

# Trends of Energy Security Status in India- A Study for the Period 1970-2022

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**ABSTRACT-** In an age characterized by soaring global energy needs and diminishing conventional energy reservoirs, energy security emerges as a pivotal pillar for national progress and enduring sustainability. Within the dynamic landscape of India, a nation witnessing swift economic expansion and urban transformation, the imperative of comprehending and tackling the nuances of energy security cannot be overstated. The present paper attempts to explore India's energy security landscape, probing the complex dynamics of energy demand, supply, and resilience amidst the intricate tapestry of socio-economic and environmental factors. Our study centers on primary energy sources such as coal, lignite, crude oil, and natural gas, which are not only scarce globally but also within India. We have employed four methodologies to assess energy security, considering both production and import of energy, as well as energy dependence. Across all methodologies, the findings suggest that India's energy security is increasingly in question, given the escalating dependence on energy imports. To mitigate these concerns, it is imperative for the Government of India to invest in and promote renewable energy production for public consumption.

**KEYWORDS-** Energy Import Dependence, Energy Import Ratio, Energy Security, Energy Security in Terms of Import, Energy Security in Terms of Production.

## I. INTRODUCTION

Energy security is defined as availability of energy sources without intermittent disruption in an affordable price range [1]. Energy security is essential for overall human development which considers economical, societal, political and environmental factors. Energy is absolutely necessary for growth and development of economy of any country. The judicious distribution of energy is necessary for human development and it has a significant effect on health, education, transport etc. Primary energy consumption leaves a negative impact on environment because it increases carbon foot print on earth and disturbs the ecological balances. Growth of economy bring with it scale of economy, actual sectoral composition of economy and carbon intensity etc. and these are found to be responsible factors for increasing CO<sub>2</sub> emission [2].

Now a days government is more concerned about energy security due to following reasons:

- Scarcity of primary energy sources because it is limited on earth.
- Government spends less on R&D of diverse energy sources because most of the government fund is spend on import of energy for various needs.
- Drain of foreign exchange due to increase in energy import.
- Exponential increase in energy demand from various sectors.
- Lack of availability, accessibility and affordability of clean energy to all.
- High cost of energy production is affecting economic condition of a country.

Energy security is very essential for economic, social and environmental sustainability. Significance of energy already admitted in Millenium Development Goal (MGDs) and Sustainable Development Goals (SDGs) (United Nation). In 17 goals of SDGs, Goal-7 is for energy target to “ensure access to affordable, reliable, sustainable and modern energy to all” by 2030. These are signifying the importance of energy security. We know that unlimited use of primary energy resources creates a concern about scarcity of energy resources, as India’s 80 % of energy demand fulfilled by fossil-fuel energy resources [1]. Their share in consumption is coal (53%), crude oil (37%), natural gas (9%) and lignite in 2022 (1%) [3]. These conditions are more challenging for developing countries because they have to balance between increasing energy demand essential for development and harmful bi-products associated with energy production (GHG, environmental pollution etc.). Developing countries faces more challenges due to limited resources also [4]. Sustainable energy production is a major area of concern. So, Government of India have to focus on energy security of country and have to address the problems related to it and find out some solution regarding it.

Consequently, researchers and policy makers have to search about mechanism through which energy sustainability can be addressed so that India become energy secured in future. India’s future is not sustainable for energy according to trend of India [5], quantitative demonstration shows that India is energy insecure [6] and energy security index (1990-2010) depicts that India is 2<sup>nd</sup> worst performer country among 18 countries [7]. In upcoming days, the concern about energy sustainability and energy security for India will also go up so India should emphasize on these problems in details and have to do something to keep it in right order.

In our study we have taken primary energy sources like coal, lignite, crude oil and natural gas, which are limited on the Earth. These sources are not going to be on Earth forever as we are using them in a very exhaustive manner; they are important from the view point of energy sustainability and energy security. We should use it in a manner that upcoming generation will not suffer from the shortage of it. In our paper we have focus upon how energy scarcity problem has been increasing over time. As we cannot see these problems in our everyday life right now but in the coming years it will become visible in the forms of climate change. Changing raining patterns, rising of sea level, extinction of major flora and fauna and many more.

## II. OBJECTIVE OF THE STUDY

Measurement of energy security of any country is quite difficult because it is multidimensional, interdisciplinary and complex in nature. Study objective is to assess the status of energy security in India from 1970 to 2022.

## III. METHODOLOGIES AND DATA SOURCES

### A. Methodologies

Energy security generally calculated in the form of import. According to different literatures we found some different approaches for measuring energy security. There are many indicators to evaluate energy security like energy resource reserve [12], energy diversity [8], [9], [10],[11],[12] energy dependence [8], energy security cost [13], energy market concentration [14] etc. We have used some simple methodologies for calculating energy security status of India. In our study we have used two indicator ESP (Energy security in terms of production) and ESM (Energy security in terms of import) for indicating energy security status of India. Energy dependence method has been used to show energy import ratio and energy import dependence of India. Methodologies are as follows:

- a) Energy Security in terms of Imports (ESM): It has been measured as the ratio of energy import to energy consumption multiplied by 100. The decline in ESM indicates increase in energy security.

$$ESM = \frac{\text{Energy Import}}{\text{Energy consumption}} \times 100 \quad (1)$$

- b) Energy Security in terms of Production (ESP): It has been measured as the ratio of energy production to energy consumption multiplied by 100. The increase in ESP indicates an improvement of energy security.

$$ESP = \frac{\text{Energy Production}}{\text{Energy consumption}} \times 100 \quad (2)$$

- c) Energy Import Ratio (EMR): It is simple index to evaluate the energy dependence of any country. It is the ratio of energy import and total imports of the country. When we indicate energy import ratio by 'EMR' then it is denoted as

$$EMR = \frac{EI_T}{AI_T} = \frac{\sum_{i=1}^N EI_i}{AI_T} \quad (3)$$

Where,  $EI_T$  = sum of total import of each primary energy sources

$AI_T$  = total of all import of country

$i$  = value of  $i$  denotes the type of energy sources index

$N$  = number of types of energy sources

- d) Energy Import Dependence (EMD): It is the widely used indicator for evaluating energy supply security of any country. It is simply defined as the how much total import energy have been used over total energy supply of any country. When we indicate energy import dependence by 'EMD' then it is denoted by

$$EMD = \frac{EI_T}{ES_T} \times 100 \% = \frac{\sum_{i=1}^N EI_i}{\sum_{i=1}^N ES_i} \quad (4)$$

Where,  $ES_T$  = Total availability of all primary energy sources

$ES_i$  =  $i^{\text{th}}$  primary energy sources

[Here, energy supply and energy import must be used in same unit.]

### B. Data Sources

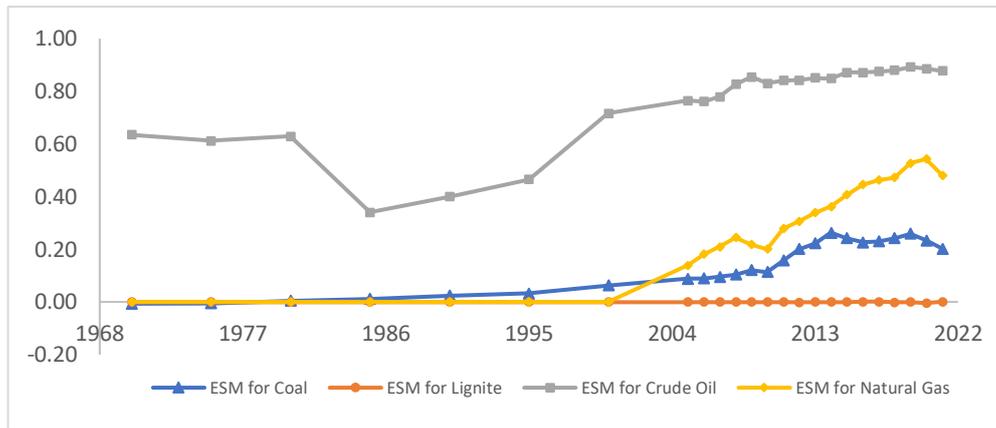
For ESM, ESP and EMD, we have used data from Energy Statistics, Ministry of Statistics and Programme Implementation (Government of India) [15]. These sources contain various years of Energy Statistics (Government of India) from 2008 to 2023. The collected data are consumption, production, import, availability and net import of primary energy sources from 1970 to 2022. For EMR, we have collected import data of energy and total import data from Handbook of Statistics on Indian Economy (Reserve Bank of India) [16]. These sources contain various years of Handbook of Statistics on Indian Economy from 2001 to 2023. The collected data are total expenditure in energy import and expenditure on total import of country from 1987 to 2022.

## IV. RESULTS AND DISCUSSION

### A. Energy Security in Terms of Imports (ESM):

As ESM increases energy security decreases. From figure 1, we can see that for all primary energy sources (coal, lignite, crude oil and natural gas) the energy security decreases in India. ESM for crude oil is always higher than other primary energy resources. From figure 1 we can see, ESM for crude oil is greater than 0.5 over time (except 1980 to 1985). Between 1980 to 1985 crude oil import was decreases due to world oil shock. After 1995 ESM of crude oil increases continuously which means, we are more dependent upon import of crude oil. The ESM for crude oil in figure 1 shows energy security for crude oil in India decreases over time.

After crude oil ESM for natural gas is higher than others. Before 1985 natural gas consumption and production were negligible. After 1985 there is significant increment in production and consumption of natural gas. Before 2000 there is no any import of natural gas so ESM for natural gas before 2000 was negligible. After 2000 due to increase in demand for natural gas in India, country have to import natural gas to fulfil its demand so after 2000 ESM for natural gas has been increasing continuously and significantly. From figure 1, in 2005 ESM for natural gas was 0.14 and in 2020 it has been increased to 0.54. In India ESM for natural gas increases over time so energy security in terms of ESM for natural gas is decreasing according to time.



Source: Authors' estimation (Based on Government of India, Energy Statistics, Various Years)

Figure 1: ESM for India for different primary energy sources from 1970 to 2022

From very early period primary energy source coal is abundantly present in India. India is mostly depending upon coal for fulfilling its energy demand. Due to sufficient production of coal in India, India have not dependent upon import of coal. This is the main reason why ESM for coal has been always lower. But as energy demand increases, India has to import coal to fulfil its energy demand so after 1980 ESM for coal continuously increases till 2022. From figure 1 we can see in 1985 ESM for coal was 0.01 and in 2020 it has been increased to 0.23. As energy demand has been increasing over time, India has to rely on import of coal in future, which is not energy secure in terms of coal in India.

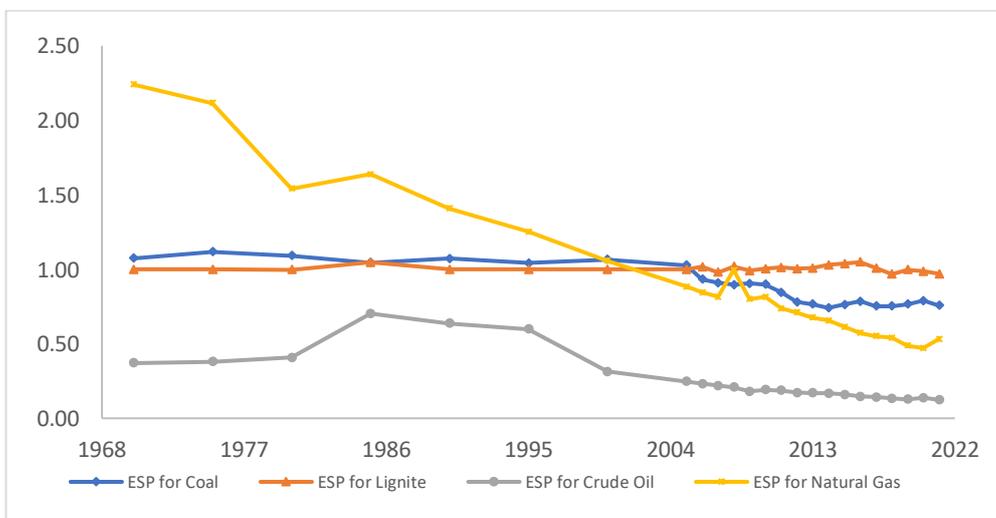
In India use of lignite is very much lesser than other primary energy sources. When we see the data, we can analyse that production of lignite and consumption of lignite are almost equal in India so from early period it has not relied on imports for lignite use. ESM for lignite has been always negligible and it has lowest ESM in primary energy sources.

**B. Energy Security in terms of Production (ESP):**

In the era of increasing energy demand energy production out of consumption decreases over time in India. From figure 2, we can see that from early period India was in better condition in ESP for all energy sources. As time passes ESP

for all energy sources decreases which means energy security in terms of energy production decreases.

Among four primary energy sources ESP for crude oil is lesser than the others from very early period. Figure 1 states, from 1980 to 1985 ESP for crude oil increases from 0.41 to 0.70 because crude oil production increased at that period over its consumption (import of crude oil decreased due to world oil shock). After 1985 ESP for crude oil decreasing continuously till 2022. In 1985 ESP for crude oil was 0.70 and its value decreased to 0.12 in 2022. ESP measures the amount of energy production out of energy consumption, ESP for crude oil has been decreasing means production of crude oil out of consumption has been decreasing. Basically, India can't fulfil its energy demand for consumption of crude oil from production of crude oil within the country, which indicates energy is insecure in terms of production of crude oil in India. Figure 2 shows ESP for natural gas was always balanced between 1970 to 2000. After 2000 ESP for natural gas suddenly started to decrease due to increasing consumption of natural gas. From 2005 consumption of natural gas is always greater than the production of natural gas, curve of ESP for natural gas decreasing after 2005 till 2021. From figure 2 we can see value of ESP of natural gas in 2005 was 0.88 and in 2021 it decreased to 0.53. Energy security in terms of production of natural gas is decreasing in India after 2005.



Source: Authors' estimation (Based on Government of India, Energy Statistics, Various Years)

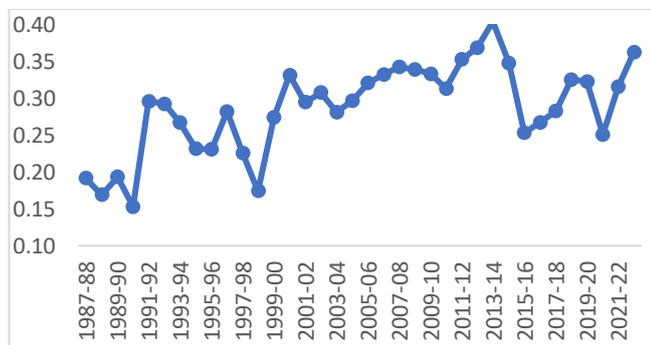
Figure 2: ESP for India for different energy sources from 1970 to 2022

From early period production of coal in India is significantly high because consumption has been always high in compared to other primary energy sources. Figure 2 shows ESP for coal was almost linear from 1970 to 2000 but as consumption increases as compare to production of coal in India ESP for coal started to decrease after 2005. If we have focused upon value of ESP for coal it has been decreasing continuously from 1970 to 2022. Figure 2 shows, in 1975 ESP for coal was 1.12, in 2005 it was 1.03 and in 2021 it decreased to 0.76. This production crisis for coal is totally energy unsustainable which indicates for energy insecurity will come in future.

ESP for lignite has been always in a linear which means production of lignite and consumption of lignite is almost equal in India. Production and consumption of lignite is very limited in compare to other primary energy sources. Figure 2 indicates ESP for lignite from 1970 to 2017 was almost 1.0 and in 2020 it decreased to 0.98 which clearly shows ESP for lignite over time is almost linear.

**C. Energy Import Ratio (EMR) (Energy import/ Total import of India):**

This measurement is very easy to understand. From 1987 to 2022 continuously the energy import ratio has been increasing which means proportion of import of energy has been increasing in total import of India. Energy import ratio shows the share of energy imports in total import of India. Both should be in same unit and we are taking unit as rupees in crores. From figure 3 we can clearly see there is many fluctuations in energy import ratio of India but when we draw trend line then we found that it is upward sloping with very slightly increment in their slope. The result shows energy import ratio is increasing over time from 1987 to 2022. In 1987 energy import ratio was 0.19 and in 2022 its value increased to 0.36 which is significantly higher than 1987. As the day passes energy demand increases and energy supply or energy production can't fulfil its demand then energy import increases over time very significantly which is not a good indicator for energy security and energy sustainability. Import drains out foreign reserve which affects countries economic development. We should rely on sources which are abundant in country like solar energy, wind energy, biomass energy, hydro energy etc. This is the only solution for problems and hazards created by energy import. Only renewables energy has power to change these situation [17].

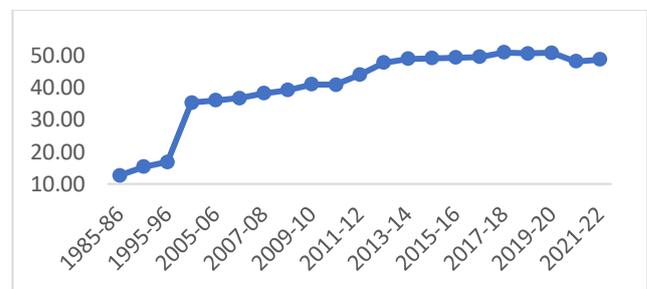


Source: Authors' estimation (Reserve Bank of India, Handbook of Statistics on Indian economy, Various Years)

Figure 3: Energy Import Ratio (EMR) of India from 1987 to 2022

**D. Energy Import Dependence (EMD) (Net import of Energy/availability of Energy):**

From figure 4 we can see that the energy import dependence for primary energy sources of India has been increasing continuously from 1985 to 2022. This means proportion of net import of energy in total available energy for consumption has been increasing day by day. Energy import dependence states how much net import of energy is available out of total available of energy. We have found net import of energy by sum up the net imports of all four types of energy sources and availability of energy have found from sum up the availability of those four energy sources. The results from figure 4 shows the energy import dependence of India has been continuous increasing from 1985 to 2022. In 1985 energy import dependence value was 12.66 and in 2022 it has increased to 48.64. These are clearly shows that India's energy import dependence for primary energy sources increases over time which is not good for country (India). It clarifies that as the year passes India will rely more and more on imported energy for its energy demand. It raises question upon energy security of India for its future.



Source: Authors' estimation (Based on Government of India, Energy Statistics, Various Years)

Figure 4: Energy Import Dependence (EMD) of India from 1985 to 2022

**V. CONCLUSION**

In this study we have assessed the energy security status of India. Four methodologies have been used and results of all methodologies reveal the worsening status of energy security for India. The results clearly indicate that energy import dependence of India is on the higher side, which is neither good for the economy nor beneficial for sustainability of the energy sector of India. In this study we see that ESP and EMD for all primary energy sources are decreasing which indicates energy security for India is under threat if primary energy sources are solely used. As per above analysis on energy dependence, both energy import ratio (EMR) and energy import dependence (EMD) of India is increasing.

Overall, India should curtail the use of coal and crude oil in the best possible way. Instead of primary energy sources India should adopt renewable energy sources which have good potential in India [18]. So, Government of India should finance and promote renewable energy production for public use and also provide economic as well as political support for its upliftment in private domain. Use of electric vehicle (by green energy sources), hydrogen fuelled transportation mechanism and other sustainable energy production techniques should be promoted by the government.

## CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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