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Evolution of sustainable energy policies in India since 1947: A review

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Abstract

India's Intended Nationally Determined Contributions in 2015 toward the Two-Degree Celsius climate change goal has endorsed 15% of renewable integration in the primary energy mix by 2020. The energy space is strategy to meet the target without affecting its immediate sustainable development goals. This study documents this strategic effort by tracking the historical trajectory of energy policy planning since its independence in 1947. An objective ontological approach was adopted in reviewing the evolution of energy policy into five distinct phases. Phase I (1947–1970), focused on supply adequacy with the overall thrust on infrastructure development as the pillar of Indian economy. In Phase II (the 1970s) the focus shifted in addressing the energy access crisis. Phase III (the 1980s) was based on increment, diversification, and streamlining on supplies for energy security purposes. Phase IV (the 1990s) is the period of modernization of the overall Indian electricity system. Phase V (the 2000s) is the present phase of market transformation and climate change mitigation energy policies. A co-assessment of India's policy to the international climate negotiations showed that India remained responsive to international climate goals. It became reactive in the planning for sustainable energy policy after its ratification of Kyoto Protocol in 2001. Since then, India has been instrumental in administering strict emission reduction norms and efficiency measures. This review concludes that the country needs to upgrade its inefficient transmission and distribution networks, which was broadly neglected. The subsidy allocations in domestic energy resources should be well-adjusted without compromising on its social costs.

Keywords: Energy planning; energy policy; history; sustainability; climate change

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List of Abbreviation

APDRP	Accelerated Power Development and Reforms Program
AT&C	Aggregate Technical and Commercial
BEE	Bureau of Energy Efficiency
CAGR	Compounded Annual Growth Rate
CERC	Central Electricity Regulatory Commission
CIL	Coal India Limited
COP	Conference of Parties
DSM	Demand Side Management
EI	Energy Intensity
FDI	Foreign Direct Investment
FSA	Fuel Supply Argument
FYP	Five-Year Plan
GDP	Gross domestic product
GoI	Government of India
IEA	International Energy Agency
IISD	International Institute for Sustainable Development
INDC	Intended Nationally Determined Contribution
INR	Indian National Rupees
IOC	Indian Oil Corporation
IREDA	India Renewable Energy Development Agency
LPG	Liquefied petroleum gas
MHRD	Ministry of Human Resource Development
MJ	Mega Joule
MNES	Ministry of Non-Conventional Energy Sources
MNRE	Ministry of New and Renewable Energy
MT	Million tonnes
MTEE	Market Transformation on Energy Efficiency
NAPCC	National Action Plan for Climate Change
NCDC	National Coal Development Corporation
NELP	New Exploration Licensing Policy
NMEEE	National Mission for Enhanced Energy Efficiency
OMC	Oil Marketing Companies
ONGC	Oil & Natural Gas Commission
PAT	Perform, Achieve, and Trade
PDS	Public Distribution System
PEC	Per-capita Energy Consumption
PSU	Public sector undertaking
RBI	Reserve Bank of India
RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
SEB	State electricity boards
T&D	Transmission and distribution
TERI	The Energy Research Institute
UI	Unscheduled Interchange
UNFCC	United Nations Framework Convention on Climate Change
WTO	World Trade Organization
ZED	Zero Defect

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1. INTRODUCTION

The fate of independent India's development is a consequence of its unprecedented population growth and the corresponding decisions made in the energy sector. While India experienced accelerated urbanisation post-independence, the climate responsive energy-policy space remained uneventful till liberalisation in 1991. The UN State of World Population Report in 2007 predicted that by 2030 the urban population of India would increase to 590 million, from 377 million in 2010 which will drive the nation's energy trends (United Nation Population Fund, 2007 p.12). The Planning Commission of India projected that by 2032, India's total primary energy demand would increase threefold (77 million terajoules) of 2010 supply (29 million terajoules) (Planning Commission, 2013, p.343). Under the current policy structure, India is poised to face an immense energy crisis in the coming decades to sustain the targeted economic growth of 8 - 10%, that is required to achieve poverty eradication and meeting the sustainable development goals (Pargal & Ghosh Banerjee, 2014, p.24).

The country's rapid growth largely defines the route of energy policy development in India, the increase in the energy deficit and the search for the alternative source of energy, mainly, solar, nuclear and wind energy. India uses 6% of the world's primary power, with coal being the most important fuel in the energy mix. Coal accounted for 44% of the primary energy mix. Figure. 1 illustrates the primary energy mix of India in 2000 and 2013.

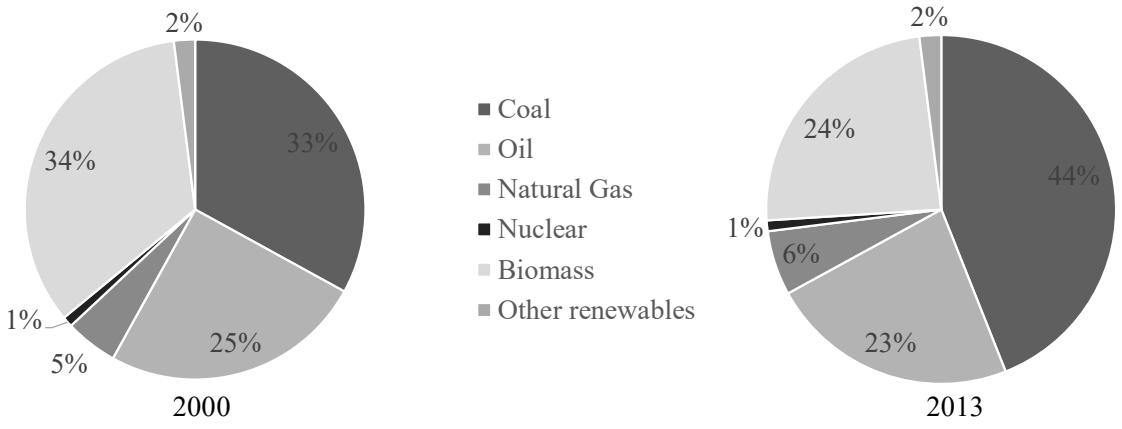

Figure 1. Primary energy mix of India (in million tonnes of oil equivalent (Mtoe)) (2000 and 2013) Source: (IEA, 2015)

The International Energy Agency stated that the energy demand in India has almost doubled since 2000 but is slower than the rate of economic growth. It is in part due to shift away from bioenergy (includes solid biomass, biofuels and biogas) consumption in the residential sector, rising

importance of the services sector and increased policy efforts for end-use energy efficiency (IEA, 2015 p.21). As a result, "it took 12% less energy to create a unit of Indian Gross Domestic Product (calculated from purchasing power parity)" (IEA, 2015 p.21). Even so, the heavy dependence on coal and imported oil is one of the most significant challenge that India needs to tackle for limiting greenhouse gas (GHG) emissions and crude oil import (S. C. Bhattacharya & Jana, 2009). The National Action Plan for Climate Change (NAPCC) was formalised in the 12th Five-Year Plan (FYP) (2012-2017) to address this challenge through renewables (Shrimali, Trivedi, Srinivasan, Goel, & Nelson, 2016). Strategies were drawn to install 100 gigawatts (GW) of solar energy capacity and 60 GW of wind energy capacity by 2022 which is approximately six times more than the current renewable energy capacity (Shrimali et al., 2016). The major bottlenecks in the rapid renewable technology deployment are the existing accounting practices that miss addressing the social and environmental costs of not using fossil fuels (Shrimali, Srinivasan, Goel, & Nelson, 2017). Energy sources like biomass were also grossly under-estimated in the early stages of renewable-energy programs (S. C. Bhattacharya & Jana, 2009). India lacks integrated, and comprehensive building energy efficiency codes which could have fast-paced the renewable integration in the system, as the building sector in India has tremendous renewable energy generation potential (Bardhan & Debnath, 2016). The progress in the energy sector will need to be consistent with the demands of urbanisation, and sustainability of the environment. It emphasises the need for a nationally coordinated approach to energy policy that can respond to the Two-Degree Celsius climate change goals (Chattopadhyay & Sharma, 2017).

In this study, we conduct a systematic review of India's energy planning approach since its independence in 1947 till the first Intended Nationally Determined Contributions (INDCs) (see Appendix) towards the Two-Degree Celsius climate change goals at the 2015. The primary aim of this study is to understand the historical paradigm of sustainable energy policy development of India since its independence and its corresponding reactions to various international climate-change regulations. The novelty of this study lies in its ontological approach in evaluating the paradigm of energy-planning of India throughout the pre-liberalisation (1947-1991) to post-liberalisation (1991-today) period. This specific time-bound ontological approach enabled in systematically reporting the cascading effect of various energy policies which were considered 'sustainable' relative to their implementation period. We primarily elaborate on the temporal evolution of the electrical energy policies from the perspective of its generation and market legislation.

2. METHODOLOGY

Energy system in India has historically been fossil-fuel dependent. The recognition and adoption of renewable energy (excluding hydro) is a recent phenomenon, which has been carved out from the pitfalls in past policy, the looming energy security crisis from heavy dependence on imported crude oil, and the critical need to meet the rising energy demand in the face of Two-Degree Celsius climate change challenge. The current energy system of India, which is still in transition, is a result of centralised planning paradigm. The multiple review articles currently available on sustainable energy policy scenarios in India mostly speak about the status, progress and futures perspectives of this

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sector (S. C. Bhattacharya & Jana, 2009; Kapoor, Pandey, Jain, & Nandan, 2014; Shrimali et al., 2017; Tripathi, Mishra, Kumar, Tripathi, & Baredar, 2016). However, there is a need to analyse the trajectory of India towards avenues for an integrated yet sustainable energy policy. This requirement is more so because, how the fastest growing economy of the world transits towards energy security post-independence, will be a lesson learned to other developing nations that are striving to mitigate the energy crisis under the urbanisation challenge. Additionally, understanding the chronological pathway will enable India's energy politics to adopt sustainable energy strategies to avert the inevitable energy crisis under the constraints of the Two-Degree Celsius climate change goal. The primary aim of this study is to understand the evolution of sustainable energy policy in India since independence in 1947, such that we can identify the temporal gap in energy-sector policy-making in the country. Here we reviewed all energy sectors based on energy sources: both conventional fossil-fuel based and renewable energy. Although fossil-fuel is not a sustainable resource, it is vital to understand India's mechanisms to reduce the uncertainties associated with this kind of fuel and imbibing sustainable practices into the conventional energy sector.

A systematic review of the energy policy, renewable and sustainable energy reviews, energy for sustainable development and in general energy-related literature were conducted to identify articles that studied the various aspects of energy policy and its evolution in India. The classification of the available research was performed using an ontological approach. The ontological approach based on objectivism was adopted for structuring, processing and analysing the policy related information. Objectivism enabled us in generating value-free knowledge that is independent of the normative standpoints of the policy agencies (Ridge, 1988). To maintain neutrality, a database of all related vocabulary and literature was prepared pertaining to energy policy in India since independence.

The database of white and grey literature was searched from 1947 to January 2017 for articles published in English, using a combination of search keywords or terms to identify energy policy evolution studies in India. The topics were related to "energy policy in India," "review," "energy trajectory," "Indian energy scenario," "renewable energy prospects," "energy politics," "climate-change," "Policy reviews," "federal renewable policies", "climate responsive policy", "India climate-change scenario." All articles that dealt with energy and climate-change {policy, status, perspectives, potential, effectiveness} of India, were used for the review process. The white literature was generated using a manual systematic keyword information search, in bibliographic (e.g., Web of Science, Scopus, Google Scholar), and full-text (e.g., ScienceDirect) databases.

We found that there is a significant lack of literature which chronologically traced India's energy system and policy initiatives and institutions involved from nascent to the current stage. To overcome this, we performed a manual grey literature search defined by energy statistics from the Central Statistical Institute, the Planning Commission of India, annual reports of various energy-related Ministries of the Government of India (see Figure. 2), documentation of draft bills and legal acts of the energy sector. An initial round of screening was conducted using titles and abstracts to exclude articles that (1) did not pertain to India, (2) did not report, review or critically appraised any energy policy of India, and (3) was a duplicate study. Full texts review was performed on the

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remaining filtered articles to assess suitability for inclusion following the criteria as mentioned earlier. Finally, the bibliographies of the screened articles were reviewed for possible additions, while maintaining the same screening criteria.

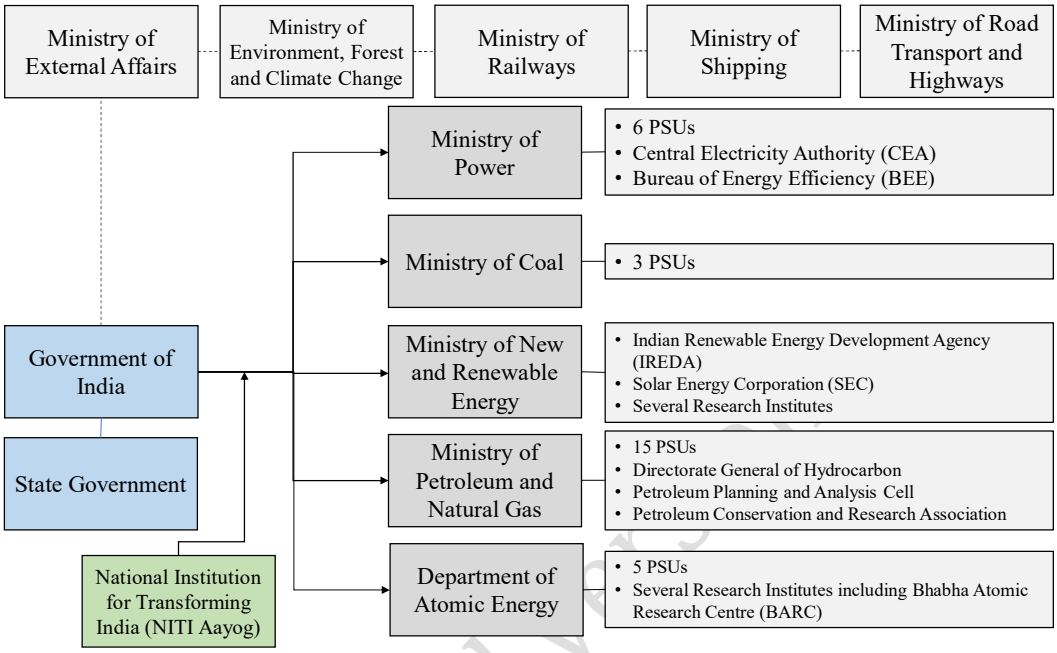

Figure 2. Main institutions in India with influence on energy policy
[Source: Adapted from (IEA, 2015)]

The review of post-independence policies was grouped into five distinct phases to track the evolution of the energy movement of India chronologically, namely:

Phase I 1947 – 1970: Post independence supply adequacy

Phase II 1970s: Addressing energy access crisis

Phase III 1980s: Streamlining national energy security

Phase IV 1990s: Modernisation of energy sector

Phase V 2000s: Mitigating climate change

A phase-wise overview of the energy policy evolution in India since its independence in 1947 is illustrated in Figure. 3.

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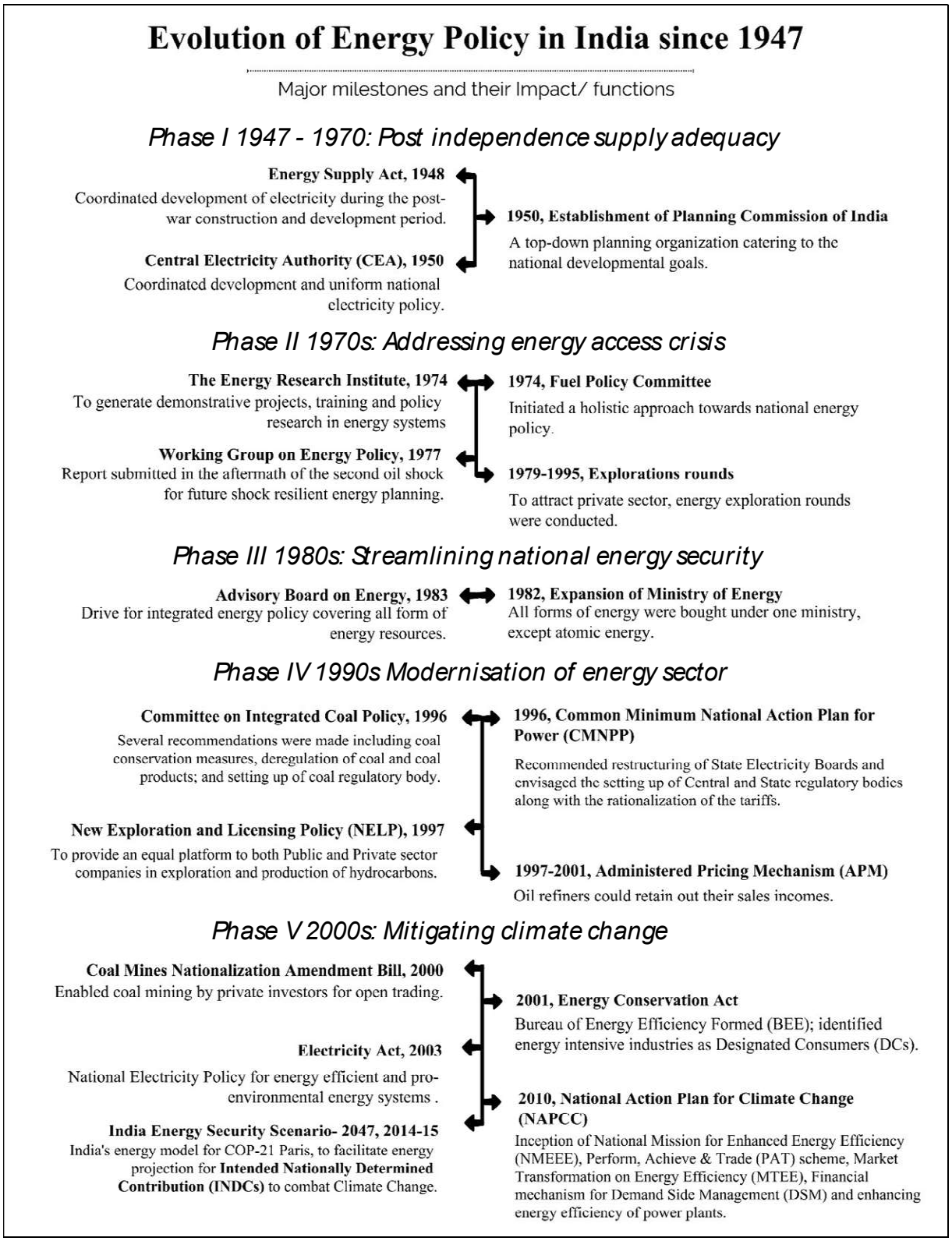

Figure 3. Evolutionary ontology of the energy policy in India since its independence in 1947 (Source: Author's)

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3. CHRONOLOGICAL EVOLUTION OF THE ENERGY POLICIES

3.1 Phase I: 1947 – 1970 Post independence supply adequacy

During this phase, the energy planning of India primarily focused on electricity supply and growth of oil and gas sector. The principal agenda was to provide policy support for supply adequacy, notwithstanding the growth in electricity demand, which was much higher in the later phases. This was in line with nuovo-independent India's thrust on infrastructure development as the pillar of Indian economy. This period marked the establishment of institutions like Planning Commission of India, Central Electricity Authority, and Energy Survey of India Committee. The Planning Commission of India was instituted with the responsibility for efficient allocation of resources and recommending policy planning. The Planning Commission formulated the energy policies during this phase (see Box 1).

The importance of 'sustainable power system' was recognised in the Electricity Supply Act of 1948, which paved the trajectory for the energy vision of India. The primary objective of the Electrical Supply Act of 1948 was the rationalisation of the generation and distribution of electricity and its development on a regional basis. The Central Electricity Authority was established as a central advisory body for national power planning, policy making, and monitoring progress, and instituted the state electricity boards (SEBs). However, the initial burden of electricity distribution policy during this phase was the development of the responsibility of the SEBs.

Regulation of the coal-mining industry for India's energy security was one of the top agendas of energy policy during this phase. The large-scale mining began in India with the introduction of railways by the British in 1885. With the introduction of Colliery Control Order 1944 during the First World War, coal prices were brought under the domain of government control to manage surge prices. It was modified under the Essential Commodities Act 1946, which continued even after independence. By 1950, the coal demand had risen to about 32 million tonnes (MTs), with railways being the single most significant consumers (31%) whereas only 7% was utilised by the power industry (Planning Commission, 2006; Sarkar & Kadekodi, 1988).

Under the Coal Mines (Conservation & Safety) Act 1952, the Coal Board was set up in 1951 for the conservation of coal resources and safety of mines. The National Coal Development Corporation (NCDC) was created in 1956 to carry on coal mining in the public sector, through the Coal Bearing Areas (Acquisition & Development) Act, 1957. However, coal mining by the private sector practised unsustainable and hazardous mining measures, questioning the safety of thousands of mining workers. It determined the phase where government began to consider imbibing regulatory and conservation practices in the coal-driven energy sector. However, climate-change adaptive strategies and regulations remained a distant affair during this period of Indian energy policy.

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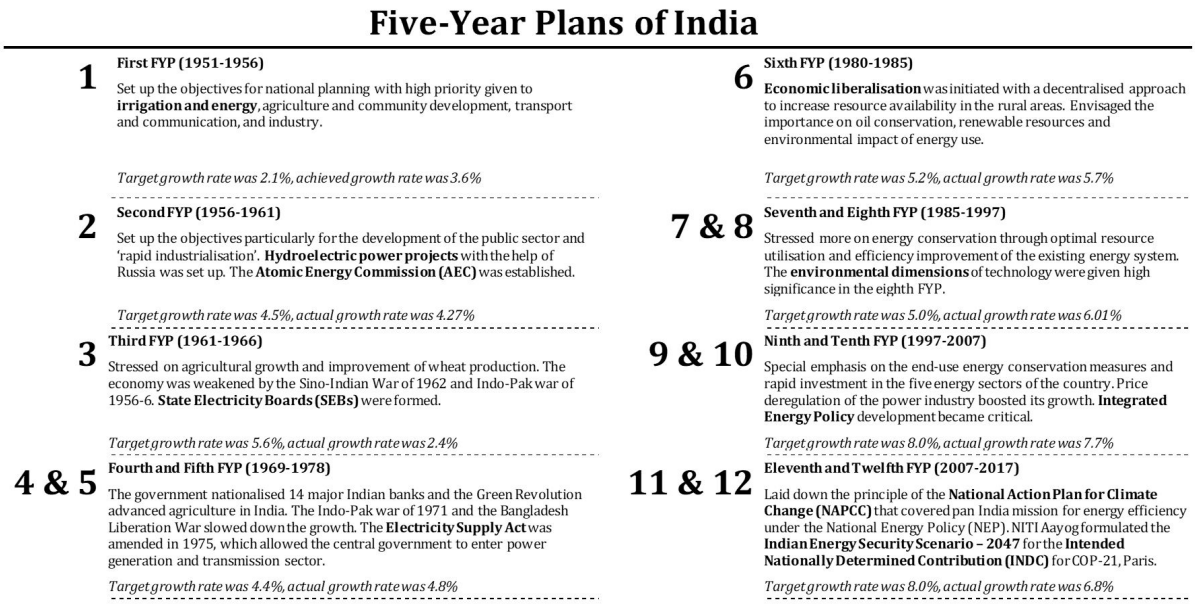
The Government of India during this period focussed explicitly on exploiting economies of scale which grew focus on exploration and production of oil and natural gas. It led to the appointment of the Oil and Natural Gas Commission (ONGC) and the Indian Oil Corporation (IOC) for refining and marketing of oil and oil products. Through this historical exploration of the energy policies of Phase I: 1947-1970, it is understood that post-independent India focused on regulating the primary energy-supply sector with an attempt to decentralise the electricity-sector in lieu of country's increasing energy demand.

Box 1. A brief note about the outcome of the Five Plans of India with emphasis on India's energy policy (Source: Adapted from Pachauri and Bhandari, 2004)



3.2 Phase II: 1970s Addressing energy access crisis

Post-1970 the focus shifted to energy conservation to meet the energy crisis triggered by the global oil shock. Reducing petroleum consumption was the primary regulatory concern during this phase. Regulation of the coal-mining industry was a highlight of this phase. It enabled the government to undertake the lumpy investments and allocate profits from a sovereign resource. It led to the nationalisation of the coal industry in two phases: coking coal in 1972 and non-coking coal in 1973. Coal India Limited (CIL) was established in 1975 for coal-mining planning and design. This company brought in regulations and revolutions in the thermal power sector in India, along with the establishment of the National Thermal Power Corporation (NTPC) in the same year (see Box 1). During this period, government began to consider administering regulatory in the 'coal-driven' energy sector. Regulatory guidelines were also introduced in the oil-and-natural-gas sector based on

the recommendation of the Oil Prices Committee of 1976 in the form of Administered Pricing Mechanism. No attempts were made to replace fossil-fuel with cleaner energy sources, while conservation mandate emerged in the energy governance of India. In 1970s, the Planning Commission was committed to fulfilling the basic need of the people regarding access to electricity and cleaner form of household energy, rather than shifting to a sustainable kind of energy sources.

3.3 Phase III: 1980s Streamlining national energy security

The 1980s was an era of rising aspirations of the business class which triggered a massive rise in energy demand. New strategies in energy productivity and management began to define the course of energy-sector in India. It was for the first-time energy saving targets were established. This phase was dedicated for increment, diversification and streamlining of the supply side for enhancing India's energy security. The Advisory Board on Energy, 1983 was set up for the establishment of an integrated national energy policy. The integrated energy policy intended to elaborate on the potential of non-conventional and renewable energy as a measure to substitute the expensive imported coal and oil. As a response the Nuclear Power Corporation of India Limited was established in 1987. All forms of energy departments, except atomic energy department, were brought under one Ministry of Energy in this phase.

3.4 Phase IV: 1990s Modernisation of energy sector

The liberalisation of the closed economy in the 1990s was the turning point in India's energy scenario. The Planning Commission of India adopted policy reforms of deregulation, privatisation and opening the energy market to foreign investment in the energy sector (see Box 1). Considering historical experience of gaps in the efficiency of Indian electricity system, and consequent leakages and losses, modernization of energy sector including demand side transformations became the key agenda of this phase. The drafting of Energy Conservation Bill and the establishment of Bureau of Energy Efficiency (BEE) portrayed increasing sensitivity of the government towards sustainable energy policy. The environmental dimension of sustainability became very important during this period, and the government publicly began to realise the importance of climate-change responsive policies in the energy supply-sector. Post-1990 saw a realisation of the importance of the renewables for India's future and a concentrated effort to the growth of renewables. A separate Ministry of Non-Conventional Energy Sources (MNES) was established in 1992, which was renamed to, Ministry of New and Renewable Energy (MNRE) in 2006.

Till 1991, the electricity sector was in a huge fiscal burden, with losses roughly around 0.7% of the country's gross domestic product (GDP) at that time. Technical indicators such as transmission and distribution losses were close to 23%, and thermal generation inefficiency was high with a plant load factor of only 54%. Peak and energy deficits were 7.7% and 18.8%, respectively (Khurana & Banerjee, 2015 p16). Amendments to the Electricity Supply Act in 1991, allowed large-scale involvement of private investors in the form of foreign investments through long-term supply

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contracts and power purchase agreements with utilities. However, these reforms could not address the underlying drivers of the electricity sector's poor performance including state governments political strongholds over the power-distributing industry (Planning Commission, 2006). Against this background, the Regulatory Commission Act 1998 was enacted to set up Central Electricity Regulatory Commission (CERC) and restructure the SEBs into State Electricity Regulatory Commission. This act brought regulatory consistency to the Indian power sector. Unbundling of the SEBs into separate companies who were responsible for generation, transmission, and distribution, was a significant regulatory reform of the CERC. The introduction of availability-based tariff by CERC in 2000, promoted scientific instruments for settling contracted sale and purchase of power and installed the desired grid-discipline.

The public monopoly of the electricity sector was dissolved with the onset of economic reforms of 1991. By 1990s the gross power generation (utilities) in the country had grown nine-folds since 1970s, reaching approximately 480,011 million KWh in 1999, of which almost 61% was generated in the thermal power plants. Coal-based thermal power stations were the leading providers of electricity in India, followed by hydro, nuclear, gas and diesel-based power plants. The design of energy policy was to guarantee sufficient power supply in the country at the least cost, while preserving the environment (Shanmugam & Kulshreshtha, 2005).

Sustainability efforts in this period included strategies like plant renovation and modernisation, new capacity creation and private sector participation. The government allowed private-sector to tap into power generating sector through foreign direct investments (FDI) and joint-ventures with a belief that private investment would accelerate the growth of greener and efficient technologies in the thermal power industry. However, the FDI could not attract satisfactory private investment, and the impetus towards shifting to a more efficient coal-based power industry was slowed down (TERI, 2017). Till date, the replacement of these inefficient and sizeable thermal-power plant remains a significant challenge for the government. It remains the most significant bottleneck for sustainable energy policy in India.

3.5 Phase V: 2000s Mitigating climate change

It is the present climate active energy planning phase of India, which has matured since the year 2000. The introduction of availability-based tariff by Central Electricity Regulatory Commission (CERC) in 2000, promoted scientific instruments for settling contracted sale and purchase of power and installed the desired grid-discipline. The Accelerated Power Development and Reforms Program (APDRP) was launched in 2002 to attract private investors but was weakened by low-investment in the distribution sector and high Aggregate Technical and Commercial (AT&C) loss levels[1]. The APDRP was further improved in 2003 through Restructured-APDRP by introducing an intensive-based system. These policies formed the background for the progressive Electricity Act of 2003 (EA 2003) (Khurana & Banerjee, 2015).

[1] This remains a critical loss factor even in current electricity systems with transmission and distribution losses at 21.46% and AT&C losses at 22.70%, as per 2013-14 (TERI, 2017).

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EA 2003 was a market-oriented framework that aimed at enhanced competition, accountability, and commercial viability of the sector (Joseph, 2010). Notable initiated were the de-licensing of the thermal generation, the promotion of rural electrification and renewable energy, the introduction of licensed power trading, and the multi-year tariff framework. It mandated unbundling corporatisation of utilities, and the establishment of independent regulators (Pargal & Ghosh Banerjee, 2014). Most importantly, EA established open access for transmission and distribution in which generators could directly sell to the highest bidder and end-users could buy power from the most cost-effective source (TERI, 2017). Important policy measures that followed EA 2003 were the National Electricity Policy 2005; the National Tariff Policy 2006; the Integrated Energy Policy 2006 and the Hydropower Policy 2008. The National Electricity Policy 2005 and the National Tariff Policy 2006 were instrumental in the development of inter-state transmission regulations. Additionally, the setting up of Indian Energy Exchange and Power Exchange India Limited in 2008 enhanced energy security situation in the country. The introduction of 'smart transmission tariff' by the CERC in 2010 was a critical step towards relieving grid congestion and expanded the scope for market-oriented grid integration of renewables (Pargal & Ghosh Banerjee, 2014). Power market related legislations are illustrated in Figure 4.

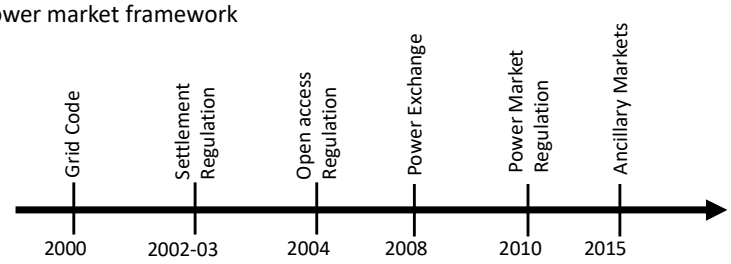
Electricity Act 2003	• De-licensing of generation • Development of a multi-buyer multi-seller market in power • Trading – licensed activity
National Electricity Policy, 2005	• Measures to promote competition aimed at consumer benefits • Promote competition through market-development
Open Access Regulations, 2004 & 2008	• Universal open access to transmission networks • Separate procedures for 'Day-Ahead Market' (collective transactions) and Over-The-Counter (OTC) transactions
National Action Plan on Climate Change, 2008	• Promotion of renewable energy market through power exchange • Promotion of energy efficiency market through power exchange
Power Market Regulations, 2010	• Providing a regulatory framework for competitive markets • Guidelines and prudential norms for setting up and operating power exchanges
Evolution of power market framework	

Figure 4 Power market legislations since the Electricity Act 2003 (IIT Kanpur, 2016)

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The National Action Plan on Climate Change (NAPCC) in 2008 put a spotlight on sustainability and energy security in India's sustainable energy policy map. The NAPCC comprises of eight national missions with concurrent goals to the energy sector like increasing the share of solar energy in the primary energy mix and raising energy efficiency through demand-side management, industrial energy savings, and more significant adoption of efficient appliances and lighting (it includes the infamous *Bachat Lamp Yojana* which involved replacing incandescent lamps with subsidized compact fluorescent lights) (PMCC, 2010). The Energy Conservation Act of 2001 and its amendment in 2010, was a significant milestone in India's efforts on clean energy and energy efficiency. It mandated building codes, standards, and labels for appliances and industry norms (Pargal & Ghosh Banerjee, 2014). The Perform, Achieve, and Trade (PAT) agreement started in 2012, became the energy efficiency trading scheme on market-based mechanisms. Additionally, the National Mission for Enhanced Energy Efficiency (NMEEE) and Market Transformation on Energy Efficiency (MTEE) were essential policy tools for imbibing energy-efficiency and energy conservation practices in the industries that could meet the high energy demands due to rapid urbanisation. The impact of these policies can be evaluated through the decline in energy intensity over the last decade, as discussed earlier (see Figure 5). A key event in the sustainable electricity sector is the synchronisation of National Grid in 2014 under the program, 'One Nation One Grid'. Currently, CERC is working towards amendments in the Indian Electricity Grid Code and unscheduled interchange (UI) regulations. It includes tightening of the frequency range from 49.2 hertz to 49.5 hertz to meet short-term needs for power by the end-users and regulate UIs (Pargal & Ghosh Banerjee, 2014).

The open access policy has had a significant implication on the energy security of India, with more than 160 large industrial end-consumers buying power from power exchanges in 2010. Captive power plants were selling surplus energy through the exchanges, which increased the availability of power and deepening the market (Khurana & Banerjee, 2015). The industries were forced to set-up their captive power plants to cope up with the rising tariff due to uneven distribution of cross-subsidy (Planning Commission, 2006). The renewable energy generators got power purchase agreements and preferential treatment in merit order dispatch (IIT Kanpur, 2016). This open access mechanism has also provided a considerable impetus to the rural electrification program. The policy pathway discusses over the five phases is cumulatively illustrated in Figure. 5.

Present electricity policies are designed following the NAPCC guidelines which lay greater importance on renewables integration in the primary energy mix. The Jawaharlal Nehru National Solar Mission 2010 envisaged 22 GW of grid-connected solar power by 2022, which is now 100 GW of solar power as per India's Nationally Determined Contributions to fight climate change (TERI, 2017). The solar energy market boomed from 17.8 megawatts (MW) in 2010, to 8513.23 MW till 30 September 2016 (TERI, 2017). However, non-renewable energy sources like coal and oil dominate the primary energy mix (see Figure. 1), making them inevitable constituents of the India power sector. The rapid increase in the commissioning of power plants, mainly led by the private sector in the 11th Five-Year Plan has caused a considerable deficit in the coal supply for power generation, increasing imported coal-dependence (currently, 18% of the total electricity production). This increase mainly affects the cross-subsidy mechanism in the country, which in turn causes a

significant roadblock in meeting the 2022 renewable targets (Bhattacharyya & Ganguly, 2017; Shrimali et al., 2016).

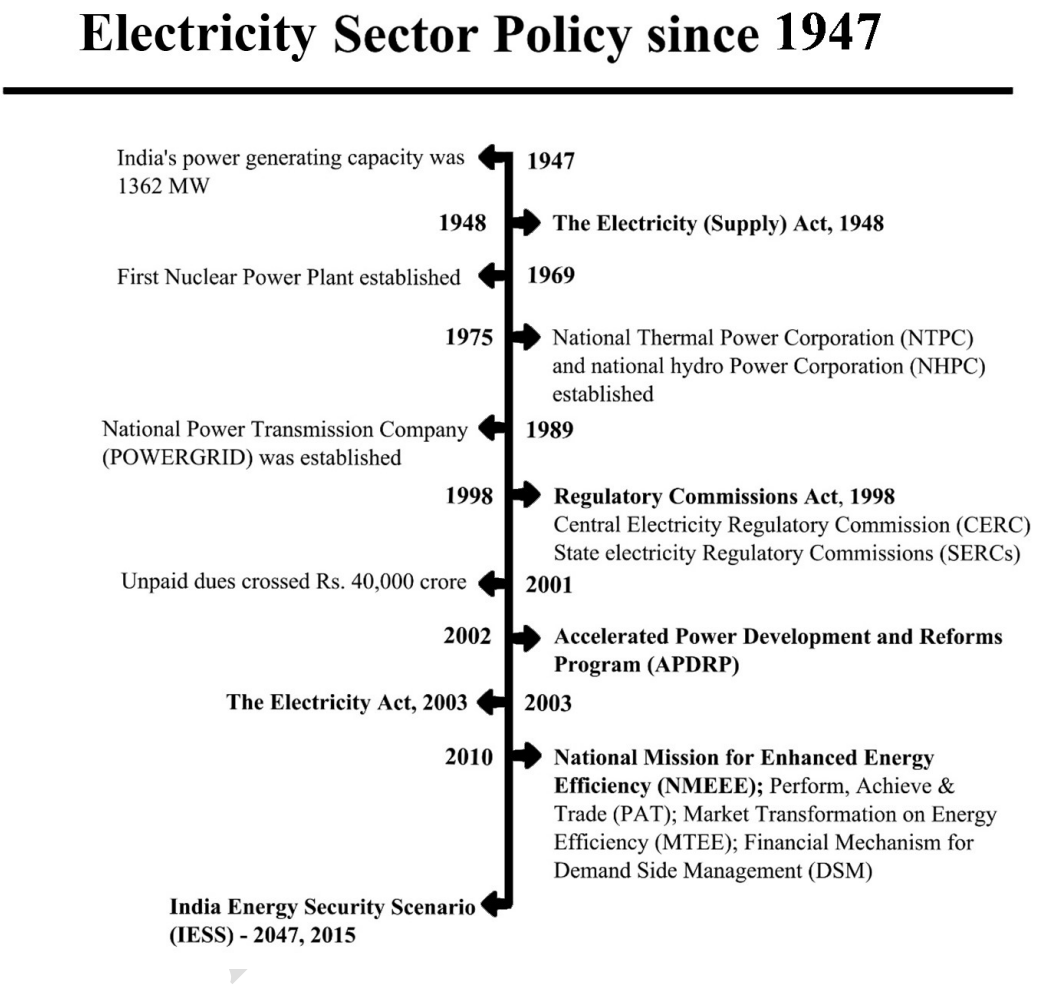

Figure 5. An overview of the major electricity sector policies in India since Independence (Source: Authors).

While assessing the cost-effectiveness of electricity sector policies for 15% renewable integration by 2020, Shrimali et al. (2016) stated that, '*to successfully replace imported coal-based power (currently, 18% of the total electricity production), wind energy serves as the most appropriate renewable source, as it is already competitive with imported coal prices, and hence does not require government support*'. Therefore, wind energy can be deployed quickly without any extensive policy support, provided the wind-turbines exist, or investors can be found to build them. In case of solar energy, a robust policy support system is needed to make it available and affordable to the masses by 2019 (Shrimali et al., 2017). The unsubsidized levelized cost of solar energy will become cheaper

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than imported coal by 2019; hence, it can be expected to be the most viable option in the coming decade. However, the current tariff policy based on accelerated depreciation needs amendments to create a more cost-effective policy option. Shrimali et al., (2016) suggests that a combined reduced cost of extended-tenor debt can lower the total cost of support by 96%.

A critical policy tool in India's electricity sector is a subsidy that helps in lowering the cost of energy production which further reduces the price paid by the electricity consumers. In India, the energy subsidy tends to be regressive as its benefits are skewed towards the higher socioeconomic status when compared to lower income groups (Acharya & Sadath, 2017; Anand, Coady, Mohommad, Thakoor, & Walsh, 2013 p9). The pending amendments in the National Tariff Policy 2016, as per recommendations of the Working Group under Section 3(3) of the Electricity Act, 2013, includes cross-subsidy surcharge trading margin and availability-based tariff, which appears as an impending 'electricity-sector reform' under the 12th -FYP (2012-2017). Regulation of tariff rates on electricity is a significant component of the energy subsidy mechanism in India (Acharya & Sadath, 2017). It is more complex than of petroleum products since policies and tariff rates on electricity vary with the state, within the state and also with the class of consumer groups (IISD, 2012). These classes have subclasses, and the tariff rates differ across each class including different subsidy rates for urban and rural consumers. The social cost of the fuel subsidy is an important fuel-pricing parameter across all the energy sectors, which significantly impacts India's vision of deep integration of renewable energy sources in the country's energy dynamics (Acharya & Sadath, 2017; B. Bhattacharya & Batra, 2009; Shrimali et al., 2017).

The current trend in energy governance in the thermal-power industry is through the regulation of pricing mechanism for imported coal. The cost of using imported-coal is the second most expensive fossil-fuel based energy in the total energy mix of India, first being natural gas (IEA, 2015). While natural gas constitutes only 8.6% of the overall energy mix due to supply side constraints, imported coal accounts for almost 18% of total electricity generation (CRISIL, 2012). Moreover, the domestic coal price is artificially lowered by government regulations, making imported coal the most expensive fossil-fuel. Thus, *"imported coal-based power plant is the marginal power plant, and the levelized cost of such plants serves as the primary baseline cost of electricity"* (Shrimali et al., 2016).

In similar subsidy-sustainability paradox in the oil and natural gas energy sector, the subsidy on the domestic petroleum products like liquefied petroleum gas (LPG) and kerosene is a significant bottleneck in adopting sustainable practices in this industry. These subsidies create a substantial financial burden on government and oil companies. The federal government had the monopoly over the pricing of oil and gas products excluding peripherals like lubricants, which makes it difficult for the private sector to foster healthy competition. It also holds up the efficiency in retailing and even upgrading to latest and cleaner technologies. The Petroleum & Natural Gas Regulatory Board Act, 2006 was enacted to keep a check on this prevalent monopoly and foster sustainable production & distribution practices (Vasudevan, Cherail, Bhatia, & Jayaram, 2011). However, at the current state of inflation and the social development goals of the federal government, it is challenging to reduce

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subsidies on domestic petroleum products. It causes designing sustainable energy policies in the oil and natural gas sector very difficult for the government (B. Bhattacharya & Batra, 2009). Moreover, if oil prices are left on its own to adjust to the international price variation, the industry will fall out drastically, which will force the government to cut down subsidies, at a much more substantial social cost. Removal of subsidies would lead to increase in fuel prices, which in turn affect the budget of all household in the country (Cameron et al., 2016).

Recent policy efforts like '*Saubhagya 2017*' and '*Ujjwala Yojana 2017*' adjust subsidy burden without compromising the social cost. Saubhagya scheme provides electricity to all households through the Gross Budgetary Support (GBS). Under this scheme the households identified in the Socio-economic and Caste Census of 2011 will get free electricity connections, while other households will be charged Rs. 500 (~7 USD). The package includes five LED lights, one DC fan, one DC power plug and Repair and Maintenance (R&M) for 5 years (MoP, 2017). Similarly, the Ujjwala Yojana scheme provides LPG connections to the Below Poverty Line (BPL) households by providing a financial support to cover the administrative cost of Rs 1600 (~23 USD) per connection (MPNG, 2017). These measures help switch adoption from highly polluting fuel which contributes significantly to the national burden of diseases.

Nevertheless, if the current government has to undertake price reform or subsidy reduction, the social cost associated with it should be minimised by adequate compensation packages for affected groups and sensitising people on the need for such action (Acharya & Sadath, 2017). Although, these subsidies aim of providing clean and affordable energy to the most sections of society. It is required to generate widespread awareness among the citizen regarding the *costs and benefits of subsidy* (IISD, 2012). It can produce informed choice sets among the citizens for shifting to a cleaner and sustainable form of fuel like wind or solar energy. It will also provide greater incentive to the government towards investment in renewable technologies (TERI, 2017).

The current energy policies in India employ the accelerated depreciation pricing mechanism for power generation through renewables which allow the developers to write off the asset values in the initial years of the project. Thereby, reducing tax liability in the short run, but when the asset value has wholly depreciated the tax becomes very high. It points towards uncertainties in the future, when the cost of maintaining renewables would become more top, and a rebound effect might cause the power-generating companies to shift back to coal with added pressure on importing coal for power generation (Shrimali et al., 2017).

Shrimali et al., (2016) suggests that reduced cost, extended tenor-debt pricing mechanism for the renewables, and leveraging the value of wind-power over the loss of importing coal is the future proofing policy for meeting the renewables target of 2022 (see Box 3), however, this will require a more significant share of the government budget as 'development debt' in initial years. Additionally, increase in the clean energy tax on coal, in the 2015-16 union budget was an excellent intensive in fostering clean energy sector. This additional charge will be used to fund renewable

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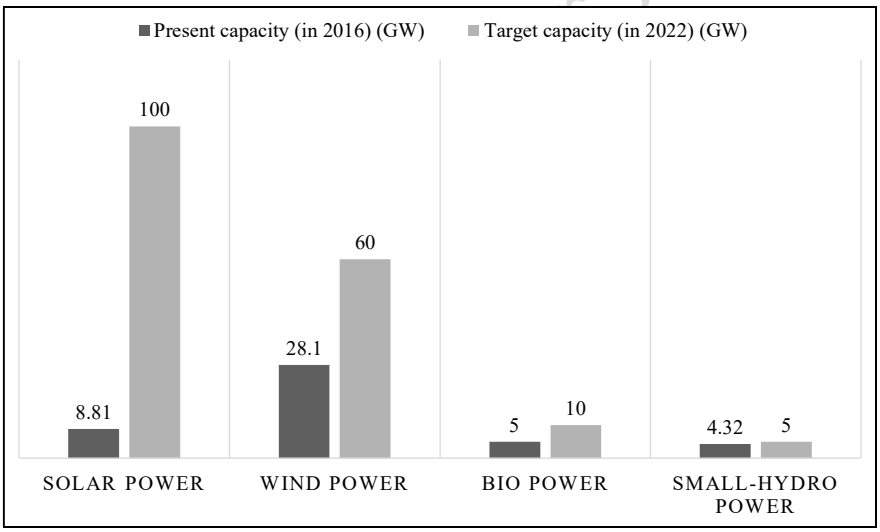
energy-based projects and green energy initiatives through the National Clean Energy Fund 2011 (TERI, 2017).

The latest development in the National Clean Energy Fund, 2011 is the issuance of renewable certificates to enable power-trading of renewable energy. The federal government had auctioned solar power at an all-time low of INR. 4.34/kWh in 2016, when the renewable energy targets were revised to 175 GW in 2022 (see Box 3) (Ministry of Finance, 2017). The CERC in 2016 institutionalised the norms for availing Renewable Energy Certificate for the Renewable Energy Generation (TERI, 2017). It is a positive step towards grid-parity for solar generation in India (Ministry of Finance, 2017). A successful grid-parity of solar-energy production in India would reduce the financial burden of the federal government, and foster a cleaner, affordable and accessible energy for all (Ministry of Finance, 2017).

Box 2. Source-wise distribution of achieving 175GW of the renewable target by 2022 and the status of the grid-connected renewable installed capacity and power-sector in India. (Source: TERI, 2017)



3.6 India's response to international climate negotiations

India recognised the importance of climate change as early as 1970's. However, its active participation and commitment came in post-2000 energy policies. The trajectory of actions that were adopted in response to international climate actions inadvertently express that those strategies were driven by enabling energy security and management of natural resources in the country, rather than climate-change mitigation or adaptation. The emphasis on renewable energy was paved out of the concern for energy security after the oil shocks of the 1970s, which resulted in several milestones in the landscape of India's energy policy. Figure. 6 elaborates the simultaneous actions undertaken by India while the international climate responsive events and protocols were taking place. Fossil fuels dominate India's primary energy consumption with world's fourth-largest

coal reserve (7% of global reserves). This abundance of reserves along with meeting the necessary infrastructural gap of electricity supply had delayed India in committing or ratifying towards green growth targets. The initial stance of India towards climate responsive actions was based on the pragmatic view that the industrialised nations should determine to curtail emission and facilitate developing countries to increase their emissions for growth and development (Government of India, 2011).

Until the beginning of the year 2000, India strongly endorsed to participate in global carbon emission reduction efforts without compromising on the development process. In Conference of the Parties (COP), COP-1 and COP-2, India broadly acknowledged the importance of low carbon growth but refused to accept binding cuts and limits on their emissions. It was until the Annex-1 countries of United Nations Framework Convention on Climate Change (UNFCC), took firm, verifiable action to reduce their emissions (i.e. the Berlin Mandate) (UNFCCC, 1995). It was because of India's initiation, the "common but differentiated responsibility" in climate emission reduction (i.e. the concept of per capita emissions) was introduced in climate negotiations.

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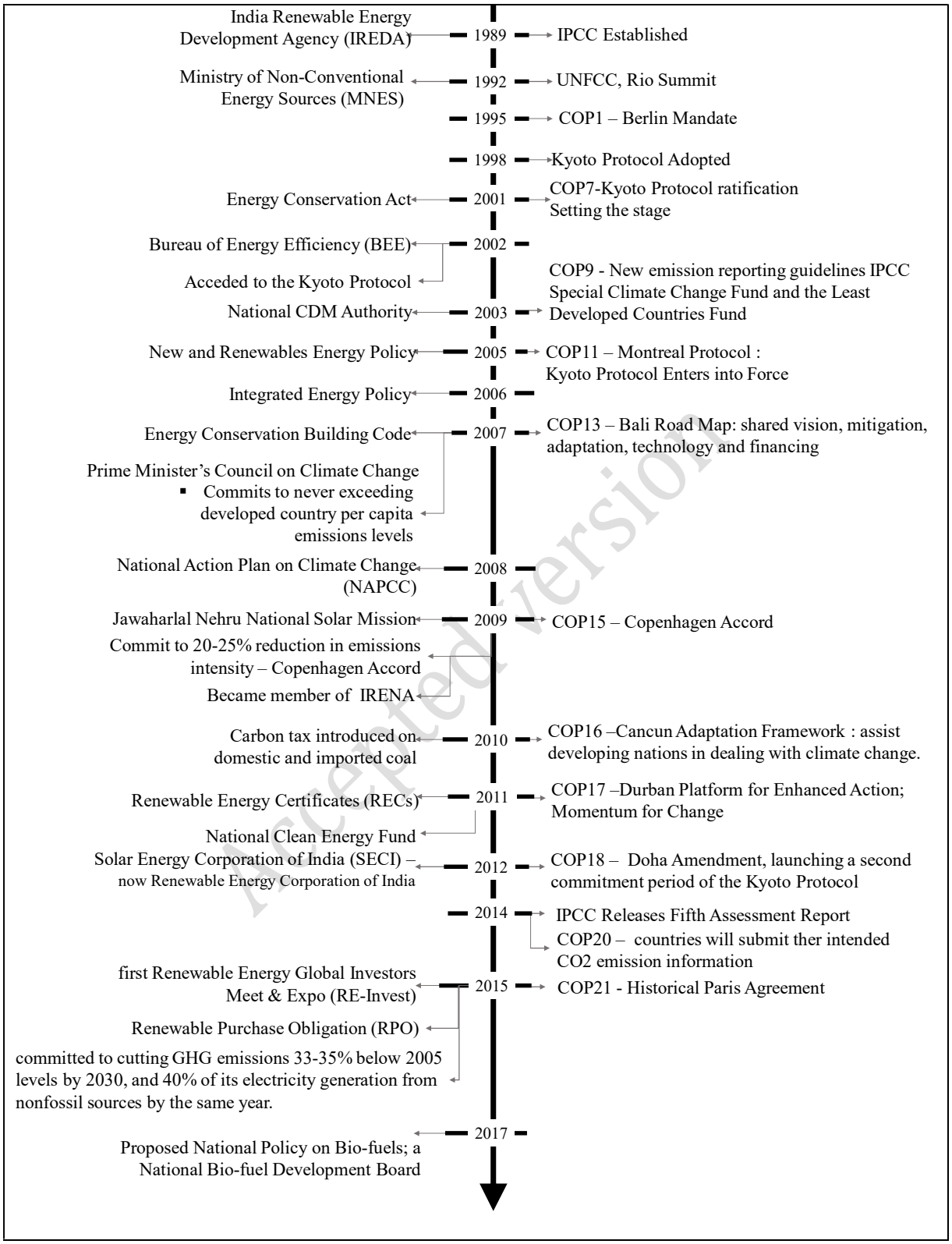

Figure 6. India's response to international climate negotiations since the independence in 1947. (Source: Author)

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The growing energy demand and the pressure from urbanisation had directed India's realisation towards renewable energy sources in the 1970s (TERI, 2015). The Solar Photovoltaic Research and Development programme was launched in 1976 to address the surge in energy demand and reduce emissions. Henceforth, there were series of follow-up actions to formalise the status of renewable energy in India. While the world was formalising the Intergovernmental Panel on Climate Change (IRCC) in 1989, India set up its first non-bank financial institution - India Renewable Energy Development Agency (IREDA). This agency was responsible for extending financial assistance to energy projects dealing with new and renewable sources of energy and energy management. A dedicated Ministry of Non-Conventional Energy Sources (MNES) was established in 1992, which was renamed as Ministry of New and Renewable Energy (MNRE) in 2006.

In COP-3, when the Kyoto Protocol was adopted in 1998, India acceded to it as an Annex II member, with no obligations towards emission reduction. However, it took concrete strategic steps towards energy management through the establishment of the Energy Conservation Act 2001, Bureau of Energy Efficiency (BEE) 2002 and formulating the Integrated Energy Policy 2006 (Planning Commission, 2006). Until 2005, India did play a critical role in the codification of Kyoto Protocol at COP-7 and emphasised that climate change and sustainable development are inter-linked and developing nations are more vulnerable to its impacts. It was in the COP-13 in 2007 and the COP-15 in 2009, India showed significant efforts in reducing emissions through technology transfer and accelerated pricing mechanisms at a global level. Nationally, it established the Energy Conservation Building Code 2007 followed by constituting Prime Minister's Council on Climate Change in the same year, where India committed not to exceed developed country per capita emission levels. Subsequently, the National Action Plan on Climate Change (NAPCC) was formulated followed by the institutionalisation of the Jawaharlal Nehru National Solar Mission. It endorsed emission reduction of 20-25% such that the maximum global average temperature rise could be limited to Two-Degrees Celsius (UNFCCC, 2009).

Since 2009, India has remained determined towards climate change commitments. The phase between 2010 to 2017 can be designated as the most active phase in India's energy planning history. With each successive COP from COP-16 to COP-21 in Paris, India has set up several instruments for facilitating renewable energy, which served the dichotomous purpose of curbing emissions as well securing the future energy scenarios (refer Figure. 6). During COP-21 in 2015, India for the first time committed to Intended Nationally Determined Contributions of 33-35% below 2005 levels by 2030, and 40% of its electricity generation from non-fossil sources by the same year. Since then India's growth plan prioritises clean energy and technologies to fuel economic growth (Ministry of Environment and Forests, 2015). Some of the policies and instruments introduced to achieve the intended targets through mitigation, adaptation and finance strategies are summarised in Box 3.

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Box 3. Policy instruments initiated to meet the INDCs
(Source: Ministry of Environment and Forests, 2015)

Initiatives for fulfilling INDCs

Mitigation

- **National Solar Mission scaled up** five-fold from 20 GW to 100 GW by 2022.
- **National Smart Grid Mission** launched for efficient transmission & distribution network.
- **Green Energy Corridor** projects being rolled out to ensure evacuation from renewable energy plants.
- **Nationwide Campaign for Energy Conservation** launched with the target to save 10% of current energy consumption by the year 2018-19.
- **Zero Effect, Zero Defect** (ZED) with Make in India campaign to enhance energy& resource efficiency, pollution control, use of renewable energy, waste management etc.
- **Faster Adoption and Manufacturing of Hybrid & Electric Vehicles** (FAME India) to promote faster adoption and manufacturing of hybrid and electric vehicles.
- Country's first passenger vehicle **fuel-efficiency standards finalized**.
- Policies to increase **production of energy efficient 3 phase locomotives** and switchover to 100% of these locos from 2016-17 onwards.
- Policy directive issued **to use 5% bio-diesel** in traction fuel in diesel locomotives.

Adaptation

- **'Give It Up'** 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.

Financial Strategies

- **Reduction in subsidies on fossil fuels** including diesel, kerosene and domestic LPG.
- **Coal cess quadrupled** from INR 50 to INR 200 per tonne to help finance clean energy projects and
- Introduction of **Tax Free Infrastructure Bonds** for funding of renewable energy projects.

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4. DISCUSSION & CONCLUSION

This study documents the historical trajectory of sustainable energy policies across the energy supply domain and establishes a systematic process to track the cascading effect of these policies towards the 2022-renewable targets. A co-assessment was performed to understand how India's policy landscape responded to the international climate negotiations over the past decades. It was evident that India's transitional economic development during the first phase of climate mandates constrained it from active emission commitments. However, the simultaneous energy actions by India demonstrated significant concern for energy security and climate change. Steps towards active involvement showed a rising interest in incorporation and improvement of renewable resources. The initial growth of renewable energy in India has been based on capital grants and subsidy, which itself was a roadblock to renewable energy development. Hence removing barriers like the high cost of financing, lack of enforcement of Renewable Purchase Obligations (RPOs), preventing scaling up of subsidy mechanism in off-grid power and poor financial health of the distribution companies, can enable smoother integration of renewable sources in the primary energy mix. There is a more significant problem for grid-integration of renewables, as the distribution companies struggle to purchase enough electricity for the population they serve. It, in turn, forces the power station to run at low capacity factors, producing less power than they are built to generate. Faster grid-integration of renewables would mean more power to the grid, and more surplus, which will lower the utilisation capacity of the power plants. Additionally, Indian transmission and distribution (T&D) systems are not built to handle the variable, intermittent, and uncertain generations from renewable energy sources. Thus, there is a need to improve the T&D infrastructure, which remains a gap in the current electricity policy.

Policies like the National Mission for Enhanced Energy Efficiency (NMEEE), the Perform, Achieve, and Trade (PAT) scheme, the Market Transformation on Energy Efficiency (MTEE) and financial mechanism for Demand Side Management (DSM) are redefining energy conservation scenarios in industries, but until T&D systems are revamped the energy systems of the country would struggle in reaching the 2022 energy targets. It would require significant investment by the government in non-conventional sources of energy, by the successful diversion of money from the investment in subsidies without compromising on its social cost, and the decrease in import of fossil fuel for energy security. The inclusion of climate and environment as the core component of energy-security in the current Indian energy policy (IESS-2047) had opened newer pathways for renewable energy integration.

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Appendix

Table 1. Key Takeaways from INDC- 2015 (Adapted from Ministry of Environment and Forests, 2015)

Sl. No.	Mitigation Strategies	Target
1	Green Generation for Clean & Energy Secure India	Renewable capacity increase from 35 GW (March 2015) to 175GW in 2022
2	National Solar Mission	20 GW to 100GW by 2022
3	Solar Powered toll plaza	Pan India
4	National Smart Grid Mission	Efficient transmission & distribution network
5	Green Energy Corridor projects	Ensure evacuation from renewable energy plants.
6	Nationwide Campaign for Energy Conservation	Save 10% of current energy consumption by the year 2018-19.
7	Smart City Mission	To develop new generation sustainable cities
8	National Heritage City Development and Augmentation Yojana (HRIDAY)	Urban planning, economic growth and heritage conservation in an inclusive manner.
9	Atal Mission for Rejuvenation and Urban Transformation (AMRUT)	Sustainable Urban Renewal of 500 cities
10	Swatch Bharat Mission (Clean India Mission)	Clean and litter free India by 2019
11	Zero Effect, Zero Defect (ZED) with Make in India campaign	To enhance energy& resource efficiency, pollution control, use of renewable energy, waste management, etc.
12	Green Highways (Plantation & Maintenance) Policy	To develop 140,000 km long “tree-line” along both sides of national highways.
13	Faster Adoption and Manufacturing of Hybrid & Electric Vehicles (FAME India)	To promote faster adoption and manufacturing of hybrid and electric vehicles.
14	National Air Quality Index	One Number, One Color and One Description to give the status of air pollution in a city.

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