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Evaluating Industrial Energy Efficiency: A Study of Haryana's Manufacturing Sector

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Abstract

India has identified the manufacturing sector as having a crucial role in its growth strategy for the future and has experienced greater growth in energy demand compared to other sectors. This sector alone consumes 41 per cent of the country's total energy. The manufacturing sector in Haryana is a key driver of the state's economy. Haryana has established itself as a prominent industrial hub, and almost all types of manufacturing industries are in Haryana (Annual Survey of Industries (ASI), (MOSPI), 2021 -22). However, to achieve the joint goals of accelerated industrial growth, sustainable energy demand and supply, and minimal environmental degradation, the manufacturing sector needs to improve its energy efficiency. To achieve this goal significant research and development efforts are needed to identify existing energy use inefficiencies and highly intensive industries in the sector and potential avenues for mitigating them. This study adopts an exploratory and descriptive research design to evaluate energy intensity across various sectors. The data has been taken from ASI. The study covers a time span of 14 years, from 2008-09 to 2021-22. Energy intensity has been measured as the ratio of fuel expenditure to the value of output. Few industries out of the 71 manufacturing industries were selected because of their high energy intensity. The study also includes calculations of the Compound Annual Growth Rate (CAGR), descriptive analysis, and the share of total output and total energy consumption of these selected industries relative to all manufacturing industries. The findings reveal that the industries with the highest energy intensity are NIC-231 (Glass and Glass Products), NIC-201 (Basic Chemicals, Fertilizers, and Plastics), NIC-239 (Non-Metallic Mineral Products), and NIC-192 (Refined Petroleum Products). NIC-192 also leads in high energy consumption and total output and has the highest CAGR in both total energy consumption and total output, along with notable variability in energy use. NIC-241 (Basic Iron and Steel) has high total output.

Keywords: Energy-intensity, Energy Consumption, Manufacturing Sector, Industry, Haryana.

Introduction

Energy forms the backbone of every economy, functioning as a fundamental input for all economic and developmental activities. It plays a pivotal role across diverse domains such as production, manufacturing, transportation, residential and commercial infrastructure, agriculture, food processing, and overall economic advancement. The rising global energy demand is primarily driven by rapid industrialization, demographic shifts, increasing urbanization, technological

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innovations, and continuous socio-economic development (Soni, 2017). Traditionally, fossil fuels like coal, oil, and natural gas have served as the dominant energy sources. However, the global energy landscape is gradually shifting toward renewable alternatives, including wind, solar, and hydroelectric power. A consistent positive correlation exists between economic growth—measured by Gross Domestic Product (GDP)—and energy consumption (Datt & Sundaram, 2006). As the global GDP expanded from USD 22.78 trillion in 1990 to USD 96.53 trillion in 2021, the corresponding per capita energy demand rose from 1,659 kilograms to 1,906 kilograms of oil equivalent between 1990 and 2014 (World Bank, 2023). The central challenge now lies in meeting this escalating demand through sustainable means, as conventional fossil fuels are finite and significantly contribute to environmental degradation and climate change. Thus, global collaboration and innovative approaches are imperative to balance economic growth with environmental sustainability.

According to the International Energy Agency (IEA, 2021), India ranks as the world's third-largest energy consumer after the United States and China, accounting for approximately 6.1 per cent of global primary energy consumption. The country's energy mix is dominated by coal (44 per cent), oil (26 per cent), natural gas (6 per cent), traditional biomass (12 per cent), renewables (3 per cent), and other sources (9 per cent). Despite national efforts to promote renewable energy, coal continues to serve as India's primary energy source. Projections under the Stated Policies Scenario (STEPS) suggest that India's share in global primary energy consumption may rise to 9.8 per cent by 2050, implying continued reliance on fossil fuels and traditional biomass. Furthermore, India is the third-largest emitter of carbon dioxide (CO_2) globally—after China and the United States—emitting nearly 2.5 billion metric tonnes in 2019, equivalent to about 7 per cent of global emissions. Most of these emissions originate from the power generation, industrial, and transportation sectors. Globally, the industrial sector is the largest consumer of delivered energy, accounting for around 54 per cent of total energy use. This sector comprises three major categories—energy-intensive manufacturing, non-energy-intensive manufacturing, and non-manufacturing activities. The nature and volume of fuel consumed vary across regions, influenced by economic structure, technological advancement, and national energy policies. Industrial energy is employed in numerous operations such as processing, assembly, power generation (steam and cogeneration), heating and cooling, and lighting and ventilation within industrial premises. Although the sector significantly contributes to economic growth, employment generation, and national productivity, it simultaneously poses serious environmental challenges, particularly due to its dependence on fossil fuels like coal. The growing global demand for industrial goods, driven by population growth and economic expansion, underscores the urgent need to adopt sustainable manufacturing practices and energy-efficient technologies. In India, the manufacturing sector occupies a central position in the national development strategy and has exhibited the highest

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growth in energy demand among all sectors (IEA, 2021). It accounts for nearly 41 per cent of total national energy consumption and generates approximately 586.5 million tonnes of CO_2 annually—around 42 per cent of India's total emissions (World Bank, 2023). Industries such as steel, aluminum, cement, paper, chemicals, fertilizers, and glass are particularly energy-intensive, consuming significantly higher energy per unit of output compared to other sectors (Sarbapriya Ray, 2011; Mukherjee, 2007; Reddy & Ray, 2009; Dasgupta & Roy, 2016; Soni et al., 2017).

Within this context, Haryana's manufacturing sector has emerged as a vital component of the state economy, contributing ₹1,30,200.60 crores to the Gross State Value Added (GSVA) and ranking among the highest across economic activities (Department of Economic and Statistical Affairs, Haryana, 2022). Haryana hosts about 3.94 per cent of India's total operational factories, generating nearly 5.49 per cent of the nation's industrial Gross Value Added (GVA). The state's industries also account for approximately 4.32 per cent of total national fuel consumption, encompassing a diverse range of manufacturing units (ASI, MOSPI, 2021–22). However, sustaining industrial expansion while ensuring efficient energy use and environmental conservation requires a focused strategy. The state must prioritize energy efficiency through research, innovation, and policy interventions to identify sectors with high energy intensity and reduce inefficiencies. Although India has witnessed a decline in energy intensity since 1999, substantial improvements remain necessary, particularly in the manufacturing domain (Mukherjee, 2007). Energy intensity—defined as the amount of energy consumed to produce one unit of Gross Domestic Product (at constant prices)—serves as a critical indicator of energy efficiency at both national and international levels (Energy Statistics India, 2023). Enhancing this indicator within Haryana's manufacturing sector is essential for achieving sustainable, resilient, and environmentally responsible industrial growth.

Literature Review

An extensive review of existing literature has been undertaken to explore the key theories, empirical findings, and methodological approaches that have contributed to understanding the dynamics of energy intensity in the manufacturing sector. The objective of this review is to synthesize the current body of knowledge, highlight significant trends, and identify research gaps that warrant further investigation.

Several scholars have documented a notable decline in energy intensity across different sectors and regions over time. Howarth and Schipper (1991) conceptualized energy intensity as the ratio of energy consumption to value added within the manufacturing sector. Their comparative analysis across eight OECD countries between 1973 and 1988 revealed a consistent decline in energy intensity—ranging from 20 per cent in Norway to 35 per cent in Japan. The authors attributed this reduction primarily to improvements in energy efficiency and the adoption of advanced production technologies. Similarly, Goldar (2010) examined the Indian manufacturing sector and reported a

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decline in energy intensity at the firm level during the post-reform period following 1992. Drawing upon cross-sectional panel data from 2006–07 and 2008–09, Goldar's study emphasized that both rising energy prices and technological progress were key determinants of improved energy performance. The research further revealed that older, domestically owned firms exhibited lower efficiency levels compared to foreign enterprises, which benefited from higher technological sophistication and positive spillover effects.

The influence of energy pricing dynamics and technological innovation in reducing energy intensity has been widely recognized in the literature. Howarth et al. (1993) found that fluctuations in oil prices during the late 1970s and early 1980s prompted significant reductions in energy intensity across five OECD nations, as industries responded to high and unstable energy costs by adopting more efficient technologies. In alignment with these findings, Goldar (2010) reaffirmed the crucial role of energy prices and technological change in driving the post-1992 decline in energy intensity within India's industrial landscape.

In addition to macro-level analyses, several studies have investigated sectoral variations in energy use. Reddy and Ray (2008) examined the physical energy intensity of five sub-sectors within Indian manufacturing—iron and steel, textiles, aluminium, cement, and paper—over the period 1990 to 2005. Their research revealed that energy intensity in these industries remained relatively high, with rising energy demand often surpassing the pace of efficiency improvements. Subsequently, Ray (2011) conducted a time-series analysis at the industry level to evaluate energy input-output ratios across seven major manufacturing sectors—paper, aluminium, iron and steel, fertilizer, chemical, glass, and cement. The results demonstrated considerable variation in energy consumption patterns, identifying the cement industry as the most energy-intensive and the aluminium industry as the least.

Overall, the reviewed literature underscores that while energy intensity has declined globally and within India due to structural shifts and technological innovation, considerable disparities persist across industrial sub-sectors. These studies collectively highlight the importance of energy pricing, technological diffusion, and firm-level heterogeneity in shaping energy efficiency outcomes.

Dasgupta and Roy (2016) conducted an in-depth analysis of energy intensity trends across seven major manufacturing industries—aluminium, chemical, cement, paper and pulp, fertilizer and pesticide, textile, and iron and steel—and compared their performance against global best-practice benchmarks. The study revealed a significant overall reduction in energy intensity across all these sectors, indicating substantial improvements in industrial energy efficiency over time. Notably, the aluminium, cement, and fertilizer industries were found to be operating near global best-practice energy intensity levels, reflecting advanced technological adoption and efficient production systems. In contrast, the iron and steel as well as the pulp and paper industries

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demonstrated comparatively higher energy consumption levels, suggesting that these sectors still lag behind in achieving optimal efficiency standards.

Ortiz and Sollinger (2002) examined the influence of structural transformations on energy intensity within the U.S. economy and observed that a gradual transition toward less energy-intensive industries within the industrial sector contributed significantly to the overall decline in national energy intensity. Similarly, **Tiwari (1999)** employed an input–output analytical framework to assess sectoral energy intensity trends in India between 1983 and 1990. The study reported a reduction in coal intensity over the period, accompanied by an increase in the intensities of oil and electricity consumption. While industries such as cement and fertilizer demonstrated notable improvements in energy efficiency, others—including coal tar products, wool, silk, synthetic textiles, non-ferrous metals, paper, leather, and non-metallic mineral products—exhibited deteriorating energy performance, indicating a divergence in efficiency progress across different sectors.

Lajina and Pavithran (2008) and **Sahu and Santosh (2008)** investigated both national and state-level patterns in energy intensity within India. Using secondary data from the Annual Survey of Industries (ASI) at the 2–3digit level, Lajina and Pavithran (2008) found that, at the national level, most industries exhibited relatively lower fuel use compared to other inputs. However, at the state level, certain sectors—particularly chemicals, metal products, transport equipment manufacturing, and textiles—showed higher energy consumption relative to capital and material inputs, indicating regional disparities in industrial energy efficiency. Complementing this, Sahu and Santosh (2008) applied general trend analysis methods to assess long-term movements in energy consumption, energy production, real GDP, population, and per capita consumption (PCC) from 1980 to 2005. Their results revealed that although all these indicators increased consistently over time, their respective growth rates displayed a gradual deceleration, suggesting a relative moderation in energy demand growth in later years.

The existing body of literature consistently demonstrates a downward trend in energy intensity across diverse sectors and regions, primarily driven by advancements in energy efficiency, technological innovation, and structural shifts toward less energy-intensive industries. However, despite these improvements, a complex relationship persists between enhanced energy efficiency and total energy consumption—where overall energy use often continues to rise even as energy intensity declines, largely due to economic expansion and increased production activities.

At the international level, a substantial volume of research has been conducted on patterns of energy use and efficiency. In contrast, studies focusing on India remain relatively limited. Notable contributions in this field include the works of Sarbapriya Ray (2011), Mukherjee (2007), Reddy and Ray (2009), Dasgupta and Roy (2016), and Soni, Mittal, and Kapshe (2017), which primarily examine national or sectoral trends. At the sub-national level, only a few attempts have been

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made—most notably the study by Geethanjali M. N. (2012), which analyzed energy intensity at the state level.

Despite Haryana's emergence as a major industrial hub within India, no comprehensive study to date has specifically analyzed the energy intensity of its manufacturing sector. Hence, the present research seeks to fill this critical gap by conducting an in-depth assessment of the energy intensity patterns within the manufacturing industries of Haryana, thereby contributing valuable insights to the existing body of knowledge on regional energy efficiency dynamics.

Objective

1. To identify the highly energy-intensive industries within the manufacturing sector of Haryana.
2. To understand the energy consumption pattern of highly intensive industries.

Methodology

The present study employs an exploratory and descriptive research design to analyze energy intensity across various manufacturing sectors in Haryana. The analysis is based on secondary data obtained from the Annual Survey of Industries (ASI), published by the Ministry of Statistics and Programme Implementation (MOSPI). The dataset follows the National Industrial Classification (NIC-2008) at the three-digit level and spans the fiscal years 2008–09 to 2021–22, encompassing a period of fourteen years.

According to the Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy, *"Energy intensity is defined as the amount of energy required per unit of output or activity and is measured by the ratio of fuel expenditure to the value of output."* This widely accepted approach has been adopted in several earlier Indian studies (Roy, 1992; Roy et al., 1999; Dasgupta & Roy, 2000; Roy, 2007; Sahu & Narayanan, 2011; Dasgupta et al., 2011; Ray, 2011; Dasgupta & Roy, 2016). In this study, fuel expenditure refers to the total purchase value of fuels, lubricants, electricity, and water used for steam generation, as reported in the ASI under the variable *Fuel Consumed*. Similarly, value of output represents the ex-factory value of products and by-products—excluding taxes and duties but including subsidies, semi-finished goods, own construction, industrial and non-industrial services, rent, net balance of goods sold, electricity generated and sold, and research and development (R&D) expenditures. The analysis encompasses 71 manufacturing industries operating in Haryana. For each industry, fuel consumption and output values are expressed in monetary terms as reported in ASI. To ensure comparability over time, the data on fuel consumption has been deflated using the Wholesale Price Index (WPI) for fuel and power, while the value of output has been deflated using sector-specific WPI indices corresponding to different manufacturing categories. These indices were sourced from the official website of the Office of the Economic Adviser, Government of India.

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From the total 71 industries, 12 energy-intensive industries were identified based on their relatively high fuel consumption and energy requirements. For these selected industries, the study computes the Compound Annual Growth Rate (CAGR), conducts descriptive statistical analysis, and examines the share of total output and total energy consumption relative to all manufacturing industries in the state. This analytical framework facilitates the identification of key growth patterns, efficiency levels, and the relative contribution of energy-intensive industries to Haryana's manufacturing sector.

Results and Discussion

Energy intensity has been calculated for all 71 manufacturing industries operating in Haryana. Among these, 12 industries have been identified as highly energy-intensive, reflecting a relatively greater use of energy inputs per unit of output.

Table 1 presents the list of these energy-intensive industries along with their corresponding National Industrial Classification (NIC-2008) codes. The selected industries include: Manufacture of Beverages (110); Spinning, Weaving, and Finishing of Textiles (131); Manufacture of Other Textiles (139); Wood, Cork, Straw, and Plaiting Materials (162); Paper and Paper Products (170); Refined Petroleum Products (192); Basic Chemicals, Fertilizers, Nitrogen Compounds, and Plastics (201); Plastic Products (222); Glass and Glass Products (231); Non-metallic Mineral Products not elsewhere classified (239); Manufacture of Basic Iron and Steel (241); and Medical and Dental Instruments and Supplies (325).

These industries exhibit significantly higher energy consumption relative to their value of output, primarily due to the energy-intensive nature of their production processes. Their inclusion in the analysis allows for a focused evaluation of sectors that exert the greatest influence on Haryana's overall industrial energy demand and efficiency profile.

Table 1: List of highly energy-intensive industries

CODE	MANUFACTURING UNITS
110	Manufacture of beverages
131	Spinning, weaving and finishing of textiles
139	Manufacture of other textiles
162	Manufacture of products of wood, cork, straw and plaiting materials
170	Manufacture of paper and paper products
192	Manufacture of refined petroleum products
201	Manufacture of basic chemicals, fertilizer and nitrogen compounds, plastics
222	Manufacture of plastics products
231	Manufacture of glass and glass products
239	Manufacture of non-metallic mineral products n.e.c.

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241	Manufacture of basic iron and steel
325	Manufacture of medical and dental instruments and supplies

Table 2 presents the trends in energy intensity for the selected highly energy-intensive manufacturing industries in India during the period 2008–09 to 2021–22. Energy intensity is calculated as the ratio of energy consumed to total output, and the industries included in the analysis are those that consistently exhibited high intensity values throughout the study period.

For the Manufacture of Beverages (NIC-110), energy intensity remained relatively stable, fluctuating between 0.06 and 0.09, indicating a balanced energy-output relationship over time. The Spinning, Weaving, and Finishing of Textiles (NIC-131) industry displayed moderate variation, with values ranging from 0.05 to 0.15, peaking in 2015–16. The Manufacture of Other Textiles (NIC-139) maintained a constant energy intensity of approximately 0.05 across all years, suggesting steady energy efficiency.

The Wood, Cork, Straw, and Plaiting Materials (NIC-162) industry showed noticeable fluctuations, with intensity values ranging from 0.04 to 0.13—experiencing a sharp decline in 2013–14 followed by a pronounced peak in 2016–17. Similarly, the Paper and Paper Products (NIC-170) industry exhibited considerable volatility, with intensity values between 0.04 and 0.14, characterized by higher levels during the initial years and a subsequent decline in later periods.

The Refined Petroleum Products (NIC-192) industry revealed significant variability in energy intensity. Beginning at 0.02 in 2008–09, intensity rose sharply to 0.36 in 2011–12, indicating a period of elevated energy consumption relative to output, before declining and stabilizing at around 0.06 from 2017–18 onward. In contrast, the Basic Chemicals, Fertilizers, Nitrogen Compounds, and Plastics (NIC-201) industry demonstrated a wide range of intensity values—from 0.10 to 2.27—with a pronounced peak in 2014–15, highlighting its status as one of the most energy-demanding sectors.

The Manufacture of Plastic Products (NIC-222) displayed relative stability, maintaining intensity values between 0.05 and 0.09 across the entire timeframe. Meanwhile, the Manufacture of Glass and Glass Products (NIC-231) showed substantial fluctuation, with intensity values ranging from 0.16 to 0.29, peaking during 2011–12 and 2012–13. The Manufacture of Non-metallic Mineral Products (NIC-239) recorded energy intensity values between 0.11 and 0.23, with a marked decline to 0.06 in 2010–11, reflecting a brief phase of enhanced energy efficiency.

The Manufacture of Basic Iron and Steel (NIC-241) maintained consistent energy intensity levels, fluctuating narrowly between 0.04 and 0.06, whereas the Medical and Dental Instruments and Supplies (NIC-325) industry showed only minor variations, with values ranging from 0.03 to 0.09. NIC-201 recorded intensity values between 0.10 and 0.27, with a total energy intensity of 2.44 and an average of 0.17. Similarly, NIC-231 exhibited values between 0.16 and 0.29, with a total of 3.05 and an average of 0.22. Following these, the Refined Petroleum Products (NIC-192) and Non-

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metallic Mineral Products (NIC-239) industries also demonstrated substantial energy intensity, underscoring their significant contribution to the overall industrial energy demand.

Table 3 provides an industry-wise analysis of energy consumption across the selected manufacturing sectors in Haryana from 2008–09 to 2021–22.

The Manufacture of Beverages (NIC-110) industry exhibits a consistent upward trajectory in energy consumption, increasing from ₹137.91 crores in 2008–09 to ₹254.61 crores in 2021–22, with a peak of ₹362.64 crores recorded in 2017–18. The total energy consumption during the study period amounts to ₹3,533.77 crores. Similarly, the Spinning, Weaving, and Finishing of Textiles (NIC-131) sector shows a steady increase in energy use, ranging from ₹280.54 crores in 2010–11 to a maximum of ₹967.87 crores in 2016–17. Although a slight decline occurred after 2016–17, the overall consumption remained considerably high.

For the Wood, Cork, Straw, and Plaiting Materials (NIC-162) industry, energy consumption fluctuated between a low of ₹53.51 crores in 2011–12 and a high of ₹174.31 crores in 2021–22, indicating a long-term rising pattern. The Paper and Paper Products (NIC-170) sector also showed a marked increase, growing from ₹140.68 crores in 2011–12 to ₹360.21 crores in 2018–19, reflecting gradual intensification in energy use.

The Refined Petroleum Products (NIC-192) industry recorded exceptionally high levels of energy consumption throughout the study period, with total usage amounting to ₹32,235.27 crores. Starting at only ₹1.44 crores in 2008–09, the sector witnessed a steep rise to ₹114.50 crores in 2011–12, followed by an extraordinary surge reaching ₹67,124.54 crores in 2017–18. Although a subsequent decline was observed, the consumption still remained significant at ₹3,670.05 crores in 2021–22.

The Basic Chemicals, Fertilizers, and Nitrogen Compounds (NIC-201) industry displayed a steady upward trend, with energy consumption increasing from ₹493.44 crores in 2008–09 to ₹1,025.39 crores in 2021–22, suggesting escalating energy requirements in recent years. The Plastic Products (NIC-222) sector showed a fluctuating yet generally upward trend, starting at ₹99.77 crores in 2008–09, peaking at ₹5,322.96 crores in 2018–19, and slightly declining thereafter.

Energy use in the Glass and Glass Products (NIC-231) industry also followed an upward trajectory, beginning at ₹940.12 crores in 2008–09 and reaching a peak of ₹3,254.08 crores in 2018–19, followed by a marginal fall in subsequent years. Similarly, the Non-metallic Mineral Products (NIC-239) industry exhibited a strong increasing pattern, beginning at ₹2,612.43 crores in 2008–09 and continuing to rise steadily over the study period.

Overall, the analysis reveals that energy consumption across Haryana's key manufacturing industries has generally increased over time, with particularly sharp rises observed in the Refined Petroleum Products (NIC-192) and Basic Chemicals (NIC-201) sectors—underscoring their dominant contribution to the state's total industrial energy demand.

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Table 2: Selected Manufacturing Industries which are highly energy intensive

CODE	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	TOTAL	AVERAGE
110	0.07	0.07	0.08	0.09	0.08	0.07	0.08	0.09	0.09	0.09	0.07	0.07	0.06	0.06	**1.07**	**0.08**
131	0.10	0.12	0.09	0.05	0.09	0.08	0.10	0.15	0.11	0.10	0.10	0.11	0.13	0.08	**1.42**	**0.10**
139	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	**0.68**	**0.05**
162	0.08	0.07	0.04	0.06	0.07	0.03	0.07	0.11	0.13	0.11	0.06	0.09	0.08	0.05	**1.05**	**0.08**
170	0.14	0.11	0.14	0.06	0.10	0.10	0.08	0.06	0.06	0.06	0.07	0.04	0.05	0.04	**1.12**	**0.08**
192	0.02	0.08	0.32	0.36	0.25	0.24	0.01	0.05	0.10	0.13	0.12	0.06	0.06	0.06	**1.86**	**0.13**
201	0.20	0.23	0.18	0.19	0.22	0.10	0.27	0.26	0.14	0.13	0.12	0.13	0.12	0.13	**2.44**	**0.17**
222	0.08	0.06	0.06	0.06	0.06	0.05	0.05	0.09	0.07	0.06	0.05	0.05	0.06	0.04	**1.33**	**0.09**
231	0.25	0.23	0.20	0.29	0.29	0.23	0.18	0.20	0.22	0.20	0.21	0.19	0.21	0.16	**3.05**	**0.22**
239	0.15	0.13	0.06	0.11	0.14	0.13	0.20	0.23	0.19	0.17	0.18	0.15	0.18	0.12	**2.15**	**0.15**
241	0.06	0.05	0.05	0.05	0.05	0.04	0.05	0.06	0.05	0.04	0.05	0.06	0.05	0.04	**0.71**	**0.05**
325	0.09	0.08	0.07	0.05	0.07	0.06	0.07	0.08	0.08	0.08	0.06	0.06	0.03	0.05	**0.92**	**0.07**

Table 3: Energy Consumption of highly energy intensive industries (values in Rs lakhs)

CODE	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	TOTAL	AVERAGE
110	13790.55	15568.78	20341.92	26439	18281.05	17779.42	21215.41	29894.8	33121.67	36263.67	36187.32	29179.06	29853.19	25461.48	**353377.3**	**25241.24**
131	33400.98	31164.43	28054.48	28744	27575.16	30322.58	46675.02	68378.03	96786.79	51578.78	57122.96	68796.48	66525.53	50995.99	**686121.2**	**49008.66**
139	15401.48	19686.5	14258.04	23109	23958.92	25148.21	38846.8	35587.28	51668.6	51415.86	65456.29	63986.3	79590.43	87251.2	**595364.9**	**42526.06**
162	7695.102	7001.919	7114.201	5351	5746.965	8238.884	7692.665	13232.37	12032.44	11400.86	8119.116	15293.54	11158.51	17430.98	**137508.6**	**9822.04**
170	18925.22	15109.4	15079.78	14068	16635.85	15377.51	22382.54	24986.13	23396.29	29409.43	36021.13	27074.36	34305.32	22658.11	**315429.1**	**22530.65**
192	144.0561	1463.852	11795.08	11450	10893.56	6489.974	793.8719	251937.6	599859.8	671245.4	601549.5	329610.6	359289.4	367004.8	**3223527**	**230252**
201	49343.61	50223.93	42812.86	45713	45377.22	25072.36	72407.61	66336.42	73301.27	75997.86	85254.56	90792.56	94729.79	102539.3	**919902.4**	**65707.31**
222	9977.452	9947.537	13471.62	7427	12296.92	8500.436	29944.29	28765.32	27783.31	25633.44	53229.59	53818	43656.38	29824.24	**354275.5**	**25305.4**
231	9401.228	11291.11	13013.45	21714	20238.1	14899.74	24515.32	26679.77	27806.49	31476.96	32540.83	23451.08	25370.21	22998.39	**305396.7**	**21814.05**
239	26124.26	26505.44	18255.07	25835	32225.96	32088.93	64181.99	82759.54	75243.34	72518.76	88040.35	73879.65	73647.87	58810.59	**750116.7**	**53579.77**
241	57240.39	77334.61	89046.05	85864	87351.07	93863.12	97622.1	115864.7	131341.8	114235.8	124358.3	124344.4	131317	128614	**1458397**	**104171.2**
325	5742.202	6730.646	7191.703	6208	6338.936	7436.792	9900.65	10139.88	12745.08	10769.56	12293.95	12230.92	13492.55	14975.92	**136196.8**	**9728.342**

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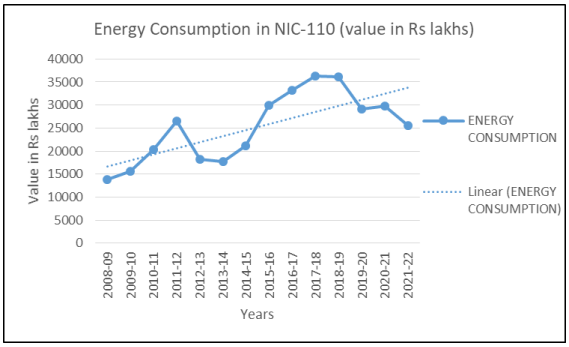
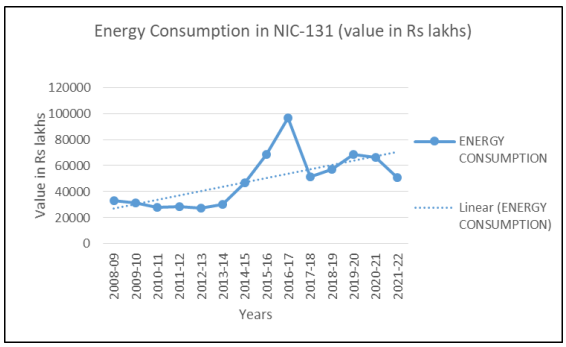
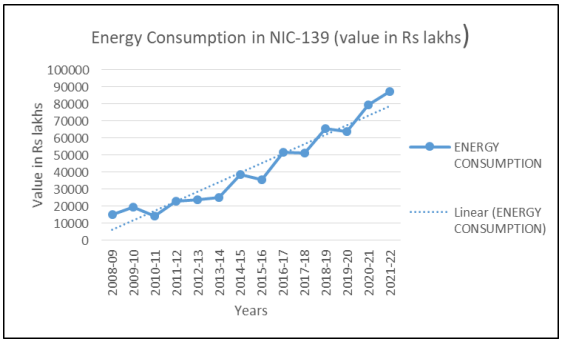
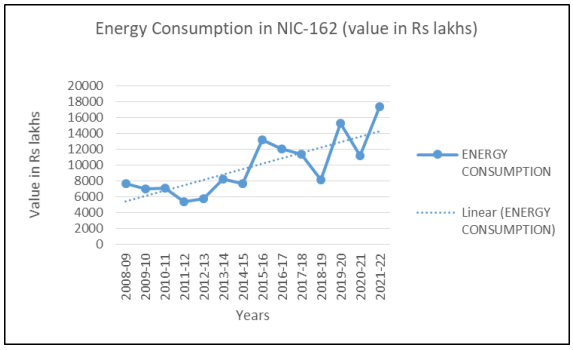
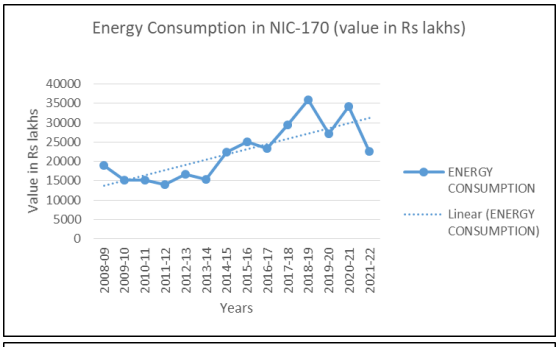
Figure 1: Graphical Representation of Energy Consumption in the selected Energy Intensive Industries from year 2008-09 to 2021-22

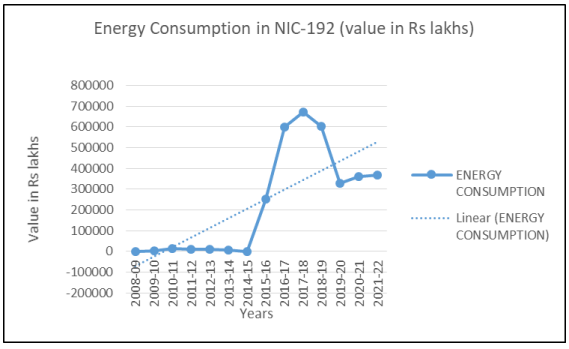


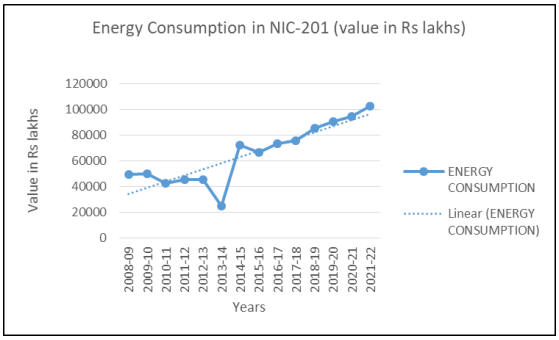


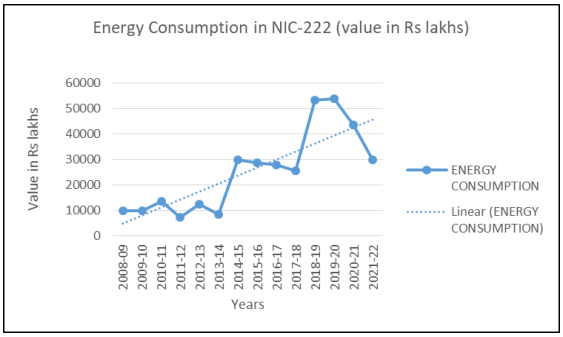












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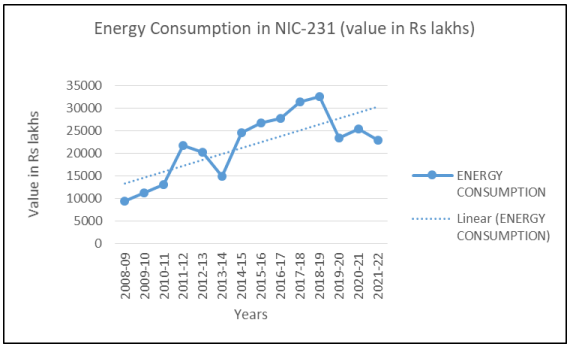

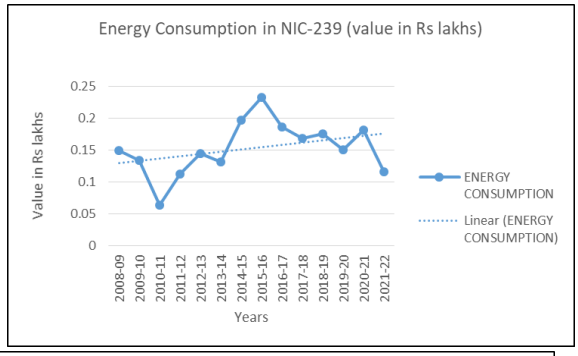

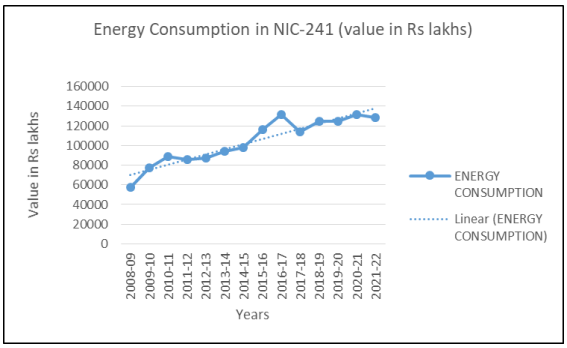

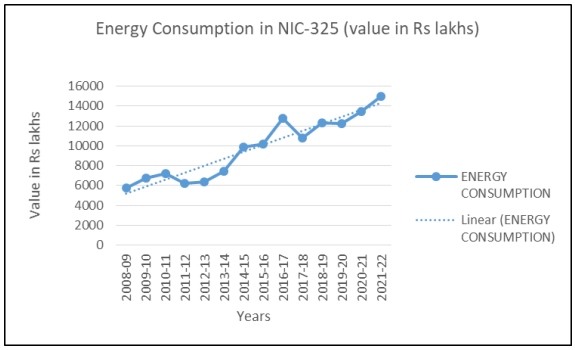

Energy consumption across several industries continued to demonstrate distinct upward trends during the study period. The Non-metallic Mineral Products (NIC-239) industry recorded its lowest energy consumption at ₹1,825.51 crores in 2010–11, reaching a peak of ₹8,804.04 crores in 2018–19, followed by a slight decline thereafter. The Basic Iron and Steel (NIC-241) industry exhibited a strong and sustained upward trajectory, beginning at ₹5,724.04 crores in 2008–09 and peaking at ₹13,134.18 crores in 2017–18. Energy consumption in this sector has remained consistently high in recent years, reflecting growing industrial output and escalating energy demand. Similarly, the Medical and Dental Instruments and Supplies (NIC-325) industry showed a gradual but steady rise in energy consumption—from ₹574.22 crores in 2008–09 to ₹1,497.59 crores in 2021–22. The graphical representation of these industry-wise consumption trends is illustrated in the accompanying Figure.

Table 4 presents the variation in energy consumption across industries over the 14-year period, measured through the Coefficient of Variation (CV). A higher CV denotes greater volatility and inconsistency in energy use, whereas a lower CV reflects relative stability and predictability. Among all industries, Refined Petroleum Products (NIC-192) exhibited the highest CV at 112.12 per cent, indicating extreme fluctuations in energy consumption. In contrast, Basic Iron and Steel (NIC-241) and Beverages (NIC-110) recorded relatively low CV values of 29.74 per cent and 22.35 per cent, respectively, suggesting more stable and consistent consumption patterns over time.

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Table 5 analyzes the share of individual industries in total manufacturing energy consumption. In 2008–09, the selected industries collectively accounted for 54.6 per cent of total industrial energy use. Their lowest combined share was observed in 2013–14 at 15.36 per cent, while the peak share occurred in 2016–17, reaching 72.36 per cent. From 2016–17 onwards, NIC-192 (Refined Petroleum Products) consistently held the highest share of total energy consumption, followed closely by NIC-241 (Basic Iron and Steel), which also maintained a substantial and stable contribution throughout the period.

Table 6 provides insights into the Compound Annual Growth Rate (CAGR) of energy consumption across different industries. The results reveal significant inter-industry variation, with NIC-192 recording the highest CAGR of 75.11 per cent, indicating a rapid increase in energy demand, whereas NIC-170 (Paper and Paper Products) showed the lowest CAGR of 1.29 per cent, signifying relatively stable and gradual energy consumption over the years.

Table: 4 Descriptive analysis of energy consumption

CODE	Mean	S.D (sample)	Coefficient of Variation (per cent)
110	25240.99	7505.85	**29.74**
131	49008.19	20863.50	42.57
139	42525.83	24282.21	57.10
162	9821.93	3668.81	37.35
170	22530.39	7214.18	32.02
192	230251.88	258154.97	**112.12**
201	65706.61	23064.18	35.10
222	25305.22	16105.00	63.64
231	21813.88	7257.13	33.27
239	53579.42	25182.61	47.00
241	104170.15	23278.68	**22.35**
325	9728.25	3105.66	31.92

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Table: 5 Share of energy consumption of individual industry in total energy consumption of all the manufacturing industries (in percentage)

CODE	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	20221-22
110	3.05	3.03	3.19	4.02	2.30	0.96	1.98	2.49	2.06	1.79	1.76	1.77	1.92	1.28
131	7.38	6.06	4.40	4.38	3.47	1.63	4.36	5.71	6.01	2.55	2.78	4.16	4.28	2.57
139	3.41	3.83	2.24	3.52	3.02	1.35	3.63	2.97	3.21	2.54	3.18	3.87	5.11	4.40
162	1.70	1.36	1.12	0.81	0.72	0.44	0.72	1.10	0.75	0.56	0.39	0.93	0.72	0.88
170	4.18	2.94	2.37	2.14	2.09	0.83	2.09	2.08	1.45	1.45	1.75	1.64	2.20	1.14
192	0.03	0.28	1.85	1.74	1.37	0.35	0.07	**21.02**	**37.24**	**33.21**	**29.23**	**19.94**	**23.09**	**18.51**
201	**10.91**	**9.76**	6.72	6.96	5.71	1.35	6.76	5.54	4.55	3.76	4.14	5.49	6.09	5.17
222	2.21	1.93	2.11	1.13	1.55	0.46	2.80	2.40	1.72	1.27	2.59	3.26	2.81	1.50
231	2.08	2.19	2.04	3.31	2.55	0.80	2.29	2.23	1.73	1.56	1.58	1.42	1.63	1.16
239	5.78	5.15	2.87	3.93	4.06	1.72	6.00	6.91	4.67	3.59	4.28	4.47	4.73	2.97
241	**12.66**	**15.03**	**13.98**	**13.07**	**10.99**	5.04	**9.12**	**9.67**	**8.15**	5.65	6.04	**7.52**	**8.44**	6.49
325	1.27	1.31	1.13	0.94	0.80	0.40	0.92	0.85	0.79	0.53	0.60	0.74	0.87	0.76
Average	**4.55**	**4.41**	**3.67**	**3.83**	**3.22**	**1.28**	**3.40**	**5.25**	**6.03**	**4.87**	**4.86**	**4.60**	**5.16**	**3.90**

Table: 6 Result of Compound Annual Growth Rate of energy consumption

CODE	CAGR (%)
110	4.48
131	3.07
139	13.19
162	6.02
170	1.29
192	75.11
201	5.36
222	8.14
231	6.60
239	5.97
241	5.95
325	7.09

Table 7 explains the total output of the selected energy-intensive industries from 2008-09 to 2021-22, measured in Rs Lakhs. NIC-192 stands out with an exceptional increase in total output, soaring from 927.69 Rs crores in 2008-09 to a staggering 38,422.66 Rs crores by 2021-22. NIC-241 also demonstrated impressive growth, with output rising from 10,113.72 Rs crores to 29,079.61 Rs crores. These sectors show a clear upward trend, reflecting expansion and increasing market demand.

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Table: 8 Descriptive analysis of total output

CODE	Mean	S.D (sample)	Coefficient of Variation (per cent)
110	334300.77	103691.89	31.02
131	484503.44	171802.51	35.46
139	863840.91	489751.85	56.69
162	141254.65	67366.25	47.69
170	347685.93	200064.32	57.54
192	2790536.62	2886110.49	103.42
201	425490.28	234744.65	55.17
222	460969.53	343714.57	74.56
231	104274.85	41387.95	39.69
239	340826.29	117828.63	34.57
241	2077114.65	547521.48	26.36
325	166549.06	101578.06	60.99

Table 8 presents the analysis of variation in total output across different industries over a 14-year period. The results reveal significant differences in output stability among the selected sectors. The Refined Petroleum Products (NIC-192) industry records the highest Coefficient of Variation (CV) at 103.42 per cent, reflecting a very high degree of fluctuation and inconsistency in its total output over time. In contrast, industries such as Paper and Paper Products (NIC-170), Other Textiles (NIC-139), Basic Chemicals and Fertilizers (NIC-201), and Medical and Dental Instruments (NIC-325) exhibit moderate variability, with CV values ranging between 55.17 per cent and 60.99 per cent. Among all, the Basic Iron and Steel (NIC-241) industry demonstrates the lowest CV of 26.36 per cent, indicating the most stable and consistent production performance throughout the period.

Table: 9 Result of Compound Annual Growth Rate of energy consumption

CODE	CAGR (%)
110	5.73
131	4.69
139	14.37
143	18.88
162	8.96
170	10.72
192	59.49
201	8.77
203	20.20
222	14.03

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231	9.82
239	7.9 4
241	8.48
325	12.12

Table: 7 Total output of selected highly energy intensive industries (values in Rs lakhs)

CODE	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	TOTAL	AVERAGE
110	208209	229419.7	254774.9	282026	228156.9	246040.9	276338.9	322293.2	371147.3	403891.5	515040.6	400628.6	487752.6	454490.5	**4680211**	**334300.8**
131	321744.9	260690.6	308508.9	557849	298360.6	357425.8	466611.4	451836.8	890485.6	518381.8	564518.2	654031.4	521053.6	611549.6	**6783048**	**484503.4**
139	294088.9	405237.6	336425.1	487101	507931.6	520646.4	817753.3	788080.1	1020585	948268.9	1300276	1219156	1521660	1926643	**12093773**	**863840.9**
162	96927.36	100883.6	169599.6	84204	87159.6	237844.3	107232.7	124261.5	92295.84	108235	130326.6	176493.6	139763.7	322337.6	**1977565**	**141254.7**
170	134762.6	139236.9	107717	226343	168154.4	153363	289238.6	418887.3	372302.8	457896.6	541814.3	604323.7	692620.4	560942.5	**4867603**	**347685.9**
192	9276.88	19318.08	37214.15	31753	42869.23	27040.24	73538.53	4982863	5945361	5064317	4902902	5746228	5149618	6390359	**38422659**	**2744476**
201	245760.5	214780.9	233131.6	238706	204191.1	240811.1	270350.6	257695.4	525350.5	565603.6	694848.9	706558.3	762005.1	797070.4	**5956864**	**425490.3**
222	124966.8	166217.5	227828	128473	215661.9	178622.9	544949.7	306664.9	412517.2	431144.9	1034466	1157378	740728.2	785344.9	**6454964**	**461068.8**
231	38309.4	49805.35	64649.14	75521	70710.63	65555.66	134313.3	134654.1	127650.1	160717.6	152239.7	124991.2	118558.2	142172.5	**1459848**	**104274.8**
239	174319.7	196942.7	284149.7	228562	222969.2	243411.2	325009.9	355987.3	403608.4	431378.9	502173.4	489495.3	405707.5	507852.9	**4771568**	**340826.3**
241	1011372	1463829	1818328	1788557	1600658	2117784	1985261	1893632	2474338	2684008	2382705	2249913	2446589	3162630	**29079605**	**2077115**
325	66325.35	83941.54	104658.8	117755	91174.89	119858.7	144069.5	121637.6	158875.1	143189.6	211628.8	208607	430768.2	329196.7	**2331687**	**166549.1**

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Table 9 presents the Compound Annual Growth Rate (CAGR) **of** total output for the selected energy-intensive industries, revealing distinct growth trajectories across sectors during the study period. The Refined Petroleum Products (NIC-192**)** industry exhibits the highest CAGR of 59.49 per cent**,** signifying exceptional expansion attributed to rising energy demand, technological progress, and major capital investments that enhanced production capacity and efficiency. Conversely, the Beverages (NIC-110) and Food Products (NIC-131) industries show relatively modest growth rates, with CAGRs of 5.73 per cent and 4.69 per cent**,** respectively. These comparatively lower figures suggest mature and stable production structures with limited fluctuations and less dynamic market transformation over time.

Table: 10 Share of individual industry in total output of all the manufacturing industries (in percentage)

CODE	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	20221-22
110	1.47	1.32	1.21	1.18	0.84	0.88	0.79	0.84	0.76	0.82	0.84	0.69	0.85	0.63
131	2.27	1.50	1.47	2.33	1.10	1.28	1.33	1.18	1.82	1.06	0.93	1.12	0.90	0.84
139	2.08	2.33	1.60	2.04	1.88	1.86	2.33	2.05	2.09	1.93	2.13	2.09	2.64	2.65
162	0.68	0.58	0.81	0.35	0.32	0.85	0.31	0.32	0.19	0.22	0.21	0.30	0.24	0.44
170	0.95	0.80	0.51	0.95	0.62	0.55	0.83	1.09	0.76	0.93	0.89	1.04	1.20	0.77
192	0.07	0.11	0.18	0.13	0.16	0.10	0.21	**12.99**	**12.17**	**10.31**	**8.04**	**9.87**	**10.04**	**8.80**
201	1.74	1.24	1.11	1.00	0.76	0.86	0.77	0.67	1.08	1.15	1.14	1.21	1.32	1.10
222	0.88	0.96	1.08	0.54	0.80	0.64	1.55	0.80	0.84	0.88	1.70	1.99	1.28	1.08
231	0.27	0.29	0.31	0.32	0.26	0.23	0.38	0.35	0.26	0.33	0.25	0.21	0.21	0.20
239	1.23	1.13	1.35	0.96	0.83	0.87	0.93	0.93	0.83	0.88	0.82	0.84	0.70	0.70
241	**7.14**	**8.43**	**8.64**	**7.48**	**5.92**	**7.56**	**5.66**	**4.93**	**5.07**	**5.46**	3.91	3.87	**4.24**	**4.36**
325	0.47	0.48	0.50	0.49	0.34	0.43	0.41	0.32	0.33	0.29	0.35	0.36	0.75	0.45
Average	**1.60**	**1.60**	**1.56**	**1.48**	**1.15**	**1.34**	**1.29**	**2.21**	**2.18**	**2.02**	**1.77**	**1.97**	**2.03**	**1.84**

Table 10 illustrates the share of total output of selected energy-intensive industries within the overall manufacturing sector from 2008-09 to 2021-22, highlighting key trends and shifts in their contributions. In 2008-09, these selected industries produced 19.2 per cent of the total output by all manufacturing industries. The contribution varied over the years, from 13.8 per cent in 2012-13 to 26.52 per cent in 2015-16 and fell after that.

Conclusion

The analysis of energy-intensive industries in Haryana over the period 2008–09 to 2021–22 provides valuable insights into patterns of energy consumption, output growth, and their overall contribution to the state's manufacturing sector. The findings reveal that while certain industries display steady and predictable energy use, others experience considerable fluctuations in both energy consumption and intensity, reflecting diverse operational dynamics and efficiency levels. It is important to note that high energy consumption does not necessarily equate to high energy intensity. Energy intensity, defined as the ratio of energy consumed to total output, depends not only on the volume of energy used but also on the scale of production. Consequently, industries with substantial output may record lower energy intensity values, even when total energy consumption is high. This distinction is crucial in assessing the true efficiency and performance of

industrial sectors. The selected industries in this study consistently exhibit significant levels of energy use relative to their output, though the degree of intensity varies across sectors and over time. Some industries maintain relatively stable intensity values, whereas others show pronounced volatility, suggesting differences in technological adaptation, production efficiency, and energy management practices. The upward trend in overall energy consumption across several industries indicates rising energy demand driven by industrial expansion, modernization, and changing production structures.

Variations in fuel consumption and energy intensity can be attributed to multiple policy interventions and external economic factors that shaped industrial behavior during the study period. Key influences include the global financial crisis (2008–09), the introduction of India's National Action Plan on Climate Change (NAPCC, 2008), the Perform, Achieve, and Trade (PAT) scheme (2012), the adoption of the Sustainable Development Goals (SDGs, 2015), the Make in India initiative (2014) aimed at strengthening the manufacturing base, and the COVID-19 pandemic (2020–21), which disrupted production and energy use globally. The present research is limited to the 3-digit level of manufacturing industries in Haryana, as firm-level (4-digit) state-specific data are unavailable. The analysis relies exclusively on secondary data sources, which restricts the ability to capture firm-specific variations and operational nuances within each industry. Moreover, the study focuses solely on the monetary values of variables, as data on physical quantities of energy and output are not accessible. Future research can expand upon this work by undertaking decomposition analyses of energy intensity, assessing sectoral energy efficiency using physical indicators, and identifying determinants of energy performance such as technology adoption, firm size, policy incentives, and regional infrastructure. Such extensions would offer a more comprehensive understanding of the factors driving industrial energy dynamics in Haryana and across India.

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