CHAPTER-2

REVIEW OF RELATED LITERATURE

2.1 Introduction

The study's primary goal is to understand the functional relationship between India's energy consumption, energy intensity, and industrial growth. Hence the central focus of this chapter is to survey various empirical studies conducted worldwide on energy supply, demand, distribution, transmission, and intensity and its impact on industrial growth. The energy reviews from various periods are listed in three sections. The first section presents an overview of the literature on energy studies in the context of world economies. The second section deals with energy-related studies in India. The end of the chapter summarizes the development in industrial energy consumption, intensity, and output linkages. Such an exercise has provided knowledge to identify the research gap.

2.2 Section 1: Energy studies in the context of world economies

The classical macroeconomic development theories neglected to recognize energy as a critical component of economic growth during the early stages of pre-industrialization. Instead, they believed economic progress was based solely on capital and labor. It was only in the seventies that the importance of energy was fully felt, owing to oil embargoes and energy crises, resulting in an increase in oil prices and causing disruption among the industrialized countries. Since then, energy demand, supply, and distribution research has gotten much attention. Roegen-Nicholas Georgescu (1972, 1976) was one of the first to call out the lack of energy studies in economic theory. Roegen stated that conventional economics ignored that "terrestrial energy and material resources are irreversibly depleted, and the detrimental impacts of pollution on the environment accrue."

To start, in the late 1970s, investigations on the causal relationship between energy use and economic growth were pioneered by Kraft and Kraft (1978). Results showed consistent and stable relationships between gross energy use and GNP using data from the United States from 1947 to 1974. The main empirical findings indicated a one-way causal relationship between GNP and energy. This demonstrated that rising GNP is associated with rising energy consumption in the US.

Erol and Yu (1987) investigated the relationship between U.S. energy and employment over the sample period of 1973 to 1984 in a related field. To determine causality, they used different time-series approaches such as the modified Box-Jenkins procedure of multiple time-series tests, the Haugh test of independence, the Sim's test of causality, and cross-correlation based on the twin approach, namely double-filter and single-filter. The findings confirmed the premise that the relationship between total employment and energy usage is neutral. Additionally, they demonstrated that pursuing energy conservation has no impact on the overall level of employment.

Masih and Masih (1996) did yet another study for six Asian nations: Indonesia, the Philippines, Malaysia, Singapore, Pakistan, and India. The study concentrated on the causal link between energy consumption and economic expansion. The multivariate cointegration tests of Johansen were used. Additionally, the Granger-cause direction was examined. In India, the results showed a one-way causal relationship between energy and income; in other nations, the relationship was reversible.

Lai (1997) studied the causality between energy and GNP and energy and employment for the Taiwanese economy for the reference period of 1955-1993. The research was supported by techniques of co-integration and Hsiao's version of Granger Causality. The study concluded that causality runs from GDP to energy consumption but not vice versa.

Worrell et al. (2003) looked at the connection between industrial productivity and energy efficiency. The study used publicly accessible databases to evaluate more than 70 industrial case studies while also attempting to calculate productivity increases in energy modeling. The study recommended a method for accounting for productivity gains when assessing the economic feasibility of energy efficiency improvement. Initiatives to improve energy efficiency have a major positive impact on industry productivity. Suppose the result mentioned above comes to be. In that case, there are significant repercussions for conventional economic appraisals of the emergence of energy-efficient technologies as a potential for more substantial productivity increases. The study examined how this change in viewpoint affects the evaluation of energy-efficient equipment in the American iron and steel sector. The cost-effective potential for energy efficiency improvement was twice as great compared to an analysis that did not explicitly consider productivity advantages in the modeling parameters.

Soytas and Sari (2003) examined the causal relationship between energy usage and income in a different study. For seven emerging markets, a time series property between GDP and energy consumption was considered. In addition to finding bidirectional causality for Argentina, the study also revealed causality from GDP to energy consumption for Italy and Korea, but from energy consumption to GDP for Turkey, Japan, France, and Germany. The research also cautioned that these nations' efforts to conserve energy would stunt their ability to build their economies.

Bilal and Mohsen (2003) looked at energy use in the Jordanian industry using data on fuel and power usage in industries. 10 percent of the industrial sector was observed for the study. Ninety percent of industrial companies were small in size. According to research, Jordanian businesses consumed about 22 percent of the nation's energy supply. The primary source of energy among them was electricity.

Canada's energy consumption and production growth causation were examined by El-Sakka and Ghali (2004) The vector error-correction model and Johansen co-integration methods were used to conduct the inquiry. The statistical results show that production, capital, labour, and energy use all move over the long term. Granger-Causality was running in both directions between output and energy use, according to the short-run dynamics of the VEC specification with variables. The findings also revealed that, for Canada, energy could only be seen as a constraint on economic expansion.

Similarly, Oh and Lee (2004) examined the causal relationship between energy consumption and economic growth in the Korean economy. Dual multivariate time series models were used in the research, one on the supply side and the other on the demand side. The goal was to examine Granger causality in the presence of variable cointegration. The VECM model was employed during the analysis. From 1981 until 2000, the inquiry was conducted. The outcome shows no short-term casualties between GDP and energy and a long-term unidirectional causal relationship from GDP to energy. According to the findings, it may be possible to conserve energy without permanently limiting economic growth.

To examine the relationship between electricity consumption and economic growth in Turkey from 1950 to 2000, Tas et al. (2005) employed two distinct types of methodologies: the Dolado-Lutkepihl test employing VARs in levels and a typical Granger causality test using detrended data. The findings revealed a unidirectional correlation between rising power use and increasing GDP growth.

Lee (2006) on the other hand attempted to investigate if a decrease in energy consumption had any impact on economic growth in industrialized economies in a different study utilizing the Toda-Yamamoto approach. Eleven industrialized economies were the subject of the study. Except for nations like the United Kingdom, Germany, and Sweden, the results showed no positive correlations between energy use and income. Instead, bidirectional causality was found in the United States, and positive correlations between energy use and GDP were discovered in Canada, Belgium, the Netherlands, and Switzerland. This demonstrated that these five countries' economic progress might be hampered by energy conservation. Additionally, the causality seemed unidirectional but reversed for France, Italy, and Japan, suggesting that energy conservation in these three nations may be feasible without detrimental economic growth.

In contrast, David and Chunbo (2006) employed the Logarithmic Mean Divisia Index (LMDI) method to break down changes in energy intensity for the period 1980 to 2003 in the Chinese economy. They found that: (1) technological advancements significantly reduced energy intensity; (2) over the period 1980–2003, structural change at the industry and sub-industry level increased energy intensity, though the structural change at the industry level was very different in the 1980s and the post–1990 period; (3) structural change in shifts of production among sub-sectors, on the other hand, decreased overall energy intensity; and (4) over the period 1980–2003, structural change at the industry level increased energy intensity.

In their study, Francis et al. (2007) looked into issues like improving energy efficiency in the Caribbean region's production, usage, and distribution. The three Caribbean nations demonstrated the presence of a short-run bi-directional Granger causal relationship between real gross domestic product per capita and energy use. The study also identified an upward trend in energy use. As a result, the conclusion required that these countries make a long-term commitment to policy, economics, and research while adopting and deploying new energy technology.

On the other hand, Chen (2007) used a panel data set to investigate the relationship between power usage and real GDP for ten Asian nations. The specific countries were Hong Kong, Indonesia, Korea, India, Malaysia, Singapore, Thailand, China, the Philippines, and Taiwan. The results showed a short-run unidirectional causality from economic development to energy consumption and long-run bidirectional causality between electricity consumption and economic growth. Any strategies for electricity conservation can be promoted without harming economic expansion, the findings also suggested.

For the G7 nations, Narayan and Smyth (2007) investigated the relationships between capital accumulation, energy consumption, and real per capita GDP growth. The results were obtained using the following methods: panel unit root, panel cointegration, granger causality, and long-run structural estimation. The results demonstrated that energy consumption and capital development have a favourable long-term impact on real GDP. The results also show that a 1 percent increase in energy consumption increases real GDP by 0.12 to 0.39 percent.

whereas the Real GDP is increased by 0.1 to 0.28 percent when capital formation rises by 1 percent.

Similar to this, Zamani (2007) investigated the causal relationship between total GDP, industrial and agricultural value-added, and energy consumption in Iran between 1967 and 2003 using a vector error correction model. For the entire economy, it was found that there was a long-term unidirectional relationship between GDP and total energy as well as a bidirectional relationship between GDP and gas and GDP and consumption of petroleum products. Value-added and total energy, electricity, gas, and petroleum product consumption, as well as gas consumption and value-added, are all correlated in the industrial sector. Long-term bidirectional linkages between values added and overall energy, electricity, and petroleum product use are present in the agricultural sector. In this sector, short-run causation exists between GDP and total energy and petroleum product consumption, as well as between industrial value-added and total energy and petroleum product consumption.

A study on the effects of disaggregated energy use on industrial production was carried out in the United States by Zari et al. (2007) Using monthly data and a variance decomposition technique, they evaluated the proportional contributions of energy and employment in real production. According to their research, unexpected shocks to coal, natural gas, and fossil fuel energy sources had the biggest impact on output variance, although a variety of renewable energy sources also have a sizable explanatory power. More than an energy source, employment explains the variation in prediction error in industrial production.

The causal relationship between disaggregate measurements of energy use, industrial production, and employment in the United States was also examined by Sari (2008) using the ARDL bound test. The years 2001 to 2006 served as the sample period. The findings suggested that for all computations of disaggregated energy consumption, output and employment were the main long-run forcing variables. The study found that industrial production and energy consumption are causally related in a single direction, save from the consumption of coal, which contributed to growth.

Bowden et al. (2009) used annual data from the US from 1949 to 2006 and a multivariate technique to investigate the relationship between aggregate and sectoral primary energy consumption indicators and real GDP. The use of Toda and Yamamoto's run causality tests revealed that there were sector-specific differences in the relationship between energy consumption and real GDP. The results demonstrated how discrepancies in the relationship between energy usage and real GDP by industry might be taken into account by properly formulated energy and environmental legislation.

On the other hand, Emmanuel (2009) conducted a co-integration analysis on the relationship between South Africa's industrial production and disaggregated energy use using annual data from 1980 to 2005. This study's objective was to establish a one-way relationship between various forms of disaggregated energy use and industrial output. According to the research, oil consumption and industrial production are inversely correlated, and industrial production and employment are long-term drivers of electricity demand.

Tsani (2010) examined the causal relationship between aggregated and disaggregated levels of energy consumption and economic development in the Greek economy from 1960 to 2006 using Toda and Yamamoto's time series technique. Statistical evidence suggested a one-way causal relationship between total energy consumption and real GDP at aggregate levels of energy use. Disaggregated empirical data demonstrated a bidirectional causal relationship between real GDP and industrial and residential energy use, but not transportation energy consumption. The significance of policy implications on energy consumption in Greece shows that significant demand-side and energy efficiency improvements are required to alleviate energy import dependence and environmental concerns without limiting economic growth.

Samhouri and Ghandoor (2009) proposed two techniques for simulating the Jordanian industrial sector's power usage. They are, respectively, multivariate linear regression and neuro-fuzzy models. The number of industries, workers, power tariffs, current fuel costs, production outputs, capacity utilization, and structural impacts were all factors that influence electricity usage. The most important elements that have a major impact on electrical power consumption have been identified as industrial production and capacity utilization. The findings revealed that both multivariate linear regression and neuro-fuzzy models are typically equivalent and may be utilized to simulate industrial power usage well. However, a comparison based on the square root average squared error of data reveals that the neuro-fuzzy model performs somewhat better than the multivariate linear regression model for predicting electricity usage.

Using the Toda and Yamamoto causality test, Payne and Bowden (2010) investigated the causal link between energy consumption in the sector and real GDP in the United States. The study used employment data and real gross fixed capital formation in its model and found that there is no causal link between real GDP and commercial energy consumption and that industrial non-renewable energy use leads to a rise in real GDP.

By using the Ordinary Least Square Engel-Granger, Dynamic Ordinary Least Square, and Autoregressive Distributed Lag Model, Loganathan et al. (2010) sought to determine the sustainability between energy consumption and economic growth in Malaysia from 1980 to 2009. The investigation showed a bidirectional co-integration between global energy consumption and Malaysia's economic growth.

Nan et al. (2011) looked into the relationship between energy use and economic growth in the Chinese province of Hebei from 1980 to 2008. The Granger Causality test and co-integration were employed in the investigation. The results demonstrated a consistent long-run causal relationship between global energy use and economic expansion. Further investigation found that the province of Hebei's rising energy usage is primarily the result of economic growth.

Ahmad et al. (2018) examined the connection between disaggregated energy consumption, economic growth, and CO2 emissions in five developing nations from 1992 to 2016: Brazil, Russia, China, India, and South Africa (BRICS). The study used methods like unit root, co-integration, and long-run elasticity estimation techniques like pooled mean group and differenced panel generalized method to evaluate empirical results. The results demonstrated that non-renewable energy use, labor, and capital all have long-term beneficial effects on economic growth. On the other hand, the usage of renewable energy has been found to have a favorable but statistically inconsequential effect on economic growth. The study generally shows that factors like population, per capita income, and the consumption of non-renewable energy all contribute to increased emissions, but renewable energy use reduced emissions.

Recently, Kassim et al. did research on the economy of Nigeria (2020). The study examined how energy use affected industrial growth from the years 1985 to 2017 under consideration. Several factors were taken into account during the analysis, including the manufacturing value added, electricity consumption, per capita income, exchange rate, imports, and exports. The results were tested using the Ordinary Least Squares method. The findings indicated that there was a weak and negative correlation between industrial expansion and energy usage.

The studies reviewed above at the global level mostly examined the relationship between energy consumption and economic growth or industrial production and energy efficiency. These studies used different techniques such as a Granger causality of a different version, vector error correction models, ARDL-bound test, fuzzy model, co-integration, and panel-generalized methods. Additionally, this research used fuel consumption as a stand-in for overall energy consumption in aggregate terms. If it had been selected in a more disaggregate manner, it might have been more fitting. Many additional associated variables, including capital, labor, and the real fuel price index, may have been taken into account in order to properly extract the results. These gaps allow for further research into the relationship in the study's later chapters.

After learning about the functional linkages between energy consumption and economic growth variables from international studies, it is also crucial to understand the literature on energy consumption, intensities, and industrial output-related research in India.

2.3 Section-II: Energy Consumption, Energy Intensities and Industrial Output related studies in India

India first realized the significance of energy in economic activities in the 1970s. Numerous studies have since been conducted, particularly on the topic of energy forecasting. In one of the early analyses, in addition to predicting energy use, Chitale and Roy (1975) looked at energy use per unit of production through time and between nations. Although the level of mechanization and automation in the US was significantly higher than in India, one unexpected finding of their research was that Indian industries consume more fuel per unit of output than their American counterparts, suggesting that there is significant room for energy conservation in India. They believed that the industry can reduce its energy use by up to 20 percent. Parikh et al. (1978) estimated India's energy availability and consumption in the year 2000. Their research indicated that India's energy demand in 2000 will be ten times greater than it was in the years 1970–1971. Finding a substitute for oil, according to the report, is also essential.

Tyner (1978) looked at the functional relationship between energy consumption and national GDP in India from 1953–1954 to 1970–1971 in a different study. According to his research, the national GDP increased by six crores for every one million TCR more energy in 1960–1961. The power industry was also examined in the investigation, and it was discovered that it had failed to meet its power goals during four five-year programmes. These problems appeared to be impeding the expansion of the agricultural and industrial sectors. The study also provided the government with specific recommendations, such as emphasizing coal-fired power generation and adopting a local oil production strategy. In contrast, Desai (1978) examined the sources of growth of energy consumption from 1955 to 1970 and found that net domestic product (NDP) accounted for 58 percent of the rise in energy consumption during this period, while energy intensity accounted for the remaining 42 percent.

Leena and Pachauri (1988) attempted to illustrate the Karnataka industrial energy future and provide energy-saving techniques in their analysis. They discovered that while per capita energy consumption in Karnataka and India was low compared to the rest of the world, energy per state domestic product in the industrial sector was at least 10–20 times greater than in industrialized nations. This showed that energy use was significantly inefficient.

Monga and Sanctis (1994) looked into the different roles and significance of non-commercial and commercial energy. They recognized a supply-demand mismatch in the commercial, non-commercial energy system, also known as alternative non-conventional energy, and decided that it should be employed domestically in the economy. According to the findings, the percentage of people who use non-commercial energy was smaller than that of people who used commercial energy. They concluded that non-commercial energy resources will be a key component of the

In contrast to the previous research, Nair (2000) conducted a study to determine the role of the power sector in energy consumption and supply and then focused on the unique characteristics of the power infrastructure by conducting a detailed examination of demand forecasting, capacity expansion, forecasts, and power infrastructure problems. He used the end-use technique to forecast power demand in the near and medium term. It was observed that India should focus on expanding its energy supply capacity.

Ghosh (2002) looked at the Granger association between India's per-capita Gross Domestic Product (GDP) and energy usage. Using annual data spanning the years 1950–1951 through 1996–1997, he achieved this. Phillips-Perron tests after logarithmic transformation show that both series are non-stationary and individually integrated of order one. The analysis concluded that, despite the lack of a long-run equilibrium relationship between GDP per capita and energy consumption per capita, there is a unidirectional Granger causal relationship between economic growth and electricity consumption. The analysis suggests that measures for energy saving can be pushed without diminishing economic side effects.

Bhattacharya and Paul (2004) used various econometric time series models, including Engle-Granger, Granger causality test, and Johnsen's multivariate co-integration technique, to examine the relationship between energy use and economic growth. In contrast to the conventional Granger causality test, which shows that energy consumption leads to economic growth, the research showed that economic growth leads to higher energy consumption over the long run.

Reddy and Kumar (2008) devised and examined physical energy intensity metrics for the Indian industrial sector. Energy consumption in five industrial sub-sectors, including iron and steel, aluminum, textiles, paper, and cement, was examined during the years 1990 to 2005. He created specialized energy consumption indicators that, in terms of reflecting physical reality, are more precise than monetary energy intensities. Physical energy intensity measurements support cross-country comparison, offer useful data to policymakers on intra-sector structural changes, and offer a thorough justification for observed variations in energy intensity. The study's conclusions highlighted the significance of employing physical indicators when determining policy as a result.

In his study, Jena (2009) sought to discover alternate energy-saving strategies using technology improvements while also attempting to investigate the shifting patterns of commercial energy usage in India's industrial sector. He accomplished this using the Divisia index decomposition technique. The overall energy intensity index was split using this method into structural and energy intensity indices. His findings showed that the industrial sub-sectors still have a lot of opportunity for energy savings, even though some sub-sectors have shown improving trends in technical efficiency. Furthermore, the change in the aggregate energy intensity index does not seem to have been significantly impacted by structural impacts. Instead, most of the change in the aggregate intensity index is explained by the reduced energy intensity index.

A study of household energy consumption patterns was carried out by Devi et al. (2009) in the Indian village of Bibipur in the district of Jind, Harayana. The households surveyed were representative of a varied population with a range of socioeconomic, educational, and social statuses. Energy availability, demand, and consumption across a range of industries, including transportation, agriculture, residential, and other uses have all been investigated. The analysis shows that the energy supply and demand in the community are very dissimilar. Non-traditional energy sources can be found more easily than traditional energy sources, albeit some of them are neglected. In contrast, Narayan and Sahu (2009) investigated the factors that determine the intensity of industrial energy in Indian manufacturing. In their study, they discovered a positive association between energy intensity and firm size, as well as an inverted U-shaped relationship between energy intensity and company size.

Blessy and Maria (2010) examined the performance of the manufacturing sector in India, in terms of productivity growth, scale efficiency, and technical efficiency, depending on whether the firm belonged to the formal or informal sector. Using aggregated data for India's total manufacturing sector, the primary distinctions between these two sectors, as well as their development over a decade, were observed and studied. Efficiency in the two sectors was compared and analyzed against factors affecting the levels of efficiency obtained for each major industry category using a stochastic frontier approach and maximum likelihood models. The findings revealed that many unorganized sectors, from 1994-95 to 2000-01 witnessed a decline in the average efficiency & extremely low average efficiency during 2000-01. Hence their study warranted for a policy suggestion to bring improvement in the unorganized manufacturing sector.

Goldar (2011) examined the factors influencing the energy intensity of the Indian industrial sector. The results implied that while an increase in real wages had a positive effect on demand, an increase in energy prices had the opposite effect. The analysis' findings suggested that improvements in energy-intensive industries' energy usage efficiency, which can be traced back to increases in the real price of energy paid by manufacturing enterprises, were primarily responsible for the decline in India's manufacturing sector's energy intensity since 1992. Additionally, the results indicated that technical advancement (as gauged by Total Factor Productivity indices) significantly influenced energy intensity.

Similarly, Ray (2011) attempted to examine the energy intensity of seven Indian manufacturing businesses to determine the degree of intensity of consumption. In his research, it was discovered that different industries have varying degrees of intensity. In particular, the study observed that industries such as paper, aluminum, iron & steel, fertilizer, chemical, glass, and cement industries have revealed different energy intensities which were well above the average intensity of the entire aggregate manufacturing industry. Moreover, energy intensity varies across the industry over years. Therefore, energy intensity changes over time and varies significantly by the type of economic activity.

As opposed to this, Mehra and Reddy (2012) investigated the influence of energy intensity on GDP. For the period 2006-2013, they calculated energy intensity as a ratio of intermediate energy input to gross value added; their findings showed that India's energy intensity has been declining since 1999, although in a sluggish manner.

The potential for energy savings for industries in India was determined by Prasad and Manish (2012) using unit-level Annual Survey of Industries data from 2007–2008. The paper then developed an econometric model for the selected industries and the model used a translog cost function, admitting substitutability among energy and other non-energy inputs as well as among fuels, to examine the behavior of the industries in response to changes in factor prices or fuel prices. The model used aggregate time series data for the relevant industry from 1991-1992 to 2008-2009. The empirical results demonstrated that energy usage was quite sensitive to price changes. Additionally, it had been determined that a significant percentage of the model's projected increase in factor productivity was caused by changes in energy prices, with the price-neutral component of technical change being quite modest.

Rena and Ramakrishna (2013) tried to analyse the energy situation in India from 1981 to 2010 in terms of energy consumption, energy security, energy efficiency, and growth trends. He investigated the causal relationship between energy consumption and GDP using co-integration and the Vector Error Correction Method in addition to trend analysis (VECM). According to the study, energy consumption and GDP were inversely correlated at the aggregate level.

On the other hand, Behera (2015) investigated whether energy use had a direct or indirect impact on economic growth since 1970. He found that lignite and power use are driven up by economic expansion as a consequence of employing the Granger causality test. It was found that there is a bidirectional association between lignite power consumption and economic growth when sample predictions were utilized in the variance decomposition of the VAR, but there is a one-way relationship between GDP growth and natural gas use.

Devasia et al. (2017) investigated the connection between India's energy use and GDP per capita for the period from1971 to 2013. The two main factors examined were the per capita GDP and energy use. Energy utilisation was measured in kilograms of oil equivalent (Kgoe). According to the study, there was a long-term link between energy use and GDP per capita, and India's GDP per capita increased as a result of energy use during the studied period.

2.4 Conclusions

The research that was reviewed above at the global level mostly focused on the link between energy use and industrial output, employment, and economic growth or the opposite. Several authors used various methodologies to analyse various nations over a range of historical periods. Most of this research made use of aggregate data. However, not all of these research findings agree with their conclusion. According to several studies, the Granger causality moves from poverty to energy use. Yu and Choi (1985) and Soytas and Sari (2003) for South Korea, Erol and Yu (1987) for West Germany, Masih and Masih (1996) for India and Indonesia, Cheng and Lai (1997) for Taiwan, Soytas and Sari (2003) for Italy, and Lee (2006) for France, Italy, and Japan are a few of these studies. On the other hand, other research discovered a causal relationship running from energy consumption to income in both emerging and developed economies. Stern (1993, 2000), for the United States, Erol, and Yu (1987), for Japan, Yu and Choi (1985), for the Philippines, Masih and Masih (1996), for India and Indonesia, Soytas and Sari (2003), for Turkey, France, Germany, and Japan, and Lee (2005), for 18 developing nations are a few examples.

Various other studies reported on bi-directional causality between energy consumption and output. For example, Erol and Yu (1987) reveal a bi-directional causality for Japan and Italy, while additional evidence for bi-directional causality was given by Masih and Masih (1996) for Pakistan's economy, Soyat and Sari (2003) for Argentina, Ghali and El-Sakka (2004) for the Canadian economy, Nanthakumar et al. (2010) for Malaysia. Similarly, Stela (2009) found a bi-directional causality from real GDP to energy consumption in the Greek economy.

Yet some recent studies posited a different conclusion like the study by Emmanuel (2009) for the South African economy concluded that consumption and industrial production are inversely correlated, and industrial production and employment are long-term drivers of electricity demand. Another study by Kassim Fatima et al. (2020) on the Nigerian economy pointed out an insignificant relationship between energy consumption and industrial output.

Studies reviewed in the first section utilized many different statistical techniques such as Vector Error Correction Method, Johansen Co-integration, Granger Causality test, Dolado-Lutkepihl test, VAR test, Logarithmic Mean Divisia index, ARDL-Boun test, Toda and Yamamoto's time series techniques, Multivariate linear regression, and Neuro-fuzzy Model. These models have been employed to satisfy the concerned objectives of their study.

Furthermore, it is noted that while the aforementioned Indian studies attempt to link aggregate energy consumption and economic growth in India, there may be practical issues in aggregating the various kinds of real energy consumption because their units of measurement differ. The efficiency and quality of energy determine the measurement conversion. As a result, the current research differs from previous studies on various forms of energy use and economic growth. As a result of this research, alternative policy methods for dealing with energy demands will be developed. Previous research has looked at aggregate energy consumption or, if there is a disaggregation, some kinds of energy consumption, leaving the most important component of energy, electricity, out. As a result, the current study works used several kinds of real energy consumption growth and attempted to integrate them with the economy's real growth rate. It's also crucial to consider how commercial and noncommercial energy might be used more efficiently.

As countries' energy consumption grows at a rapid rate, the majority of research shows that energy use changes with low levels of efficiency. There has been numerous research on India since 1979. The majority of studies focused on determining the haphazard link between energy use and GDP growth. Chital launched one of the early studies on the optimal production level of coking coal mines in eastern India in 1979. In 1983, the National Power Plan examined the transportation of electricity between western and southern states. Deshmukh and Parikh1992 worked on peak demand reduction and energy conservation in the later stages of energy research. Sejal Ghosh (2002) examined India's energy consumption per capita and GDP per capita using a causality test. In a similar vein, Nagabhushan Raju (2007) focused on two major restraints in the power sector: one, the availability of financial resources for energy capacity expansion, and the other, the mitigation of energy's environmental implications. Others, such as Ramakrishna, G., and Rena, R. (2013), used co-integration and the vector error correlation method to study energy consumption, energy security, and energy efficiency, as well as their growth trends (VECM). Sarbapriya Ray (2011) investigated energy intensity measurement for Indian manufacturing companies in the same context. While Jyothimera and Sreelatha Reddy (2012) studied intensity and its impact on GDP, many others, including Narayan (2009), Sudhakaraa Reddy and Binay Kumar (2008), Blessey and Maria (2010), studied energy intensity and efficiency. The results of their research have been varied.

All of the research listed above is from different periods, yet they all take place in India. These studies can be divided into three categories: one focuses on the energy-economic growth nexus, another on energy usage in industrial sectors, and the third on energy intensity and industrial output. The findings of these studies provided insight into the subject, framing objectives, variable selection, variable adjustment, time series length, sample size, data sources, and various methodologies used. Moreover, most of the previous studies have been carried out to analyse the linkages between energy consumption and economic growth. Very seldom or no research has been disaggregatedly carried out for energy consumption and industrial output. Aside from that, the current study is distinguished on the ground by a larger sample size and the use of robust models such as fixed and random effect models, Trans-log production function, Allen Partial elasticity of substitution, Vector Error Correction Models, and Data Envelopment Analysis for variables such as labour, capital, total fuel consumed and real price of energy. As a result, the nature of this research acquires traction in terms of producing useful outputs to promote industry development, advocate government policies, and accomplish economic progress.

In the foregoing chapters, the above-underpinned aspects will be incorporated into the analysis.

2.5 References

- Ahmad, B. (2018). Renewable and non-renewable energy consumption- impact on economic growth and CO2 emissions in five emerging market economics, *Environmental Science and Pollution Research*, (25) 35515–35530.

- Behera,J. (2015). Energy consumption and economic growth in India: A reconciliation of Disaggregate Analysis, *Journal of Energy Technologies and Policy*, 5 (6), 15-27.

- Bowden, N., & Payne, J. E. (2009). The causal relationship between US energy consumption and real output: a disaggregated analysis. *Journal of Policy Modeling*, *31*(2), 180-188.

- Chen, S.T., Kuo, H.I., & Chen, C.C. (2007). The relationship between GDP and electricity consumption in 10 Asian countries. *Energy Policy,* 35(4), 2611–2621.

- Cheng, B. S., & Lai, T. W. (1997). An investigation of co-integration and causality between energy consumption and economic activity in Taiwan. *Energy economics*, *19*(4), 435-444.

- Chitale, S.D. (1979). Depletion and Locational Advantage in the of mineral extraction programmes, The case research work of coking coal in India, Ph.d Dissertation, *Indian Statistical Institute*, New Delhi.

- Chitale, V. P., & Roy, M. (1975). Energy Crisis in India. *Economic and Scientific Research Foundation*, 102 pages,

- Desai, A. V. (1978). India's energy consumption: Composition and trends. *Energy Policy*, *6*(3), 217-230.

- Deshmukh & Parikh.J. S.G, (1992). Policy alternative for Western and Southern Power Systems in India, *Utilities Policy*, 2(3),240-247.

- Devi, R., Singh, V., Dahiya, R. P., & Kumar, A. (2009). Energy consumption pattern of a decentralized community in northern Haryana. *Renewable and Sustainable Energy Reviews*, *13*(1), 194-200.

- Dimitriu, M., & Blessy, M. (2010). Econometric Analysis Of Efficiency In The Indian Manufacturing Sector, *Journal for Economic Forecasting*, Institute for Economic Forecasting, 0(1),182-197.

- El-Sakka., & M.I.T. Ghali, K.H, (2004). Energy and output growth in Canada: A multivariate cointegration analysis. *Energy Economics,* 26(2), 225–238.

- Emmanuel, Z. (2009). Disaggregate Energy consumption and industrial production in South Africa, *Energy policy*, 6, 2214-2220

- Francis, B. M., Moseley, L., & Iyare, S. O. (2007). Energy consumption and projected growth in selected Caribbean countries. *Energy Economics*, *29*(6), 1224-1232.

- Georgescu-Roegen, N. (1986). The entropy law and the economic process in retrospect. *Eastern Economic Journal*, *12*(1), 3-25.

- Golder, B. (2011). Energy intensity of Indian manufacturing firms: effect of energy prices, technology and firm characteristics. *Science, Technology and Society*, *16*(3), 351-372.

- Jena, P. (2009). A study of changing patterns of energy consumption and energy efficiency in the Indian manufacturing sector. https://mpra.ub.uni-muenchen.de/id/eprint/31195.

- Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. *The Journal of Energy and Development*, 3(2),401-403.

- Lee, C.C. (2006). The causality relationship between energy consumption and GDP in G-11 countries revisited. *Energy Policy,* 34(9), 1086–1093.

- Leena Srivastava, R.K. & Pachuari, (1988). Perspectives on energy policy for the household sector, *Energy policy,* 4 ,Tata energy Research Institute.

- Loganathan, N. & Suramaniam, T. (2010). Dynamic Cointegration Link between Energy Consumption and Economic Perfomance: Empirical Evidence from Malaysia, *International Journal of Trade, Economics and Finance*, 261-267.

- Masih, A. M., & Masih, R. (1996). Energy consumption, real income and temporal causality: results from a multi-country study based on cointegration and error-correction modelling techniques. *Energy economics*, *18*(3), 165-183.

- Mehra., J & Reddy,S. (2012). Energy Intensity in India and its Impact on GDP, *Journal of Business and Management*, *3(4),* 06-12.

- Monga, G.S., & Sanctis, V.J. (1994). Energy consumption pattern in India, Indias Energy Prospects, *Vikas publications*, New Delhi.

- Moseley, L., & Francis, B.M. (2007). Energy consumption and projected growth in selected Caribbean countries. *Energy Economics,* 29(6), 1224–1232.

- Mousa, B.M., & Bilal, A.A. (2003). Current situation of energy consumption in the Jordanian industry, *Energy conservation and Management*,44(9), 1501-1510.

- Nan, F., & Yang Li, (2011). Relationship between Energy Consumption and Economic Growth: Empirical study Based on Data on Hebei Province from 1980-2008, *System Engineering Procedia1*, 117-123.

- Nandakumar, V.T., Devasia.M.D., & Thomachan, K.T. (2017). Interaction between Energy Consumption and Economic growth in India. *International Journal of Research*- Granthaalayah, 5(4), 62-71.
- Narayan, P. K., & Smyth, R. (2007). Are shocks to energy consumption permanent or temporary? Evidence from 182 countries. *Energy policy*, *35*(1), 333-341.
- Narayanan, & Sahu, S. (2009). Determinants of Energy Intensity: A Preliminary Investigation of Indian Manufacturing, *MPRA*, Paper 16606.
- Oh, W., & Lee, K. (2004). Causal relationship between energy consumption and GDP revisited: the case of Korea 1970–1999. *Energy economics*, *26*(1), 51-59.
- Pachauri, R.K. (1977). Energy & Economic Development In India. *Praeger Publishers*, New York, 1977.
- Parikh, J. K., & Parikh, K. S. (1977). Mobilization and impacts of bio-gas technologies. *Energy*, *2*(4), 441-455.
- Paul, S., & Bhattacharya, R.N. (2004). Causality between energy consumption and economic growth in India: a note on conflicting results. *Energy Economics*, 26(6), 977–983.
- Payne, J.E. Bowden, N., (2010), sectoral analysis of the causal relationship between renewable and nonrenewable energy consumption and real output in the US. Energy Sources, *Economics, Planning, and Policy*, 5(4), 400–408.
- Pindyck, R.S. (1979). The structure of world Energy Demand, *MIT press*, Cambridge,
- Raju, K. N. (2007). *Industrial Energy Conservation Techniques:(concepts, Applications and Case Studies)*. Atlantic Publishers & Dist. www.atlanticbook.com,
- Ramazan Zari et al, (2007). Disaggregate energy consumption and industrial output in the united states, *Energy policy*, 35(2), 1274-1281.
- Ray, S. (2011). Measuring energy intensity in selected manufacturing industries in India. *Journal of Energy Technologies and Policy, 1 (1)*, 31-45.
- Reddy, B.S., & Ray,B.K. (2008). Understanding industrial energy use: Physical energy intensity changes in Indian manufacturing sector",*Indira Gandhi Institute of Development Research, Mumbai*. http://www.igidr.ac.in/pdf/publication.
- Rena, G., & Ramakrishna, R. (2013). An empirical analysis of energy consumption and economic growth in India: are they casually related? *Study of Economica*, 58(2), 22-40.
- Roegen, R. M. (1974). Intergenerational equity and exhaustible resources. *Review of Economic Studies 41: Symposium on the Economics of Exhaustible Resources*, 29–46.

- Sajal, G. (2002). Electricity consumption and economic growth in India. *Energy Policy* 30, 125-129.

- Samhouri, M. (2009). Electricity consumption in the industrial sector of Jordan: Application of multivariate Linear Regression and Adaptive Neuro-Fuzzy techniques, *Jordan journal of mechanical and industrial engineering*, 3, 69-76.

- Sari,R. & Soytas, U.,(2003). Energy consumption and GDP: causality relationship in G-7 and emerging markets. *Energy Economics*, 25(1), 33–37.

- Tas, F., Ustuner, Z., Can, G., Eralp, Y., Camlica, H., Basaran, M., ... & Topuz, E. (2005). The prevalence and determinants of the use of complementary and alternative medicine in adult Turkish cancer patients. *Acta Oncologica*, *44*(2), 161-167.

- Tsani, S. Z. (2010). Energy consumption and economic growth: A causality analysis for Greece. *Energy Economics*, *32*(3), 582-590.

- Tyner, & Wallace E, (1978). Energy Resources and Economic Development in India. *Allied Publishers*, Delhi, 1978.

- Worrell, E., Laitner, J. A., Ruth, M., & Finman, H. (2003). Productivity benefits of industrial energy efficiency measures. *Energy*, *28*(11), 1081-1098.

- Yu, E.S.H. Erol, U., (1987a). Time series analysis of the causal relationships between US energy and employment. *Resources and Energy,* 9(1), 75–89.

- Zamani, M. (2007). Energy consumption and economic activities in Iran. *Energy Economics*, 29 (6), 1135-1140.

******