gets ESCerts equivalent to the extra savings. The DC incurs a savings of 9.11 million INR at the end of five years, against the savings made. Additionally, the DC also earns through the sale of ESCerts.

It could be seen that investing in energy efficient technologies in itself is rewarding. ESCerts may add to additional revenue, and bring down the payback period of the investment. However, the price of ESCerts is completely market dependent, upon demand-supply economics.

9.0 Feedback on PAT scheme

The feedback on PAT scheme has been taken on various aspects such as Baseline, target setting, normalization, support from BEE/SDA, capacity building, etc. Some feedback has been collected by conducting interview with stakeholders over a phone or in person. However, for mass feedback, a set of questions were prepared and the stakeholders were requested to share their views.

More than 70 designated consumers participated in taking the questionnaire and provided their valuable feedback.

The feedbacks are summarized below, as per various aspects of PAT Scheme. A rating of 1 is highly unsatisfactory and 5 is highly satisfactory.

Figure 39: Feedback on overall aspects of the scheme

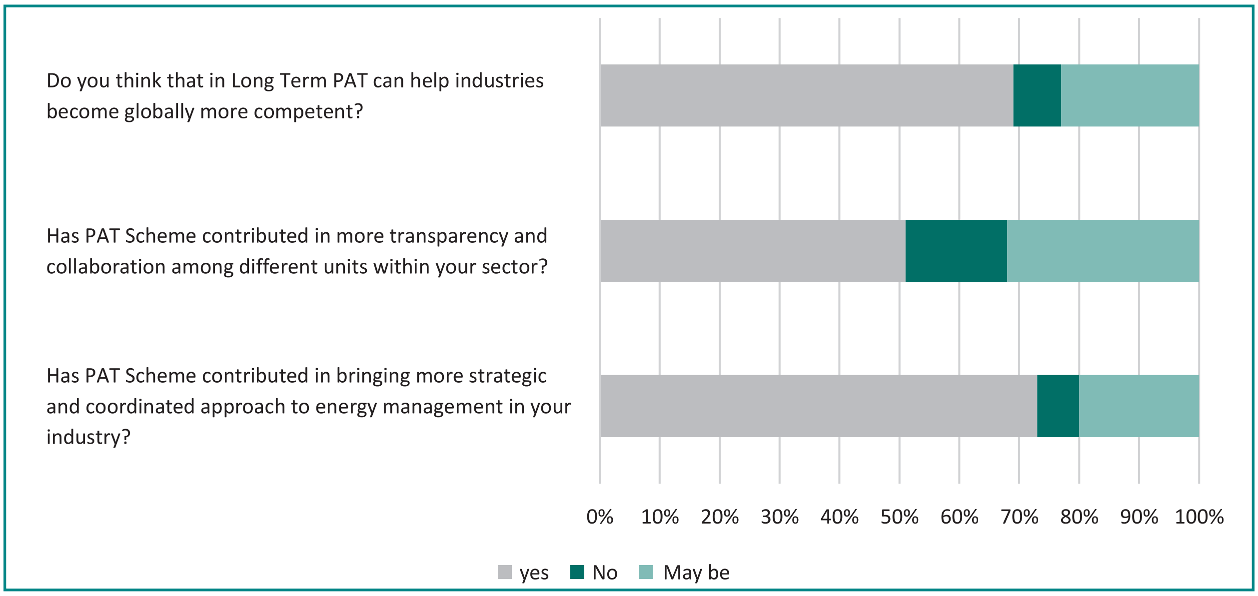


Figure 40: Feedback on key benefits

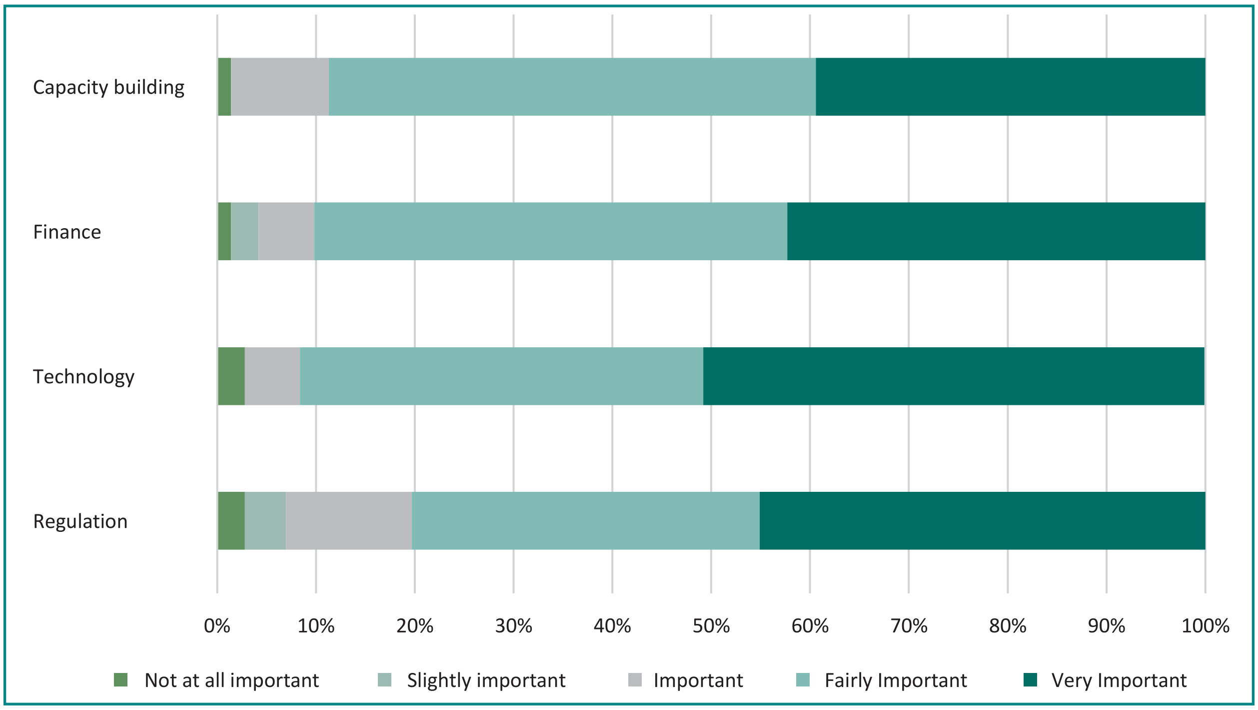
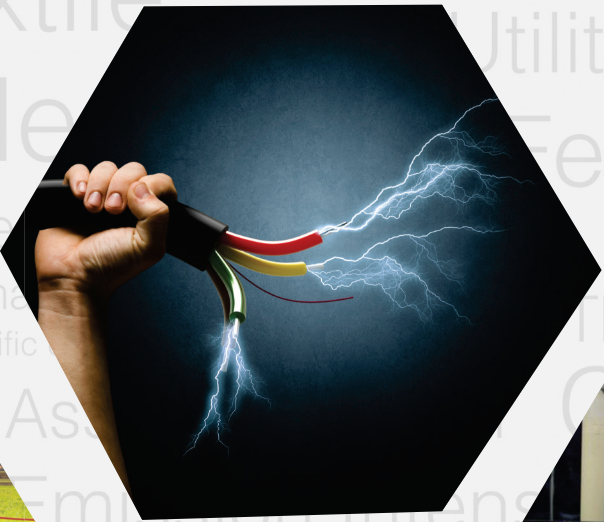


Figure 41: Feedback on need assessment in taking PAT forward

SECTORAL



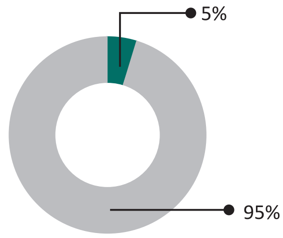
SNAPSHOTS

ALUMINUM

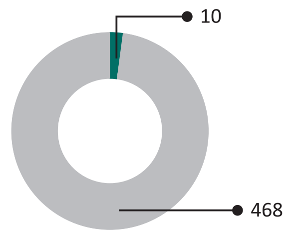
SECTOR HIGHLIGHTS……

- India contributes to 3% share of global aluminium capacity
- The annual production of aluminium was 2.88 million tonnes in 2016-17
- Increase in demand from key sectors becoming the key drivers for aluminium market
- Dominated by three key market players – NALCO, HINDALCO & Sterlite
- Per capita aluminium consumption is between 2.4 kg while world average is 8 kg

Baseline Energy Consumption

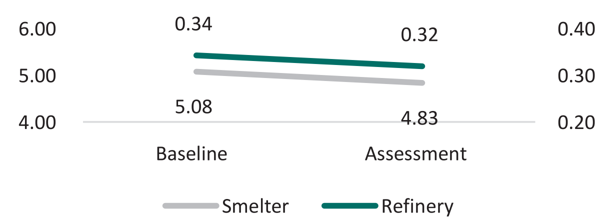


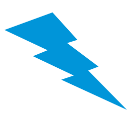
Designated Consumers (Cycle 1)



Aluminium Others

SEC Improvement (TOE/Eq. Product)





Energy Savings
0.73 mMTOE

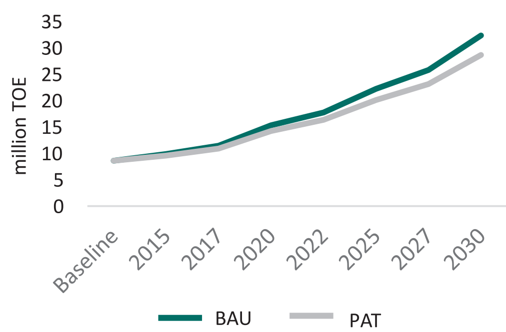
1.65 million
tonnes of coal

3.1 million
tonnes of CO_2
equivalent

Savings
7.52 billion INR

Reported
Investment
09 billion INR

Total Energy Consumption - BAU Vs PAT



Through subsequent PAT cycles by 2030 the cumulative energy savings possible in Aluminium Sector is 27.89 million TOE

Savings from the sector in PAT Cycle -I is equivalent to

2.6 million Homes' energy use for one year

1.15 million Cars taken off the road

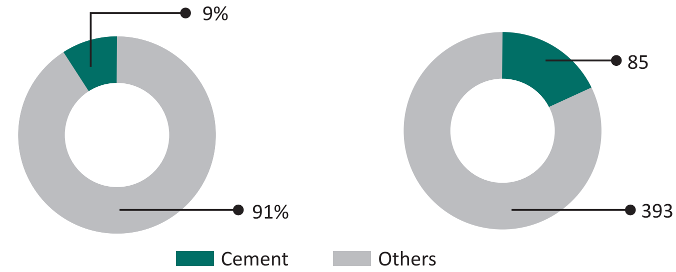
CEMENT

SECTOR HIGHLIGHTS……

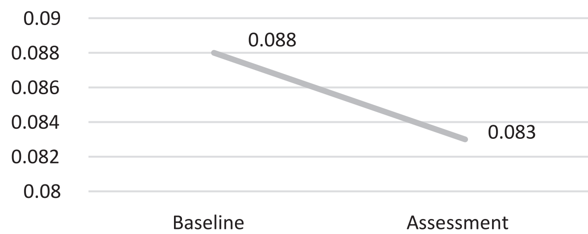
- India is the second largest producer of cement in the world.
- The country's per capita consumption stands at around 225 kg
- India's total cement production capacity is nearly 425 million tonnes as of September 2017
- The cement production in India likely to grow at 6% CAGR and the expected cement production in India by year 2030 will be around 598 million tonne.
- Contributes approx. Rs. 32500-35000 crore annually to the national exchequer through various taxes and levies.

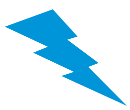
Baseline Energy Consumption

Designated Consumers (Cycle 1)



SEC Improvement (TOE/Eq. Product)





Energy Savings
1.48 million tonnes of oil equivalent

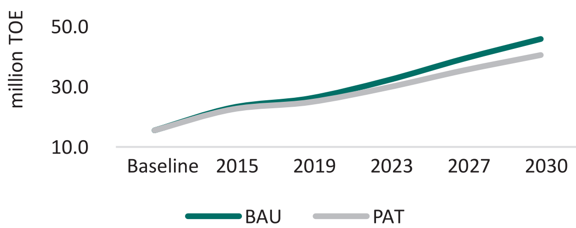
3.42 million tonnes of coal

4.34 million tonnes of CO_2 equivalent

Savings
16 billion INR

Reported Investment
25.68 billion INR

Energy Consumption
BAU vs PAT



Through subsequent PAT cycles by 2030 the cumulative energy savings possible in Cement Sector is 34.46 million TOE

Savings from the sector in PAT Cycle -I is equivalent to

5.3 million Homes' energy use for one year

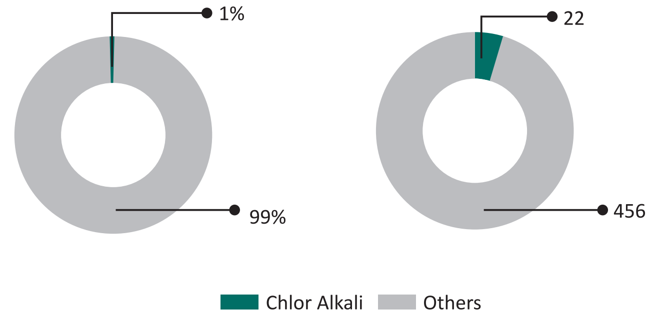
2.35 million Cars taken off the road

CHLOR ALKALI

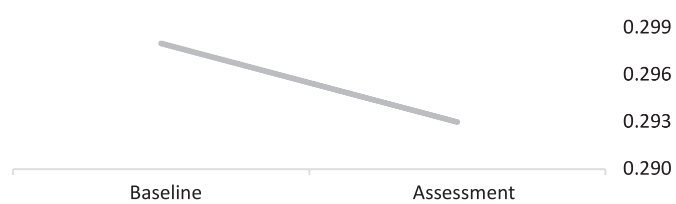
SECTOR HIGHLIGHTS......

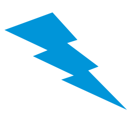
- India contributes to 4% share of global Chlor alkali capacity
- Phase out of mercury cell technology by 2012 for caustic soda production
- Adoption of latest generation energy efficient electrolysers and membranes
- Increase in electricity consumption through CPPs up to 74% in 2014-15
- Increase in 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 kg

Baseline Energy Consumption   Designated Consumers



SEC Improvement (MTOE/tonne of Product)





Energy Savings
0.093 mMTOE

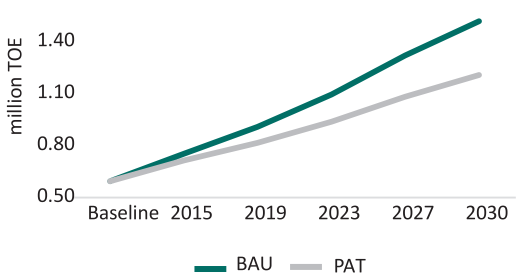
0.21 million
tonnes of coal

0.62 million
tonnes of CO_2
equivalent

Savings
1.02 billion INR

Reported
Investment
3.94 billion INR

Energy Consumption PAT vs BAU



Through subsequent PAT cycles by 2030 the cumulative energy savings possible in Chlor Alkali Sector is 2.51 million TOE

Savings from the sector in PAT Cycle -I is equivalent to

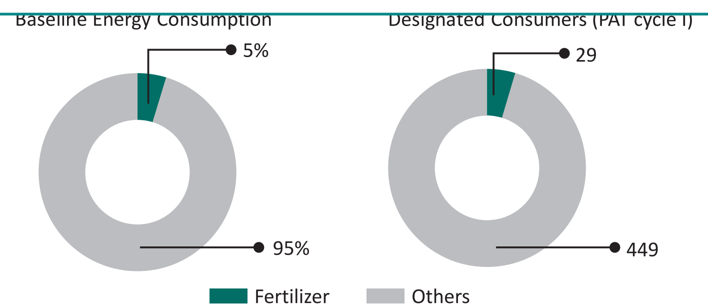
0.33 Million home's energy use for one year

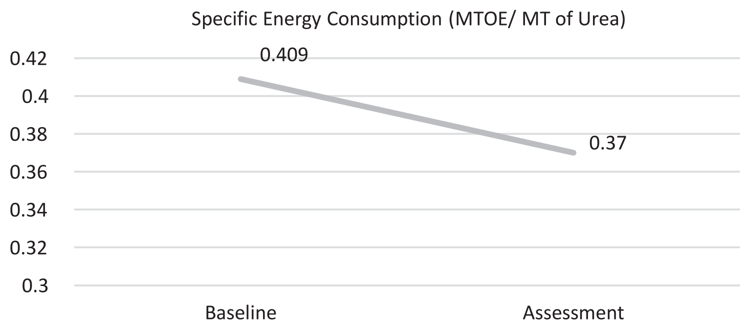
0.15 Million cars taken off the road

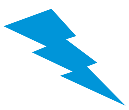
FERTILIZER

SECTOR HIGHLIGHTS……

- India contributes to 16.81% share of global Fertilizer production
- The annual production of Fertilizer was 41.31 million tonnes in 2015-16
- Dominated by three key market players – IFFCO, NFL & NFCL
- Identified as one of the eight core sectors by Ministry of Commerce







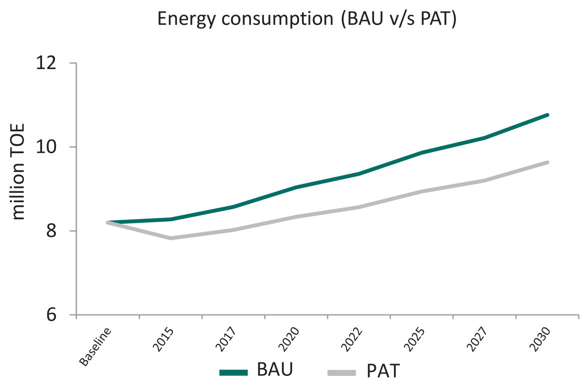
Energy Savings 0.78 million tonnes of oil equivalent

1.8 million tonnes of coal

0.93 million tonnes of CO_2 equivalent

Savings 8.54 billion INR

Reported Investment 87.33 billion INR



Through subsequent PAT cycles by 2030 the cumulative energy savings possible in Fertilizer Sector is 12.95 million TOE

Savings from the sector in PAT Cycle -I is equivalent to

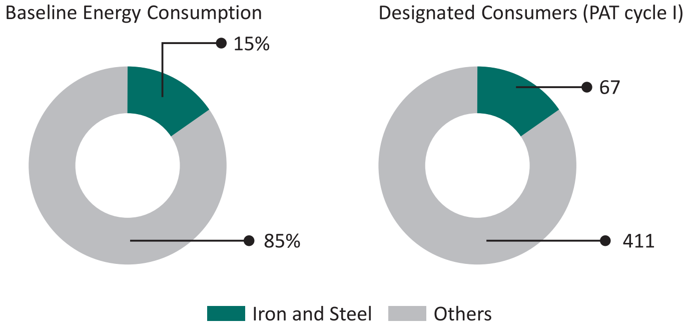
2.8 million Home's energy use for one year

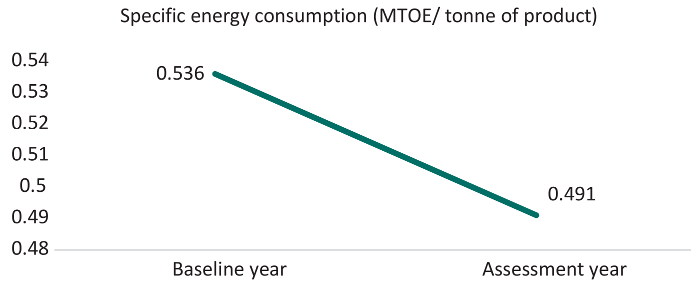
1.24 million Cars taken off the road

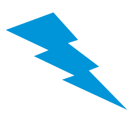
IRON AND STEEL

SECTOR HIGHLIGHTS……

- Iron and Steel sector contributes to 2% of India's GDP in 2015
- India is the third largest manufacturer of steel in the world
- Indian Steel Industry is expected to become the second largest steel manufacturer by 2018 (Ministry of steel)
- The annual production of Steel in India was 89 million Tonnes in the year 2014 – 15
- Per capita Steel consumption is 61 kg in India







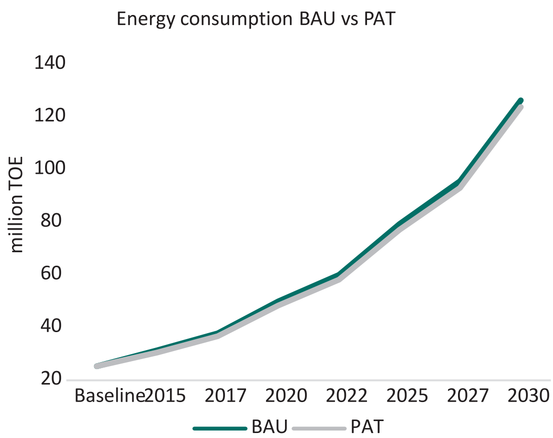
Energy Savings
2.1 million tonnes
of oil equivalent

4.9 million
tonnes of coal
Equivalent

6.51 million
tonnes of CO_2
equivalent

Savings
23 billion INR

Reported
Investment
61.75 billion INR



Through subsequent PAT cycles by 2030 the cumulative energy savings possible in Iron and Steel sector is 29.88 million TOE

Savings from the sec tor in PAT Cycle -I is equivalent to

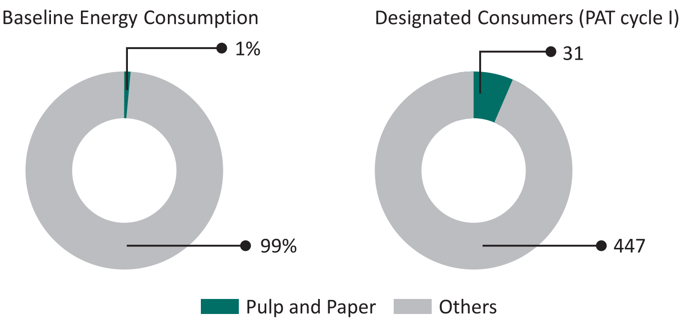
2.6 million Home's energy use for one year

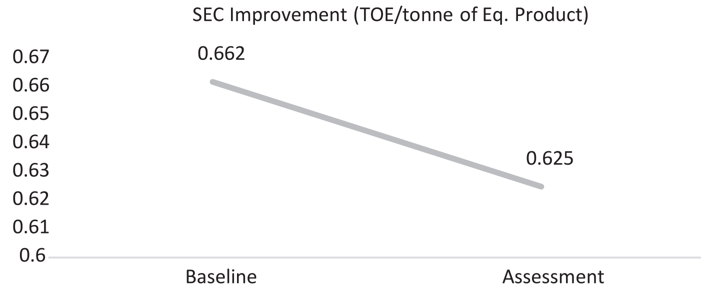
1.15 million Cars taken off the road

PULP AND PAPER

SECTOR HIGHLIGHTS……

- India's Paper sector contributes approx. Rs. 500 billion to its GDP
- Indian Paper industry accounts for 3.7% of worlds paper production
- Total installed capacity around 22 million tonnes
- Paper production in 2014-15 was approx. 15 million tonne
- Country's per capita consumption 13.2 kg





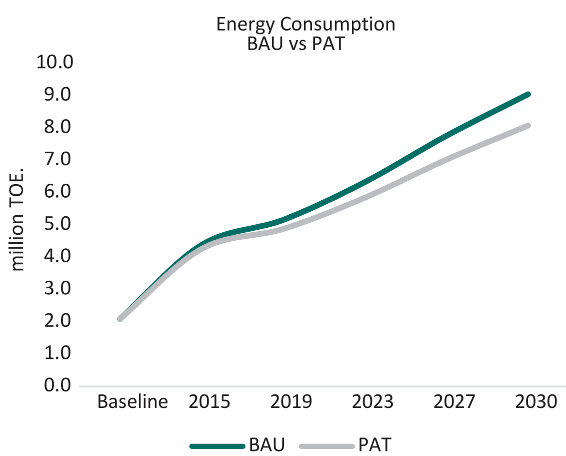
Energy Savings 0.289 million tonnes of oil equivalent

0.67 million tonnes of coal Equivalent

1.24 million tonnes of CO_2 equivalent

Savings 3 billion INR

Reported Investment 18.84 billion INR



Through subsequent PAT cycles by 2030 the cumulative energy savings possible in Paper Sector is 7.81 million TOE

Savings from the sector in PAT Cycle -I is equivalent to

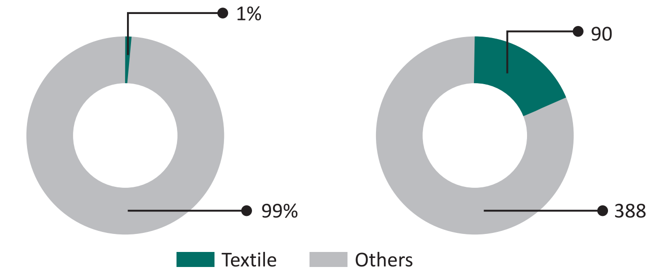
1.0 million Homes' energy use for one year

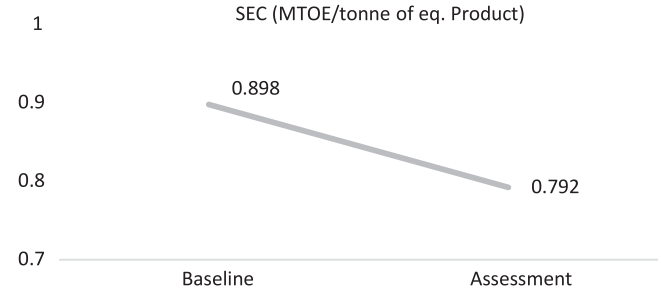
0.46 Million cars taken off the road

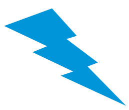
TEXTILE

SECTOR HIGHLIGHTS......

- India is the third largest exporter of textiles in the world
- Indian textile sector contributes to 4% share of country's GDP
- The sector contributes to 14% of overall index of Industrial Production
- A highly diversified sector in terms of products and processes involved







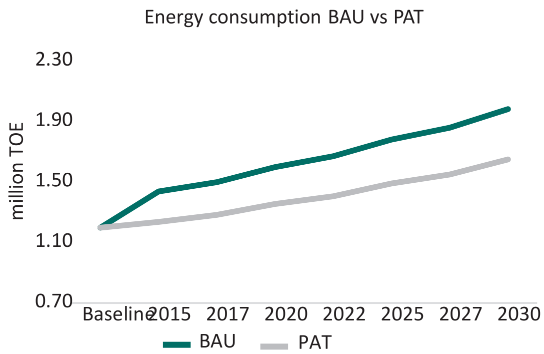
Energy Savings
0.129 million tonnes
of oil equivalent

0.30 million
tonnes of coal
Equivalent

0.62 million
tonnes of CO_2
equivalent

Savings
1.4 billion INR

Reported
Investment
29.86 billion INR



Through subsequent PAT cycles by 2030 the annual energy savings possible in Textile Sector is 4.28 million TOE

Savings from the sector in PAT Cycle -I is equivalent to

0.46 million Homes' energy use for one year

0.2 million Cars taken off the road

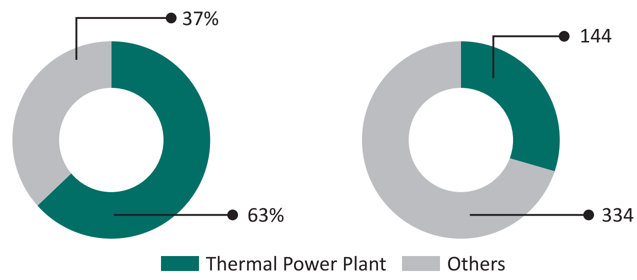
THERMAL POWER PLANT

SECTOR HIGHLIGHTS……

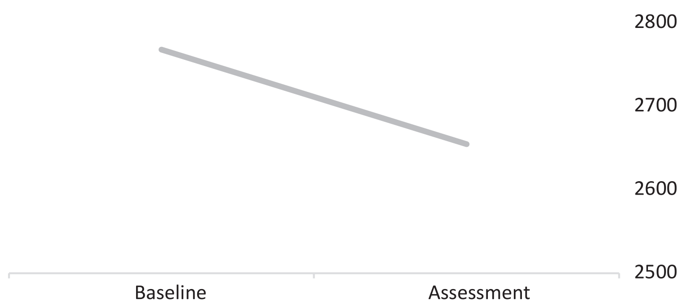
- India is ranked 5th in overall power generation capacity and 3rd in overall generation
- India's installed capacity stands at 344 GW as on March, 2018
- Electricity demand forecasts estimates as increase of 5.5% CAGR
- Govt. of India developed roadmap to achieve 175 GW capacity in Renewable Energy by 2022 & 275 GW by 2027
- India's share of installed renewable capacity stands at 20% as on March 2018

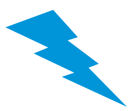
Baseline Energy Consumption

Share of DCs



Net Heat Rate Improvement (kCal/kWh)





Energy Savings
3.06 mMTONEt

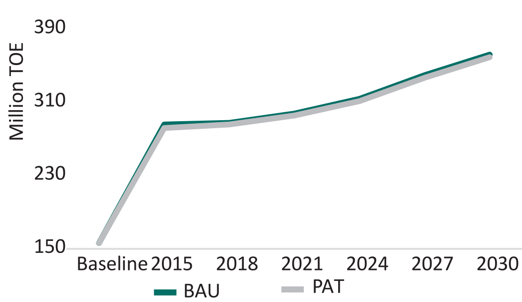
7.07 million
tonnes of coal

13.64 million
tonnes of CO_2
equivalent

Savings
33.5 billion INR

Reported
Investment
32.65 billion INR

Energy Consumption PAT vs BAU



Through subsequent PAT cycles by 2030 *the cumulative energy savings possible in Thermal power plant Sector is 45.45 million TOE*

Savings from the sector in PAT Cycle -I is equivalent to

11 million Homes' energy use for one year

4.8 million Cars taken of the road

Abbreviations

B

BAU
Business as usual, 4

C

CAGR
Compounded annual growth rate, 35

CII
Confederation of Indian Industry 11

CO_2
Carbon dioxide, 11, 35

CPP
Captive Power Plant 14, 15

D

DCs
Designated consumers 1,11, 18,19

E

ESCerts
Energy saving certificates 11, 0

G

GDP
Gross domestic product 35

IEA
International energy agency 35

INR
Indian ruppees 0, 1

M

million TOE
million metric tonne of oil equivalent 11, 35, 4

MTPA
million tonnes per annum 6

MW
Mega Watt 9

N

NAPCC
National action plan for climate change 11

NMEEE
National mission for Enhanced energy efficiency 11

O

OPC
Ordinary Portland Cement 9, 11

P

PAT
Perform Achieve and Trade 5,9,11,14, 17,18,19

PPC
Pozzolana Portland Cement 9, 10

PSC
Portland Slag Cement 9, 11

S

SEC
Specific energy consumption 6,11,15

T

TOE
Tonne of oil equivalent 0

U

ULF
Unit Load Factor 15

UOM
Unit of Measurement 11, 22

USD
United states dollars 35

W

WHRS
Waste Heat Recovery System 9

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