

## India's Energy Policies Transition and Significance of Science Communication: A Review

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### ABSTRACT

Global environmental problems and constrained petroleum supply require sustainable energy solutions. This article examines the necessity of transitioning to alternate sources of energy and highlights the importance of effectively communicating scientific information. This review paper tracking the historical direction of energy policies in India since 1947. An objective phenomenological approach was used in examining the structural transformation of energy policies. The energy policies transformation is presented in five different phases. In its early stages, India's energy policy primarily focused on ensuring a reliable electricity supply and promoting the expansion of the oil and coal sectors. In the second phase, policymakers redirected their attention to preserving energy in order to address the ongoing energy problem. The subsequent two stages were dedicated to enhancing, expanding, and solidifying the energy resources in order to bolster the nation's energy sovereignty. The power sector has undergone many reforms, including privatisation and the facilitation of foreign direct investment (FDI). In the Fifth phase focus shifts towards climate friendly energy policies and special attention is given to renewable energy sources (RESs) over fossil energy sources (FESs) for mitigating the adverse climatic conditions. An assessment study was done to know how India replies to global climate agreements/accords demonstrated that Indian policy makers remained sensitive to international climate objectives. This review article also presents the role of science communication for accomplishing the Intended Nationally Determined Contributions (INDCs).

**Keywords:** Energy policy, Climate change, Intended Nationally Determined Contributions, Renewable energy sources

## **Introduction**

### **Energy transitions requirement and importance of Science communication**

In light of the worldwide impact of climate change and the limited availability of petroleum resources, it is imperative for the world to transition towards sustainable energy systems. Historically shifts between main sources of energy have typically been prolonged, lasting for a century or more (Allcoat & Mullainathan 2010); (Kemp 2010). These transitions were primarily driven by factors such as limited resources, expensive labour, and advancements in technology. The energy transition in the 21<sup>st</sup> century must be accelerated. Regrettably, there is limited knowledge regarding methods to expedite energy transitions (Tollefson 2011).

Energy transitions encompass a range of significant sustainability concerns that society must confront, such as global and national policy adjustments, swift technical advancements, and public decision-making processes. The achievement of a sustainable future is contingent upon our cognitive processes, modes of communication, and utilisation of energy resources. Communication scholars can contribute to a deeper understanding of the societal role of energy by conducting analyses on the influence of public opinion regarding energy choices, assessing attitudes and beliefs surrounding various energy technologies, examining the emergence of just transition and renewable energy movements, and evaluating the strategic connections and disconnections among energy and the environmental crisis. By conceptualising energy as a routine social activity encompassing daily conflicts regarding energy resources and usage, established frameworks for comprehending the significance of energy, and both collective and individual decision-making processes, the focus shifts towards perceiving the energy transition as an ongoing communication phenomenon (Verbong & Geels 2007); (Soloman & Krishna, 2011).

Energy is a vital necessity for human survival, much like air, nourishment, and water. The welfare of individuals, the industrial sector, and the economy relies on energy that is both sustainable and cost-effective. It is not unexpected that the public has a steady and steadily growing interest in energy-related

matters. Energy is a widely known concept. The topic of energy supply and utilisation is now a subject of regular coverage, not only in specialised publications but also in mainstream media. Nevertheless, it is not necessarily the case that ordinary individuals possess a correct understanding of energy-related subjects (Boyd 2017).

Furthermore, there is a lack of information regarding several facets of energy consumption and generation and a general lack of "critical awareness" despite an interest in scientific advancements. This frequently engenders apprehension, scepticism, and resistance towards numerous cutting-edge technologies and breakthroughs (Kinsella 2015).

In order to effectively regulate carbon emissions and optimise the use of advanced technologies, it is imperative that the public, regardless of their level of education, possess comprehensive knowledge and comprehension of scientific concepts and issues. This will enable them to discern between plausible and implausible information and make informed decisions.

A public lacking knowledge is more susceptible to deceptive notions. Hence, more substantial endeavours are required to accurately educate individuals. Science communication plays a crucial role in addressing the pressing global issues of sustainable energy supply, global warming, and environmental and safety problems (Renzi, *et al.* 2017); (Arlt *et al.* 2023); (Sanctis 2013).

### **India's current energy policy scenario**

India's growth is attributed to its exceptional population dividend and the corresponding policies implemented in the electricity industry. Following its independence, India saw a rapid process of urbanisation. However, the formulation of a climate-sensitive power plan remained unresolved until the advent of neoliberalism in 1990. The UN produced research in 2022 called "World Cities Population," which anticipated that the urban population of India would exceed 610 million by 2035. This population growth will have an impact on the country's energy trends United Nation Population Fund (2007); (Demirbas *et al.* 2004). According to the NITI Aayog, India's total primary

energy demand is projected to increase by approximately threefold (85 million terajoules) by 2035 compared to what was available in 2011 (28 million terajoules) (Pargal & Banerjee 2014); Agrawal & Tripathi (2019); Kumar & Choudhary, (2023); (Bobde & Tanaka 2020).

The rapid advancement of the country necessitates significant modifications in the trajectory of power policy formulation. Currently, there is a greater emphasis on RESs compared to FESs (Kumar & Choudhary 2022). There are primarily two factors contributing to this issue: a rising energy shortage and an increase in releases of pollutants. As a result, there has been a need to explore alternate sources of energy, such as renewables, including wind, solar, and ocean energy (Kumar & Choudhary 2021); (Kumar *et al.* 2021).

Figure 1 depicts the present capacity of various energy sources in megawatts (MW). Coal is clearly the most important power source, accounting for 211 gigawatts (GW) of India's total energy-producing output. Petroleum gas, diesel oil, and nuclear fuels contribute 24.8 GW, 0.58 GW, and 6.7 GW, respectively, to the total production of energy. Hydropower comprises 13% of the portion. Solar energy leads the RESs with 64 GW, followed by wind power and bioenergy, respectively (Central Electricity Authority, 2023).

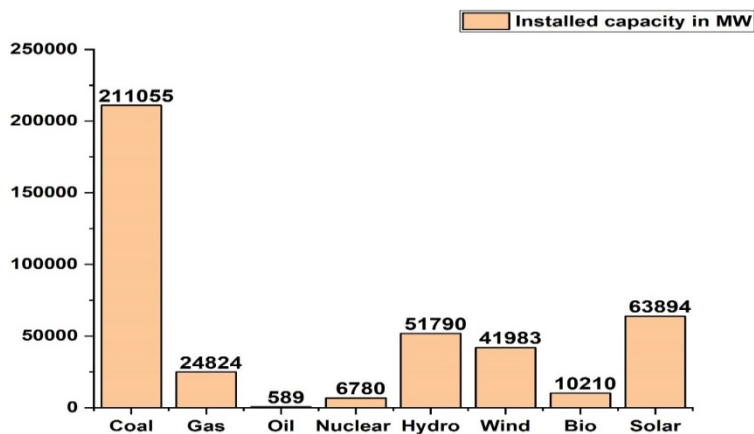


Fig. 1 — Installed capacity of energy sources in India (in MW)

The requirement for energy in the sector has more than doubled since 1999 (Ministry of New and Renewable Energy, 2021). Currently, the FESs are able to meet the majority of this need. India must address the significant challenge of reducing pollution by finding alternatives to coal, as the energy industry heavily relies on FESs such as coal (International Energy Agency, 2015). The government established the National Action Plan for Climate Change (NAPCC) with the aim of efficiently addressing this issue by utilising RESs (Bhattacharya & Jana 2009). The initial objective was to establish a total capacity of 100 GW with solar power and 60 GW using wind power by the year 2022 (Chabhadiya *et al.* 2021).

The primary challenge faced during the implementation of renewable energy projects (REPs) is a lack of sufficient knowledge, poor legal frameworks, inefficient existing facilities, and flawed auditing practices that underestimate the environmental and societal costs associated with using FESs (Shrimali *et al.* (2016). The RESs, such as wind power and geothermal, were significantly underestimated during the early stages of the deployment programmes for RE (Shrimali *et al.* 2017). The expansion of power generation must align with the demands of a rising population and ecological sustainability. The statement highlights the necessity of implementing a comprehensive national energy strategy plan in India to effectively achieve sustainable energy objectives International Renewable Energy Agency (2017); Planning Commission (2006); Planning Commission (2013); Ministry of Environment and Forestry (2010); (Bardhan 2019).

### **Periodic shift in India's energy strategies:**

This article provides a chronological analysis of India's energy strategies following its independence. The energy strategies can be categorised into five distinct periods. The periods are as follows:

- ❖ The initial period (1947-1969): Ensuring sufficient power supply
- ❖ Second period (1970-1981): Addressing the energy problem
- ❖ The third period (1982-1991): Aimed to strengthen the security of energy supply at national level.

- ❖ Fourth period (Last decade of 20<sup>th</sup> century): Power sector reform
- ❖ Current phase (First two decades of 21<sup>st</sup> century): Mitigating the effects of climate change

### **The initial period (1947-1969): Ensuring sufficient power supply**

In the beginning, India's energy strategy primarily focused on ensuring electricity supply and promoting the expansion of the FESs. The main objective was to offer policy assistance for ensuring sufficient supply. The Energy Supply Act was established during this time in the year 1948. The primary goal of this legislation was to streamline the allocation and production of power, thereby facilitating the establishment of multiple state power boards (SEBs) nationwide.

During this time, significant organisations such as the Central Electricity Authority (CEA) and the Planning Commission were established (Sarkar & Kadekodi 1988); (Pachauri & Bhandari, 2004). The planning commission was responsible for drafting all energy policy during this period, with assistance from the CEA. During that period, coal served as the primary means of generating power. Consequently, coal received greater emphasis due to its role in guaranteeing the country's energy security (Shukla & Swarnakar 2022). Nevertheless, legislators of that era displayed minimal care regarding environmental matters such as carbon emissions and various other forms of pollution releases.

### **Second period (1970-1981): Addressing the energy problem**

During this period, there was a worldwide oil shock that culminated in the Middle Eastern region in 1973, giving rise to an enormous crisis of energy (Gasser *et al.* 2020); (Kok 2015); (Owen 2004). Legislators redirected their attention towards saving energy during this period in order to address the power crisis. At that juncture, the foremost priorities were the reduction of oil usage and controlling the use of lignite. The nationalisation of the coal industry followed these occurrences. The year 1975 also saw the formation of the National Thermal Power Corporation (NTPC) and Coal India Limited (CIL). This ushered

in a paradigm shift within the energy generation industry in India. As a result of these events, this period was also referred to as the coal-driven era. Environmental concerns were not, however, reflected in energy legislation at the time Gupta & (Mosiño 2020); (Haq *et al.* 2020).

**The third period (1982-1991): Aimed to strengthen the security of energy supply at national level**

This period experienced a substantial surge in energy consumption as a result of swift industrialization. The use of energy-saving initiatives was initially implemented in the energy industry (Acharya & Sadath 2017). This period was dedicated to enhancing, expanding, and strengthening the energy sources to bolster the nation's energy stability (Anand *et al.* 2013). The Board of Advisors was established in 1983 with a primary focus on the melding of various energy sources. It first became apparent that RESs were replacing expensive and foreign FESs. Consequently, the Nuclear Power Corporation of India Limited (NPCIL) was established in 1987. In that same period, many energy agencies were consolidated under the control of the Ministry of Power, with the exception of nuclear power (Bhattacharya & Batra 2009); (Bhattacharyya & Ganguly 2017).

**Fourth period (Last decade of 20th century): Power sector reform**

This phase saw major power sector restructuring in India. Modern consolidated coal regulations and SEBs reorganisation allowed tariff adjustment in this era. Power industry transformations included divestiture and FDI. The fundamental goal of these improvements was to reduce energy losses and improve the electrical system's efficiency. The administration showed its RE policy attention by passing an environmentally friendly energy bill and creating a ministry for unconventional energy. The environmental impacts of FESs were discussed in the recently introduced energy plan (Khurana & Banerje 2015); The Energy and Resources Institute (2017); (Reddy 2002); Cameron *et al.* 2016); (Joseph 2010); The Energy and Resources Institute (2015; (Tripathi *et al.* 2016). Thus, MNRE was established in this era.

**Current phase (First two decades of 21st century):  
Mitigating the effects of climate change**

This phase has seen coal mine amendment bills, energy conservation laws, and the Electricity Act (EA) 2003. The 2001 energy conservation law was a milestone in India's green energy goals. The EA 2003 strengthened generation, transmission, and distribution (T&D), trade, and utilisation of electricity rules in the country's energy industry to create a market. This act established a national energy plan that prioritised RESs. Energy safety was nearly solved by launching the country's power exchange in the year 2008 (Bhattacharya 2005); (Thakur *et al.* 2009); (Thakur (2004).

The NAPCC comprises eight national objectives, including enhancing energy efficiency, augmenting the proportion of RE in overall generation, promoting energy conservation in commercial sectors, and advocating for the use of energy-efficient equipment (Moallemi *et al.* 2017); (Goodman 2016); (Pandey & Sharma 2021).

India is a signatory of the Paris Accord, a global agreement on environmental issues, and has set its own specific aims. The organization has established a goal for the calendar year 2030 that is as follows: i) To reduce the carbon emissions of its gross domestic product by approximately 35%, and ii) to boost the contribution of renewable energy sources to around 40% of the total installed capacity for energy generation. In order to accomplish these objectives, the use of RESs is essential and vital (Clemencon (2016); (Swarnakar *et al.* 2022).

Figure 2 shows RESs installed, implemented, and targeted capacity in GW. Solar energy leads with 64 GW of capacity in operation, followed by wind with 41 GW. Micro-hydropower and biomass have 5 GW & 11 GW operational capacities, respectively Central Electricity Authority, (2023).

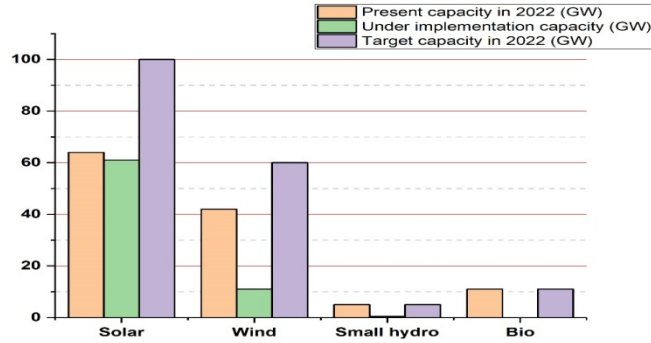


Fig. 2 — RESS installed, implemented, and targeted capacity in GW (In India)

**India's response to international environmental initiatives**

India has observed the magnitude of environmental shifts since the beginning of the 1970s. However, its active participation and involvement began in the current period (early decades of the 21st century). Following the energy crisis of 1973, the RE was given top emphasis. Figure 3 illustrates India's concurrent responses to international environmental initiatives.

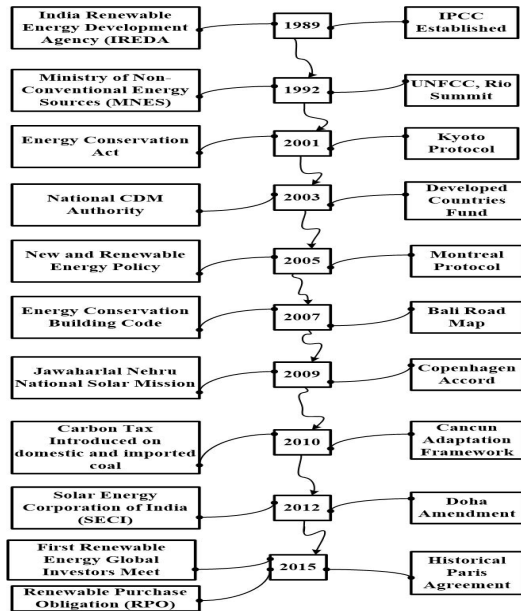


Fig. 3 — India's response to international environmental initiatives

India Renewable Energy Development Agency (IREDA) was founded by the government in reaction to the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1989. This company supports REPs financially. In 1992, the Ministry of Non-Conventional Energy Sources (MNES) was established with a dedicated goal. In reaction to the Kyoto Protocol, India passed the Energy Conservation Act in 2001 with the goal of reducing emissions. Similarly, as a reaction to the Bali Plan of Action and Copenhagen Agreement, the Energy Preservation Building Regulations and the Jawaharlal Nehru National Solar Mission (JNNSM) were enacted in 2007 and 2009, respectively. This has a significant impact on reducing emissions of carbon and raising the share of RESs, particularly solar power.

India remained steadfast in its commitment to addressing climate change after 2009. One could consider the years 2009 to 2015 to be the most productive in India's history of electricity planning (Gupta *et al.* 2015); (Dubash & Khosla 2016); (Falkner 2016); (Dubash *et al.* 2018); (Thaker & Leiserowitz 2014); (Zheng *et al.* 2019).

### **Science communication a tool for energy policy transition**

Science communication is an effective means to cultivate a climate of mutual understanding and trust between the scientific community and society, as well as to generate a high level of curiosity and excitement for research. Additionally, it aids in expediting the integration of new information, which would otherwise be tediously slow, by bridging the gap between existing knowledge or acceptance and the unfamiliar. In order for the scientific enterprise to remain viable and innovative, it must establish close and effective communication with society, maintaining a high level of continuity. If the general population lacks knowledge or apathy, students will lack motivation to pursue scientific studies. Consequently, scientists will face a decline in research funding and will be unable to exert their influence on public and political perspectives regarding critical matters such as energy security and climate change. Consequently, scientists now have a genuine obligation and an important challenge in the form of scientific communication (Loy L S, Hamann K R S and Reese G, 2020).

The dissemination of science should accurately convey the essence of science: a collaborative endeavor by humans to seek a comprehensive and logical understanding of the natural world. Careful observation of natural occurrences and/or the execution of controlled experiments intended to mimic natural processes are both effective ways to achieve this. Furthermore, science communication should promote knowledge of the scientific process, including its inherent characteristics and limitations, and equip the general public with a fundamental comprehension of the dynamics of risks and uncertainty Lyytimäki (2018).

Science is primarily a methodological endeavor aimed at comprehending the workings of the cosmos, both in the realms of nature and society, as well as within our own beings. It surpasses the mere accumulation of factual knowledge. In order to engage in scientific thinking, one must possess a variety of essential tools: a conceptual understanding of cause and effect, a deep appreciation for empirical evidence and logical consistency, a sense of curiosity and intellectual integrity, a readiness to formulate testable hypotheses, and a willingness to revise one's views based on empirical findings. The following are the fundamental abilities required in the field of science and by scientists. The approach used in science is founded upon the premise that the act of observing serves as the arbiter in determining the veracity of a claim. The understanding that observation serves as the ultimate and definitive arbiter of the validity of an idea allows for a direct comprehension of all other facets and attributes of science (Cozen *et al.* 2017).

It is important to remember the global dimension of science and communication. Science is a universal human interest; its concepts and terminology are identical for all individuals. It surpasses or goes beyond any social and geopolitical limitations. Scientists possess mutual comprehension while discussing scientific issues, enabling them to communicate more effectively on geopolitical or social matters, even if they hold differing viewpoints. The scientific community acts as a conduit across different domains, serving as a vanguard for fostering global comprehension (Huijts *et al.* 2007).

### **Role of science communication for accomplishing the Intended Nationally Determined Contributions (INDCs)**

Diverse theoretical frameworks in the field of communication science propose that individuals gain and assimilate knowledge through the consumption of news and information. Agenda-setting theory posits that the media plays a crucial role in informing the public about significant societal issues. The media exerts influence over citizens' thoughts and perceptions by selectively highlighting specific problems on the agenda, thus shaping their awareness and prioritization of these issues. Hence, the messages transmitted by the news media have a significant influence on individuals' perceptions and understanding (McClymont *et al.* 2008); (Bradbury *et al.* 2009).

India implemented several measures during the 2015 Paris Accord to support the deployment of RESs. These measures aim to achieve two objectives: lowering emissions and ensuring future energy requirements are met. Subsequently, India has placed clean and sustainable energy as a top priority in order to expedite economic growth.

Nowadays more preference is given to RESs. But there are many problems in adopting the RESs. Lack of general awareness regarding RESs among public and social acceptance are the main problems. It is mandatorily desirable to know the social impacts of RESs locally. These impacts have various aspects like infrastructure development, skill development and job creation. So, the proper knowledge of all these factors makes the process of adoption of RESs easier and smooth.

There is a firm relation between public awareness, adoption of renewable projects and policy making. The positive aspects of RESs are easily highlighted by various science communication tools (newspapers, magazines, television shows, public talks etc.) to the general public. This will further mould general public attitude in a positive way towards RESs and enhances their social acceptability. Various policies and methods were created to achieve the INDCs via adaptation, mitigation, and financial measures. Figure 7 illustrates strategic roadmap for achieving the INDCs (Jain 2020); Bhardwaj & Gupta 2021).

<b>Mitigation</b>	<b>Adoption</b>	<b>Economical Strategies</b>
<ul style="list-style-type: none"> <li>- <b>National Solar Mission scaled up</b> five-fold from 20 GW to 100 GW by 2022.</li> <li>- <b>National Smart Grid Mission</b> launched for efficient transmission &amp; distribution network.</li> <li>- <b>Green Energy Corridor projects</b> being rolled out to ensure evacuation from renewable energy plants.</li> <li>- <b>Faster Adoption and Manufacturing of Hybrid &amp; Electric Vehicles (FAME India)</b> to promote faster adoption and manufacturing of hybrid and electric vehicles.</li> <li>- <b>Policies to increase production of energy efficient 3 phase locomotives</b> and switchover to 100% of these locos from 2016-17 onwards.</li> </ul>	<ul style="list-style-type: none"> <li>- <b>‘Give It Up’</b> Campaign launched to encourage citizens to give up subsidy on cooking gas to meet the needs of the truly needy citizens, thereby promote shift away from inefficient use of biomass in rural areas.</li> </ul>	<ul style="list-style-type: none"> <li>- <b>Reduction in subsidies on fossil fuels</b> including diesel, kerosene and domestic LPG.</li> <li>- <b>Coal cess quadrupled</b> from INR 50 to INR 200 per tonne to help finance clean energy projects</li> <li>- Introduction of <b>Tax Free Infrastructure Bonds</b> for funding of renewable energy projects</li> </ul>

Fig. 4 — Strategic roadmap for achieving the INDCs

## Discussion and Conclusion

This article explores the need of shifting towards alternative energy sources and emphasises the significance of proficiently conveying scientific information. This review paper examines the historical development of energy legislation in India and establishes a systematic approach to analysing the subsequent effects of these regulations. An assessment was conducted to ascertain India's response to worldwide climate accords throughout time. India's economic success throughout the early stages of climate mandates clearly limited its ability to effectively fulfil emission duties. Nevertheless, India's current energy policy demonstrates significant attention to both environmental issues and the security of energy. The pursuit of effective involvement has generated a growing interest in the inclusion and improvement of the RESs. In India, the initial development of the RE sector has relied heavily on monetary support and incentives. It was a significant hindrance to RE

growth. Eliminating barriers such as high expenses and weak financial performance of T&D businesses can enhance the seamless integration of RESs into the overall energy portfolio. The implementation of policies such as the National Mission for Enhanced Energy Efficiency (NMEEE) and the Market Transformation for Energy Efficiency (MTEE) is reshaping the energy management landscape. However, without the necessary upgrades to the T&D infrastructure, India may encounter difficulties in meeting its energy targets. Various policies and instruments were developed to achieve the INDCs via adaptation, mitigation, and economic measures.

The government would need to provide substantial amounts of subsidies to invest in RESs without compromising societal spending. Additionally, there would be a reduction in the importation of FESs to achieve energy sufficiency. The incorporation of environmentally sustainable elements into the current energy strategy has facilitated the incorporation of RE.

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