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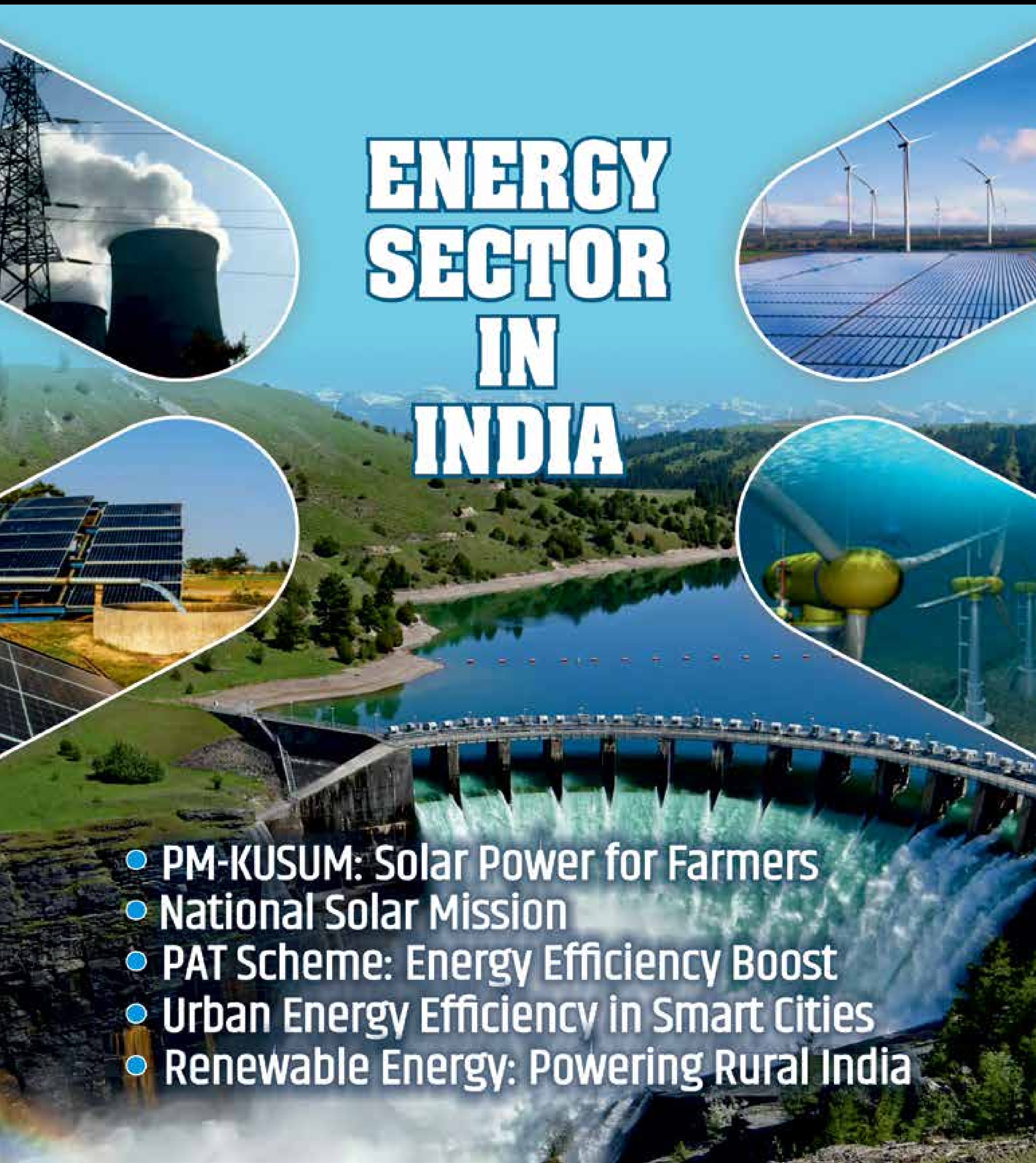

ENERGY SECTOR IN INDIA

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The Perform, Achieve, and Trade (PAT) Scheme

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India's ambitious national goals under the *Viksit Bharat* and *Atmanirbhar Bharat* programmes focus on continuous economic growth and alleviating equity and poverty issues. Energy, being the most important element driving economic growth, faces challenges like increasing demand, climate change, and pollution. The PAT mechanism under the National Mission for Enhanced Energy Efficiency aims to improve energy efficiency in industrial sectors. It involves setting energy-saving targets, implementing measures, and trading Energy Saving Certificates (ESCerts). The PAT scheme has shown significant success in reducing energy consumption and CO_2 emissions, contributing to India's energy intensity and net-zero goals.

India has set ambitious national goals for overall human development under the *Viksit Bharat* and *Atmanirbhar Bharat* programmes. A key aspect of these programmes is continuous economic growth concomitant with the alleviation of issues related to equity and poverty. Globally, energy is the single most important element that drives economic growth in key sectors such as industries, electricity generation, transportation, and buildings. Energy production from fossil fuels has been the mainstay for most of the twentieth century; however, challenges such as ever-increasing energy demand, climate change, pollution, and access to fossil fuel resources have begun a process of shifting energy production towards non-fossil sources such as solar, wind, hydro, and nuclear. India has crossed 200 GW in installed capacity of renewable energy (RE), accounting for about 46 per cent of the total installed capacity. As part of its commitments to the United Nations Framework Convention on Climate Change, India has also set goals such as reducing the energy intensity of its economy by 45 per cent by 2030 compared to 2005 levels and achieving net-zero emissions by 2070.

The demand for energy in view of India's predicted economic growth for the next several decades implies that electricity generation and energy usage will continue to grow, exacerbating the challenges of climate change and pollution. The two key levers that can accelerate the growth of energy supply while tackling climate change and the surging demand are RE and Energy Efficiency (EE). EE implies that the efficiency of energy usage must be constantly measured and analysed, and effective measures deployed to reduce energy waste. This will help in reducing the overall energy demand. India has enacted the Energy Conservation Act, 2022, which provides the legal framework for designing and implementing EE measures in key energy-intensive sectors such as industries, buildings, and transportation.

Anecdotally, readers will be familiar with the transition in lighting from incandescent lamps to CFLs and now to LED lamps. These transitions to more energy-efficient forms of lighting have resulted in enormous energy savings in India's national demand while reducing the electricity bills of the consumer. Such transitions highlight the multidimensional benefits of EE measures since they reduce CO_2 and air pollution emissions at power plants and the economic cost of installing additional power plants, all the while financially benefitting the consumer.

The industry sector is a major component of India's energy consumption, and the consumption from the sector is expected to rise for the next several decades as demand for steel, cement, and other products will be driven by economic growth. Iron and steel and cement are examples of energy-intensive sectors, along with other sectors such as pulp and paper, textiles, fertilisers, aluminium, chlor-alkali, refineries, railways, power distribution, thermal power generation, buildings, and MSMEs. Many industrial plants in India are among the most energy efficient in the world, but each sector has plants that are lagging because of various factors, including technology, vintage, the process used, and financial access. It was envisioned that a mechanism be evolved to enable industries to accelerate EE transitions while addressing the multidimensional technical, economic, and competitiveness issues involved.

The PAT Design Framework

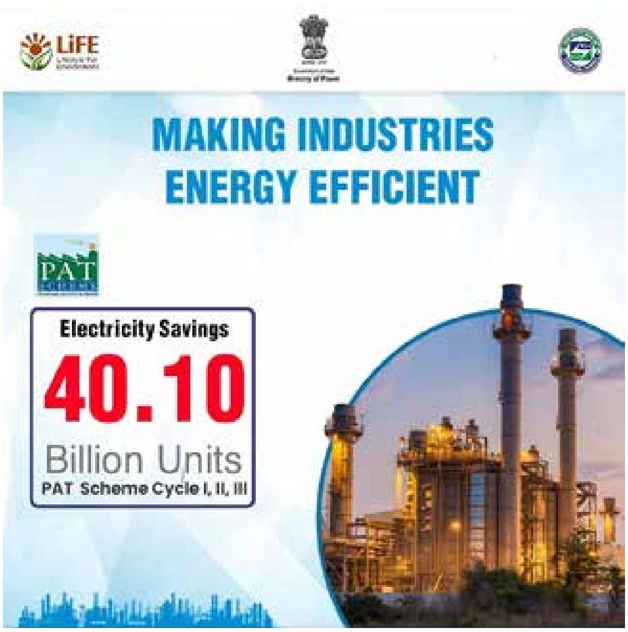
The National Mission for Enhanced Energy Efficiency under the Prime Minister's National Action Plan for Climate Change (NAPCC) lists the Perform, Achieve, and Trade (PAT) mechanism for driving EE improvements in industrial and allied sectors.

The PAT mechanism enables the design and implementation of EE goals in several energy-intensive industries in a graded and phased manner. The design of such an ambitious industrial EE programme was challenging for various reasons. This mechanism was the first-of-its-kind in the world, involving many of the largest industrial plants in India, with a diversity of manufacturing processes and products and a deep, rigorous study of the technical and economic dimensions of the programme.

The Bureau of Energy Efficiency (BEE) under the Ministry of Power is the lead agency that designed and implemented PAT. The approach taken by the BEE to design and implement this programme was consultative. It entailed numerous workshops with all industrial bodies, ministries, and stakeholders concerned. This was to develop a robust mechanism with technical and financial frameworks that would work given the nature, scale, and scope of the programme.

The first step involved the identification of designated consumers (DCs), which are industrial plants that would mandatorily participate in PAT. Such DCs would then be analysed by accredited energy auditors to compute the specific energy consumption (SEC) of that DC, which is the energy used to produce one unit of a product (such as a tonne of cement or steel). This baseline SEC number would be computed for all DCs and used as the SEC at the start of a PAT cycle. An SEC reduction target would be issued for each DC based on how its baseline SEC compares with the sector average and leaders.

Technical studies were conducted for each sector to model various processes, sub-processes, unit operations, mass and energy balances, variability factors, and input and product characterisation. These were accompanied by plant visits for data collection and validation. Sample energy economic audits were used to generate EE measures available for specific DCs in each sector to understand the technology options and economic parameters such as rate of return and payback period. Consultations with financial institutions enabled the availability of funds to DCs to implement EE measures, which might involve large investments with larger payback periods. These studies helped develop the technical, financial, and market-trading frameworks, which



are integrated into PAT to ease the implementation process of such a large industrial EE programme.

A PAT consultation document was prepared and circulated to all DCs and stakeholders before the first cycle of PAT. This document is evolving, with feedback and analyses from each PAT cycle.

The DC would have to analyse, prioritise, and implement a set of EE measures in its processes, which would entail a financial investment and resultant energy savings every year. Each DC would evaluate a suite of recommended EE measures from the energy audit study and decide, based on various financial parameters, the EE measures that could be applied within the overall design of the specific plant. Typically, each DC would have a suite of available EE measures ranging from a large number of small investment in small SEC per cent reduction measures to a smaller number of large investment in larger SEC per cent reduction measures.

A PAT cycle is typically three years, at the end of which the DC's SEC would be recomputed. The achieved SEC would then be compared with the DC's target SEC. If the DC exceeded this target, energy savings certificates (ESCerts) would be issued proportional to the amount of excess energy saved. These ESCerts could be used by the DC to offset future SEC targets in the next PAT cycle or sold to a DC that needed to purchase these ESCerts to compensate for the shortfall in achieving its SEC targets. This market option was added to address the asymmetry in DCs' SECs and provide flexibility to DCs to adjust to their specific technical and economic situations so that they could time their investments better given the huge investments and technical and logistic issues involved in making many of the larger process-related changes to existing plants.

Each energy-intensive sector has a large, diverse set of technical and economic factors that need to be considered before measuring baselines, assigning SEC reduction targets, and estimating achieved SEC numbers. This intra-sector diversity includes the scale of production, use of raw material type and quality, process technology at each unit operation within the plant, the vintage of various technology and equipment, operation and maintenance practices, and variability of the output product within the same plant from the

Table 1: Target Energy Savings and % Energy Intensity (SEC) Reduction; NHR: Net Heat Rate

Sector	Baseline SEC, toe/ton product	%SEC Reduction	Target SEC, toe/ton of product	Target Energy Savings, Mtoe	Number of DCs
Aluminium	2.005	5.354	1.897	0.456	10
Cement	0.088	4.793	0.084	0.816	85
Chlor-Alkali	0.393	6.138	0.369	0.054	22
Fertiliser	1.375	2.775	1.337	0.478	29
Iron and Steel	0.549	5.863	0.517	1.485	67
Pulp and Paper	0.656	0.656	0.622	0.118	31
Textiles	0.227	0.227	0.215	0.094	90
Industry Total	**0.230**	**5.486**	**0.217**	**3.501**	**334**
	Baseline NHR (kCal/kWh)	%NHR Reduction	Target NHR (kCal/kWh)		
Thermal Power Plants	2775.56	2.149	2715.919	3.359	144
TOTAL				**6.86**	**478**

baseline year to the target year. For example, raw material input has high variability in the pulp and paper, fertiliser, and textile sectors; process and technology vary widely in aluminium, iron and steel, among others; final product output varies in the iron and steel, textile, and cement sectors; and vintage and capacity utilisation vary across all sectors.

As a case study, we examine the iron and steel sector to understand the challenges faced by the sector, which have an impact on the SEC of a DC. The raw material quality varies from plant to plant, given that iron ore mines have variable characteristics of ore. There is high moisture content and a high alumina and silica ratio in the raw material. Coal, typically of Indian origin, has high ash content even after washing. Low availability of coking coal, a need for import of higher-grade coal, albeit at a higher cost, increased risk of supply chains, and a lack of scrap recovery and import infrastructure are some of the issues that impact SEC at any plant in addition to the plant-specific challenges listed in the previous paragraph.

Some of the EE measures available are to improve the quality of coal, coke, and raw materials using sinter and pellet plants. Waste heat recovery systems are useful for the utilisation of waste heat energy, moisture reduction in coal and raw materials, and power generation. Utilising RE for specific processes and plant and housing colony operations is another attractive EE measure. Various EE technologies, such as variable frequency drives for industrial fans, blowers, and motors, can bring energy savings with lower payback periods. A shift in the process flow of the plant can bring larger benefits at a higher initial investment. Increasing scrap utilisation and the car scrapping framework recently introduced in India can significantly increase the amount of steel scrap available for recycling in steel plants and reduce SEC.

PAT Cycle Performance

PAT cycle I was set up with 478 DCs, and the total energy savings target was 6.86 million tonnes of oil equivalent (MTOE) apportioned to each industrial sector, as shown in the table-1.

PAT cycle I (2012–2015) exceeded targets and saved 8.67 MTOE, translating to reductions of approximately 31 million tonnes of CO_2 based on BEE and other reports. Cycle II from 2016 to 2019 saved about 14.08 MTOE, and subsequent cycles have added new sectors and DCs. PAT cycles V and VI had energy savings targets of 0.5130 MTOE and 1.277 MTOE, with 110 and 135 DCs participating in each cycle, respectively. PAT cycle VII is ongoing

between 2022–23 and 2024–25, involving 509 DCs with an overall energy savings target of 6.627 MTOE.

The PAT mechanism has had a considerable impact on improving the EE of industrial plants, which results in a reduction of CO_2 emissions and energy usage, as well as unlocking investments for improving the technology and processes at various industrial and building sites. This has been made possible through the collaborative and consultative efforts of the BEE and other stakeholders, all working towards a common goal. The framework includes both technical and economic initiatives, along with a growing number of accredited and certified energy auditors and managers that the BEE has developed over the past decade and beyond. These energy auditors and managers are the backbone of the system whose success depends on the measurement, reporting, and verification of the energy audits of each DC, followed by random sample checks of the energy audit.

PAT Lessons and Way Forward

While PAT design and implementation have been a successful flagship beginning for India's industrial EE journey, it must be continuously improved and tuned based on careful techno-economic analysis and feedback. This evolutionary growth will be critical for the programme to contribute as a powerful engine of India's development journey goals, such as *Viksit Bharat* and *Atmanirbhar Bharat*.

1. ESCert trading: In most of the cycles of PAT, a majority of the DCs exceeded their targets and obtained ESCerts that needed to be traded at the approved exchanges in the country with other DCs or banked for use in future PAT cycles. The trading exchange data suggests that the buyer demand was much smaller than the supply of ESCerts, leading to low prices. A price floor and ceiling are dynamically needed based on the demand and supply data at any designated trading window.
2. Target setting: The setting of energy savings targets needs careful analysis of technical and economic parameters to result in a more balanced market of ESCerts, which can lead to prices that better reflect the weighted average cost of EE improvement measures within sectors.
3. Widening and deepening of sectors: For PAT to contribute strongly to India's energy intensity and net-zero goals, it has to continuously transform into a more robust mechanism that can accommodate more sectors and eventually all of the Indian industry, including MSMEs.
4. Buildings sector: The buildings sector is projected by most estimates to be one of the largest consumers of embodied and operational energy, and this provides an excellent opportunity to integrate EE from the design stage of each building through PAT and other mechanisms, which can mandate EE while providing auditing, technical, and financial initiatives to enable stakeholders to move in the direction of EE buildings.
5. Carbon Credit Trading System (CCTS): The Government of India adopted the CCTS recently, and this would provide another framework for PAT to play a complementary role in enabling a roadmap for net-zero and decarbonisation transition for the Indian economy. ❑

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