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State-wise Study of Energy Intensity, Fuel Consumption and Total Output in Indian Manufacturing Sector

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ABSTRACT

The study investigates energy intensity in the manufacturing sector across states and Union Territories (UTs) of India, with the objective of identifying highly energy-intensive regions and examining fuel consumption and output production. Using exploratory and descriptive research design, the analysis is based on data from the Annual Survey of Industries (ASI) for the fiscal year 2022–23, categorized at the 3-digit level of the National Industrial Classification (NIC-2008). Energy intensity is measured as the ratio of fuel expenditure to the value of output. The findings reveal that states and UTs with the highest levels of fuel consumption or output do not necessarily exhibit the highest energy intensity. In particular, Meghalaya, Mizoram and Puducherry emerge as the most energy-intensive regions, despite relatively lower levels of total output and fuel consumption compared to other states. Gujarat, Maharashtra, and Tamil Nadu are the leading contributors to output, while Gujarat, Maharashtra, and Odisha account for the highest levels of fuel consumption. These results highlight the importance of considering energy use relative to output rather than absolute consumption, this highlights the need for policy measures to improve energy efficiency in India's manufacturing sector.

Keywords: Energy Intensity, Fuel Consumption, Total Output, Manufacturing Sector of India.

Introduction

Energy is a fundamental driver of economic development, as it supports nearly all productive activities across sectors such as manufacturing, transportation, agriculture, food production, and infrastructure (Soni, 2017). Fossil fuels such as coal, oil, and natural gas have dominated global energy use, but concerns about sustainability and climate change have encouraged a gradual

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transition towards renewable sources like wind, solar, and hydropower. Despite this shift, fossil fuels, especially coal, continue to play a central role in meeting the growing energy needs of emerging economies.

India occupies a critical position in the global energy transition. It is the world's third-largest energy consumer, after the United States and China, accounting for 6.1 percent of global primary energy consumption, dominated by coal (44%), oil (26%), natural gas (6%), traditional biomass (12%), renewables (3%), and others (9%) (IEA, 2021). With rapid economic expansion, urbanization, and population growth, India is expected to experience the fastest increase in energy demand worldwide over the next decade (World Energy Outlook, 2024). Projections suggest a 35 percent rise in demand by 2035, with manufacturing, construction, and transport sectors as the key contributors. While India has become the third-largest renewable energy producer, coal continues to underpin its energy mix. Moreover, India is currently the third-largest emitter of CO_2 globally, with emissions reaching 2.5 billion metric tons in 2019, accounting for about 7 percent of global emissions (IEA, 2021).

The industrial sector, particularly manufacturing, plays a pivotal role in India's energy landscape. Globally, industry consumes about 54 percent of total delivered energy, and in India, manufacturing alone accounts for approximately 41 percent of national energy use (IEA, 2021). In 2023–24, industry contributed nearly half of India's total energy consumption and 42 percent of electricity use (Bureau of Energy Efficiency, 2023–24). Energy-intensive industries such as steel, cement, aluminium, paper, fertilizers, and chemicals remain key consumers, often operating with higher energy consumption per unit of output compared to global standards (Ray, 2011; Mukherjee, 2007; Reddy & Ray, 2009; Dasgupta & Roy, 2016; Soni et al., 2017).

Despite improvements in energy efficiency, industrial energy use in India continues to increase, driven by structural changes and rising demand. Energy intensity—defined as the amount of energy required to generate one unit of Gross Domestic Product (at constant prices)—serves as a key indicator for monitoring efficiency at both national and international levels (Energy Statistics India, 2023). Analysing energy intensity at the inter-state level can provide valuable insights into regional disparities, policy effectiveness, and potential pathways for improvement.

This study contributes to this field by examining state-wise energy intensity, fuel consumption, and total output in the Indian manufacturing sector with the latest available Annual Survey of Industries (ASI) dataset for 2022–23.

Literature Review

A wide body of literature has explored patterns of energy intensity across countries, sectors, and industries. Much of the earlier work focused on developed economies. For instance, Howarth and

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Schipper (1991) defined energy intensity as the ratio of energy use to value added in the manufacturing sector and reported a significant decline across eight OECD nations between 1973 and 1988, with reductions ranging from 20 percent in Norway to 35 percent in Japan. They attributed this to improvements in energy efficiency. Similarly, Howarth et al. (1993) linked reductions in energy intensity in five OECD countries during the late 1970s and early 1980s to high and volatile oil prices. Studies such as Ortiz and Sollinger (2002) highlighted the role of structural changes, showing that a shift in the U.S. economy toward less energy-intensive industries contributed to overall declines.

In India, the majority of research has concentrated on national or industry-level trends. Goldar (2010) found that energy intensity declined in the post-reform period after 1992, using firm-level panel data, and emphasized the role of rising energy prices and technological advancements. Reddy and Ray (2008) studied five manufacturing sub-sectors—iron and steel, textiles, aluminium, cement, and paper—between 1990 and 2005 and observed that energy demand increased at a pace that outstripped efficiency gains. Building on this, Ray (2011) examined seven manufacturing industries and reported large variations in intensity, with cement ranking the highest and aluminium the lowest. Dasgupta and Roy (2016) compared seven Indian industries against international best practices, finding sharp declines overall, with aluminium, cement, and fertilizer approaching global standards, while iron and steel and paper lagged. Tiwari (1999), using an input–output framework, reported falling coal intensity between 1983 and 1990 but rising oil and electricity intensities, with some industries such as coal tar products and paper showing deteriorating performance.

At the broader regional level, Lajina and Pavithran (2008) analyzed ASI data at the 2–3 digit level and reported that, while industries at the national scale used less fuel compared to other inputs, certain state-level industries such as chemicals, metals, textiles, and transport equipment consumed disproportionately high energy inputs. Sahu and Santosh (2008) examined macroeconomic trends between 1980 and 2005, showing increases in energy consumption, production, GDP, population, and per capita consumption, though their growth rates slowed over time. Geethanjali (2012) is among the very few studies to explicitly focus on energy intensity at the state level.

Mukherjee (2008) is one of the few to conduct an interstate analysis of energy use efficiency in Indian manufacturing, highlighting differences in performance across states. More recent studies have also focused on subnational and sector-specific patterns. Rohtas et al. (2024) analyzed energy intensity in Haryana's manufacturing sector, examining trends in 12 of the most energy-intensive industries over several years. Their study discussed changes in fuel consumption, total output, and energy intensity, thereby providing a long-term picture of energy use in one of India's key industrial states. Extending this, Jakhar et al. (2025) applied decomposition analysis

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to the same set of industries in Haryana and found that the activity effect was the most significant factor contributing to the rise in overall energy consumption.

Although research on energy intensity in the Indian manufacturing sector has expanded in recent decades, most studies remain focused either at the national level (e.g., Goldar, 2010; Reddy and Ray, 2008; Ray, 2011) or on specific industries (Dasgupta and Roy, 2016; Tiwari, 1999). Subnational analyses are much rarer, with Mukherjee (2008) conducting one of the first interstate studies, Geethanjali (2012) providing limited state-level evidence, and recent works such as Rohtas et al. (2024) and Jakhar et al. (2025) focusing only on Haryana. Thus, while some progress has been made, comprehensive interstate comparisons of energy intensity remain scarce.

This study seeks to fill this gap by using the latest Annual Survey of Industries (ASI) 2022–23 data to compare states and Union Territories in terms of energy intensity, fuel consumption, and total output in the manufacturing sector. By identifying the most energy-intensive regions, this research provides updated knowledge that is critical for policy formulation and targeted efficiency improvements.

Methodology

This study adopts an exploratory and descriptive research design to evaluate energy intensity across the states and Union Territories (UTs) of India. The data has been sourced from the Annual Survey of Industries (ASI), Ministry of Statistics and Programme Implementation (MOSPI). The data has been classified according to the National Industrial Classification (NIC-2008) at 3-digit level for the fiscal year 2022–23.

Energy intensity is measured as the ratio of fuel expenditure to the value of output (Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy). This method has been widely applied in previous research on India (Roy, 1992; Roy et al., 1999; Dasgupta & Roy, 2000; Roy, 2007; Sahu & Narayanan, 2011; Dasgupta et al., 2011; Ray, 2011; Dasgupta & Roy, 2016; Rohtas et al., 2024; Jakhar et al., 2025).

The variable **fuel consumed** represents fuel expenditure, which includes the total purchase value of fuels, lubricants, electricity, water (for steam), and related inputs. The **value of output** is taken as 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 R&D expenses (ASI, 2021-22).

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The study covers all states and Union Territories of India for which data was provided in ASI 2022–23, analysing both fuel consumption and output value in monetary terms for the overall manufacturing sector. In addition to energy intensity calculations, the analysis includes total fuel consumption and total output level of these regions. These measures help in identifying not only the regions that consume the most energy or produce the largest output, but also those that are relatively less energy efficient.

Result and Analysis

Table 1: Top five states in terms of their percentage shares in the value of overall aggregates for each of the characteristics

Rank	Characteristics (Estimates of Fixed Capital, Output and GVA are in ₹ Lakh)					
	Total No. of Factories	**No. of factories in operation**	**Fixed Capital**	**Total persons engaged**	**Output**	**Gross Value Added**
1	Tamil Nadu (15.66%)	Tamil Nadu (15.26%)	Gujarat (19.64%)	Tamil Nadu (15%)	Gujarat (17.72%)	Maharashtra (16.33%)
2	Gujarat (12.25%)	Gujarat (12.01%)	Maharashtra (11.97%)	Maharashtra (12.84%)	Maharashtra (14.78%)	Gujarat (14.78%)
3	Maharashtra (10.44%)	Maharashtra (10.04%)	Odisha (8.06%)	Gujarat (12.62%)	Tamil Nadu (9.97%)	Tamil Nadu (10.33%)
4	Uttar Pradesh (7.54%)	Uttar Pradesh (7.87%)	Tamil Nadu (7.93%)	Uttar Pradesh (8.04%)	Uttar Pradesh (7.03%)	Karnataka (7.04%)
5	Andhra Pradesh (6.51%)	Andhra Pradesh (5.93%)	Karnataka (6.10%)	Karnataka (6.58%)	Karnataka (6.17%)	Uttar Pradesh (6.09%)

Source: ASI, 2022-23

Table 2 shows the state-wise distribution of fuel consumption, total output, and energy intensity across India's States and Union Territories. In terms of total output, Gujarat contributes the highest share (17.72%), followed by Maharashtra (14.78%), Tamil Nadu (9.97%), Uttar Pradesh (7.03%), and Karnataka (6.17%). These states dominate India's manufacturing industrial base. On the other hand, regions such as Andaman & Nicobar Islands, Arunachal Pradesh, Chandigarh, Ladakh, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura record very low levels of total output, reflecting their relatively smaller industrial base and limited manufacturing

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activities. This may be due to the fact that several of these are Union Territories or belong to the North-Eastern region, where industrial development and large-scale manufacturing are comparatively limited.

Table 2: Fuel Consumption, Total Output, and Energy Intensity across States and Union Territories of India

States & Union Territories	Fuel Consumption (in ₹Billion)	Total Output (in ₹Billion)	Energy Intensity
A & N. Island	0.02	0.35	0.06
Andhra Pradesh	305.85	6138.67	0.05
Arunachal Pradesh	1.35	14.00	0.10
Assam	41.52	1441.96	0.03
Bihar	22.52	1425.36	0.02
Chandigarh	0.71	44.24	0.02
Chattisgarh	258.60	3122.58	0.08
Dadra & N Haveli and Daman and Diu	67.84	2109.00	0.03
Delhi	15.12	534.79	0.03
Goa	21.79	691.05	0.03
Gujarat	1044.14	25677.33	0.04
Haryana	291.99	8802.70	0.03
Himachal Pradesh	64.82	1784.57	0.04
Jammu and Kashmir	10.50	361.14	0.03
Jharkhand	340.75	2648.26	0.13
Karnataka	290.55	8940.63	0.03
Kerala	140.47	2491.41	0.06
Ladakh	0.02	1.28	0.01
Madhya Pradesh	212.36	4301.22	0.05
Maharashtra	729.22	21222.42	0.03
Manipur	0.63	6.68	0.09
Meghalaya	16.35	108.94	0.15

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Mizoram	0.12	0.78	0.15
Nagaland	0.16	5.68	0.03
Odhisha	436.97	5082.79	0.09
Puducherry	301.08	366.03	0.82
Punjab	201.40	4620.24	0.04
Rajasthan	290.27	5670.18	0.05
Sikkim	3.57	281.98	0.01
Tamil Nadu	382.90	14442.59	0.03
Telangana	172.83	3683.32	0.05
Tripura	1.98	20.62	0.10
Uttar Pradesh	396.9248	10188.3729	0.04
Uttrakhand	82.50	2566.39	0.03
West Bengal	244.68	6068.49	0.04

Source: ASI & Self Computed

In terms of fuel consumption, Gujarat accounts for the largest share (16.00%), followed by Maharashtra (11.40%), Odisha (6.83%), Uttar Pradesh (6.20%), and Tamil Nadu (5.98%). These states, being major industrial hubs, consume a significant portion of the country's fuel resources to sustain their large-scale manufacturing and production activities. On the other hand, regions such as Andaman & Nicobar Islands, Arunachal Pradesh, Chandigarh, Ladakh, Manipur, Mizoram, Nagaland, Sikkim, and Tripura exhibit very low levels of fuel consumption. This is largely due to their smaller industrial base, geographical constraints, and lower levels of manufacturing activities.

Interestingly, North-Eastern states and Union Territories with comparatively low output often exhibit higher energy intensity. For instance, Puducherry, Mizoram, and Meghalaya consume relatively small amounts of fuel but generate disproportionately lower levels of output, resulting in higher energy intensity. This suggests that structural limitations, smaller production scales, and inefficiencies in energy use contribute to elevated intensity levels in these regions. In contrast, industrially advanced states like Gujarat, Maharashtra, and Tamil Nadu maintain lower energy intensity despite their large-scale fuel consumption, indicating more efficient energy utilization.

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Figure 1: State-wise Fuel Consumption in the Manufacturing Sector (in ₹ Billion)

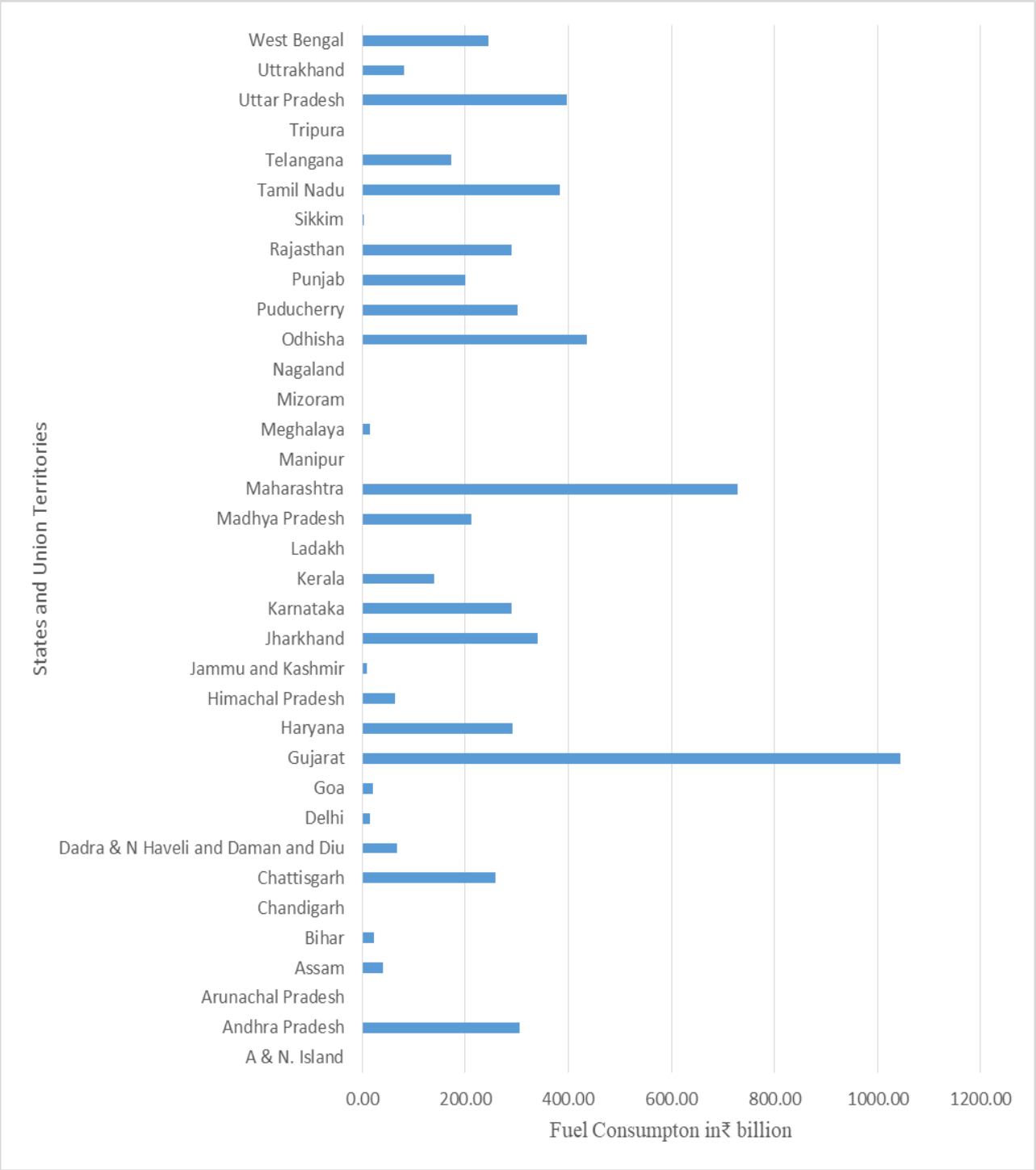

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Figure 2: State-wise Total Output of the Manufacturing Sector (in ₹ Billion)

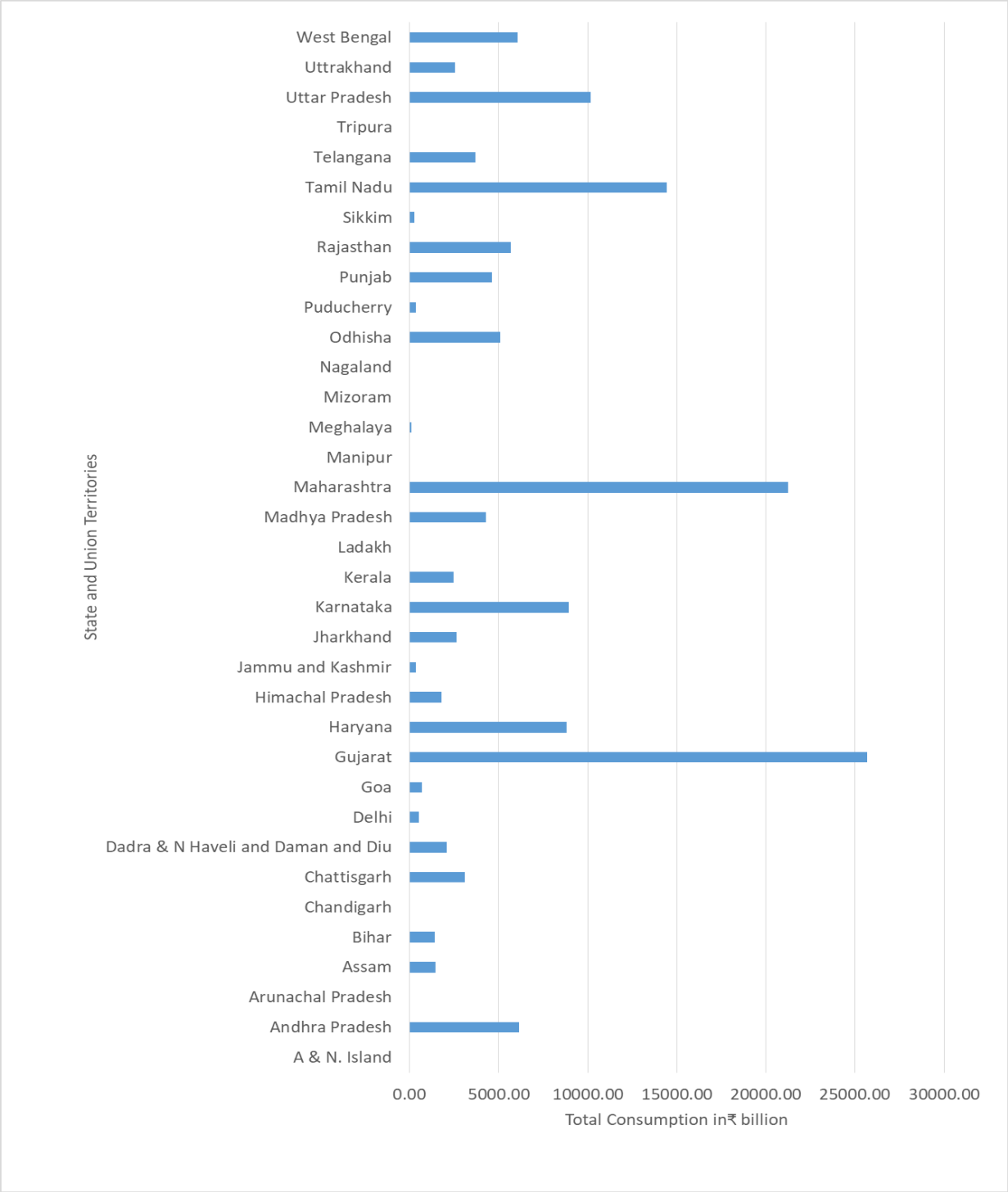

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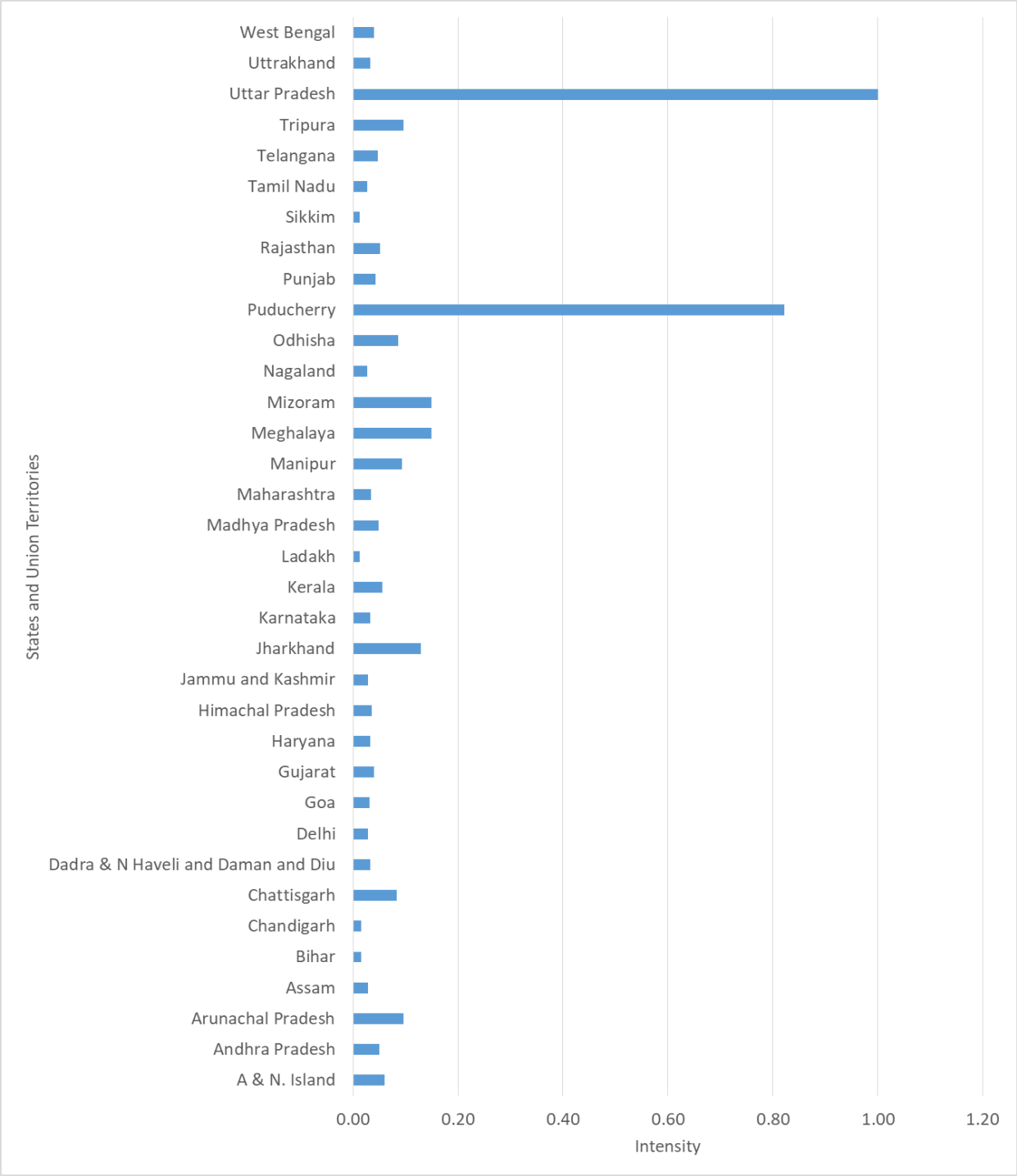
Figure 3: Energy Intensity of the Manufacturing Sector across States and UTs



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Conclusion

Energy use in India's manufacturing sector varies widely across states and Union Territories, reflecting differences in industrial development, scale of operations, and energy management practices. This study reveals that industrially advanced states such as Gujarat, Maharashtra, Tamil Nadu, Uttar Pradesh, and Karnataka not only lead in total output and fuel consumption but also demonstrate more efficient energy use, as reflected in their lower energy intensity. These findings highlight the positive impact of scale, technological adoption, and optimized processes in reducing energy per unit of output.

Whereas, smaller industrial regions and several Union Territories, including Puducherry, Mizoram, and Meghalaya, exhibit disproportionately high energy intensity relative to their production. This indicates structural constraints, limited production capacity, and inefficiencies in energy utilization, suggesting that targeted interventions are needed to enhance efficiency in these areas.

By examining state-wise variations in energy intensity, fuel consumption, and output, this study provides a clear understanding of where energy resources are used efficiently and where inefficiencies persist. The insights can guide policymakers and industry stakeholders in designing region-specific strategies that promote sustainable industrial growth, improve energy productivity, and reduce environmental impacts.

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