ENERGY TRANSITION IN INDIA AND GERMANY: DEVELOPMENTS IN GRID-CONNECTED WIND AND SOLAR ENERGY, 2006-2016

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DECLARATION

I declare that the thesis entitled "**'Energy Transition in India and Germany: Developments in Grid-Connected Wind and Solar Energy, 2006-2016**" submitted by me for the award of the degree of **Doctor of Philosophy** of Jawaharlal Nehru University is my own work. The thesis has not been submitted for any other degree of this University or any other university.

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List of Abbreviations

ACS: Average Cost of Supply

APM: Administrative Price Mechanism

BCD: Basic Custom Duty

BPCL: Bharat Petroleum Corporation Limited

CDM: Clean Development Mechanism

CEA: Central Electric Authority

CHP: Combined Heat and Power

discom: Distribution company

EDC:Electricity Distribution Company

ETP:Energy Transition Project

ETS: Emission Trading Scheme

FBC: Fluidised bed combustion

FFEG: Fossil-fuelled Electricity Generation

FIT: Feed-in Tariff

G77: Group of 77

GAIL: Gas Authority of India Limited

GBI: Grid Based Incentive

GHG: Greenhouse gases

GoI:Government of India

GST: Goods and Service Tax

GW: Gigawatt

HPCL: Hindustan Petroleum Corporation Limited

IEA: International Energy Agency

IEP: Integrated Energy Policy

INDC: Intended Nationally Determined Contribution

IPCC: Intergovernmental Panel on Climate Change

IPP: Independent Power Producer

IREDA: Indian Renewable Energy Development Agency

IRENA: International Renewable Energy Agency

ISTS: Inter State Transmission System

JNNSM: Jawaharlal Nehru National Solar Mission

kWh: Kilowatt hour

LCIG: Low Carbon Inclusive Growth

LCOE: Levelised cost of electricity

LLP: Limited Liability Partnership

LNG: Liquified Natural Gas

MBtu: Million British Thermal Unit

MMSCMD: Million metric standard cubic feet per day

MMT: Million Metric Tonne

MOEF&CC: Ministry of Environment, Forest and Climate Change

MoPNG: Ministry of Petroleum and Natural Gas

Mtce: Million tonne coal equivalent

MW: Megawatt

MWh: Megawatt hour

NAPCC: National Action Plan on Climate Change

NCEF: National Clean Energy Fund

NDA: National Democratic Alliance

NELP: National Exploration Licensing Policy

NIMBY: Not in my backyard

OECD: Organization of Economic Co-operation and Development

ONGC: Oil and Natural Gas Corporation

OPEC: Organization of Petroleum Exporting Countries

PGCIL: Power Grid Corporation of India Limited

PIBL Press Information Bureau

PLF: Plant Load Factor

PPA: Power Purchase Agreement

PSC: Production Sharing Contract

PSU: Public Sector Unit

PV: Photovoltaic

RBI: Reserve Bank of India

RE: Renewable Energy

REC: Renewable Energy Certificate

RET: Renewable energy Technologies

RGGVY: Rajiv Gandhi Grameen Vidyuikaran Yojana

RGTIL: Reliance Gas Transportation Infrastructure Limited

RPO: Renewable Portfolio Obligation

RPS: Renewable Portfolio Standard

RVE: Remote Village Electrification

SEB:State Electricity Board

SECI: Solar Energy Corporation of India

SERC: State Electricity Regulatory Commission

STET: Socio-technical energy transition

TM: Transition Management

TSO: Transmission System Operator

UDAY:Ujwal Discom Assurance Yojana

UMPP: Ultra Mega Power Project

UPA: United Progressive Alliance

VGF: Viability Gap Funding

VLCC: Very Large Crude Carrier

WTO: World Trade Organisation

CHAPTER I

Introduction

1.1 Background

The fears of oil shortages in the 1920s, brought about by an exponential increase in the use of automobiles in the industrialised countries at the end of World War I, was followed by an oil glut in the 1930s. Similarly, the oil shocks of the 1970s were followed by a prolonged oil and gas glut throughout much of the 1980s and early 1990s. In both cases, the gluts were initiated by the development of new sources of crude oil and gas. However, in the case of the latter, another development played a very important role in reining in the high prices prevalent in the 1970s. Energy efficiency and conservation were promoted by the industrialised countries of the Europe, North America and Asia as measures to ensure optimum usage of fuel. It led to a sharp drop in demand for fossil fuels from the Organisation of Petroleum Exporting Countries (OPEC) nations (Yergin 1991: 717-718).

The high prices of oil and natural gas, stemming from the 'demand shock' of 2008 and geopolitical disturbances across West Asia, was the result of increasing demand for hydrocarbons from the developing economies of Asia, led by India and China. The retardation of oil and gas supplies due to geopolitical events in several large oil supplying nations also greatly contributed to the high energy prices (Yergin 2011). This period also witnessed strong strides made in the sphere of renewable energy (RE), especially wind and solar energy. Larger amounts of renewable energy could now be extracted using improved technology. While increasing energy supplies from West Asia to counter the large amounts of oil extracted from shale rocks and tar sands in North America have led to a sharp drop in energy prices in this decade, the increasing role of renewables in the energy mix of several nations also demands an understanding. Never before, have renewable energy technologies (RET) come to play such a major role in the energy agendas of countries. Compounding this issue with fossil fuels is the concern surrounding the anthropogenic emissions of greenhouse gases (GHG) into the atmosphere. Such a scenario thus necessitates an analysis of an energy transition that could possible lead to a dominant role for renewables in the energy mix of nations.

The history of transitions that took place in the eighteenth century shows that it was an easy, albeit long, process. In contemporary times however, the diversification of industries and fuel sources has complicated this process. The introduction of non-fossil fuels like solar and wind energy has gained universal acceptance quickly but its implementation globally has been rough. Several authors cast a pessimistic view of the ascendance of renewables, plagued with problems of intermittency, through the substitution of fossil fuels. The process will be long drawn, spanning several decades. Several points for consideration against rapid decarbonisation may be considered. Smaller transitions, from wood and coal to oil, in the larger context were achieved quickly at the national level. While the contribution from oil and natural gas increased rapidly in the second half of the twentieth century, coal still contributed thirty percent of the global primary energy (Smil 2016). The competition between various fuels is so strong that no single fuel type could achieve a dominance over others.

Energy transition is not a new phenomenon, but the rapid transition since the nineteenth century is. By 2015, fossil fuels supplied eighty six percent of the world's energy needs. Renewables supply a mere three percent of the world's electricity. China, which has tremendously increased the installed capacities of solar and wind energies, sourced just two percent of its power from renewables in 2014.

According to the International Energy Agency, almost 900 gigawatts (GW) of power is needed to satisfy the increasing demand for electricity in the future in India. India possesses an installed generation capacity totalling 307.27 (GW). The IEA foresees India turning into the largest importer of coal surpassing the European Union (EU), Japan and China. Currently it is the world's third largest importer of petroleum. The electricity grid in India is increasingly saddled with new connections being enhanced at the rate of five percent per annum. More than half of the total number of thermal power stations have been constructed in the previous one decade. This means that the demand for coal will remain constant and many even increase if older and inefficient power plants are replaced prematurely by super critical coal-fired power plants with larger production capacities. The adoption of super critical technology for coal-fired plants has increased capital costs that have been offset by a reduced expenditure on fuel and increased fuel efficiency.

The power generation industry receives more preferential prices for domestic coal than other industrial users. 'Coal linkages' is a term used to designate contracts for the supply of coal over an extended period. The opaqueness in the process of the allocation of coal linkages and large government subsidies maintain the dominant position of domestic coal in India’s energy mix.

Lacking sufficient gas reserves to cater to the growing domestic demand, India has invested heavily in regasification facilities for serving LNG transports mainly from West Asia as the outlook of pipelines from Central Asia or Iran remains bleak due to the security dynamic between India, Pakistan and Afghanistan as well as doubts on the ability of the supplier states in maintaining uninterrupted supply. Infrastructure for gas is located on the Western coast or in the north western region on India.

Since the mid-2000s, and particularly after the release of India’s Integrated Energy Policy in 2006, global climate change concerns have come to take into account India’s contribution to global warming. Possessing eighteen percent of the global human population, India consumes an annual total of six percent of the world’s total primary energy resources. While India’s per capita fossil fuel use is extremely low, future estimates expect this trend to change rapidly. India’s coal-led power sector is the leading emitter of carbon emissions in India. The Indian government has engaged with international agencies led by the United Nations to appease international pressure. Taking these into consideration the Indian government is caught between the devil and the deep sea – give in to domestic pressures or risk international animosity. Germany’s energy transition roadmap offers an alternative.

Renewable energy (RE) has been at the receiving end of a string of favourable legislation, the first of which was released in 1991 to make it an attractive investment. ‘*Energiewende*’, whose closest translation to English would mean ‘energy turnaround’, was perceived as a concept to drastically slash Germany’s carbon emission levels by eighty to ninety five percent from their levels in 1990. Nuclear energy, with its zero carbon emissions, and the most practical option, is to be completely phased out of the German energy mix by 2022. Instead, the German strategy conceptualises two ‘pathways’ to steer Germany to a stable transition, ensuring secure and inexpensive access to energy (Sturm 2017: 41). The first pathway foresees RE contributing sixty percent of the energy generated in Germany by 2050. The second seeks to reduce by half the domestic energy consumption levels calculated in 2008 by 2050 using energy efficiency measures. However, Sturm (2017) argues that Germany’s active involvement in an intensely socio-technical process, heretofore unseen, could increase economic risks to consumers as well producers.

It involves a slew of strategies, some of which include the off-grid systems that are weighed down heavily by solar and wind power systems. The German power industry, among the most competitive in the world, offers an ideal platform to test the capability of renewables in reaching a very large number of consumers.

Considering the fact that almost twenty percent of the total energy produced in the European Union (EU) is disbursed to Germany it is expected that the country, through the Energiewende, will convince the other major players in the EU that energy climate change mitigation targets are achievable.

A combination of grid-connected onshore and offshore wind, solar PV (photovoltaic) and bioenergy which will replace nuclear power has been planned on maintaining a secure and carbon-free power generation for the country.

Germany's experiment could prove to be a vital lesson for the Indian power sector by juxtapositioning the differing capabilities and challenges facing the developed as well as developing nations in widely expanding their renewable energy initiatives. .

Shortly after announcing that the country intended to double its annual coal output to close to 1 billion million metric tonnes (MMT) by 2020, India amplified its solar power capacity target from 20,000 megawatts (MW) to an ambitious 100 gigawatts (GW) by 2022 under the Jawaharlal Nehru National Solar Mission (JNNSM). Wind energy capacity is to comprise 60 GW. As of 2015, Renewable Energy Sources (RES) constituted 13.3% of the total installed capacity of power in India.

With a view of examining India's seemingly fragmented energy policy in a changing carbon controlled environment, this study will attempt to analyse the position of RES in India's energy mix. Germany's aggressive push for renewables, espoused in successive government policies, and its struggle to wean its dependence on coal presents itself as a suitable case study to gauge the impact of policy on renewable energy generation.

Thus, the central question which this study seeks to answer is: Is a committed transition towards grid-connected renewable energy, which could challenge the dominance of coal, underway in India?

1.2 Review of Literature

The intention in this section is to survey the existing literature on global trends in energy transition, particularly regarding the renewables' policies, to the extent that some initial hypothesis can be derived, gaps in literature be identified and a suitable research design can be formulated.

Several studies on Indian and German energy transition, their economic policies in general and energy policies in particular are available. For ease in understanding, this section is divided into three sub-sections that examine energy transition and energy transition trends in India and Germany. While India may not seem as aggressive as Germany in its pursuit of the expansion of utility-scale renewable energy infrastructure, a review of contemporary literature highlights the commonalities they share.

1.2.1 Energy Transition as a concept

A study of global energy transition necessitates a study of the historical changes towards its conceptualisation. Abelson's 1980 article is subsumed by a Cold War narrative formed around access to energy – especially oil – as a strategic asset on which the US military is wholly dependent. While dealing a death knell to 'cheap and secure' oil, Abelson argues for US led 'energy independence', and not transition per say, through energy efficiency measures and, the exploration and marketing of other non-renewable fuels like natural gas, nuclear power and coal. Staving off the Soviet dominance of oil dependant Third World nations and, Western dependence on West Asian oil was the major focus rather than environmental concerns.

Lensenn and Flavin (1986) predicted a smooth replacement of oil and coal with natural gas and renewables through the rapid expansion of cheap technological innovations. The transition from oil and coal would require a substantial dependence on natural gas as an intermediate, before the final transition to renewables is underway.

The authors presented an optimistic outlook with regard to the reduction of coal and crude oil, population stabilisation and increased efficiency. In hindsight, low oil prices during the 1990s and much of the 2000s (the 2008 oil shock remaining the only exception) and increasing population growth in developing countries negates all optimistic speculation of emission reduction. While admitting that natural gas remained largely unexplored in Asia, the authors fail to account for the expensive and challenging infrastructure required to transport it.

The authors presented an overly optimistic speculation that with mass production, renewables could displace oil as the second largest source of energy in the world by 2050. Nevertheless, the authors remain oblivious to the fact that oil is the primary fuel in transportation. Current efforts at reducing the carbon footprint of the transportation sector are directed towards increasing energy efficiency and not outright replacement. According to the authors, a long-term shift towards more efficient and less carbon-intensive fuels could be termed as a 'decarbonisation' of the world energy system. The authors posit that hydrogen fuel would outscore renewables as the more dominant energy source in the future. However, this does not seem to be the case given the high costs of mass-producing hydrogen.

Contemporary literature juxtaposes carbon emission mitigation and the need for larger dispersal of RE technologies. Smith and Kerr (2008) make a study of the 'transition management' (TM) model being perpetuated by the Dutch government to 'restructure' domestic energy systems. They follow up the execution of the TM model, approved of in the wake of the enactment of the Fourth Dutch National Environmental Policy Plan (NMP4) in 2001. The Plan seeks to reduce by forty to sixty percent the 1990 levels of carbon dioxide in three decades by complementing technical innovation and structural change on multiple levels. Through the conduct of personal interviews with stakeholders and critics of the energy sector, the authors test the strength of the TM model in resisting being taken over by the current energy regime.

According to them transitions may be defined as "social transformation processes in which (socio-technical) systems change structurally over an extended period of time" (Smith and Kerr 2008: 4094). The TM model, true to its sociological and historical roots, seeks to move away from the short-term techno-centred processes of the incumbent energy regime, through the formation of 'transition arenas' that suggest structural changes to institutions of policy-making. Its focus always rests on one positive long-term goal. A critical review of the Dutch origin TM model is lacking. The transitions approach has been hijacked by actors of the incumbent energy regime. They choose the targets as well as the pathways. Niches (radical, and often expensive, inventions) demanding radical structural change will find it hard to be absorbed in the

TM debate. Their dominance makes them immune to calls for structural change. Pressure to implement changes might drive them away from any engagement with the transitions process. The Dutch case study cautions readers about the overly optimistic role played by the government in the process of transition.

Verbong and Geels (2007) argue that with increased liberalisation and Europeanisation, the decades old transition within the Dutch electricity system has picked up pace, instead of being pushed by traditional environmental aspects. The concept of 'change' is immersed in technical innovation converging on 'new' systems while ignoring 'existing' systems and regimes. A transition within the electricity has been taking place since the late 1990s. While production and distribution were a single process, dictated by internally set targets, they are now separate processes oriented towards the demands of the market. This transition did not take place in one sudden shift, but was rather a series of minute changes taking place since the 1960s. Accordingly, the authors argue that more than climate change and environmental sustainability, it is liberalisation and Europeanisation that are the main drivers of energy transition in the Netherlands. In the Netherlands, the emphasis on energy efficiency and the twin policies of liberalisation and Europeanisation has indicated a neglect of renewable energy targets (ten percent of electricity production by 2020). The authors describe this situation as "a gap between policy goals and real policy measures" (Verbong and Geels 2007: 1032).

While presenting readers with a background on energy transitions in developed countries, O'Connor (2010) ignores policy decisions and focusses on technological and market-oriented factors that spurred energy transition. The limited financial means of the population of developing countries denies them the opportunity of accessing commercial energy. Infrastructure, the key to energy transitions, is highly dependent on economic and political stability. O'Connor argues that greater the formal limits placed on carbon dioxide emissions, greater will be the pace of energy transition.

O'Connor offers a definition of 'energy transition' as, "a particularly significant set of changes to the patterns of energy use in a society, potentially affecting resources, carriers, converters, and services" (O'Connor 2010: 2). Curbs on carbon emissions leads to the adoption of costly low carbon fuels, beneficial to the quality of life in the long term, while advances in energy technology blunts the financial impact of these costly fuels. Restrictions on high-carbon fuel use does not have any worse economic impact on the economy than limits enforced due to scarcity or domestic policy.

Kerr (2010) expresses suspicion of the 'self-conscious' global efforts towards transitioning to an energy source that has remained unproven at the macro level and is land-intensive. Renewables, at their 2010 levels, produced a mere 0.6 terawatts, far short of the 12 terawatts produced by coal, oil and natural gas.

He argues that no matter how strong government policies favouring renewables may be, they cannot cover the fundamental differences between fossil fuels and renewables – power density, intermittency and geographical variations. On all three fronts, renewables are far behind. Compounding these handicaps is the cost of installation and lack of storage for surplus electricity. While the public may be aware and even support the inclusion of renewables within the national energy mix, they are hesitant to sustain additional taxation for the growth of renewables.

1.2.1.1 Renewable Energy policies

Liu et al. (2018: 330-331) define renewable energy generation policy as "policies which can directly support renewable energy generation, or indirectly stimulate its development by limiting fossil energy consumption and increasing the costs of fossil energy generation". Liu et al. stress the distinction between RE policies and emission policies. Renewable energy generation policies convey strong socio-economic effects. The inclusion of all renewable energy policies in their study allows the authors to assess the socio-economic and environmental impact of renewable energy generation policies.

Cadoret and Padovano (2016) assess the influence of political features on the disposition of renewable energy sources (RES). Their study targets those EU countries that are close to achieving a 20 percent gross final energy consumption by 2020. The data highlights the fact that pressure tactics adopted by the manufacturing industry have a negative impact on the deployment of renewables. This is also reinforced by Hughes and Meckling (2017: 256) who argue that in the past decade, government support has assisted in the growth of the RE sector; by widely popularising the debate on climate change and energy conservation and creating favourable manufacturing and trade policies. It also indicates that manufacturing standards established by the government show a marked improvement in quality. Last, left-wing parties have a greater tendency to implement a broad RE policy than right-wing parties.

Aguirre and Ibikunle (2014) study a survey of thirty eight countries, including BRICS nations, over a 20-year period to determine the factors influencing the development of renewable energy in a country. Their investigation finds out that government policies surrounding conventional sources of energy often impede the development of strong renewable energy policies. The majority of renewable energy policies are sloppy actions, only designed to temporarily abate public demands for the inclusion of RES in energy policy. Governments remain unconvinced of the capacity of RES to fulfil large energy demands. Suspicions regarding the efficacy of renewables have long existed. They are not exactly new technologies, as they have existed since the 1970s. These intermittency issues are the primary weakness of renewables – even in the twenty first century - They conclude that sloppily designed RE policies may obstruct their development and are examples of 'failures in policy design'.

Using data obtained from 122 countries in a 31-year period beginning 1980, Zhao et al. (2013) study the impact of renewable electricity policies on renewable electricity generation. While policies play a vital role in initially developing renewable electricity generation, their increasing complexity as the sector expands gradually shrinks their efficiency. Renewable electricity policies also had a greater impact before 1996 especially in the developed and developing countries. The authors argue that feed-in tariffs and investment incentives are the most effective policy instruments in promoting all types of renewable energy sources.

1.2.2 India's energy policies

The Integrated Energy Policy (IEP) [2006] confronts the fact that the supply of electricity in India remains intermittent with industries shouldering the financial burden; the remedy of which is important to secure higher economic growth figures. At the outset, the report calls for an expansion in coal output, being the most plentiful domestic fuel resource, to over 2 billion tonnes per annum to fuel expectations of increased economic growth. Clean coal technologies are of primary importance, as coal shall remain the most dominant fuel well into the 2030s, contributing seventy eight percent of power generation (IEP 2006: xiii). Only 54.5% of the combined cycle gas generation capacity, totalling 12,604 MW, remained utilised (IEP 2006: xv). The IEP defines energy security as, "primarily about ensuring the continuous availability of commercial energy at competitive prices to support its economic growth and meet the lifeline energy needs of its households with safe, clean and convenient forms of energy even if that entails directed subsidies" (IEP 2006: xxiv). The IEP argues that renewable energy will cover barely six percent of the country's total commercial energy demand. The document, although commendable for attempting to streamline energy policy, is also guilty of ignoring the position of renewables as a major contributor to India's power requirement.

Released in 2008 by the Prime Minister's Council on Climate Change, the National Action Plan on Climate Change (NAPCC) categorically states that at no point in the future will India allow the per capita greenhouse gas emissions to exceed those of the developed countries. This document was the first, outlining India's strategy to tackle the issue of climate change while adhering to the UNFCCC's principle of common but differentiated responsibilities. The Plan encompassed eight national missions, of which the National Solar Mission is most relevant to our field of study. It argues that the variabilities and uncertainties of a time frame of climate change compel India to focus on its development objectives of poverty alleviation and improved standards of living. Lacking the financial might of the developed world, India must achieve high growth rates if it intends to tackle climate change. India has chosen to prioritise 'strategies' instead of creating all-encompassing strategies that diminish economic targets by focussing solely on climate change.

The document viewed solar photovoltaic technology only as an off-grid, decentralised option powering rural areas with lower energy consumption instead of urban areas with high energy consumption. The goal here seemed to be rural electrification and reduction of transmission and distribution losses (AT&C) instead of lowering emissions in the urban areas.

The document also outlines the government's desire to pursue clean coal technology through the setting up of super-critical thermal plants with 40% efficiency. The dominant sub-critical thermal plants in India have thirty five percent efficiency figures. While solar PV is viewed as a stand-alone technology, wind energy, with an installed capacity of 8000 MW, is seen with applications to grid-connectivity. The reason for this could be the then unproven status of solar PV in a large set-up.

According to the IEA (2015), in 2013, forty-four percent of India's primary energy mix is served by coal. This was closely followed by biomass at twenty four percent and oil at twenty three. The increasing number of coal-fired power plants, the expansion of the steel industry (which is heavily dependent on coking coal) and finally its plentiful domestic supply and low cost are the main reasons why coal continues to dominate India's primary energy mix. Biomass has witnessed a ten percent reduction because of the increasing dependence on LPG and the electrification of rural homes.

In the Low Carbon, Inclusive Growth (LCIG) scenario by the Planning Commission (2014), it was observed that if per capita carbon dioxide emissions fell by 1 tonne per person, from 3.6 tonnes per person (based on the Baseline, Inclusive Growth), the GDP rate would fall by 0.15 percentage points. Both scenarios see a continuous rise in carbon emissions till 2030. India emitted 1,728 million tonnes CO2 equivalent of GHG in 2007, according to data from National Communication (to the United Nations Framework Convention on Climate Change) [NATCOM]. This made it the world's sixth largest emitter. The NAPCC was a voluntary commitment to mitigate these effects (Planning Commission 2014: 1).

Several scholarly works point out the seemingly fractured nature of India's renewable energy policy. According to Sen et al. (2016), the idea of renewable energy (RE) as a 'substitute' must be done away with; instead the recognition of its significance in a sustainable and inclusive growth economy must be at the forefront of public policy.

Nathan (2014) questions the logic of introducing a distributed system of energy led by solar PV when essential maintenance of this technology is not prioritised in rural India. Distributed solar PV has largely failed to make an impact in rural India due to the delineation of the power needs of rural and urban India. Krithika and Mahajan (2014) observe that the inclusion of specific targets for installation of renewable capacity is testimony to the support renewables have received from policymakers. According to them, the Electricity Act of 2003 forms the bedrock from which RE in India has sought recognition as a viable alternative source of electricity. Under the act, State Electricity Regulatory Commissions (SERC) were directed to actively pursue grid-connectivity for renewables. The National Tariff Policy, 2006, maintained a minimum share of renewable power to be purchased compulsorily by grid operators.

They further argue that the objectives of the National Clean Energy Fund (NCEF), funded through a cess on domestic as well as imported coal, to finance world class R&D into renewables, have remained elusive due to financial misallocation. The additional funds have been directed to bridge the deficits (budgetary allocations) of several ministries involved in financing off-grid and small-scale renewable technologies. As such the NCEF has failed to increase the scope of renewables into the larger, and more polluting, urban framework. The compulsory purchase of Renewable Portfolio Obligations (RPO)[1] by distribution companies has not been strictly adhered to. Several states have cited low installed capacity of renewables and high costs that will have to be borne by consumers. In most cases, the regulator has permitted defaulters to carry forward the backlog into the next financial year.

1.2.3 Germany's *Energiewende*

Already in possession of a highly advanced and stable power production and supply system, Germany, according to the White Paper (2015), is attempting to establish a 'flexible capacity' (White Paper 2015: 3). This flexible capacity for the future aims to ensure 'a secure, low-cost and environmentally compatible electricity supply when a large share of the power is derived from renewable energy sources' (White Paper 2015: 4).

German energy transition also encompasses energy efficiency measures (White Paper 2015: 4). With the ceasing of operations pertaining to the generation of nuclear power in Germany by 2022, policy makers expect renewables to fill the vacuum (White Paper 2015: 5).

The White Paper of 2015 was preceded by the Green Paper of 2014, a debate involving several stakeholders (including trade unions, individual citizens and research institutes among others) in the power sector and concerning the next phase of the German power sector. Faced between a choice to augment existing capacity or further upgrade the existing electricity market, the White Paper of 2015 settled for the latter, terming the next phase, 'Electricity Market 2.0.'

Bahgat (2011:1) talks about a "sense of vulnerability" stemming from an over dependence on energy resources fuelling major economies, in stark contrast to the secluded location of these deposits within mostly politically and economically fragmented regions around the world. These geopolitical instabilities aggravate the intensely volatile global energy price index. He goes on to expand the realm of

[1] Compulsory targets for renewables in India are called Renewable Portfolio Obligations (RPO) while in the West they are called Renewable Portfolio Standards (RPS).

traditional energy security by envisaging environmental mitigation as an important aspect, as important as the access to inexpensive energy prices (Bahgat 2011: 2).

In a sense, German moves to switch fuels stems from a combination of nuclear safety concerns, sensitivity to global rise in crude oil prices and environmental issues. The European Union has a binding target for greenhouse gas (GHG) reduction of twenty percent by 2020 compared with levels in 1990 and intends to increase its share of renewables to twenty percent by 2020. The renewables target is covered by different supporting schemes at the national level, and the energy efficiency target is addressed by a variety of standards and regulations (Edenhofer et al. 2013: 11667).

Saini (2014: 770) states that prime among the problems associated with grid-scale renewables is intermittent supply: neither wind nor solar can provide constant power. In the worst case, this may mean that Germany will need to resort to a higher proportion of fossil fuels than planned. Another option is for consumers to be encouraged to use less energy during times of lower supply, through temperature controls erc.. She continues by adding, “Most PV cells in Germany, as in the rest of the world, are standard crystalline silicon, with efficiencies below twenty percent, usually 16–18%. There is a theoretical limit on the efficiency of all standard crystalline silicon solar cells of around thirty percent. Although PV cells with efficiencies above forty percent exist, their high cost only makes them appropriate in ‘blue sky’ regions with high amounts of direct sunlight—not in Germany” (Saini 2014: 771).

Worse, that fossil-fuelled electricity got dirtier because renewable power preferentially displaces expensive natural gas from the grid rather than cheaper coal (Boisvert 2013: 64).

Smil (2015) argues that in 2014, despite fast-tracking the consumption of renewable energy through its Energiewende, Germany managed to source 15% of its electricity from renewables. Fossil fuels still supplied about fifty percent of the electricity destined for the German grid.

Smil (2015) does not criticise the introduction of renewables in power generation, but he criticises the over optimism that accompanies renewables. Sourcing even forty to fifty percent of electricity from renewables is a tall order considering the fact that renewables lack huge storage capacities during periods of intermittency, and spare capacity during the night. The reach of renewables has been most significant in power generation. Transport and industry still consume copious amounts of fossil fuels. Strides in efficiency have been subsumed by increasing demand. He concludes that energy conservation, rather than the unilateral dependence on new renewable technology, is a more promising step towards the reduction of carbon dioxide emissions.

Smil (2016) criticises Germany's *Energiewende* as expensive and ineffective. From 2000, when 83.7% of electricity generated was derived from fossil fuels, to 2015 when that figure has fallen to 79.4%, Germany has recorded a measly 0.3% decline in fossil fuel consumption per year. During the same period, the use of lignite increased drastically while natural gas use decreased by ten percent. France with no concrete transition plan has recorded an overall decline of eighteen percent in the consumption of fossil fuels, six percent more than Germany (Smil 2016: 195).

Dependence on renewables which are intermittent by nature, led to increase in established spare capacity for fossil fuels. Fossil fuel generation capacity rose from 84.2 GW in 2000 to 87.5 GW in 2014. Renewables' capacity recorded an increase from 6.2 GW in 2000 to 84.8 GW.

Sturm (2017) argues that Germany's active involvement in an intensely socio-technical process, heretofore unseen, could increase economic risks to consumers as well producers. The author questions this inability to pass on the benefits to individual and small industrial consumers. The author argues that though the market price of power has come down significantly, the costs to keep RE systems online are far higher. Secondly, to prevent the flight of highly energy-intensive (consuming forty percent of electricity) but economically vital industries to countries with cheaper power to offer, no additional charges are imposed on these industries. The author argues that the performance of *Energiewende* has been mixed. - the integration of intermittent RE sources within the exiting energy systems has failed primarily due to a lack of storage capacity. Collapse of the entire grid has been forestalled through the uneconomical operation of conventional power plants, on cloudy and windless days, and the absorption of excess supply by the grids of other countries, on sunny and windy days. The author concludes that Germany's *Energiewende* is a classic example of the 'unintended consequences of well-meaning intervention into complex socio-technical processes' (Sturm 2017: 46).

The decision to phase out nuclear power from the German power grid by the government of Chancellor Schroeder in 2000 was one of appeasement, intended to secure the political support of the anti-nuclear Green party. Unknown to most analysts, policies protecting subsidies (and jobs) for the exploitation of domestic lignite and hard coal were pursued.

Johnson (2014: 1-2) presents a pessimistic view of Germany's ambitious attempt to wean itself off completely from nuclear energy, while replacing it with alternative energy generated from wind and solar power. The re-orientation of Europe's largest economy has not met with expected results. The goal of the *Energiewende* or turn-around, of making a huge dent on Germany's GHG emissions is no closer; instead the use of coal to tide over decreasing nuclear power inputs into the electricity grid has increased German GHG emissions. The programme has also led to higher electricity tariffs for small and medium enterprises. The reduction of US GHG emissions due to its domestic shale gas boom may now seem paradoxical to Germany's alternative energy programme. The paradox seems even sharper when the US' lack of a comprehensive alternative energy policy, when compared to Germany's abundance of the same, is considered. The reduction of US GHG emissions due to its domestic shale gas boom may now seem paradoxical to Germany's alternative energy programme. The paradox seems even sharper when the US' lack of a comprehensive alternative energy policy, when compared to Germany's abundance of the same, is considered.

The following conclusions may be drawn upon review of relevant literature. India and Germany, both having sizable economies, are both struggling with the dominance of coal. India, unlike Germany, lacks a pronounced commitment towards energy transition. Second, beginning with the enactment of the 2003 Electricity Act and the release of the IEP and NAPCC, institutional support for a change, if not a total transition, in achieving a cleaner energy mix in India.

1.2.4 Gaps in the literature

The dominant literature forms mere footnotes, overshadowed by the debate around strategic energy security fears. Definitions of energy transition provided only, by Smith and Kerr (2008), and O'Connor (2010), offer a wide gap in existing literature. Both authors remain focussed on just technological change while ignoring behavioural changes towards the adoption of renewable energy systems (RES). How can readers differentiate between reform and transition? Another inference from this review is the weight that climate change initiatives bring to bear on the implementation of carbon-control policies on individual countries. A further study into socio-economic factors should reveal the motive into state-backed energy transition. Most scholarly works focus on the historical phases of the transition of several fossil fuels beginning from the nineteenth century. The disruptive power of new technology makes literature, even a few years old, quickly outdated. Further, transition to RE is still viewed in terms of stand-alone systems. Literature on India fails to highlight the need for a central renewable energy law like the EEGs in Germany. Only one article (Goodman 2016) contains a direct comparison of Indian and German perspectives; but it is restricted to dialectical issues regarding the conceptual arguments between climate versus energy policies. The link between coal and renewables is unrepresented in academic works. Instead, reports by think tanks and other research organisations prove more useful in elucidating the challenges faced by RE in India. The literature originating from Germany is rich and succinct, dealing with issues like average power cuts and balancing issues. Despite the expansion of installed RE capacity in India, the Central government has not released any report detailing the nature of operations of the RE sector or the challenges faced it from the entrenched sources of electricity.

1.3 Definition, Rationale and Scope

The study primarily deals with understanding the transition of India's energy policies related to renewables after the release of India's Integrated Energy Plan (IEP) in 2006. Notwithstanding the transitions that have taken place within the field of renewable energy during the course of reform, the study at hand attempts to explain the continuity in policies vis-à-vis coal consumption in India and Germany despite their deep integration with the world economy and active involvement in climate change discussions. Many observers have commented that a comparison between India and Germany represented a 'chalk and cheese' study to describe the asymmetries in their renewable energy capacities.

Glaser and Strauss (1967: 59) state that, "The probability of fruitful comparisons is increased very greatly by choosing different and widely contrasting countries." As they remind readers that the collection of theoretically relevant data overarches the effort of ethnographical research that collaborates a comprehensive work on a specific piece of data. Cross-national comparisons, between India and Germany, will compare data on the most relevant renewable energy policy influencing the outcome of the national economy in the long term. Their Constant Comparative Method of Qualitative Analysis only necessitates a 'saturation' of (relevant) data and not necessarily 'all' data, as espoused by the traditions of analytic induction. One of its main traits is the simultaneous analysis of data during (theoretical sampling) data collection.

However, the concept of transition that has surfaced during the course of formulating the research proposal necessitates further clarification, mainly what is meant by the term 'transition'.

The rhetoric of 'transition' as understood by international agencies and consultants fundamentally confuses and distorts the underlying basis of the process. They tend to view 'transition' as a highly instrumental, top-down image of both the process of change and the nature of control. Nevertheless, the study engages with the term 'transition' in a slightly different way. The diversity of interests and goals involved in the process defy encapsulation under one overarching umbrella. While in India's case, 'transition' is mostly a top-down process, external forces and pressures from the international agencies pose their own problem of autonomy and capacity. Therefore, the 'transition' of the Indian and German power sector is understood as describing a multifaceted process of strategic actions in several fields by state business interests (like COAL India in the Indian case), state bureaucrats, inter-party politics (Green party politics in Germany) and other state actors who are engaged in the process of administering and streamlining state energy policies. The differentiation between 'reform' and 'transition' is often overlapping. It shall be the aim of this study to provide a clear demarcation between the two.

There are policy-relevant reasons behind the pursuit of such a study. First, the transitioning of the Indian power sector, as evident from the inclusion of additional fuel sources, the push for rural electrification etc. has been an integral part of the economic reform program of the government. Thus, a study of the energy transition policies would clearly help us tackle two important questions: How can the portfolio of renewables be raised within the Indian energy mix? What role did coal play in India's economic integration in the past and how will that role develop in the future? Second, government industrial policies are the institutional setting that assists in the determination of the success of energy transition because it defines the legal parameters of the environment in which transition can develop. Thus, studying such policies shall provide not only the background for an understanding of the rationale, process, consequences and the problems of the reform but also a base from which to predict the future development of enterprise reform.

While discussing renewable energy (RE) the study shall be limited to literature and data including only grid connected/utility-scale solar (solar photovoltaics) and wind energy. Yergin (1991: 1003) broadly defines ‘renewables’ as “an inexhaustible and environmentally friendly energy source”. Biofuels are limited to the transportation sector, while tidal (still in its infancy), biomass and geothermal energy are limited in scale. Although biomass still comprises a large component for fuel used in cooking in India, and heating in Germany, it does produce large amounts of air pollution. According to the IEA, biomass use in India is declining rapidly due to government led efforts to replace it with Liquefied Petroleum Gas (LPG) cylinders. In the case of Germany too, gas is gradually replacing traditional fireplaces.

Although the study is limited to the examination of energy policies of Indian energy transition from 2006, this investigation necessitates a comparison with the policies at the beginning of the reform era in 1991, in the case of India, and 1990, in the case of Germany. The year “2006” marks the starting reference point of the study due to the necessity for maintaining the ten-year timeline recommended by the School of International Studies at Jawaharlal Nehru University, New Delhi. However, more importantly, it precedes the climate change discussion of the Bali Action Plan of 2007 and, more significantly, it will assist the researcher in studying the impact of the energy crisis in 2008 on the economies of both developing as well as developed countries; and the subsequent reorientation of their energy policies to include alternative energy.

1.3.1 Research Questions

1. What are the patterns in energy transition among developed and developing countries?
2. Is renewable energy still being viewed as a substitute conciliating global climate change mitigation efforts?
3. What explains India’s commitment to coal as the dominant source of fuel in the production of electricity?
4. What lessons can India learn from Germany’s *Energiewende*?

5. How can grid-connected wind and solar energy challenge other major fuel sources for a larger share of the national electricity grid in both India and Germany?

1.3.2 Hypotheses

Reduction of fuel import dependency and climate change are the reasons for India and Germany's push towards renewables.

Intermittency remains the primary issue inhibiting the wider adoption of wind and solar energy into the centralised grid system.

1.4 Research Methodology

The proposed study is motivated by a puzzle in India's mainstream energy supply: Is a committed transition towards renewable energy, which could challenge the dominance of coal, underway in India? Clearly, therefore, it eschews any one particular theoretical standpoint to start with.

The study will apply the Constant Comparative Method of Qualitative Analysis that is espoused in Barnery G. Glaser and Anselm L. Strauss' Grounded Theory. Their seminal work titled, *The Discovery of Grounded Theory: Strategies for Qualitative Research* in 1967 dealt with the adoption of Grounded theory to depict perceptions concerning caregiving for terminally ill patients in hospitals and the concept of social loss.

1.4.1 The applications of Grounded Theory in a time-bound study

Having sociological roots, this type of a research methodology attempts to generate a theory based on a detailed analysis of data, and is hence inductive in nature. Its four stages involve the collection and analysis of preliminary data, followed by limited interviews. The analysis of these limited interviews allows for a theoretical sampling strategy that allows for more focussed interviews.

Grounded theory is an attempt to close the gap between theory and empirical research; something that the research methods prior to the 1960s, focussing more on overhauling methods than working theory into them, failed at. The focus remains on creating theory, rather than verifying it, from data acquired through detailed social research.

In the words of authors Barney G. Glaser and Anselm L. Strauss (1967: 1) the emphasis remains on "how the discovery of theory from data - systematically obtained and analysed in social research - can be furthered". A practitioner of this form of research does not approach the available data as a *tabula rasa* i.e. an absence of preconceived notions. Instead the researcher already has a perception of what kind of data is relevant to the study at hand, and how can it be applied. The authors explain that studies based on an intensive study of empirical data often conclude with the application of a deductive theory to enhance easily understandable interpretations of the argument. The stress on the verification of facts in logico-deductive theory has blunted efforts at culturing independent arguments based solely on the data generated. A replication of grounded theory will not easily fit into the work of another on account of its uniqueness of interpretative data generated from a different source.

Qualitative data is generally termed to be mere 'impressions' of the researcher (Glaser and Strauss 1967: 15). It is often interpreted as the foundation for conceptual theories and hypotheses. Fact-finding and verification of the concept to conclude the investigation is often left to quantitative research. In fact, qualitative data is constrained by the need to be transformed into quantitative data. Clarifying that their work is not a vilification of quantitative research, Glaser and Strauss challenge the emphasis of the quantitative over the qualitative, on which the generation of a theory and its subsequent verification rely. They welcome every form of data. The authors stress on the practice of minimising and maximising differences in groups from which data is to be collected. These must be performed during the initial phases of data collection. Minimising differences in groups selected for comparative analysis assists in the establishment of categories to be studied as differences become stark. In the same way, the maximisation of differences delineates the scope of study and highlights the properties of each separate category.

Glaser and Strauss (1967: 21) assert that comparative analysis, as a general method may be applied to units of any size. Units do not necessarily have to be large or even the same size. Restriction on the size of case studies will produce repetitive data, evident only in those particular units, while forgoing the element of generation of theory. Theory is assumed to be an ever-developing process. They rely on a discussional form of generating theory. A propositional form of theory-making lends to it a codified element that cannot evolve easily. The formation of either substantive or formal theory is the function of a comparative analysis. Substantive theory includes may include empirical issues like energy management or plant load factors. The latter category may include conceptual issues like energy transition, climate change or energy efficiency.

The process of data collection is known as ‘theoretical sampling’. Geared towards the generation of a theory, theoretical sampling is controlled emerging theory. This study begins by borrowing Glaser and Strauss’ idea of the importance ‘local’ concepts (pg. 45). In their book, the authors research caregiving in hospitals. For instance, a researcher would be aware that a hospital would include the presence of doctors, nurses, assistants, hospital admission policies etc. In the same way, ‘local’ concepts like regulators, policymakers, engineers, technicians, grid-connectivity etc. will be studied to draw out a better understanding of the renewable energy sectors in India and Germany. Facts contributing to ‘theoretical purpose and relevance’ rather than a stubbornness to conform to structural conditions are considered useful at any time of research. They caution against the loss of ‘theoretical sensitivity’. In the case of this study, this could mean a focus on only formal structures and mechanisms (policymakers), backed by official state policies. A narrow focus on state-backed policies and mechanisms could act as blinders, ignoring the operational capacity of renewable energy, the role of public participation or challenges to grid-connectivity. Theoretical sampling, as opposed to statistical (random) sampling, searches for categories and their properties which could equip interrelationships within a theory. A category is a component of theory, while a property is an element of a category. Statistical sampling studies the distribution of certain behaviours or scenarios within specific categories for the purpose of verification. Grounded theory does not assert the compulsion of random sampling to back the results of theoretical sampling. This is vital when measuring public perceptions of the importance of renewable energy.

The simultaneous generation of theory from data works out well in a time-bound Ph.D. course of study, relying heavily on the interpretation of empirical data. However, ideas or concepts may not necessarily have to be sourced from data alone. Even cognitive processes can account for sources of ideas/models, with the caveat that these should be interpreted through data alone. The tendency to verify already established ‘grand theories’ had led to the stagnation of theory generation by the contemporary generation of researchers. These new researchers are mired in a cycle of testing out the theories of superior and established academicians instead of generating new theories. The authors highlight the significance of the simultaneous collection of data, its classification and its analysis. While every investigation does carry with it the performance of all three actions simultaneously, the rigour of verification and description quite often tends to divert consideration of its implications of the generation of a theory.

The first stage of this method involves "comparing incidents applicable to each category.” Every piece of data is coded to obtain as moany categories as possible. The authors pronounce the basic rule underlying this method as, “while coding an incident for a category, compare it with the previous incidents in the same and different groups coded in the same category.” For instance, the introduction of alternative energy policies as a subset of energy conservation measures in Germany and India in the past to showcase trends in energy transition. To prevent overreaching, Glaser and Strauss maintain that coding past incidents are not necessarily required to be put on paper; they can be based on memory.

The second stage is ‘integrating categories and their properties’. The coding of data from every source (literature, conferences, informal interviews etc.) is compiled to compare not incident with incident (in this case renewables’ policy in India and Germany) but a comparison of incidents with the properties emerging from initial incident with incident comparisons. In this study, a shortage of domestic natural gas reserves and reduction of emissions from coal-fired plants could explain India’s push towards renewables. In the case of Germany, the decommissioning of nuclear power plants could be the main point of concern.[2]

The third stage, ‘delimiting the theory’ occurs when reduction is imperative upon the detection of several homogeneities among various categories or their properties. The recognition of similarities signals theoretical saturation, where no new hypotheses may be inferred upon the coding of large volumes of data.

The analysis of systematically coded data gives birth to theory. ‘Writing theory’, the fourth stage, presents the analyst with the dominant *themes* which his study will encompass.

The study also sets out a clear demarcation between the independent and dependent variables. Renewable energy policies are the dependent variable. International climate change discussions and agreements; upgraded renewable energy technology and

[2] Refer to Appendix D for further information on operational and decommissioned nuclear power stations.

processes; and the dominance of coal are the independent variables. However, this study seeks to concentrate on one particular intervening variable - political leadership.

The study would rely on primary as well as published secondary sources. As mentioned earlier, it will be based on a survey of existing literature. The first category, viz. primary source material, consists of White papers related to energy reform, statements issued by various government sources in that connection [the Central Electric Authority, the Ministry of New and Renewable Energy, the Coal Ministry in India and, the Federal Ministry for Economic Affairs and Energy, the Federal Ministry of Economics and Technology and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, reports by the IEA, World Bank, International Renewable Energy Agency (IRENA) and World Trade Organisation (WTO) documents]. Data can also be found in newspaper reports, editorials of major dailies, writings of major leaders, especially those intimately connected with power sector reforms and various other official documents. Structured interviews with individuals from the fields of business, academics and policy-making, possessing knowledge of the renewables sector in Germany and in India, shall comprise another component of this study. Associated with collecting and analysing the archives, an in-depth field research will be conducted in Germany to collect more resources from business organisations, firms, and think tanks.

The insistence on verifying qualitative sources of data limits the scale of acceptable sources. Typically, experiences in the field are recorded as observations, which are in turn verified by borrowing perspectives from established sources of literature. However, this emphasis on verification of qualitative data in some social sciences has led to a push to get into the field. Interviews and fieldwork are given vitality through their perception as portraying the real scenario. Data available in literature maybe shunned as the analyst may feel that his own work may be thought of as unoriginal. Glaser and Strauss (1967: 163) argue that literature from the library should always form the backbone of qualitative research. Toeing this argument, this study shall be based heavily on available sources of literature. The time-bound nature of this study as well as limited financial means curtails the period of fieldwork, especially with regard to the case study, to a limited time scale .

Grounded theory envisages the possession of four fundamental properties. The theory must substantially ‘fit’ the general area being studied; it should ‘understandable’ to an individual not entirely unfamiliar with the concept or theory being discussed; it should be applicable to varied scenarios by being 'general' in nature; and finally, an analyst should establish limited 'control' over the theory so as to include changing scenarios. In the case of 'generality', a diversity of qualitative facts on several situations in the relevant area of research allows theory to contain broad concepts and account for emerging scenarios in the current period (Glaser and Strauss 1967: 237-243).

The authors argue that 'insights' based on prolonged experience in the field should not be discounted as plain opinions. They could act as potential foundations for a methodical formation of new theories (Glaser and Strauss 1967: 252).

1.4.2 Distinctive features of this study

In-text references in this study follow the author-year style promoted by the Research Manual of the School of International Studies, Jawaharlal Nehru University, New Delhi. The SIS style of referencing is not included in referencing softwares like Mendeley or Zotero, and not even in MS Word's own referencing service. The unavailability of the SIS style of referencing makes it cumbersome to use in an era with several accessible, free and easy-to-use alternatives. Additionally, it throws up surprising results in plagiarism check softwares, like Turnitin (commonly used in JNU). The author has faced several instances in earlier drafts when cited sentences were tagged as plagiarised. Here, the only viable remedy was a change in the voice of the sentence or an extensive use of the thesaurus. The SIS Manual states that 'when in doubt, cite – over-citation is better than under-citation' (SIS Research Manual 2006: 11). Typically, a direct quote/s should include the page number within the in-text citation - for example, Janardhanan (2017: 23). This study has extended the SIS Manual's dictum on over-citation to include a majority of the text. The intention to over-cite is borne out of the incompatibility observed within the dreaded 'red highlight' of plagiarism softwares and the technical shortcomings of the SIS style or citation.

1.5 Layout of chapters

The study shall include the following chapters tracing historical patterns of the energy transition and the contemporary transition process. The expansion of renewables in India vis-à-vis the dominance of coal shall be studied. The development of the German *Energiewende* illustrates the challenges faced by renewables against entrenched sources of energy. The political economy of the transition process is analysed along with a need for symbiosis between a national framework and international scenarios. Finally, the findings of the study will be outlined in the last chapter.

1.5.1 Chapter 1: Introduction

This chapter would serve to introduce the main thrust of the research. It will outline the current state of global energy transitions among developing and developed nations. It would discuss the state of existing debates on the issue and would bring out the gaps in the relevant literature therein. It will introduce the methodology, in this case Grounded theory, used to analyse the data collected. The introduction will discuss briefly the histories of the various transitions, to different fuels, that have taken place over time. The idea here is to introduce the concept of energy transition and the urgency in its application to contemporary energy systems. Emphasis will be placed on how previous transitions were efficiency-based while the current transition to renewables is a necessity to limit the effects of climate change. More importantly the section will also recreate the effects that the price shocks of fossil fuels have on bringing renewable energy (RE) back into mainstream understandings.

1.5.2 Chapter 2: Transitioning to a low-carbon economy

This chapter will discuss the current state of affairs in developing and developed countries vis-à-vis renewable energy. Besides issues of finance, the chapter shall study the social and technical issues hampering the dissipation of grid-connected renewables. It shall also serve to highlight the lacunae/benefits of policies adopted to strengthen transition in various countries with different capabilities. This chapter will outline the nature of energy transitions throughout history. Faster forms of mobility and greater speeds in processes of manufacturing led to the first energy transition being characterised as a top-to-bottom change. The contemporary energy transition has also been carried on the legacy of a top-to-bottom application. Competition for a specific sector is rife in every aspect of life. No one fuel dominates any particular sector. However, this transition delineates itself from its previous two lineages. To prove this, the chapter highlight three examples of the RE expansion from countries with varying strengths.

1.5.3 Chapter 3: The Role of Renewables in India's Energy Transition: Analysing the Coal Versus Renewables Debate

It would encompass an analysis of policy decisions taken by India that have an impact on the coal versus renewables debate. An investigation into the institutional decision-making process, along with shortcomings in policy, in India will be included. While all components of renewable energy will be discussed, the focus shall remain on grid-connected wind and solar technologies. Avoiding a deep discussion on the Indian power system due to complicated linkages that will take us away from our main area of focus, this section will outline the basic conditions like capacity and generation and demand. A clear portrayal of all stakeholders in the sector shall be presented, along with an investigation of the Renewables plus Gas option that could significantly balance intermittency within the former; and allow

1.5.4 Chapter 4: Understanding Energy Transition through Germany's *Energiewende*

It will explain the suitability of the German case study in a comparative analysis with the India's renewable energy policies. Germany's *Energiewende* plan will be explored to shape the contours of policy needed to further the range of utility-scale renewable energy in India. The imperative here is to paint a picture of Germany's transition process that began with efforts to reduce import dependencies, then moved on to opposition to nuclear and thermal energy, and finally, its inclusion of climate change arguments in the midst of a sharp demand-induced rise in oil prices and post-Fukushima opposition. The history here begins from the 1970s but the focus will be brief. The basic idea here is to showcase the pattern of energy transition in Germany down the decades.

1.5.5 Chapter 5: Political Economy of the Global Energy Transition process

This chapter will examine the internal and external pressures that determine the positions of the Indian and German roadmaps to energy transition. The stands of both countries' at climate change platforms and their concerns on maintaining a stable, affordable and clean supply of power will be deduced. The role of the International Solar Alliance (ISA) will also be examined. The main point to be examined here is the challenge from energy efficiency measures to the successful expansion of RE capacities in the energy mix. This section shall also analyse the development of the Green lobby and its attempts to woo national governments with the promise of job creation. Furthermore, the global challenges to RE vis-à-vis other conventional sources of fuel shall be examined.

Chapter 6: Conclusion

The implementation of active polices fermenting the growth of stable RE systems catering to large urban (echoing the large proportions of GHG stemming from them) communities will be studied. The two hypotheses shall be tested. This chapter would enlist major findings from the study and provide explanations for the research puzzle which underlies this study.

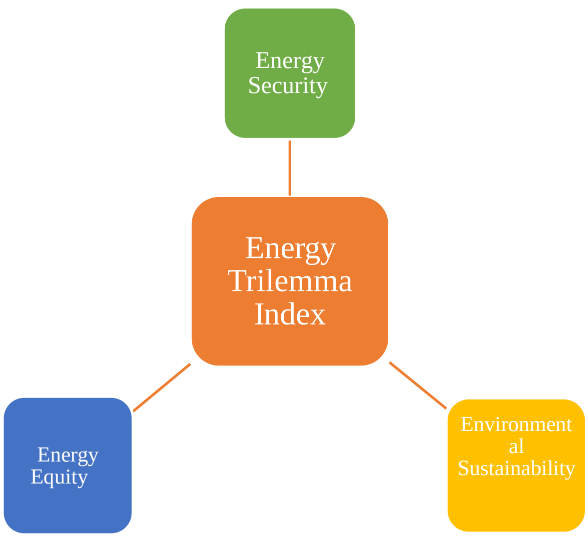
CHAPTER II

Transitioning to a Low-Carbon Economy

The energy system of every industry is vital to the economic development of the country. It is subservient to the needs of the economic configuration of the country. Both structures essentially adapt to the changes in the functions of the global economic system. Natural resources, the fuels consumed by the household, industrial and transport sector, the dynamics of demand-supply in the domestic and international arena collectively influence the energy system of a country. Additionally, two distinct factors – technological improvements and policy formulation exert strong influence on the contemporary energy system (Patra 2017). Popular demands to improve the sustainability of the energy process to create environmentally benign energy system emphasises transition from a high emission to a low carbon economy (Pant 2016).

Initially, countries strived to improve energy security to enhance equitable access to energy. Enhanced energy access would facilitate the attainment of human capital. The introduction of the sustainability factor in developing energy resources compels policy makers to balance all three factors. **Figure 2.1** explains that governments strive to find the sweet spot at the centre of the pyramid maintain the balance while reaching out to give citizens at the bottom of the pyramid equitable access to modern and clean forms of energy.

Figure 2.1 Energy Trilemma Index



Source: World Energy Council, as cited in Federation of Indian Petroleum Industry (2017), *Voice of Indian Oil and Gas Industry*, 16(3): 21.

This chapter outlines the fundamental facets of the contemporary energy transition. As already stated earlier in chapter I (pg. 7), energy transition is not a new process. What makes this particular transition unique is the ingress of the sustainability element in the energy system. The chapter begins with charting the historical processes involved in energy transition. Next it traces the distinct nature of the contemporary transition and follows it up with minor case studies to emphasise its extensive adoption in countries with widely varying socio-political and economic competencies.

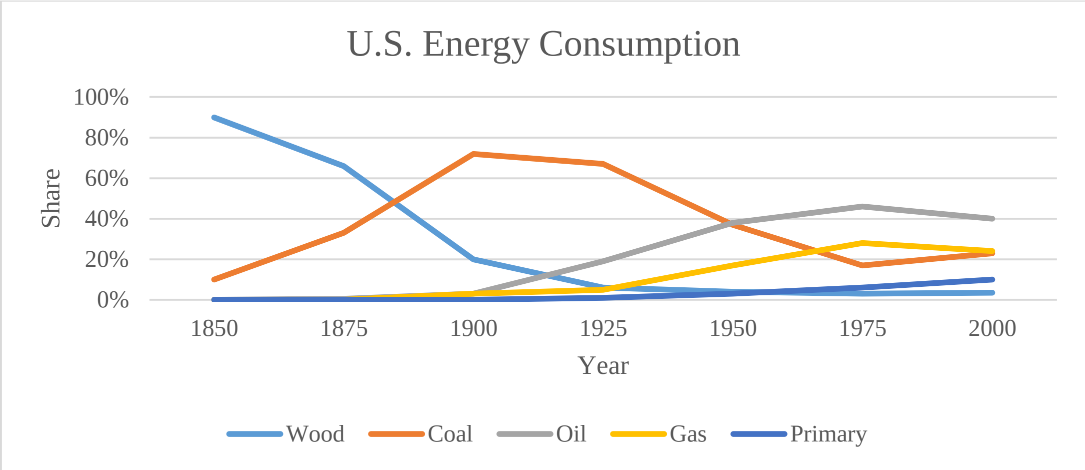
2.1 Conceptual undertones of Energy Transition

Although the US has a mature energy system with an equally mature energy market, the process of energy transition is evident in the changes witnessed within the first country to initiate the first challenge to entrenched fuels like coal and wood. Scholars may argue that the energy transition process in the US was restricted to changes in the production and consumption of fossil fuels; European influences in the 1960s gradually overcame the US' reluctance to adopt renewable technologies. However, early US experience was negative given the shortcomings of the emerging technology (Yergin 1991). The US, with its scientific advances and early discoveries of the uses of new energy resources, presents readers with a perfect example to understand the historical background of the contemporary energy transition.

O'Connor (2010: 2) defines Energy Transition as, "a particularly significant set of changes to the patterns of energy use in a society, potentially affecting resources, carriers, converters, and services." The patterns of energy use primarily includes the process of the conversion of 'energy resources' like crude oil, coal etc. to 'energy carriers' like petrol or electricity, which in turn power 'energy converters' like tube lights and motor vehicles .

The replacement of wood with coal and coal with crude oil and natural gas are the first two phases of energy transition. These transitions were first noticed in the U.S. economy **(Figure 2.2)**. Around 1885, wood, the dominant energy source for centuries was replaced coal. The expansion of military infrastructure during the World Wars propelled oil and gas to the largest share of US energy consumption. However, unlike the earlier transitions of the 1800s, the switch to hydrocarbons was less pronounced. The diversification of the U.S.' energy mix led to the entrenchment of specific fuels in certain sectors (O'Connor 2010). Coal moved out of the home heating sector to dominate the power generation sector. Likewise, oil came to dominate the transport sector.

Figure 2.2 U.S. Energy Resources by Share



Source: O’Connor (2010: 8).

Unlike earlier times, where a fuel captured a market share of more than 75% in all sectors, contemporary resources have limited diversification by catering to a particular sector. Energy resource transition has a deeper impact on climate change than transition of energy converter. The converter, which is wholly dependent on the resource used, might emit little or no carbon emissions. Energy converters while improving services may also lead to an improved quality of life (Yergin 1991).

The kerosene lamp is an illustration, rather a testament, to the greater efficiency that can be achieved by tweaking the energy converter instead of changing the energy resource. Whale oil has been replaced by kerosene, but the oil lamp has undergone several upgrades, lasting longer than the change to the energy resource it consumes. This condition could facilitate a switch in energy converters (to LEDs or CFLs) in off-grid areas, leaving the energy resource untouched.

A change in energy resources would not have as resounding an impact on patterns of usage as new energy converters. If coal or gasoline were to be taken out of the equation then demand for alternate fuels would drop owing to rising costs of alternate fuels.

Energy resources that were being gradually phased out have been provided a renewed life through the introduction of electricity. Monetary aspects determine fuel choice.

Electricity can overcome fuel-switching and improve the quality of life at the same time.

The high cost of low-carbon fuels should not as act as a deterrent as the benefits obtained from switching energy converters is advantageous. Modern energy converters may control increasing demand for electricity. It must be noted that O'Connor fails to consider additional cost of energy converters.

Competition and replacement transform energy resources into dynamic entities that initiate 'minor transitions', which eventually give rise to larger ones. Today the role of several resources and carriers has morphed; coal contributes greatly to power production; oil, while losing to electricity as a resource for lighting, dominates transportation (replacing electricity in a role reversal).

While energy converters or energy resources may change gradually, they are both dependent on demand for energy services. The demand for energy services is constant. The resources and converters used to provide these services though are subject to technological and market forces. Over the years, energy converters might have changed more often than the resources they are supplied with on account of improved performance in efficiency. According to O'Connor (2010: 15), 'the resources used do not *necessarily* change'.

O'Connor (2010: 16-21) goes on to outline four factors that determine the popularity of an energy resource or energy converter in energy transition. *Supply constraints* is the first factor. It is exclusive to energy resources; when a particular resource fails to meet with increasing demand. He illustrates this through the example of the stagnating share of hydroelectricity within the US power supply system. Expansion of hydroelectric infrastructure continued well into the 1960s but its share in the total US power generation decreased to 16% by 1974, down from its peak of 32% in 1949. Though demand for electricity has increased exponentially, the levels generated from hydropower have continued to stagnate along the same level.

O'Connor (2010) also cites the decline of geothermal energy, the dominance of coal over firewood in the UK, and of kerosene over whale oil in the nineteenth century as other examples of supply constraints in energy transitions.

Cost advantages incorporate the tangible cost of the resource as well the cost of labour, energy converter costs and costs associated with other economic aspects. The fickle figures for nuclear and solar energy in the US and the takeover by natural gas in the home heating business are a few examples.

The shift from wood to coal in the early US railway system is a good example.[3] Wood, though abundant in the rural interior, was found to be scarce within the urban junctions. This scarcity was reflected in increasing prices. Around the same time the price of coal fell from the range of $7-$10/tonne in the 1830's to less than $1/tonne in the 1860s. Wood (1979: 79) however, contends that the fall in coal prices led to its replacement of wood within the US railway system.

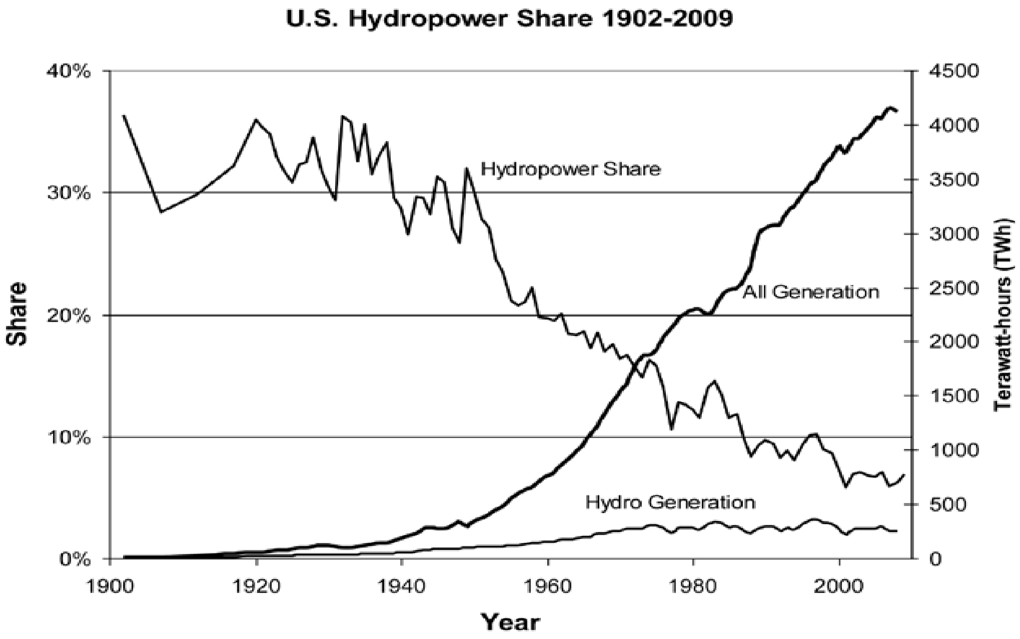
Performance advantages comprises features that may be implied, dependent on individual choices and behaviour, and not necessarily included within actual costs. 'A subset of cost advantages', they are closely linked to improvements in energy converters. The debate between performance and efficiency in the transport sector is a classic example. Luxury and military assets prefer the former.

Policy decisions may include initiatives taken by a government that have an impact on the provision of energy services or the adoption of a particular energy resource or converter. Dedicated railway lines transporting coal, carbon emissions tax, subsidies promoting new energy technologies, the politically driven oil supply crises in 1973 and 1979 are examples.

Often stemming from performance advantages, technology has often reversed immediate and local environmental drawbacks by 'externalising' them. Dealing with the larger issue of climate change would require government intervention in the form of policy decisions to create a transition. Minute transitions in energy converters led large scale 'energy resource transitions'.

[3] White, John H. (1979). A History of the American Locomotive: Its Development 1830–1880. New York: Courier Dover Publications.

Figure 2.3 Hydropower Share of U.S. Generation



Source: O'Connor (2010: 17).

The adoption of technologies and practices that reduce carbon emissions into the atmosphere, when ignited by environmental concerns, necessitates the intervention of the state machinery. The decline of the share of hydropower in the US' power generation from a high of over 35 percent in the 1940s to a low of below 10 percent in the 2000s highlights public concerns regarding inundation of land and threats to power generation during sustained drought years **(Figure 2.3)**.

Of all the components of energy transition, energy services are the most perceptible to the consumer. The author divides energy services into five spheres - *heating*, *transportation and mechanical power*, *light*, *cooling*, and *information*

Increasing demand for the provision of energy services induces a gradual change in energy converters. Advantages in performance have proven to be the key in this process. Savings in labour costs complemented with state backed initiatives promoting natural gas reduced the dominance of coal in the heating sector.

In 2010 of the total energy consumed in the US, 27% was directed towards the transport sector while lighting consumed 6% (O'Connor 2010: 29).

Over the last century, the US has witnessed the growth as well as decline, and sometimes, the revival of various energy resources. The country saw the growth of nuclear energy from a mere 6% of total electricity generated in 1974 to a solid 20% in 1988. Further hopes of growth were dashed by falling coal prices and the difficulty of replacing older thermal power stations, as well as the mounting public apprehension in the aftermath of nuclear accidents.

Natural gas is presented as an illustration of a ‘delayed transition’ (O’Connor 2010: 32). The term is indicative of the versatility of an energy resources. Many fuels that lost ground to others on account of performance and cost advantages reversed the trend by finding new markets, enabled by transformations in energy converters. Unlike oil, that had penetrated deeper and less accessible rural markets as a source of light, natural gas dominated the urban centres of production. Their short-lived dominance in their respective markets ended with the entry of electricity. Coal, which had been pushed out of the field of lighting by natural gas, was found to be an excellent resource for the production of electricity; natural gas, in turn, was a cleaner substitute for coal in the field of heating. The invention of the internal combustion engine provided a new lease of life for oil which has come to dominate the global transportation sector.

The upward trend of per capita consumption of energy, primarily due to increasing individual incomes in a manufacturing economy begins to wane as the very high levels of personal income are reached, with the economy beginning to streamline itself as one oriented towards the provision of services (O’Connor 2010: 33).

In his conclusion O’Connor (2010) says that a noticeable improvement in the quality of life can be gauged, but only up to a certain point, if it is accompanied with increasing use of energy; but a continuous trend of increasing consumption of energy, while being highly inefficient, does not contribute greatly to human welfare.

2.1.1 Soft Energy Paths – balancing the influence of technology in the transition process

Schelley and Banerjee (2016: 1) argue that technology is acknowledged to form an intrinsic module of the energy transition debate. Indeed, its contribution is primary factor for the successful transition from fossil-fuel systems to clean energy systems. In formulating the concept of ‘soft energy paths, Amory Lovins (1976) argues for the study of the socio-political impact of a switch to alternative energy systems. The urgency of energy transition places emphasis on environmental exigencies rather than social, economic and political factors.

This emphasis on choosing an environmentally benign energy technology often ignores two important factor – politics and practice. As we shall see later, in China's case, it was the national government, pressured by international criticism and limited local unrest that spurred the tilt towards renewable energy. The authors argue that delinking energy technology choice from fire-brand environmentalism, the strain of which is most visible in the US, guarantees success. Energy technology choice, if put forward as a political decision rather than an environmental decision, is far more acceptable for adoption by the general public. This recognition as a political choice, in turn, shows the effects on human habits and social structures resulting from economic and infrastructural changes brought on by alternative technologies.

In response to the argument for the application of fossil fuel reliant technologies, where allied system for power generation and transmission were highly centralised, in developing nations, Amory Lovins (1976) proposed an alternative to this 'hard path'. The inflexible hard path was devoid of consideration of any environmental and socio-political implications. The 'appropriate technology movement' encompassed the alternative 'soft path' approach suggested by Lovins (Yergin 2011). Lovins argues that technologies should be viewed as a supplementary to politics as it defines the social set up of a community in terms of access to resources, knowledge etc. For example, mine owners and not miners belong to a higher social hierarchy. The control of technology enables a higher social standing.

Soft path energy technologies share five distinct characteristics: they rely on energy flows; they are varied and decentralised; they are easily adaptable to local conditions and a higher skill set is not a precondition for their operation; they are limited to genuine human needs; they are highly adaptable to suit the energy needs of individual consumers. But this path fails to account for the spiralling demand for energy and a higher, but healthier, standard of living.

Lovins (1976) criticises the impersonal transmission of electricity by those with specialised skills, belonging to a higher class, who define prices and supply of energy unilaterally. This highly debateable argument stems from the fact that the contemporary energy system made society highly dependent on a centralised decision making framework. Distortion of priorities, increased bureaucracy and the concentration of power in the hands of a few are all the accompanying aspects of a hard path.

Lovins (1976) insists on the cultural incompatibility of both paths. One stresses the fulfilment of material needs, the other focusses on the universal access to energy as a basic right.

The debate on energy transitions excessively focus on the environmental context. It is missing the social critique proffered by proponents of the soft path. As opposed to the traditionally humanistic approach to energy transitions, contemporary approaches form concentric arguments around the cleaner emissions of renewable energy technologies. The benefit to uplift or breakaway from societal barriers is neglected. Schelley and Banerjee (2016: 4) argue that the influence of dominant players of the fossil fuel era has remained intact on account of their control of technology and critical infrastructure. The most damaging components of the current transition, mining and siting, continue to remain in the interior; staffed by communities on the fringe. This division of resources increases the opposition to energy transitions, where local rural communities are exploited for the benefit of the urban population – to mitigate pollution caused by the latter in the first place.

The authors state that current literature's obsession with only the environmental aspects of energy transitions and its enabling technologies is misplaced. Economic and geopolitical which delegate responsibility for shouldering mitigation measures according to share of emissions are assumed to be a subset of environmental issues. Lovins (1976) is criticised for failing to consider the issue of transition induced job loss or challenges to national security. Of a more direct concern would be pattern of ownership. For example the dominance of western technology in the renewable energy sector could have increased Indian concerns surrounding the supply of foreign technology for its domestic market. At the same time, energy security concerns have increased the use of coal in India's energy mix.

Schelley and Banerjee (2016: 6) argue that such a myopic assumption surrounding renewable energy technology transitions considers only large centralised generation and transmission systems feasible. Decentralised community driven projects provide participants with a degree of autonomy and a distinct self-identity that makes them self-reliant.

2.2 Changing Trajectory of the contemporary Energy Transition

Frogatt (2010) argues that the oil spill following the Deepwater Horizon disaster in the waters off the Gulf of Mexico in 2010 has accentuated the risks involved in the exploration of areas considered highly hazardous for even highly developed technology. Beyond the urge to acquire larger sources of fossil fuels lies the urgency in the knowledge that current global reserves of energy, while at their highest, will be unable to sustain the high standards of living that have become commonplace in a globalised world. The same urge to prospect in hazardous conditions has also led several societies to begin the process for a 'transition' to non-conventional energy systems. Speculations arise, not around the 'need' for a transition, but more importantly on the performance of systems, untested on a larger demography, with a slow rate of absorption into a nation's energy basket.

Frogatt (2010: 36) believes that the introduction of non-conventional energy systems into the mainstream will have the same effect as that following the introduction of coal, and later oil, into the global economy. It is this "third industrial revolution" that will form the bedrock of political debates into the economic effects of the replacement of fossil fuels with non-fossil fuels for the coming three decades. The author cautions against the alacrity into forming a knee-jerk reaction to the tragedy of Deepwater Horizon. Indeed, there are several similar wells operating around the world with reasonable success. Consensus has to be garnered in addressing not the issue of prospecting in dangerous territory for what the author terms "frontier energy resources", but more specifically on the predicaments that might push players into taking such high risks.

The *first predicament* deals with the depletion of global oil and gas reserves. While the reserves of oil produced are being exhausted at an annual rate of four percent, the current reserves of produced natural gas are being consumed at a tad higher rate of five percent per annum. Expending such copious amounts of energy, at a rate never before witnessed by history compels energy producing nations to release greater reserves of energy into the market. Frogatt (2010) argues that at the current rate of demand, Saudi Arabia, the world's largest oil producer, will have to reach full production capacity or 'come on stream' every three years. In the case of Russia, the world's largest producer of natural gas, it will have to come on stream every twelve years. Increased outputs by producing countries will prove to be a logistical nightmare for energy companies.

Larger outputs may lead to a glut in the market. The fear of a global glut may deter energy producing nations from increasing outputs. This vicious cycle may lead to short term approaches to remedy price differences while concealing the fact that counter-reactions will only serve to delay the inevitability of shortage.

High energy prices for conventional fossil fuels have tempted energy producers to expand their activities to sourcing non-conventional fossil fuels that are found in oil or tar sands, shale rocks and at extremely deep oceanic depths. Yergin (1991) also argues along the same lines, that energy companies, be they private or government-owned, will always have a tendency to gain and hold on to different sources of oil and gas. The fears of depleting reserves, stronger competition, and the hopes of high energy prices during geopolitically shortages induces companies to maintain large reserves of oil and gas.

The *second predicament* facing the energy industry is the sudden surge in the demand for energy by emerging economies. The expanding markets of especially China and India has created an unanticipated strain on the provision of several services in these countries, services that are the norm in developed countries. The author presents the example of China's demand for energy, which alone is comparable to the energy consumed by all of the European Union annually.

The *third predicament* is the string of climate change agreements, agreed upon globally, that quicken the pace of a transition towards a low emission society by 2050. Prevalent thinking among energy companies may be extract and sell (or hold) as much reserves as possible before alternative energy technologies come into play.

The author fails to account for the difficulty in the application of alternative technologies to burgeoning energy demand to maintain a two degree limit on the rise of temperature above preindustrial levels is difficult to achieve. Climate change commitments on the part of fossil fuels have been achieved through the enforcement of energy efficiency measures. This is mere tweaking as opposed to enacting a widespread change to the current energy system.

The author cites Bloomberg Finance's research on the more than six fold increase of investments in alternative energy sources from 2004. This increase in financing has been complemented by the 39% growth of installed new installations of renewables in Europe. Wind power has been growing faster than any other energy source. The author goes on to say that the idea that the growth in renewables could stave off the tightening supply of fossil fuels seems implausible; neither will it be able to introduce a massive cut in carbon dioxide emissions. Kerr (2010) raises similar suspicions on the capabilities of renewables to shoulder the burden of global energy supply.

Renewable energy technologies may themselves fall prey to supply chain bottlenecks that may arise due to the larger adoption of these technologies. These technologies are heavily dependent on rare earth metals. The prevalence of these elements is far more constricted than those of others.

The adoption of renewable energy technologies is economically delicate to energy companies as they possess high investment costs, and their technology is susceptible to intermittency and unproven in larger contexts. Players making the first move into renewables will face higher costs. The article also throws light on the adjustments that other businesses will have to make to accommodate high energy cost and potentially unstable energy supplies. Those adopting the 'just in time' business model, that assumes a stable and continuous energy supply, might be compelled to reorient their approach to logistics. The Boeing Aircraft Company, for example, sources its components from around the world. The 'just in time' model cuts off the need to add storage capabilities and thus keep costs down.

The challenge of maintain stable energy supplies that have become a prerequisite for a robust economy is further complicated by the introduction of climate change mitigation mechanisms requiring the same robust economy but with lower energy consumption. Nations will have to rework their views on energy security in the face of the requirements of a low carbon economy. The process of attaining secure supplies of foreign energy will be reduced to strengthening domestic institutions.

2.2.1 New priorities for Global Energy Transition

Smil (2015: 36) examines the feasibility of a total replacement of fossil fuels by renewables. Energy transition is not a new phenomenon, but the rapid transition since the nineteenth century is. By 2015, fossil fuels supplied 86% of the world's energy needs.

It was believed that nuclear energy and hydropower would shoulder the burden of global energy supply, but environmental concerns in their respective fields has dampened popular opinion. Renewables supply a mere 3% of the world's electricity.

China, which has tremendously increased the installed capacities of solar and wind energies, sourced just 2% of its power from renewables in 2014.

Smil (2016: 194-195) casts a pessimistic view of the ascendance of renewables, plagued with problems of intermittency, through the substitution of fossil fuels. The process will be long drawn, spanning several decades. As of 2015, the concentration of carbon dioxide in the atmosphere reached 400.83 ppm as opposed to 315.97 ppm in 1959, the inception of the Mauna Loa measurement. The Mauna Loa measurement measures carbon dioxide emissions. Since 2000, wind and solar energy have increased by about 22% and 37% respectively. But as of 2015, they contributed less than 2% of the energy generated.

He contends that smaller transition, from wood and coal to oil, in the larger context was achieved quickly at the national level. The discovery of natural gas quickened this process, especially in the Netherlands. But generally, transition at the global level has taken a fairly longer period. While the contribution from oil and natural gas increased rapidly in the second half of the twentieth century, coal still contributed 30% of the global primary energy. The competition between various fuels is so strong that no one fuel will achieve a dominance over others.

While international climate mitigation agreements have accepted the ‘possibility’ of the 2 degree Celsius scenario, Napp et al. (2017: 1) investigate the ‘plausibility’ of the same. They argue that contemporary scenarios overestimate the rate of deployment of current low-carbon energy technologies. Historically, the average rate of deployment of new energy technologies was a static 20% per year. Energy systems scenarios also overestimate the rate at which fossil-fuel systems will transition to low-carbon systems. The rate of deployment and the transition of fossil fuels systems form the key indicators of understanding the 2 degree Celsius limit, and of global energy transition as a whole. Taking into account several historical constraints to the 2 degree Celsius scenario the authors argue that a 2.1 degree Celsius scenario would be a much more acceptable limit. Their views are quite similar to that of Frogatt (2010) and Kerr (2008) but differ in the sense of the plausibility of a transition

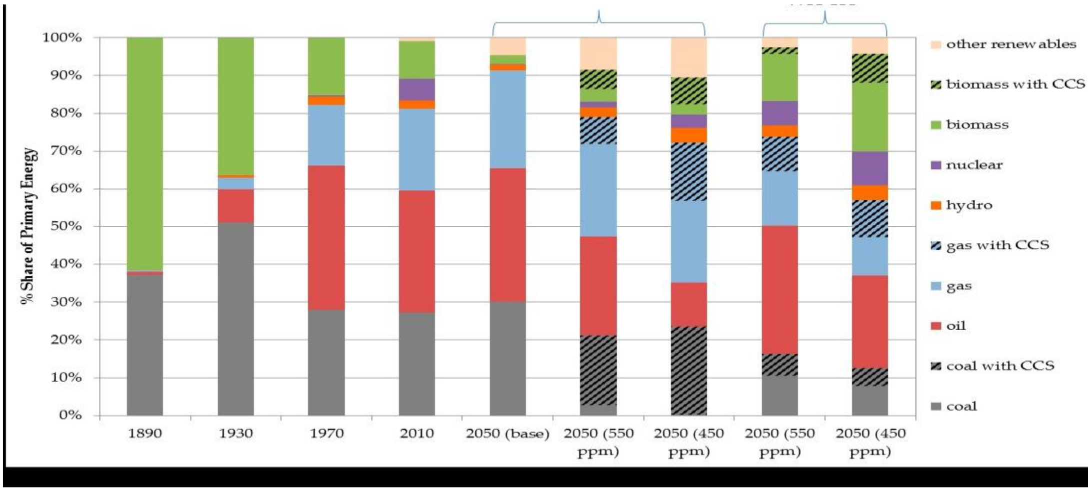
The reports of the Intergovernmental Panel on Climate Change (IPCC) were most expedient in clinching the support of the scientific community by convincing it of the ability of low-carbon scenarios in carbon emission mitigation. The studies by the IPCC adopted the energy systems model that integrates the effects of greenhouse gases on the environment. This model utilises a least cost optimisation scenario which in turn is welfare-oriented. The paper argues that such scenarios must have constraints, bereft of climate change induced limits, applied to them to analyse their true potential plausibility.

Napp et al. (2017) present reviews of literature containing the application of economic models to analyse primary energy demand to determine historical changes in their use. They also present readers with data from economic models like WITCH (A World Induced Technical Change Hybrid Model) by Bosetti et al. (2006) and MESSAGE (Model-based decision support in energy planning) by Messner and Strubegger (1999). The two models differ from each other regarding cost of technology, cost of supply of fossil fuels, storage of carbon capture and storage (CCS), and change in energy demand and use. The authors compare projections in data guided by scenarios considering the period till 2050 as the timescale and atmospheric GHG levels between 550-450 ppm CO2e (parts per million of carbon dioxide equivalent).[4]

According to these projections primary energy use of fossil fuels will outweigh that of other fuels for the next forty years. In the 450 ppm scenario, low carbon energy systems like renewables, biomass and CCS will increase their share of the energy mx, rising from 10% in 2010 to 50% in 2050 **(Figure 2.4)**.

[4] Based on data from the Intergovernmental Panel on Climate Change (IPCC) Data Distribution Centre the rate of atmospheric CO2 concentrations in 2008 were measured at 385 ppmv (parts per million volume). Online [Online: web] Accessed 12 January 2018, URL: http://www.ipcc-data.org/observ/ddc_co2.html

Figure 2.4 Historical, current, and projected mix of global primary energy at 40 year intervals



Source: Napp et al. (2017: 3)

In their review of literature, the authors cite the works of Eom et al. (2005) and Van der Zwaan et al. (2013)[5]. The former argues that in a 2030-2050 period and a 450 ppm scenario, countries may opt to pursue a nuclear programme if regional mitigation efforts fall short. Depending on the level of mitigation initiatives the establishment of 27-103 nuclear power globally per year is a possibility, with 103 as an "unprecedented" figure. The deployment of solar energy could grow by 50-360% over the annual figure of 3-4 GW in 2011. It is important to understand that this rate has increased tremendously in the last decade. Zwan et al. (2013) argue that with sustained global mitigation initiatives following a period of inactivity until 2020 (a delayed response), the annual deployment of 150 GW of wind and solar energy between 2030 and 2050 could be pursued. Readers should bear in mind that the rate of deployment is dependent of other factors like the available technical skill financing, the availability and state of infrastructure and most importantly, the availability of the source of energy itself.

The IPCC's Fifth Assessment Report (AR) acknowledges that integrated models used to predict the feasibility of mitigation pathways present unfeasible scenarios when contributing factors and their corresponding constraints are ignored. Riahi et al. (2015) further this debate by arguing that political and social issues may impede the

[5] Van der Zwaan, B.C.C. et al. (2013), " A cross-model comparison of global long-term technology diffusion under a 2_C climate change control target", Climate Change Economics, 4, 1340013. As quoted in Napp et al. (2017), "Exploring the Feasibility of Low-Carbon Scenarios Using Historical Energy Transitions Analysis", Energies, 10(116): 1-37.

dissemination of new energy technologies, but they may also be accelerated on specific issues like pollution control.

Smil et al. (2010) and Gruebler et al. (2012) argue that the change of individual energy systems like coal, oil and gas took decades to grow **(Table 2.1)**. The former argues that new technologies begin with a 5% share of the market and take decades (between 40 to 130 years) to capture market share. The latter argues that the development of low-carbon systems slowed considerably in the mid-1970s. This slowdown is attributed to the economies of scale which came into play. The networks of then prevailing energy systems was very large. Technological innovation in low-carbon systems did not keep up with that of fossil fuel-intensive systems. The authors, however, fail to take into account the role played by energy conservation programmes following the 1973 oil shock. The comeback of coal and cheap oil in the 1980s also had a major role to play in the limiting the interest in low-carbon energy systems, mainly renewables (Yergin 1991).

Table 2.1 Time for coal, oil and gas to achieve given shares of total global energy supply

Fuel	**5% - 25% Global Share**
Coal	35 years
Oil	45 years
Gas	55 years

Source: Smil et al. 2010. As cited in Napp et al. (2017), pg. 4

Kramer and Haigh (2009) claim that the growth of new energy systems follows two ‘laws’ that contribute to the growth of energy technology development. They state that the introduction of new technologies is met with ‘exponential’ growth measuring 26% annually for the first few decades. This is followed by a decline in growth when that specific energy technology reaches the global stage where only 2-4% growth can be achieved due to the size of the existing energy network and the difficulty of adopting new energy technologies.

Iyer et al. (2015) performed a study of the historical trends in the growth of low-carbon energy technologies in France, Denmark and the Netherlands (**Table 2.2)**. Nuclear energy grew at an average of 11% per annum. The discovery of the massive gas fields at Groningen in 1959 led to the rapid growth of gas in the Netherlands. Efforts to diversify the primary energy mix, the antagonism towards nuclear energy coupled with the historic presence of wind energy enabled Denmark to achieve high growth rates of the same.

Table 2.2 Rate of growth of technologies and energy resources in rapid energy transition examples

Country	Fuel	Rate of growth
France	Nuclear (PWR)	19% per year (1977–1997), maximum rate 9 GW per year (1980)
Denmark	Wind	20% per year (1977–2008)
The Netherlands	Gas	5% of primary energy in 1965 to 50% in 1971

Source: Iyer et al. (2015). As cited in Napp et al. 2017, pg. 5.

Napp et. al. (2017: 5) outline several challenges to the 'take-up' or adoption of low-carbon technologies that could facilitate energy transition. The high sunk costs of a coal-fired power plant might deter decision makers from lowering its profit. The popularity and dominance of a particular energy system might lead to a 'technological lock-in' where costs of development or limited skill prevent new innovation from gaining traction. High capital costs and few co-benefits could also deter investment. Co-benefits may also be described as additional benefits. For instance, laying a lawn over a dusty patch of ground may require large amounts of water. The newly laid lawn will beautify the surroundings as well as prevent dust from it getting into the air.

The authors argue that socio-technical energy transition (STET) models are alternatives to the energy systems models that include social, cultural, political and economic factors within their scope. Energy systems models are unable to consider these non-technical impediments to energy transition. STET offers a multi-disciplinary approach to analyse the interaction of these factor so as to predict the feasibility of particular pathways. However, it is this multi-disciplinary character of STET that is criticised on the basis of a bias towards qualitative narratives by supporters of quantitative analysis.

The authors consider historical energy transitions in order to better understand impediments to the feasible development of pathways to energy transition. They aim to achieve a scenario where a 2 degree Celsius limit by the year 2100, stipulated by global climate change mitigation forums, can be achieved. They create two scenarios including constraints within the framework. The first involves restricting average annual growth rates of the supply of low-carbon technology to the historical 20%. The second scenario involves constrains place on the growth of solar and wind energy, with the addition of increased coal usage. Under these constraints, it was noticed that only a 2.1 degree Celsius temperature change was achievable.

However, while espousing the inclusion of historical constraints in predictive models, the authors also caution readers against the shortcomings of historical transitions. One, they are not linear and short-term growth of specific technology using a particular energy resource is noticeable. Co-ordinated efforts by all stakeholders can cut across non-technical barriers.

Secondly, energy systems models capture largely technical, and some economic, constraints while ignoring socio-political constraints. Thirdly, contemporary predictive models show only energy supply-side aspects of impediments. The success of the penetration of energy efficient energy systems among end-users could retard energy demand. While supply-side shortage of resources are included in projections, demand-side shortages like lack of skilled personnel and the availability of rare earth elements are not accounted for. Napp et al. (2017) conclude their work by stating that the planned transition to low-carbon energy systems will necessitate the reduction of fossil fuel usage and the faster deployment of their technologies, at a rate never witnessed in human history.

2.2.2 Faster dissemination of a Global Energy Transition: The emergence of a dedicated renewables approach

Unlike earlier transitions or even the current fossil fuel-dominated energy systems which were and still are to a great extent limited to national or regional frameworks, the most recent transition is taking place at a more faster pace; the fast pace being deliberate. The hazards of climate change traverse national boundaries making it imperative for all big nations to adopt RE technologies. Transition in smaller less developed nations have emphasised more on the threats to the future of secure energy supplies.

Initially, RE emerged as an alternative to the supply-constrained conventional sources of energy in the 1980s. This discussion underwent a drastic transformation in light of increasing security of supply in the late 1980s. In the 1990s, renewables had come to represent the concept of sustainability – targeted at greenhouse gas emissions. Today renewables have come to represent an assortment of several goals consisting of a diversified economic component, greenhouse gas mitigation, environmental protection and energy security (Aguirre and Ibikunle 2014: 374). IEA (2010) data reveals that the global deployment of renewables over ten years until 2009 was recorded at 165.4%. This deployment is concentrated in developed nations and has still not dissipated largely among developing nations. Coal-fired power still accounted for 40.9% of total power generation[6].

Aguirre and Ibikunle (2014) argue that several factors account for the disparities in the deployment of renewables. They cite Marques et al. (2010)[7] who argue that the factors that determine renewable energy deployment are classified into three categories – political, socio-economic and country-specific. Political factors, otherwise known as policies, include feed-in tariffs, obligatory allocations, R&D and investment subsidies etc. Socio-economic factors include income and energy generation. The third factor, country-specific, includes renewable energy potential.

Of these three factors, Aguirre and Ibikunle (2014) argue that political factors are the most crucial component of renewable energy deployment. The cost factor separates the internal benefits like environmental concerns and the externalities of fossil fuels. To create a level playing field subsidies are crucial to renewables. These subsidies will also account for environmental benefits. Similarly, the taxing of GHG emissions is another component of increasing the competitiveness of renewables. Together, these policies can increase the cost of fossil fuel power generation and lower the price of renewables to foster a larger trend towards RE-based power generation.

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[6] IEA (2010), *Energy Prices and Taxes*, OECD Publishing, Paris. As cited in Aguirre and Ibikunle (2014: 374).

[7] Marques, A.C.,Fuinhas,J.A.,PiresManso,J.R. (2010), "Motivations driving renewable energy in European countries : A panel data approach, *Energy* Policy, 38: 6877–6885. As cited in Aguirre and Ibikunle (2014: 374).

Menz and Vachon (2006)[8] suggest five policy instruments – Renewable Portfolio Standards (RPS), Fuel Generation Disclosure Requirement (FGS), mandatory green power option (MGPO), public benefit fund (PBF) and retail choice (RET). Aguirre and Ibiunle (2014) extend Marques et al. (2010) definition by positing several determinants within their three factors.

I. Political factors:

a. Public Policy: While R&D initiatives comprised the majority of policy instruments within the broader policy framework of the 1970s, quotas and trading certificates were the main policy instruments of the 2000s. With the passage of time, policies become more complex; thus, increasing the difficulty in assessing their influence.
b. Institutional variable – ratification of the Kyoto protocol: Abiding by international commitments – in this case, the Kyoto protocols of 1997 – is a positive influence on the deployment of renewables.
c. Energy security: If import dependency is large, the need to diversify the energy basket is much more critical. In this scenario, the deployment of RE is greater because of the positive influence on the overall energy security of the country. However, environmental concerns are a greater influence than import dependency.

II. Socio-economic factors:

a. Carbon dioxide emissions: Public concerns surrounding the dangers of high carbon dioxide emissions have a positive effect on RE deployment.
b. Prices (oil, natural gas, coal and electricity): Tighter regulations on fossil fuel-based GHG emissions lead to the introduction of efficiency measures or RE sources in power generation. Low capital costs but high maintenance requirements make this determinant a mixed bag. High electricity rates because of new RE investment and emissions tax are a negative influence.

[8] Menz, F.C.,Vachon,S. (2006), "The effectiveness of different policy regimes for promoting wind power: Experiences from the states", Energy Policy, 34: 1786–1796. As cited in Aguirre and Ibikunle (2014: 375).

c. Welfare: The authors posit that the economic status of a country greatly affects RE deployment. This is true in the case of developed countries, which have a higher proportion of RE deployment than developing nations.
d. Contribution of traditional energy sources to electricity generation: Nations with a high proportion of fossil fuel-based power generation infrastructure are under pressure from lobby groups. This has a negative effect on RE deployment.
e. Energy needs: High energy consumption in a heavily populated nation often has a negative effect on RE deployment.

III. Country-specific factors:

a. Renewables potential: Higher the potential for RE generation, higher is the chances of RE deployment.
b. Deregulation of the electricity market: A deregulated market could promote energy efficient technologies as well as renewables. However, it may also promote fossil fuel sources of energy because of their cost advantages.
c. Continuous commitment: Investment and R&D subsidies are crucial to establishing economies of scale for RES.

In 2010, the total electricity produced from renewable sources was estimated at less than 21%. Renewables possess higher fixed costs than their non-renewable counterparts do. This is further complicated by long lag periods in generating revenues and longer periods to generate profits. Zhao et al. (2013: 888) list out six policy instruments vital for the development of RE generation. (1) Investment incentives (2) Tax incentives (3) Feed-in tariffs (4) Voluntary programs (5) Production quotas (6) Tradeable certificates.

Complementary polices like incentives for the acquisition of capital goods during construction and tax incentives in the sale of the final product may effect a faster development of renewable electricity generation. However, if the policies clash or even overlap then the effect diminishes.[9]

Policies promoting RE production mainly focused on R&D. In 1982, only 20 countries had such production polices in place. With growing energy demand, the focus on actual electricity generation from renewable sources led to the introduction of the first taxes and incentives in the 1990s. By 2012, more than 120 countries had RE policies in place

[9] For instance, duties imposed on the import of solar panels, wind turbines and blades in 2018 only increase the capital costs of project developers because of the inability of domestic Indian manufacturers to meet high demand.

(Zhao et al: 894). In conclusion, the authors state that “policy crowdedness” led to the weakening of the effect of RE policies. (Zhao et al: 896).They also argue that governments must focus on increasing compatibility between RE policies and regulatory mechanisms.

Liu at al. (2018) analyse seven policies introduced to develop of renewable energy generation in China. The introduction of the “Notice on Carrying out the Pilot Work of Carbon Emissions Trading” in Shenzhen in June 2013 was the first step in establishing a carbon emission trading market in China. The increase in fuel costs wold lead to a change in fuel sources and/or practices.

A year later, the “Measures for the Assessment of Renewable Energy Generation Quotas”, similar to the Renewable Portfolio Standards of the US and India’s Renewables Purchase Obligations (RPOs), was introduced by the NDRC. Furthermore, the “Notice on Improving the Policy of Onshore Wind Power and PV Power Grid Benchmark Price” was introduced in December 2015 to increase the competitiveness of renewables. Several local governments have introduced investment subsidies that will reduce the generation costs of renewables.

A carbon tax, like the one imposed on coal in India[10], is expected to be introduced only in 2020 because of issues surrounding the rate of the tax. A carbon tax is considered to be an indirect stimulus that, unlike subsidies, reduces the financial burden of the government.

The paper studies multiple renewable energy-related polices, whether direct or indirect, as a “framework” for the growth of “renewable energy generation policy”. Direct polices improve the competitiveness of renewables vis-à-vis conventional fuels. Indirect policies on the other hand target the use of coal and emission reduction in power generation.

Liu et al. (2018: 331-332) create a framework of renewable energy generation policies into direct and indirect policies **(Figure 2.5)**. Direct polices include renewable portfolio standard & green certificate trading, electricity price subsidy for renewable energy and, technology R&D subsidies for renewable energy. Indirect polices include Carbon Tax,

[10]Rs. 400 per metric tonne of coal.

the elimination of backward production capacity, optimization of industrial structures and, a pollutant discharge permit system.

i. **Renewable Portfolio Standards (RPS)**, which establishes a compulsory obligation for the transmission and distribution streams to source renewable energy in power production, was first conceptualised by the United States' Environment Protection Agency (EPA) in the 1990s.

   Green Certificate Trading is an example of a policy instrument that complements RPS. The sale of green certificates by renewable energy producers to thermal power producers allows the latter to meet the requisite RPS, while avoiding the payment of heavy fines. They also bring in vial financing for renewable energy producers.

ii. **Electricity Price Subsidy** for renewable energy balances the massive disparities in the operational costs of the thermal sector and renewable energy firms. With three times the operational costs of the thermal sector, the benchmark price of renewables in China is two times less than that of its rival. This has compelled the Chinese government to subsidise the gap in the benchmark price between the two sectors.

iii. **Technology R&D Subsidies** are offered by the central and provincial governments to ease the financial strain of researching new renewable energy technologies.

iv. **Carbon Tax** was first introduced in the 1990s in Finland to discourage the use of coal – a negative externality – by increasing its purchase price. However, this policy instrument is laden with socio-economic repercussions with the 'environmental protection tax law' still being debated within the government.

v. **Elimination of backward production capacity** involves the closure of small and inefficient thermal power units. The vacuum will be filled by renewable energy.[11]

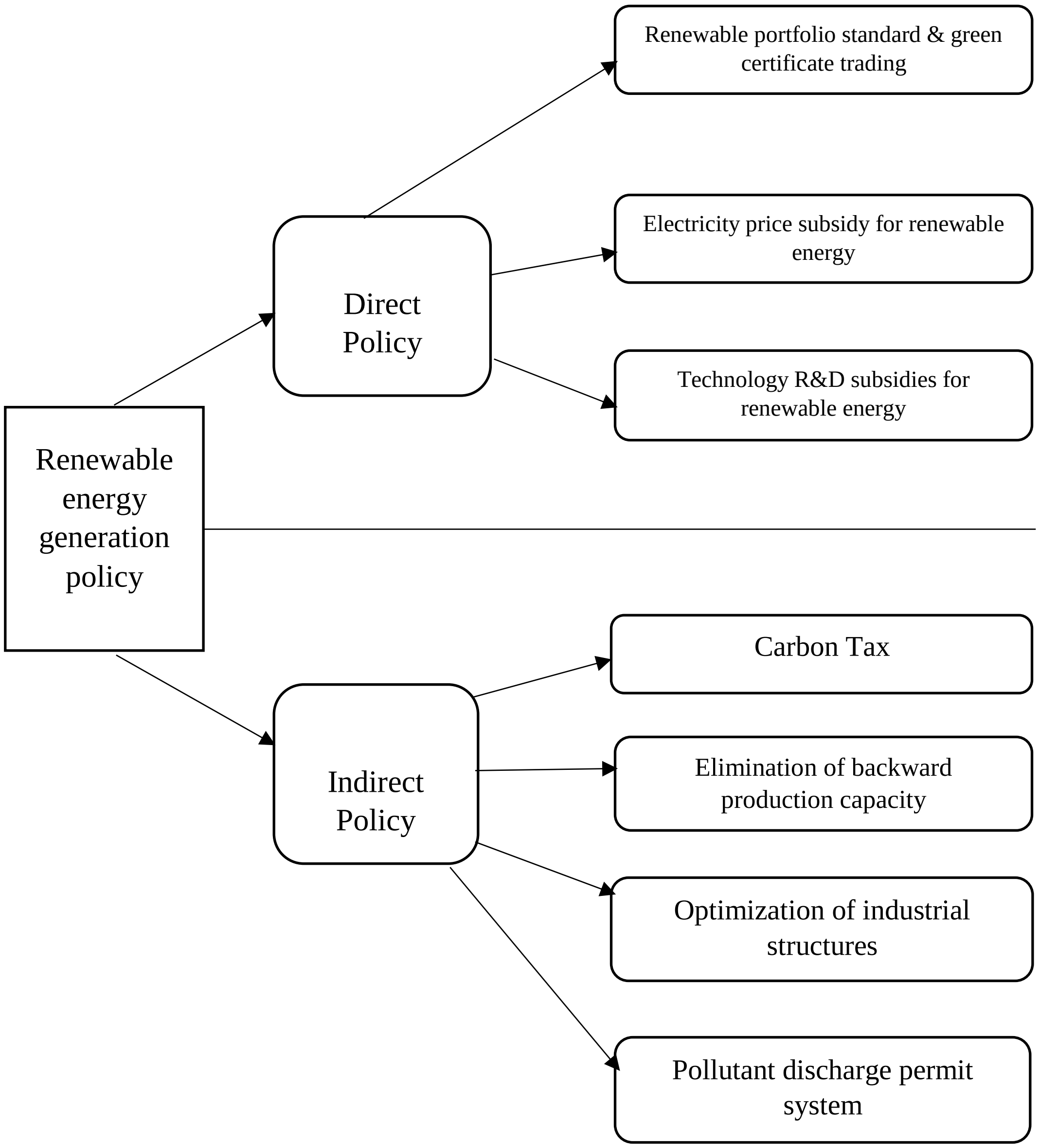
vi. **Pollutant discharge permit system** created by the government charges thermal power generation units a high fee to secure the same. Like a carbon tax, this policy instrument also leads to an increase in electricity prices.

The authors argue that the severe air pollution experienced in China's urban spaces is the principal reason behind the formulation of renewable energy generation policies. Among all the seven policies, the authors argue that a carbon tax and a strict pollution discharge permit are the most effective mechanisms to develop renewable energy generation capacity. However, their implementation will translate into an increase in electricity prices.

RPS and the elimination of backward production capacity create a void in capacity that can be filled with renewable energy systems. These are "milder" policies providing the government with minor social benefits. Both R&D and electricity price subsidies increase the financial burden on the government, although the latter is more effective in combating emissions.

[11] Old units with less than 200 MW capacity are retired or forcibly shut. The latter receives compensation. To encourage voluntary closures, the government pays lower on-grid tariffs to these units (Lo 2015). See section 2.3.2.2.

Figure 2.5 Policy framework



Source: Liu, et al. 2018, 332.

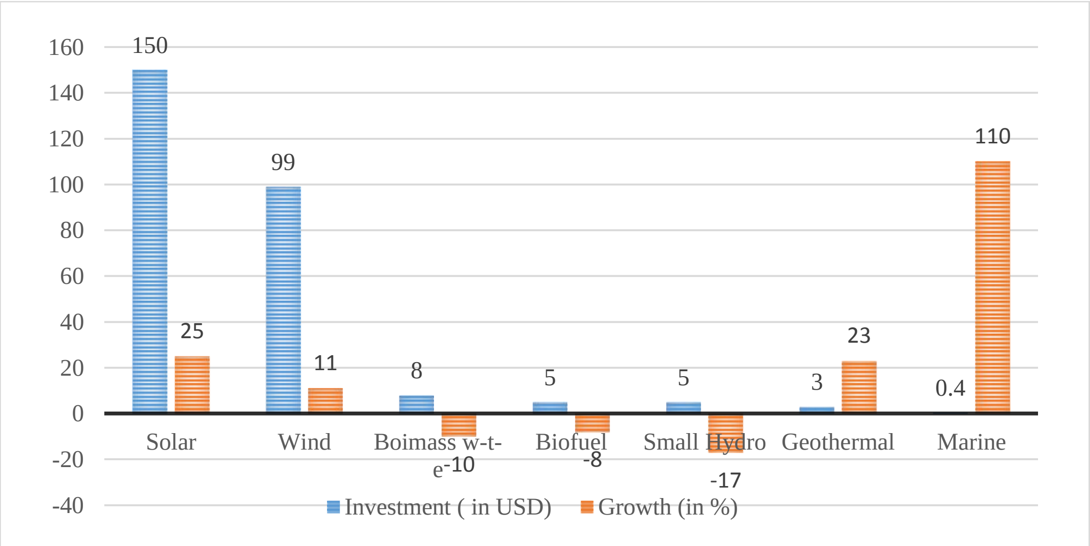
RE deployment is a good indicator of the level of commitment that a nation has for the development of sustainable environmental policies. They argue that initial investment into the RE sector is essentially a political decision on account of the lobbying by environmentalists as well as the nuclear and the oil and gas sector.

Secondly, its characteristic as a ‘hot policy issue and public interest has ensured a target-oriented approach for RE deployment by the EU. One of these targets insists that member states should ensure renewables achieve a 20% share of gross final energy consumption by 2020 (Cadoret and Padovano 2016: 261). The authors suggest that increased energy use in a booming economy is met through by fossil fuels as they are easy to import and have more flexible capacity, particularly their ramp-up rates. This leads to a decrease in RE consumption. However, the expanding economy also leads to an expansion of the energy basket to include RE.

2.2.3 Ascendance of Solar and Wind power

This section will outline the histories of these two RES beginning from the 1973 price shocks and the failure of these two technologies to emerge independently due to cross-sectional motivations. It will then look at their emergence in the 2000s, first in the midst of flat crude oil prices, and then as an afterthought to the 2008 demand shock. It will include the influence of falling costs and increasing capabilities to supply larger proportions of clean energy through grid-connectivity.

Figure 2.6 Global new investment in renewable energy by sector, 2014 compared to 2013



Source: UNEP, Bloomberg New Energy Finance. As quoted in KPMG (2015: 6).

Figure 2.6 indicates the complete dominance of solar and wind energy in attracting investments among all RES. China – the global leader in investments – directed almost ninety percent of investments into grid-connected infrastructure. Wind energy received over US$37.9 billion in investments in 2014; it indicated a rise of over 30 percent over the past year. China created a world record 21 GW capacity for wind power in 2014. This is much larger than a combined 5-year figures for wind power capacity growth in India since 2015. In 2014, the solar sector received about US$30 billion in investments; a 20 percent increase over 2013. Here too, the investment patterns reflected those of the wind sector. Among the European nations, Germany followed the U.K. regarding investments in offshore wind projects (US$11.4 billion) [KPMG 2015: 9]. Investments in Germany's solar sector fell by half in 2014 because of the contraction of FITs paid to small-scale projects and the imposition of a self-consumption charge that was introduced in August 2014. Offshore wind saw more investments – S$8.2 billion in 2014 – echoing the dominance of wind over solar in Germany.

In 2002, out of the total installed capacity in India comprising 17 GW, renewable sources contributed 0.34 GW or just about two percent. In 2014, this figure climbed to 31.7 GW (12.5%) of renewable capacity out of a total installed capacity of 250 GW. The article traces the expansion of solar and wind technology capacities in India (Nagamani et al. 2015: 1205). India's push for access to energy for all citizens, its commitments at international climate change platforms and its massive dependence on foreign energy imports have convinced policymakers in India of attempting a transition to renewable energy sources.

Wind power in India is mainly harnessed through the use of the wind energy conversion system (WECS). A variable-speed WECS is more popular than its fixed-speed counterpart due to the former's ability to adapt to low-maintenance asynchronous generators, better quality and faster power output. However, a majority of India's wind turbines are old and inefficient. In the case of solar, the import of wafers for the construction of photovoltaic cells defeats the objective of energy independence (Nagamani 2015).

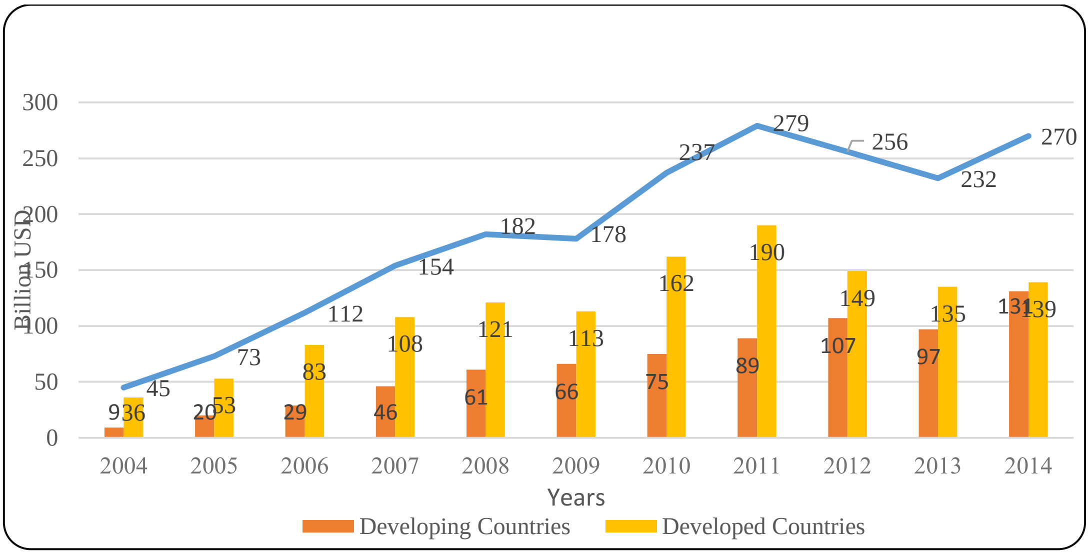
2.3 Energy Transition in a national framework

Several countries like France the Netherlands and the United States have recorded lower emission figures. Others, like China, have recorded large RE installed capacities. It will closely examine the impacts of grassroots movements. The idea here is to lay the foundation of the defence of Germany as a case study for the framing of appropriate policy and implementation.

This section will consider limited two case studies restricted to one developing and developed country each.

Figure 2.7 underscores rising investments made by developing countries in their nascent renewables sector. In 2013, China alone accounted for more than US$83 billion in investments among developing countries. The figure leads analysts to believe that developing countries will soon possess greater renewables capacity than their developed counterparts. The slight dip in investments from 2011 to 2013 reflects the emerging US-China trade dispute at the WTO. In 2014, China invested more than US$40 billion in grid-connected renewables (KPMG 2015: 4). The total investment figures for 2014 (US$270 billion) was larger than investments made in expanding capacities for conventional sources.

Figure 2.7 Global New Investment in Renewable Power and Fuels, Developed and Developing Countries, 2004–2014



Does not include investment in hydropower > 50 MW.
Source: KPMG (2015: 6).

2.3.1 The Dutch Socio-technical Energy Transition

Smith and Kern (2008) argue that gradual, albeit long-term, changes in various social processes encompassing socio-technical systems within occur due to the development of the latter. Together, they lead to broad-based transitions.

It was the Ministry of Economic Affairs (EZ) which undertook the lead, as the transition manager, to develop linkages between businesses, towards an energy system that was sustainable – the energy transition project (ETP). However, as energy companies are the most dominant players in this field, the ETP is threatened by the dominance of old actors. The establishment of a dialogue with stakeholders has highlighted the need for official support for the regulation and financing of experiments.

Funded by a combination of private investment and public subsidies, the ETP also receives part of the profits from the export of Dutch natural gas.

Partially fused with the R&D sector, the ETP has failed to establish permanent linkages with the national policy on renewables. The latter has been criticised as too fickle. The closure of the feed-in-tariffs scheme within three years of its inception is a case in point. The non-closure of the country's only nuclear plant (supplying 4.1% of total electricity generation) to meet carbon emission reductions targets, was made independent of the ETP. Although the Dutch government has committed to increasing the share of renewables within the energy mix to 9% (from 6% in 2005), a total integration of 'regular' energy policy with the ETP remains elusive.

Social change is neglected in favour of top-down technological innovation, stemming from the heavy involvement of players from the arena of business. This leads an ignorance of the social aspects of transition, like energy conservation. The paper suggests that changes in lifestyle are not included in debates on energy transition.

While the influence of the present energy regime may have a strong influence on the transition process, the influence of the latter is negligible. They rue the fact that, "the energy transition process is perceived to be carried out as an 'elite-driven process' of regime incumbents with vested interests" (Smith and Kern 2008: 4100).

The liberalisation of the Dutch energy system has led to limited investment in increasing peak capacity to stave off supply disruptions as private players are more focussed on achieving returns in a highly competitive European electricity market.

While studying the challenges to the transitions approach, the authors outline four main obstacles to the political realisation of socio-technical change. The first is the risk-averse strategy adopted by all participating actors to achieve perceptible outcomes. The transition process is long-term; placing institutional players at the risk of public pressure that might not obtain the long-term benefits.

The implementation of policies for maintaining a 'level playing field' may backfire on the government as private players, in search of long-term contracts, fear that commitments made by the former may not be robust.

Choice of stakeholders is the fourth obstacle. Regime actors have proven records while the entry of new actors may not pan out. Regime actors, backed by large financial resources, have come to dominate the debate on ETP; and may prevent structural change. The fourth dilemma is the thin line between controls (sticks) and incentives (carrots). Controls are needed to goad regime actors to implement structural changes, but they risk being bureaucratic.

In 2006-07, the Netherlands had a low share of renewables when compared with other European countries. Verbong and Geels (2007) do not criticise policy makers for the low share of renewables. Instead, they argue that consumers, utilities, firms and special action groups have an equal say.

The authors seek to explain the breakout of transitions by explaining the socio-technical regime, at the meso-level, using the multi-level perspective (MLP). The MLP comprises of three levels – (a) network of actors and social groups (b) formal, normative and cognitive rules that guide the activities of actors and, (c) material and technical elements. The first comprises households, utilities, government ministries, big industries. The second comprises of laws, regulations and standards. Electricity grids, power production capacity and other technical aspects comprise. The authors argue that dimensions, unique to each of them, restrict each of these levels. Incumbency may create selfish motivations in the first. The stability provided by regulations leads to ignorance of advances outside of the purview of players. Existing technologies gain permanency as sunk investments (Verbong and Geels 2007: 1026).

At the micro-level, 'niches' acting as 'incubating rooms' require protection from a limited group of interested actors (usually pioneers and inventers); seeking to protect the new from the dominant and incumbent technologies. The enlarging of this protective circle through social networking could possibly lead to a wider adoption. The lesser of the two levels seek to influence the slow-moving and entrenched 'socio-technical landscape' at the macro-level. It is only when the relationships between all three levels are bolstered that new technologies or practices gain popularity.

Pre-1973, the Dutch government struggled for influence within the traditional electricity regime, dominated by regional utilities. Attempts at establishing a fledgling domestic nuclear industry were frustrated when these regional utilities conducted nuclear research independent of that of the government's, with one of them even purchasing a nuclear plant in Germany.

The discovery of natural gas led to the creation of a national monopoly involving the Dutch government and private oil companies. Supply of gas was restricted to heating in buildings and households, a very niche field that generated high profits for the government. Only the introduction of gas-fired turbines to tide over peak load demand opened the way for traditional utilities to source gas, thereby replacing coal gradually in the 1970s. Households and industry had very little say in policy discussions.

Unlike other oil importing countries, which sought to reduce oil dependency in the wake of the 1973 oil shock, the Netherlands, as outlined by the Energy White Paper of 1974, chose to increase the proportion of expensive imported oil within its fuel mix. According to the government, natural gas was a strategic resource, invaluable in a future crisis. Another caveat was that all final decisions regarding the use of various fuels in power stations as well as the acquiring of foreign nuclear plants were to rest with the Ministry of Economy Affairs. Energy efficiency and diversification were encouraged.

The 1984 Chernobyl disaster put an end to government efforts to increase nuclear power within the fuel mix due to large scale public opposition. 1989 was a major turning point in electricity reform in the Netherlands with the implementation of the 1989 Electricity Law.

With the creation of the Electricity Distribution Company (EDC) the production and distribution aspects of electricity was separated. Four new EDCs came into being; these were also allowed to produce electricity along with industrial firms.

The diffusion of efficient Combined Heat and Power (CHP) plants was planned through liberal investment rules as well as reduced natural gas prices for producers. Because of these measures, the number of CHP plants burgeoned, leading to overcapacity in the grid. Only in the 2000s was this over-expansion arrested by high prices of natural gas, competition from international players and falling consumer revenues.

Only with the inception of the Maastricht Treaty in 1992, which espoused deregulation, privatisation and liberalisation, did the government limit its direct interference in the electricity establishment. The introduction of a new Electricity Law in 1998 created an electricity regulator, allowed industries and households to choose suppliers independently, and made way for the privatisation of EDCs.

Advertisements by EDCs to improve their public image and exemption from the energy tax (1996) gave ‘green electricity’ parity with ‘grey electricity’. Feed-in-tariffs for domestic producers were introduced to stem the increase in imported renewable energy. However, these were soon lowered drastically once the burden on the exchequer increased (Verbong and Geels 2007: 1027-1032). Interference by electricity utilities at the research phase of wind turbine trials distorted research goals, which eventually led to its failure in the 1980s.

Environmentalists gradually come to oppose wind energy by viewing them as blots on the natural landscape and terming them 'bird-shredders'. Utilities view them as unreliable due to changing wind patterns, which may damage the stability of the established grid.

Featuring as a feasible renewable energy option in the Third Energy White Paper of 1995, the initial excitement surrounding photovoltaics (PV) was dampened as soon as it was realised that PV sourced electricity was expensive.

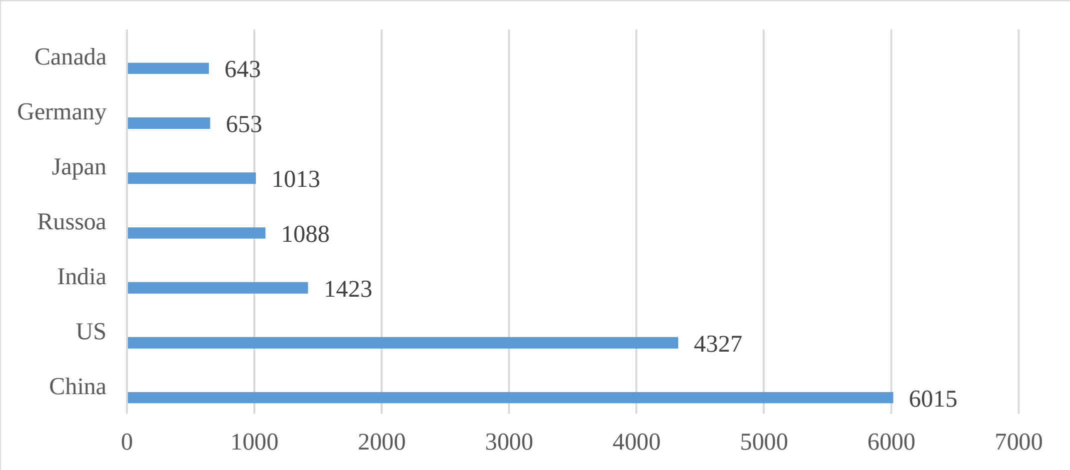
Niche-innovation projects like PV or wind turbines share non-linear pasts. Initially both were perceived positively but enthusiasm died down once their cost-inefficiency and unreliability were taken into account.

The authors argue that all players interested in energy transitions do so because of its potential to increase environmental efficiency. This only goes to prove a dilution of the altruistic character of the transition's climate change goals (Verbong and Geels 2007: 1033-1035). The co-firing of biomass and coal shows more feasibility, albeit not far-reaching on the climate change front, as it can work on available infrastructure. The authors believe that "major shifts to new systems" will not necessarily pave the way towards sustainability. Instead, they advocate a combination of improved gas turbines, carbon dioxide sequestration, clean coal technology etc. They suggest that massive investments and favourable state policies towards what they term as the "radical options" will be hazardous owing to scepticism about their mass adaptability.

2.3.2 China's inclination towards renewable energy

According to Zhao (2016: 449), since 1996, China, possessing the world's second largest installed capacity for power generation, is the world's second largest power generator. In 2011, China outpaced the USA to become the largest power producer in the world **(Figure 2.8)**.

Figure 2.8 World's leading Power Generators in 2017

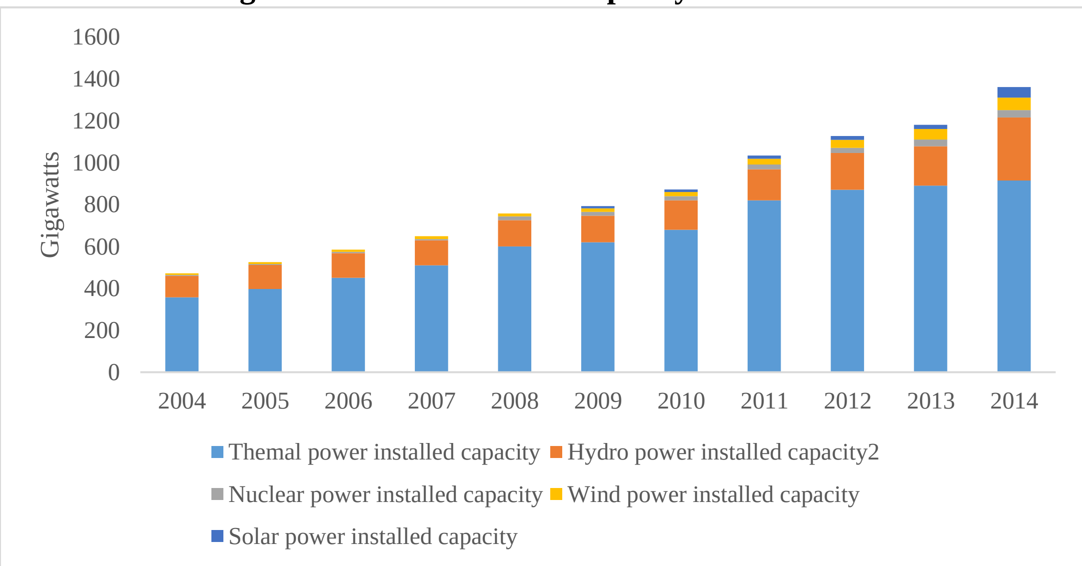


*All figures in terrawatt hours (TWh)

Source: Atlas Data Brand Equity Foundation. As quoted in Sushma, U. N. (2018), "India is now the world's third-largest electricity producer", *Quartz India*, 26 March 2018, [Online: web] Accessed 18 November 2015, URL: https://qz.com/india/1237203/india-is-now-the-worlds-third-largest-electricity-producer/ .

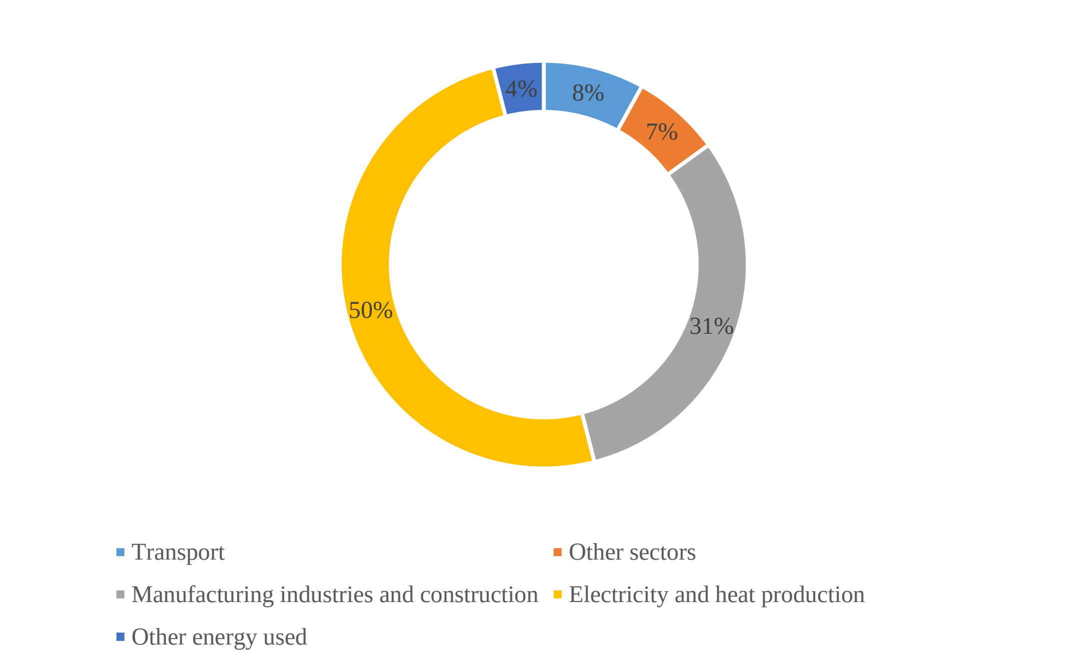
In 2014, as indicated in **Figure 2.9** the total installed capacity in China was an estimated 1.36 TW (1360 GW). Out of this, thermal power generation – mainly coal power capacity – consisted of 0.91 TW (915.69 GW). Thermal power came to consist of 70 percent of total installed capacity and 75 percent of power generated by 2014. Zhao states that, "the high scale of production in China, have in turn brought serious environmental externalities" (Zhao 2016: 449).

Figure 2.9 Power installed capacity mix in China



Source: Zhao et al. 2016: 449.

Figure 2.10 Carbon dioxide emissions of various sectors in China (2014)



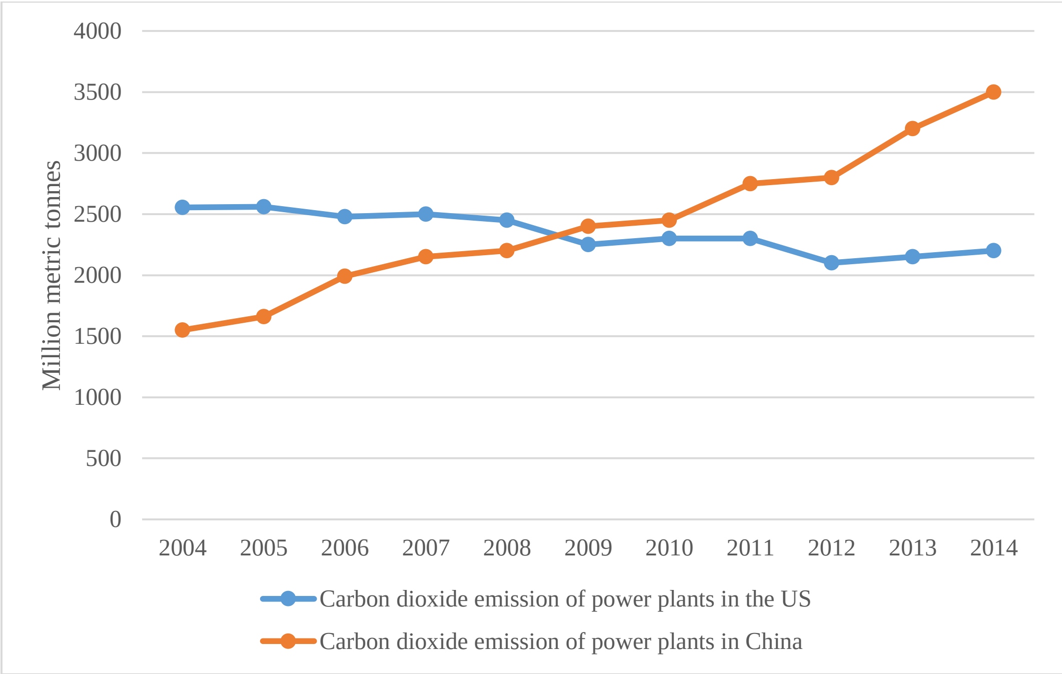
*Note: Other energy used indicates energy consumer by the oil and gas industry;

Source: IEA (2014); NBS (1978–2014). As quoted in Zhao, Xiaoli (2016), "Issues in Greening China's Electricity Sector" in Song et al. (eds.) *China's New Sources of Economic Growth: Vol. 1: Reform, Resources and Climate Change*, ANU Press, pg. 451.

Figure 2.10 highlights China's emission China's power generation industry produced half of the nation's total carbon dioxide emissions in 2014. The 11th Five Year Plan focussed on the expansion of desulphurisation technology. The author claims that desulphurisation measures have halved sulphur dioxide emissions from 13.2 million tonnes in 2006 to 6.8 million tonnes by 2014. Effective emission standards in thermal power plants were addressed through the Thermal Power Plant Air Pollution Emission Standards GB13223-1996 and up to GB13223-2011. The enforcement of these measures has led to a 23 percent decrease in industrial dust emissions from the thermal power industry in 2014. At its peak, the thermal power industry generated 39 percent of the total dust emissions recorded in China (Zhao 2016: 451).

In 2009, Chinese power plants surpassed the carbon dioxide emission levels produced by power plants in the USA. The author, in **Figure 2.11**, suggests two reasons for this scenario. At 5,650 TWh in 2014, the Chinese power generation industry produced 1,770 TWh of additional power when compared to levels produced by its US counterparts. Secondly, coal-fired power plants comprised a larger share of China's power generation infrastructure. Only 40 percent of the US' power production industry comprises of coal-fired plants when compared to the 75 percent of coal-fired capacity in China (Zhao 2016: 452).

Figure 2.11 Comparison of carbon dioxide emissions from Chinese and American power industries, 1998–2014



Source: EIA (1998–2014); China's carbon dioxide emissions are calculated using data from NBS (1978–2014, 1998–2014a). As quoted in Zhao, Xiaoli (2016), "Issues in Greening China's Electricity Sector" in Song et al. (eds.) *China's New Sources of Economic Growth: Vol. 1: Reform, Resources and Climate Change*, ANU Press, pg. 453.

The power industry has historically been regarded as an ancillary of other industries like iron and steel - a "means to an end". This misrepresentation has led to inadequate and inefficient management of a vital sector (Zhao 2016: 459).

The Chinese government implemented tariff increases twice in the last decade to contribute to the application of pollution control measures in the power sector. In 2004, the government increased the price of power RMB15/MWh. The tariff rise in 2013 was RMB8/MWh. These tariff increases were termed as 'pollution increases'. The Ministry of Environmental Protection (MEP) is a key stakeholder in the power generation debate (Zhao 2016: 465-66). The regulation of environmental norms for the power industry is based largely on command-and-control regulation (CCR). However, the influence of market-based reforms (MBR) and government subsidy (GS) are steadily eroding the dominance of CCR.

Zhao (2016: 472) argues that the dominance of coal-fired plants in China's installed capacity makes the Chinese power industry extremely 'energy and emission-intensive'. The author attributes reforms in the sector and environmental regulations as key contributors in the strengthening of energy efficiency measures. China lacks a carbon dioxide emissions allocation for power producers. This is critical for investors in large-scale power production projects.

2.3.2.1 The Role of Techno-nationalism in developing China's renewable energy capacities

According to Kennedy (2010: 909), the rapid increase in the share of renewables in China stems from the Chinese leadership's reliance on techno-nationalism to outline pragmatic pathways of development. However, this conviction is not inflexible if challenged by the country's economic alliances. At 117 GW capacity, hydropower comprised the entire spectrum of renewable energy capacity in China in 2005. Political support, in the form of the Renewable Energy Law of 2005, has led to the growth of the capacities of wind, solar and biomass to 70 GW in less than a decade. China is the world's leading wind energy producer with 63 GW capacity in 2012. Renewables and nuclear energy comprised 94% of the growth of Chinese power generation capacity in 2012, leading to the stagnation of coal and gas-fired infrastructure. Nine percent of China's power demand was met through non-fossil fuel sources in 2012. The growth of RE is a step towards the realisation of the twin goals of climate change mitigation and energy security. Reduction in GHG emission gradually leads to the diversification of energy sources along with the reduction of import dependency. However, China's transition to a larger share of RE is exceptional for two reasons. The growth of RE notwithstanding, China's reduction of import dependency has transformed into a reduction of imports foreign technology. The use of subsidies and domestic regulations to preserve the predominance of Chinese companies in the domestic market has obstructed the entry of foreign entities China has accentuated caution in permitting the entry of foreign technology in the RE sector as this would counteract with Chinese moves on self-reliance, a traditional Chinese trait stemming from the colonial period.

The paper highlights the blend of China's quest for technological independence as a pursuit immersed in nationalism, which is termed 'techno-nationalism' (Kennedy 2013: 909-910).

The term 'techno-nationalism' was coined by Robert Reich in 1987 in opposition to foreign attempts to undermine the US economy through exports of goods based on US technological innovation. He defined techno-nationalism as actions to 'protect future American technological breakthroughs from exploitation at the hands of foreigners, especially the Japanese.'[12] Reich's definition has been absorbed by several national contextual explanations for the preservation of technological and economic independence.

Richard Samuels defines techno-nationalism as "the belief that technology is a fundamental element in national security, that it must be indigenized, diffused, and nurtured in order to make a nation rich and strong."[13] The term emphasises technology as an enabler of national power in an anarchic global order, Secondly, techno-nationalism has come to encompass the importance of two distinct features – competition and collaboration.

The importance of technological innovation in the development of a highly industrial society in China was recognised in 1995 through the adoption of 'science and technology' as a core area of interest. S&T was implemented within the country's higher education system (Kennedy 2013: 913).

In response to the sluggish pace of this grassroots-level process, the Chinese government released the The National Medium- and Long-Term Plan for the Development of Science and Technology (2006-2020), known by its acronym – MLP. The MLP prioritised clean energy, and the need to apply it on a commercial scale, to bridge the gap between energy demand and supply. At a time when several developing nations, including India, were clubbing hydropower with renewable energy, the MLP chose to delink it from energy sourced from solar, wind and biomass. Hydropower, a Mao-era pillar symbol of development, has faced considerable opposition from citizens.

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[12] Robert Reich, ''The Rise of Technonationalism,'' The Atlantic (May 1987), p. 62. As quoted in Kennedy (2013: 911).

[13] Richard J. Samuels, Rich Nation, Strong Army: National Security and the Technological Transformation of Japan (Ithaca, N. Y.: Cornell University Press, 1994), p. x. As quoted in Kennedy (2013: 911).

More importantly, large hydro is expected to peak in 2020 due to the exploitation of the most convenient sites system (Kennedy 2013: 914).

The beginning of the economic recession in 2008 spurred senior politicians like Wen Jiabao and Li Keqiang to strengthen their support for low-carbon technologies. Recognising that competition with the developed world in the field of clean energy technology can only increase, the Chinese leadership promoted alternative energy sources within the Strategic Emerging Industries (SEI) framework in 2010. The SEI emphasises technology not on par, but leading the developed world. This was to be achieved by allowing foreign companies to set up R&D centres in China and encouraging investment in the clean energy sector. The author argues that the SEI, although ambitious, does not disprove of international collaboration. The path is therefore – pragmatic system (Kennedy 2013: 916-918).

The 'Catalogue for the Guidance of Foreign Investment Industries' of 2002 that classified foreign investment in China into three categories – 'prohibited', 'restricted' and 'encouraged' – placed renewable energy in the third. Construction of solar plants and onshore wind farms was encouraged, while the construction and ownership of offshore wind farms was restricted to Chinese companies. In 2005, the stipulations laid down by the National Development and Reform Commission (NDRC) required all wind projects in China to source a minimum of 70 percent of their technology locally (Kennedy 2013: 920).

The 70 percent domestic content stipulation of 2005 perhaps acted as an enabler for China's nascent wind power industry. In five years, Chinese companies controlled 85 percent of the domestic market; they also supplied an estimated US$22 billion (almost half) of the world's wind turbines. On one hand, foreign firms that established factories in China were unable to win government contracts because Chinese firms sold wind power turbines at a cheaper price. On the other hand, domestic suppliers set up to support foreign companies allowed Chinese companies to appropriate reliable foreign technology (Kennedy 2013: 921).

Kennedy (2013: 922) argues that by the time the Obama-led US government pressured the Chinese government to withdraw the domestic content requirement in 2009, Chinese wind energy firms were strongly established and ahead of their foreign counterparts. The US government also pressured the Chinese government to withdraw the 'Special Fund for Wind Power Equipment Manufacturing' that incentivised the use of Chinese-made equipment by domestic wind energy firms. The fund, launched in 2008, offered a maximum of US$22.5 million in grants. US threats to approach the WTO tribunals forced the withdrawal of this scheme in 2010. The MLP singled out several Chinese products that were eligible for preferential treatment by the government during procurement. Several provincial and local governments acted upon this suggestion by creating a 'catalog' (sic). The Ministries of Science and Technology and, Finance included the procurement of alternative energy equipment in 'Circular 618' for preferential treatment. The NDRC also supported this move. Once again, international outcry compelled the Chinese government to withdraw the controversial circular.

The author states that although the Chinese government is partial towards Chinese technology, global opposition to preferential treatment of domestic energy has whittled down official support to Chinese industries. However, China has adopted a harder stance at global efforts targeting its support of its domestic solar sector. China has retaliated to global scrutiny of its solar industry by countering opponents in other industries. Chinese actions stem from three reasons – its reluctance to appear weak, plummeting prices in an over-supplied market and lastly, a lack of a cohesive response by the US and the EU (Kennedy 2013: 923-924).

Two strains of a narrative on Chinese techno-nationalism have emerged – China has pushed back against opposition to its domestic solar energy industry; China has backed down in the face of opposition to its domestic wind energy industry. These narratives question the balance between collaboration and confrontation within Chinese techno-nationalism. The author has three conclusions. One, challenges from the domestic industry has led to the withdrawal of alternate energy companies from China. Two, techno-nationalism has encompassed the sphere of renewable energy, like that of the ICT industry. Three, increasing competence in the renewable energy sector will only increase global interdependence (Kennedy 2013: 928).

2.3.2.2 The Practice of Flexible Implementation in China

Lo (2015: 13255) argues that the absence of field reports and on-the-ground assessments has failed to present scholars with a clear picture of the success of China's much-vaunted alternative energy policies. Official reports are obscure, lack specific and show a disjuncture between policy and performance (Lo 2015; Verbong and Geels 2007). The author attempts to analyse the pros and cons of flexible implementation with relation to the desired outcomes of the government. He specifies four areas of research: scope and character of flexible implementation; policies and their impacts; behavioural patterns of local bureaucrats; and finally, the implementation of central policy at the local level.

The Eleventh Five Year Plan (2006-2010) that called for a massive twenty percent reduction in energy intensity is often touted as China's first step in achieving a transition to clean energy. It was shortly followed by the Energy Development Strategic Plan (2014–2020) that sought a massive reduction in coal use (regulating coal consumption to 4.2 billion tonnes), the diversification of the country's energy mix to include ten percent of gas and fifteen percent of alternative energy sources and the peaking of China's energy consumption by 2030.

With an energy profile heavily dominated by coal and high energy intensity, China has now prioritised energy from renewables over cheap energy. The prioritisation of clean energy resources is accompanied by new policies facilitating an easier transition. In order to facilitate this transition, local official are allowed a leeway in adapting policies created in Beijing to suit conditions at the local level. This is known as 'flexible implementation' (Lo 2015: 13256). However, the author argues that the latitude granted to local official has produced a disconnect between what official documents are claiming and how much progress has been achieved in the field. This knowledge gap can be bridged only through in-depth empirical studies into the implementation of policies.

As the world's largest consumer of energy and emitter of greenhouse gases, China's transition to clean energy is relevant to global issues like energy security, energy trade, climate change mitigation initiatives and energy geopolitics. It also serves as an example for several developing nations in changing their outlook towards clean energy transition. This is relevant for a country like India which has invested heavily a broad expansion of its coal-based infrastructure and at the same time announced strong policies supporting the growth of renewables.

China's cooperation in changing climate change mitigation trends was evident from its stand at the 2009 Copenhagen summit. Several nations, led by the U.S., have gone back on their commitment to enforce climate change mechanisms citing the laconic response of the developing world to active participation in domestic mitigation efforts. However, China has belied expectations by sticking to its climate change commitments.

Lo (2015: 13256) outlines the framework for any energy transition policy to include two critical aspects: energy efficiency and conservation, and the dissemination of renewables and low-carbon energy systems. The former involves the application of technological developments to reduce energy intensity and increase efficiency. It also involves behavioural changes regarding energy consumption. The latter involves the introduction of low-carbon energy systems (nuclear and gas-based) along with renewables (solar, wind and geothermal) to replace fossil-fuel-based systems.

A revision of the Energy Conservation Law in 2007 followed the release of the twenty percent energy intensity reduction target stated in the Eleventh Five Year Plan. The Ten Thousand Enterprise Low-Carbon Energy Conservation Programme (Ten Thousand Enterprises Programme) was introduced in 2011. It targeted about 16,000 energy-intensive industries that were collectively responsible for 60% of China's total energy consumption. It offered funding for the reduction of energy use by these enterprises through efficiency measures. Between 240-300 RMB (in 2015 1 RMB was equal to $0.15) is provided for one tonne of standard coal equivalent (tce). Expected to last over five years the programme is expected to provide energy savings of 250 million tce. China's total energy saving target is 670 million tce. The government is also applying other methods to compel old and inefficient units to curb pollution and inefficiency. Under the economic element local governments are permitted to apply an additional surcharge to that of the central surcharge of 0.2-0.5 RMB/kWh. The administrative element involved the forced closure of old units. Forced closure is compensated by the government. From 2006-2010, the Chinese government has distributed about $3.3 billion in compensation. Production capacities totalling 122 million tonnes of iron, 70 million tonnes of steel and 330 million tonnes of cement were taken off the market.[14]

[14] This could also be attributed to the culmination of major infrastructure projects which were launched in the run up to the 2008 Olympics.

To improve energy efficiency in existing buildings, the Central government provided subsidies of 55 RMB per square metre in very cold regions and 45 RMB per square metre in cold regions through the introduction of effective insulation and heating systems. Between 2011 and 2014, 750 million square metres have been effectively retrofitted with such systems. Since 2010, strict compliance in building codes has also been achieved (Lo 2015: 13257).

In the transport sector, subsidies amounting between 23,000 to 55,000 RMB per vehicle and an exemption from annual Vehicle and Vessel Tax for electric and hybrid vehicles have failed to increase their popularity on the roads. Lack of charging points, limited range of vehicles and the short span of battery life have resulted in only 120,000 electric vehicles entering the roads against the target of 500,000 vehicles in 2014. The introduction of Fuel Economy Standards in 2005 has increased the efficiency of ordinary vehicles. By 2020, combustion engine vehicles must have a mileage of 20 kilometres per litre. The higher the mileage, the lower the payment of the annual Vehicle and Vessel Tax.

The passing of the Renewable Energy Law and the Mid- to Long-Term Development Plan for Renewable Energy in 2007 brought ushered the development of renewable energy to the forefront of Chinese policymaking. A standard national feed-in tariff ranging from 0.49 RMB/kWh to 0.61 RMB/kWh has been applied since 2015 to encourage private entry into onshore wind energy generation. Initial standard tariff was enforced in 2009 to counter very low bids received from state-owned enterprises that dominated this sector. These earlier prices ranged from 0.373 RMB/kWh to 0.519 RMB/kWh. The participation of private players (local/foreign/joint venture) in 2013 was 19% while the rest of the 81% of the 1300 companies was represented by state-owned enterprises (Lo 2015: 13257).

A feed-in tariff scheme is a financial policy instrument benefitting renewable energy developers. This policy initiative guarantees a profitable price for electricity generated from renewable sources. It usually offers long-term compensation and tariffs, in order to encourage energy producers to invest in the emerging industry (Chen 2016: 28). Unlike Germany's decentralised approach to initial renewables development, the Chinese example was centralised through the inception of the Renewable Energy Law in 2005 (Chen 2016: 31).

The 2006 amendment implemented a surcharge on all electricity consumers to cover the difference between power sourced from renewables and desulfurized coal. This would then fund feed-in tariffs introduced by a 2006 amendment to the Renewable Energy Law. Unlike India, power prices are fixed Beijing.

Table 2.3 International Comparison of Feed-In Tariffs (FITs) for Wind Power and Solar Power

Country	**Wind power FIT (RMB/kWh)**	**Solar power FIT (RMB/kWh)**
China	0.51–0.61	1.00
Canada (Ontario)	0.85–1.01	2.80–2.96
Germany	0.40–0.80	1.71
Spain	0.64	2.34
United Kingdom	0.42–2.17	0.69–1.55
Ukraine	0.54	1.97
Malaysia	0.47–0.72	2.57–3.59

Note: kWh denotes kilowatt hour.

Source: Kevin Lo, "A Critical Review of China's Rapidly Developing Renewable Energy and Energy Efficiency Policies", *Renewable and Sustainable Energy Reviews* 29 (January 2014): 510. As cited in The Forging of State-Led Ecological Modernisation: Renewable Energy in Jiangsu and Zhejiang Provinces, China – Chen 2016..pg. 32.

The revised RE Law of 2010 obligated power generations companies to source a minimum amount of electricity from renewables. Renewable energy is to contribute 15% of annual power output by 2020. Thus, the feed-in tariff and obligatory market share are the two prominent features of the RE Law. In 2009 the Golden Sun Project was instituted to grant subsidies to competent solar PV producers (Chen 2016: 32).

Grid-connected PV in 2013 had a fixed tariff rate from 0.90–1.00 RMB/kWh; offshore wind received between 0.75 and 0.85 RMB/kWh; and decentralised PV received a subsidy of 0.42 RMB/kWh **(Table 2.3)**.

Local governments often offer an additional increase in subsidies to attract foreign investment. These subsidies are sourced from a renewable energy surcharge, where in industrial consumers have to pay a higher rate (0.015 RMB/kWh) and residential/agricultural consumers pay a lower rate (0.008 RMB/kWh). This national surcharge is not applied in the Tibetan Autonomous Region (TAR).

Grants covering 50% of the costs of setting up large normal PV projects were given under the Golden Sun Demonstration Programme from 2009-2013. In rural areas, 70% of construction costs were covered.

In 2014, the total installed capacity of wind power was recorded at 95,810 MW, up from the 1260 MW recorded in 2005. The installed capacity of solar photovoltaics was 26,520 MW in 2014, a 60% increase in capacity from 4670 MW. RE comprised 32% of the total installed capacity in 2014. To tide over the problem of absence of grid-connectivity, the government is mulling the implementation of renewable portfolio standards that would require utilities to source a certain amount of RE for distribution.

The government is also actively expanding the development of nuclear energy and natural gas, along with the closure of inefficient coal-fired plants. Nuclear energy, being cost-competitive, has received several tax rebates. Natural gas is intended to replace coal-fired capacity with gas-fired plants, and be used in the transport sector.

Coal-fired units with capacities of less than 50 MW contributed more than 121 GW of total installed capacity in China in 2006. These cheap but inefficient units were operational despite a loosely implemented government directive tin 1999 to shut operations (Lo 2015: 13258). In 2006 the government decided on a multi-pronged approach. It decided to shut down units with capacities of less than 50 MW or units with capacities less than 200 MW that had been in operation for long and exceeded their shelf life. To enforce this policy, the government adopted an economic mechanism wherein on-grid tariffs paid to these minor units were lowered. The policy has been successful in shutting down 76.8 GW out of the 121 GW capacity of inefficient coal-fired units by 2010. At the same time, to maintain generating capacity the government has ensured the bundling of new capacity with the closure of old and inefficient units. What this means is that, for local governments to received approval for large power projects of 1000 MW, it is imperative that 600 MW of old capacity must be withdrawn from service. The focus on the closure of smaller units, which were designed to be independent producers in times of shutdowns of larger units, has been replaced by the popularity of large projects, similar to the Ultra Mega Power Projects that has been the trend in India.

The implementation of the clean energy initiative in China has moved away from the Mao-era centralised diktats which outlined not only the target, but also the process on how these targets could be achieved. The sector is highly decentralised with the central government formulating the policy. The local provincial bureaucracy is given the flexibility to implement the programme in accordance with the local conditions dominating that region. This is known as 'flexible implementation.' The success of this approach can be gauged from China's massive economic strides. However. The author argues that the inability of the China's unitary government to monitor the implementation of its environmental polices has led to local governments emphasising economic progress over environmental action.

Flexible implementation has led to huge successes in establishing a symbiosis between energy efficiency/conservation and the construction sector. Favourable polices have also increased the popularity of electric vehicles (EVs) to an extent. But these polices tend to focus on the reduction of energy consumption that would lead to lower energy imports or limit mining for local resources. Reduction of GHG emissions, a priority for the smog affected northern Chinese cities, including Beijing, is less emphasised by local governments in the rest of the country. Several local governments have tweaked central government policies to allow inefficient units to continue operations.

An empirical study of flexibility and implementation will be highlight the degree to which the local government may tweak central policies. It is known that although targets are non-negotiable (a remnant of Mao-era policies) implementation is flexible. Empirical studies will also give readers an idea of the different local measures adopted in different provinces. It will also gauge their success by verifying official data. The social impacts of implementation of clean energy initiatives should not be ignored.

Empirical studies will investigate the argument that the closer a policy resembles 'local interests', greater is the enthusiasm to see to its success. The author seeks to apply a more detailed explanation for a policy's failure rather than the traditional excuse of ‘lack of local interest’. Lastly, Lo (2015: 13261) underlines the need to study the measures applied by the central government to ensure local level compliance. A study of the ‘target responsibility system’, featuring political incentives for officials achieving successful implementation, is of vital interest; a study of ‘policy implementation’ and ‘flexibility’ will help scholars understand the challenges of establishing a transition to clean energy amid the context of a fossil-fuel reliant China (Lo 2015).

2.3.3 Case Study of Ontario, Canada

The previous two case studies show the impact of policy changes on the expansion of RE in the Netherlands and in China. These policies are rooted in changes to governance and administration – essentially bureaucratic processes. Let us now examine a key argument policy mechanism, a financial mechanism to be exact, that proved vital in developing the early global RE sector. Although Canada may not be a major player in the field of RE, minor attempts to develop the sector, against a strong conventional setup in a country with a population much smaller than China but larger than the Netherlands, make these a suitable case study.

In a study of Ontario’s power industry, Rivard and Yatchew (2016: 221) analyse the exponential growth of renewable energy at the cost of coal-fired generation in a ‘hybrid’ market, where electricity is sold based on free-floating wholesale prices, and planning is conducted by a single centralised agency. With wind power now comprising 10% of total electric capacity, coal-based power no longer contributes to electric supply in the province.

The authors delve into the seemingly seamless integration of renewables into Ontario’s power industry by studying three aspects of the transition: operational and market integration, prices and merit order effect and the purchase of supplies. To deal with problems of variation, the Independent Electricity System Operator (IESO) has introduced better real-time forecasting facilities accompanied with improved communication networks (Nongpiur 2017).

They also advise the creation of an independent system of supply procurement with separate divisions between policy-making and regulation (the former is prone to political interference). Decentralisation in the form of subsidiarity is their second proposal.

The current scenario involving a centralised supply procurement process has led to overcapacity, in the wake of the entry of renewables into the market, which has led to negative prices in the hourly electricity market.

The electricity market in Ontario was deregulated in 1998; but the wholesale market , created in 2002, was dominated by a single government power supplier (Rivard and Yatchew 2016: 223). The control exercised by this power generator was so complete that the government was compelled to freeze electricity prices soon, when Ontario Power Generation could not maintain supply. Private investment remained absent. This prompted the enactment of the Electricity Restructuring Act in 2004, which created the ‘hybrid’ market, with the Ontario Power Authority ensuring stable supply. The IESO took charge of the wholesale market.

Compulsory long-term supply contracts attracted private investment.

The Green Energy, Green Economy Act of 2009 (GEA) used feed-in tariffs to expand the involvement of renewables within Ontario’s power industry.

The creation of the ‘hybrid’ market led to diminished GHG emissions in Ontario with the introduction of renewables and the subsequent purging of coal from the energy mix .

Recently, the province has experienced over-capacity compounded by falling overall demand for power. The addition of overhauled nuclear facilities, increased supply of natural gas and renewables has added to the over-capacity in baseload supply. It has resorted to selling low- priced ‘clean’, ‘surplus baseload generation to neighbouring provinces.

Solar and wind power comprise 140 MW and 3234 MW respectively, of the province’s total installed generation capacity of 35221 MW. Fall in electricity demand was noticed after the recession of 2008. Government mandated efficiency measures, higher electricity prices and the expansion of distributed capacity generation have contributed to this negative trend.

Interestingly, a decrease in wind power in noticed during the peak summer months requiring the need for natural gas as a backup (Rivard and Yatchew 2016: 229).

Following the implementation of FITs for the installed grid connected capacity of wind power increased from 500 MW in 2009 to more than 3000 MW in 2015. However, the authors suspect the effectiveness of the decarbonisation potential of renewables. With coal out the picture, wind power, with peak production at off-peak hours competes with other carbon-free forms of energy. Its intermittency prohibits its effective deployment to reduce the use of gas-based power during peak hour demand. However, the authors are quick to point out that, if exported, wind power has a strong chance of displacing other carbon emitting sources of power.

Inference

The global energy transition has emerged only after the resurrection of renewed solar and wind energy capabilities. As the most competitive energy market, the US is constantly contributing new factors that change the fuels of the game. For instance, the rise of shale oil and gas has not only pushed down petroleum and gas prices but has challenged the capability of renewables. The latter portion of this chapter traces minor case studies the Netherlands, China and Canada. They focus on technical capabilities, dynamism in administration and beneficial financial mechanisms respectively. Transitioning to a low-carbon economy is a popular trait among all governments. However, the patterns in every country differ. The transition itself is a vortex of innovations, price dynamics, competition from entrenched sources etc. and answers the first research question - *What are the patterns in energy transition among developed and developing countries?* - by focussing on the sheer increase in total global installed capacity of renewables.

CHAPTER III

The Role of Renewables in India's Energy Transition: Analysing the Coal Versus Renewables Debate

In November 2016, the total installed capacity of the Indian power generation system was approximately 308 GW. The installed capacity of non-hydro RES was almost 46 GW (CEA 2016: 7). Oddly, the Indian power market has surplus capacity despite millions living without access to any source of electricity. The failure to increase demand in India has led to 'oversupply' (Powell 2018). The growth in generation capacity is not reflected with a proportionate increase in transmission capacity. Multiple sources of energy compete for the limited transmission capacity in India. Renewables are the newest player in the fray, yet they have been present in India for more than three decades.

This chapter shall trace the growth of renewables in India since the mid-2000s. The study shall first outline the incumbents within a mature but changing electricity market. It highlights the deep roots of the coal industry in India and the challenge it poses to an industry intent in gaining a market share at its expense. India's renewed interest in the capabilities of renewables is discussed, as well the challenges it faces from entrenched sources. Finally, a considerable section is devoted towards a possible partnership between renewables and gas to provide a stable alternative to thermal power.

3.1 Current scenario of the Indian power system

The electricity grid, grappling with financial losses among distribution companies due to transmission losses, is increasingly saddled with new connections being enhanced at the rate of 5% every year (IEA 2015: 25). Almost 900 GW of power is needed to satisfy the growing demand for electricity in the future. The demand for electricity in India touched 897 terawatt hours (TWh) in 2013. In 2000, the same was registered at 376 (TWh). Of the total 290 gigawatt (GW) of electricity generated in India in 2015, coal claimed the largest share at 60%, followed by hydropower at 15% and natural gas at 8% (IEA 2015: 25).

The IEA foresees India becoming the largest importer of coal surpassing the EU, Japan and China. Currently it is the third largest importer of crude oil (IEA 2015: 12-14).

India's climate change commitments also have an important role in deciding the energy mix of the nation. India has pledged to reduce its emissions intensity by 2030 to 33-35% below levels measured in 2005.[15]

In 2013, 44% of India's primary energy mix is served by coal; followed by biomass at 24% and oil at 23% (IEA 2015). The increasing number of coal-fired power plants, the expansion of the steel industry (which is heavily dependent on coking coal) and finally its plentiful domestic supply and low cost are the main reasons why coal continues to dominate India's primary energy mix. Biomass has witnessed a 10% reduction because of the increasing dependence on LPG and the electrification of rural homes.

The optimism at the discovery of significant reserves of natural gas in the Krishna-Godavari basin in the early 2000s quickly faded away due to the geological complexities of extraction and contractual disputes between the government and the private players involved. At its height, domestic production reached 34 billion cubic meters.[16]

India, as of 2013, has an installed capacity of 45 GW of hydropower, with a further 14 GW under construction. A majority of this capacity is devoted towards large hydro projects which face backlash from the public due to resettlement, environmental concerns, high capital costs and the need for large support infrastructure. Currently, the focus is on the development of small hydro power projects (IEA 2015: 35).

Power generation is divided into 15 minute slots; 96 slots per day; a demand curve built every day, all year by distribution companies. Long-term needs are classified into 5 years; medium-term needs range between 1-3 years; and short term needs range from 3 months to 1 year. Various forecasts are termed as 'month ahead' or 'weekly forecasts'. Distribution companies have tie-ups with weather forecasters eg. Reliance has a tie-up with Skymet weather (Nongpiur 2017). Within Reliance, power demand includes 2 peaks – 12-2 pm (commercial industrial establishments) and 9-11 pm (residential use) {D'Souza 2018}. New technology (like Boiler Turbine Generator units) is introduced by generally paying royalty or through outright purchase.

In case of huge demand, the Indian Power Exchange (IEX) caters peak load. For instance, Reliance has purchased power for Rs5 per unit (which is then passed on to

[15] Ibid.
[16] Ibid.

customers); or RECs are purchased (to fulfil RPOs). Day-ahead or even 6 hours and 3 hours purchases are allowed. If the RPO remains unfulfilled then penalties are paid by the discoms; they cannot be passed on the customers {D'Souza 2018}. Discoms have a USO (universal service obligation). Up to sixteen percent of regulated returns (profits on assets) can be kept by the company; the rest have to be passed on to customers (D'Souza 2018).

3.1.1 Institutional setup of India's power sector

India's domestic energy sector is supervised by four ministries - the Ministry of Power, the Ministry of Coal, the Ministry of Petroleum and Natural Gas, and the Ministry of New and Renewable Energy and one department (the Department of Atomic Energy). The Directorate General for Hydrocarbons (DGH) as the upstream regulator, was created specifically in the wake of India's New Exploration Licensing Policy (NELP); the Ministry of Petroleum and Natural Gas (MoPNG) counts fourteen PSU's under its ambit. All exploration, refining, marketing and distribution by these PSU's is carried out under the aegis of this ministry. The decade old Petroleum and Natural Gas Regulatory Board (PNGRB) is staffed by officials nominated by the government but acts as an independent downstream regulator (Corbeau 2009: 9-12).

Oil India Limited (OIL) and Oil and Natural Gas Corporation (ONGC) dominate the upstream sector. A few private companies like RIL and Cairn have entered the Indian market, but most foreign players have been deterred by the domestic policy on pricing.

The Indian electricity grid system is divided into five regions that were interconnected in 2013. Electrification of rural households carried out under the aegis of the Rajiv Gandhi Grameen Vidyuikaran Yojana (RGGVY) since 2005 has reduced the number of those living without any supply of electricity to approximately 240 million people (IEA 2015: 28).[17]

Nationalised in 1973, the coal sector in India permitted coal mining for captive consumption by the power sector in 1993. The larger share of coal provided for the power sector is regulated by the Coal Linkages Committee comprising of officials from publicly owned mining companies, the railways and from the power ministry (along

[17] This scheme has now been replaced by the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) that divided rural households into agricultural and non-agricultural households and, more importantly, aimed to cut down on transmission losses.

with those from the steel and cement sector). Prices of coal were deregulated and set by Public Sector Units (PSUs) involved in mining. Although rising gradually (depending on the quality of the coal and transportation costs) domestic coal continues to be cheaper than that sold in the international market (Shukla 2009: 3525).

3.1.2 Energy-climate policy mechanisms covering renewable energy in India

Electricity from coal-fired power plants comprised over 60 percent of India's total power generation in 2010; it was also the source of 34 percent of India's total emissions. With more than one-third of India's emissions stemming from coal-fired generation, Indian climate change mitigation should prioritise coal-fired emissions reduction (Goodman 2016: 186).

The initial RE plans started in India in 70s with the promotion of cooking gas facilities based on cowdung. However, those initiatives were rudimentary and highly fragmented approaches as a response to the increasing demand for cooking need in villages. The second set of responses from the government to the Persian gulf (geopolitics) turmoil was through the promotion of Energy conservation and Electricity Act of early 2000. The latter also contributed to the surge in RE production. All these developments were prior to the 2008 NAPCC.

India's role in international climate platforms is highlighted by its leadership role in the Group of 77 (G770 where along with China it steers the debate on climate change to underscore the liability of developed countries in carrying the burden of financing, technological transfer and restriction of emissions-intensive economic activities (NAPCC 2008: 1-2). The unveiling of India's Climate Action Plan, otherwise known as the **NAPCC**, in 2008 prior to the UN's Copenhagen Climate Summit was its first attempt to create a framework emphasising the inclusion of sustainability issues into mainstream economic issues. It prioritised economic growth over climate change to alleviate poverty and by doing so India threw its weight behind ecological modernisation – a school of thought stressing the transfer of benefits – co-benefits - created by economic growth to mass environmental concerns (Goodman 2016: 186). Ecological modernisation believes that efficiency measures alone could regulate the increase in GHG emissions by reducing emissions intensity.[18] Therefore, 'growth' here is an all-encompassing term – indicating poverty reduction as well as sustainability.

Acknowledging that the focus on economic growth would increase GHG emissions, the Indian government promised to restrict per capita emissions to below those visible in industrialised countries (NAPCC 2008: 2; Goodman 2016: 186). This limit would be achieved through efficiency measures, underlined in the Third Principle of the NAPCC, 'devising efficient and cost-effective strategies for end-use Demand Side Management' (NAPCC 2008). At 4.25 metric tonnes, the 2004 world average of carbon-dioxide emissions per capita was much higher than the 1.02 metric tonne per capita emission in India. The per capita emissions of US, EU and Japan were measured at 20.01, 9.40 and 9.87 respectively (NAPCC 2008: 14). Simply put, India's commitment left a very huge room for expansion of emissions, which would defeat any serious climate change initiative. The NAPCC sought to distance itself from designing policies based on observed changes in weather patterns and not necessarily long-term climate change caused by human economic activities. These 'changes', with 'no firm link to anthropogenic climate change' included increase in surface temperature, rainfall, increases in sea level, incidents of extreme weather and the melting of Himalayan glaciers (NAPCC 2008: 15; Goodman 2016). Goodman (2016: 186) argues that deficit in confidence in the findings of climate science is unobscured in the phrasing of the NAPCC when he claims that, "The Plan stressed uncertainties about the 'magnitude of climate change impacts' and throughout stated it 'could' or 'may' have serious impacts (not would or will)".

The disconnect between India's energy and climate policies is profound when the NAPCC of 2008 is compared with India's **Integrated Energy Policy (IEP)** of 2006. India's energy-climate objectives, rather commitments, can be gauged from the study of these two documents. Emphasising the precedence of India's energy security, the IEP nearly tripled the forecast of coal consumption **(Table 3.1)** from 337 metric tonnes (Mt) {at 8% growth rate} in 2006-07 to 1475 (Mt) by 2031-32 (IEP 2006: 22; Goodman 2016: 186). Although the NAPCC accounted for the increase in electricity generation from coal-fired power plants, it idealised the integration of 'clean coal' infrastructure by 2013.

[18] Discussed in detail in Section 5.3

Table 3.1 Sources of Electricity Generation – One Possible Scenario

Year	Electricity Generation at Bus Bar (BkWh)		Hydro (BkWh)	Nuclear (BkWh)	Renewables (BkWh)	Thermal Energy (BkWh)		Fuel Needs					
								Coal (Mt)		NG (BCM)		Oil* (Mt)	
	8%	9%				8%	9%	8%	9%	8%	9%	8%	9%
2003-04	592	592	74	17	3	498	498	318	318	11	11	6	6
2006-07	711	724	87	39	8	577	590	337	379	12	14	6	6
2011-12	1026	1091	139	64	11	812	877	463	521	19	21	8	8
2016-17	1425	1577	204	118	14	1089	1241	603	678	33	37	9	10
2021-22	1981	2280	270	172	18	1521	1820	832	936	52	59	12	12
2026-27	2680	3201	335	274	21	2050	2571	1109	1248	77	87	14	15
2031-32	3628	4493	401	375	24	2828	3693	1475	1659	119	134	17	20

*includes secondary oil consumption for coal-based generation
Source: Integrated Energy Policy 2006: 22

A report by the erstwhile Planning Commission, renamed NITI Aayog (National Institution for Transforming India) and author of India's Five Year Plans veered away from the idea of massively expanding coal production to bridge energy demand. The Final Report of the Expert Group on Low Carbon Strategies for Inclusive Growth (hereafter called the Low Carbon Report) in April 2014 suggested the expansion of renewable energy in the national energy mix along with increased focus on the growth of nuclear power . Increasing capabilities of renewables and zero carbon emissions of nuclear power played a huge role in convincing the Expert Group to suggest these enhancements to reduce emissions, whose effects were gradually being felt in India. The Low Carbon Report (2014) essentially made a stronger pitch for the consideration of major changes to climatic conditions in India. Now, although the NAPCC (2008) did not view climate change in India as benign alterations in overall climatic conditions, it suggested the incorporation of climate action to stave off climate change that would affect India in the future. The Low Carbon Report (2014) indicated that India already was in the throes of climate change and a worldwide commitment to negate its impact was the need of the hour. By adding a 'now factor' to climate change the Low Carbon Report (2014) put forward an immediacy to act on climate change with active mitigating measures like development of renewables.

The Low Carbon Report (2014) continued to endorse the co-benefits approach of the NAPCC (2008). Its modelling showed that a 22 percent reduction in emissions intensity under a business as usual (BAU) scenario will escalate emissions from 1.7 gross tonne (gt) in 2007 to 5.2 gt by 2030. The report suggested that an expansion of emissions reduction intensity to 42 percent under a 'low carbon inclusive' scenario would lead to a decline of 3.8 gt of annual emissions by 2030. (Goodman 2016). However, the report pointed out that coal would continue to generate 63 percent of India's electricity and coal demand would rise from 540 mt in 2011-12 to 1300 mt by 2030 (under a BAU scenario coal demand would increase to 1500 mt by 2030). The alternate scenario envisaged renewables and nuclear power to comprise 24 percent and 8 percent of power generation capacity respectively. The development of these low carbon alternatives was also dependent on its reception by the public, where NIMBY is a strong influence. It also suggested that a gradual amalgamation of climate and energy policies would result in a 'multiple benefits' approach – one that would assimilate goals like reduction in emissions, economic growth, environmental protection etc. However, it failed to show a pathway towards this kind of assimilation.

India cemented its commitment to a diversified energy mix including a large non-fossil fuel capacity at the COP21 Summit at Paris in 2015. An Intended Nationally Determined Contribution (INDC) of 35 percent reductions in emissions intensity by 2030 over 2005 levels was made to the UNFCCC. It expanded India's previous emissions reduction suggestion of 25 percent by 2020 made by the Low Carbon Report (2014). India also committed itself to a rise in non-fossil contribution in power generation to 40 percent by 2030. India's INDC also went one-up on the Low Carbon Report by limiting power generation from coal-fired plants to 53 percent instead of the 63 percent proposed by the latter. According to Goodman (2016), a reduced coal commitment would limit coal demand to 1100 mt instead of the low carbon scenario of 1300 mt by 2030. The INDC assures the UNFCCC that although the contribution of India is limited given its prediction of a massive growth in energy demand, the values of energy security and universal access to energy will be included within the development narrative (India INDC 2015:8).

3.1.3 Legal and financial aspects involved in India's renewables sector

The low efficiency of renewable technologies i.e. the need to construct more devices to match the levels of electricity produced by conventional sources characterises them as land-hungry technologies. These negative externalities necessitate additional support from governments to provide favourable mechanisms to develop an industry whose benefits will only be visible in the long-term (Faiman: 2014).

An examination of National Oceanic and Atmospheric Administration (NOAA) data reveals that of the 35 grand tonnes (Gt) of carbon dioxide emissions emitted in 2012, 11 Gt of emissions were released in the course of fossil-fuelled electricity generation (FFEG). Infrastructure for FFEG continues to expand. The paper argues that though it is possible for solar photovoltaics (PV) and wind power to cover the global annual expansion of electricity demand, the capital expenditure alone would cost $500 billion per year. Minute increases in consumer tariffs in the form of an electricity consumption tax proves to be the best approach.[19] It would add about two to five cents per kilowatt hour (kWh) to tariffs (Faiman 2014: 1).

Financial encouragement by government agencies ignited demand for renewable technologies that were heretofore very expensive. The adoption of wind turbine technology was more popular owing to its lower per watt production costs. Solar, however, is gradually eating away that lead. 45 GW and 30 GW of additional solar and wind capacities respectively went online in 2012 (Faiman 2014: 3). However, will this fast pace of additional renewable capacity drastically bring down carbon emission levels?

According to Faiman (2014), some of the government backed financial mechanisms vital to lowering the cost of new renewable technologies include tax breaks to developers of renewable capacities, the application of a 'carbon cess' on emissions, and a feed-in tariff (FITs) obligating distribution companies to purchase a specified amount of power from renewable technologies. In the case of FITs, electricity producers are paid an amount in excess of the actual price of each unit supplied. This is a mode of

[19] In India, the cess on coal is paid by the coal producers, but this does not mean that they will not pass on the burden to the end-consumer. Unlike countries like Germany, a tax funding clean energy will not be popular among the Indian masses, whose income is very limited.

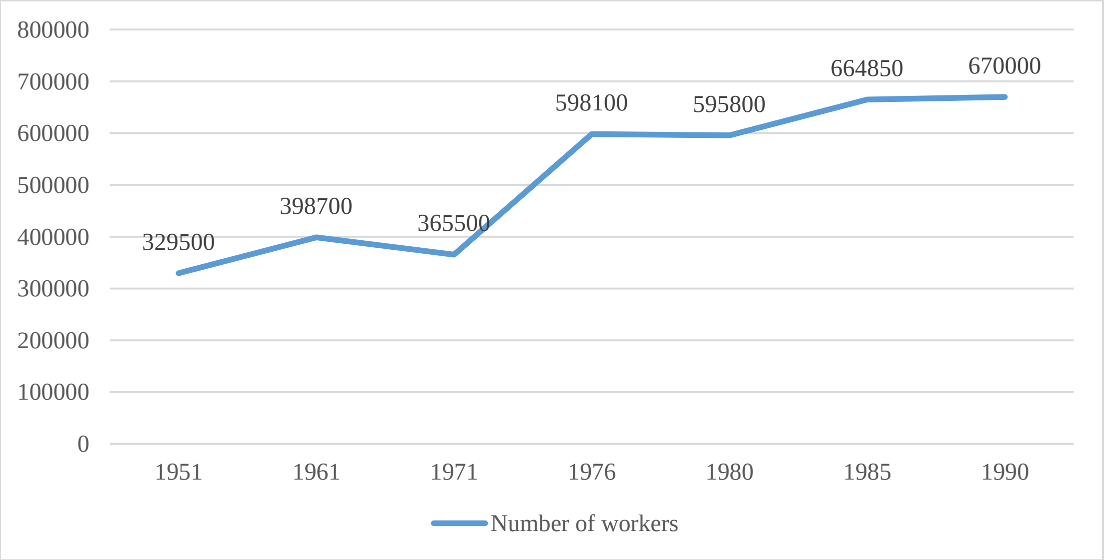
recognising the environmental attributes of renewables. Where smaller individual producers, operating technologies like rooftop solar, are concerned, ‘net-metering’, or a payment made to a small producer supplying excess electricity to the grid, may be practiced.

There are three approaches to creating the pool of funds catering to the capital expenditure costs of solar and wind technologies. The first, government-issued bonds are possible only in stable and economically strong countries. The option to transfer global annual subsidies offered towards FFEG to cater to renewable energy generation would cause economic havoc by halting construction of FFEG capabilities in economically weaker states. The third, an electricity consumption tax (ECT) would be the only feasible option providing long term funding for setting up solar and wind plants.

3.1.4 Sketching the socio-political linkages of India’s coal industry

Labour intensity that had already been high in the domestic coal industry increased as post-Independence industrialisation was prioritised. **Figure 3.1** highlights the historic trend in employment levels. These figures represent only those in the payroll of Coal India Limited. Contract labour employed in allied processes push the final employment figures to well over one million. Enhanced social spending after the nationalisation of the industry from 1973 onwards gave a further impetus to labour intensity **(Figure number 3.2)**.

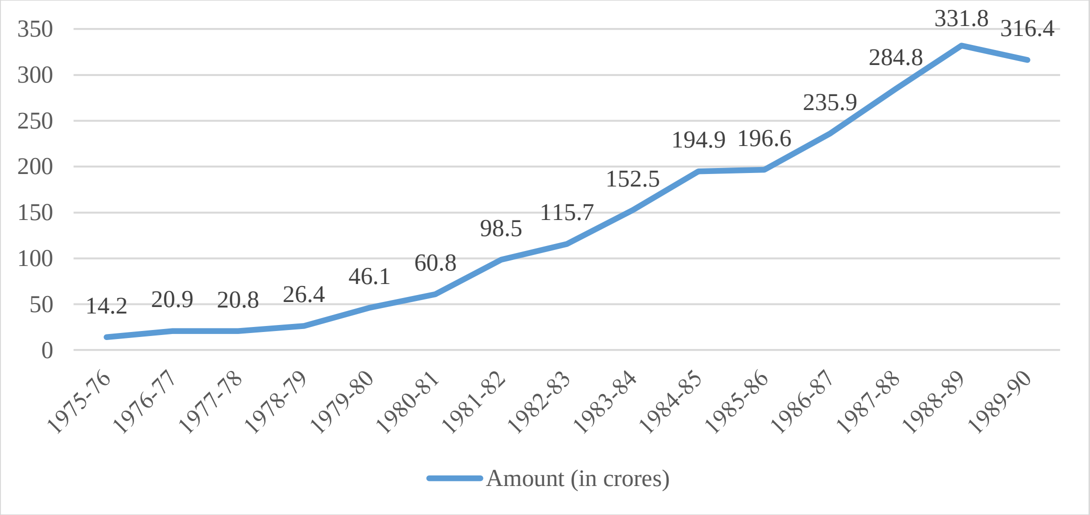
Figure 3.1Trend in employment



Source: Dhar B.B. and Saxena, N. C. (1994), pg. 13

The workforce lived a poor quality of life fraught with safety hazards until nationalisation improved living conditions for the workers' families and enhanced health and safety measures for the mineworkers themselves (Dhar & Saxena 1994: 14).

Figure 3.2 Social overhead expenses on coal



Source: Dhar B.B. and Saxena, N. C. (1994), pg. 14.

In 2003, the per capita consumption of electricity in India was 553 kWh. It was 6898 kWh in Germany, 1379 kWh in China and 13066 kWh in the USA. Although consumption in India is low, the main reason is due to non-electrification of the rural interior and semi-urban areas. In 2004-05, wind power capacity totalled 3,600 MW. In 2004-05, per kWh of a unit of solar energy costed Rs. 20, which was deemed far too expensive (IEP 2006: 38-39). Even with low power consumption in India, the limited scale of renewables and their cost factors prevented them from expanding to replace coal-supplied power. Furthermore, steadily expanding power demand, especially from the urban areas, was deemed too great to be handled by technologies that had not yet proved themselves in markets with a large consumer base. Besides these hurdles, India's coal industry has entrenched itself from pre-Independence (Powell 2018). Powell (2018) adds, "India's coal policy does not say that it will increase renewables at the cost of coal. In fact, the Bharatiya Janata Party (BJP) government increase coal exploitation by 1.5 billion tonnes {1 billion by Coal India Limited CIL} alone. It encompasses a myriad of socio-political issues that are far too great to outline in detail in this study. Some of these, like subsidised power and large employment opportunities shall be discussed in this section.

The IEP (2006) calls for the dismantling of capital subsidies that assists in the setting up of grid connected wind power plants but does not guarantee an outcome. It suggests that a premium (savings due to avoidance of conventional power production) should be added to the feed-in tariff on electricity supplied to the grid. In the case of stand-alone Distributed Generation (DG) system, a Tradable Tax Rebate Certificates (TTRCs) depending on the power supplied should be paid in addition to capital subsidies. The report also clubs together hydropower, biofuels and biomass with modern solar and wind renewable technology. India, a signatory to the United Nations Framework Convention on Climate Change (UNFCC) in 1994 and the Kyoto Protocol in 2002, at the time, was not charged with limiting her GHG emissions by these agreements.

Dadwal (2013) argues that the policy of subsidised fuel pricing induces debt-laden State Electricity Boards (SEBs) to remain dependent on hand-outs while ignoring private sector investment in supply logistics. The demand-oriented policy has failed to invest in new sources of fuels for power plants despite increased demand for electricity. Coal output from CIL remains inadequate as the coal sector remains mired in controversies relating to land acquisition, government clearances, labour-intensive practices and corruption (Dadwal 2013). Powell (2018) comments that, "Slackening demand from industry in 2015-16 resulted in low coal exploitation. However, the penalties for underdeveloped blocks are high with a majority paid by private companies. The system of penalties for non-exploitation was introduced in light of the Coalgate Scam of 2012.[20] In this case, companies would bear losses or penalties rather than sell at low rates. Such a scenario affects employment in an industry traditionally considered as a stable source of employment."

With the cost of imported coal increased due to the addition of various taxes within the exporting countries, like Indonesia and Australia, most power producers have demanded a reconsideration of power rates – a demand that political parties oppose. Another point for consideration is the government-mandated responsibility for coal importers to provide alternatives in case the exporting country prevents coal exports. The government is also opposed to revision of rates according to market conditions, relying on fixed rates, agreed at the time of initial negotiations. These measures together have deterred large private involvement in contemporary coal-power generation.

[20] Discussed in Section 3.3.2.

Although natural gas can lead to mitigation of GHG, a lack of infrastructure compiled with low domestic prices and, over-estimation of domestic resources prevents the expansion of its use in the power sector (Dadwal 2013: 11).

Despite its favourable position in India's power industry, coal-fired capacity has gradually come under the public scanner due to its negative externalities. "The coal industry in India has never been organised as a lobby like the oil and gas industry so recent opinions have turned against coal use" (Powell 2018). The industry guzzles and pollutes large amounts of water – a commodity in short supply across agriculture and sanitation. Opposition to land acquisition has become particularly intense among rural inhabitants. Section 2 (2) of Chapter I of The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 states that private firms must secure the consent of "at least eighty percent" of project-affected families. In the case of public private partnership projects, 'at least seventy percent' of project-affected families should consent (Land Acquisition Act 2013: 7). Failure to secure parliamentary approval for setting aside this requirement compelled the government to pass an Ordinance[21] in 2014, setting aside this requirement, reasoning that it was needed to push projects pivotal to national development. Fearing rural ire, the government allowed the ordinance to lapse with the result that the provisions of the earlier 2013 Act are still in place today.

Chatterjee (2012: 1) argues that the shortcomings of India's electricity policy are an outcome of the innate nature of the country's indecisive administrative machinery. In short, responsibility is 'displaced', deflected or "dissipated'. Fear of isolating their critical rural electorates encourages the political leadership in the states to persevere with a financially draining subsidy programme, fed by high tariffs paid by industrial consumers. Forming the executive arm, a vicious cycle involving politicians from state governments and bureaucrats produce annual renditions of so-called 'reforms', but are least interested in implementing them. Self-preservation is their only motive. Power reforms, however, which follow a top-to-bottom approach, cannot take place in the absence of the executive (Chatterjee 2012: 2).

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[21] The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Amendment) Ordinance, 2014. Ordinances are valid for six months and must be renewed only with Parliamentary assent. They are initially introduced when Parliament is not in session or commonly when the executive faces hostility from the legislature.

3.2 Challenges within the Indian power sector

The growth-driven urgency in strengthening energy security was obsessed with the expansion of domestic coal mining to reduce coal imports. The 12th Five Year Plan (2012-17) by the Congress-led government increased annual coal production estimates from 660 mt in 2010 to 980 mt by 2020. This urgency was not unfounded – coal is the largest fuel resource available in India and renewables had not acquired a reputation for technical and systemic stability. This concern with stability led to increasing confidence in nuclear power. India's homegrown nuclear set-up was well established; however, safety risks and land acquisition woes have stifled its development. According to Goodman (2016: 187), 'the National Plan (12th Five Year Plan) thereby entrenched coal as the mainstay of Indian growth, and the main source of rising emissions'. The Plan also sought to smoothen out hurdles in coal extraction by quickening the pace of licensing and coordination between the different ministries involved. It suggested a special mechanism encouraging inter-ministerial dialogue with strict deadlines for approvals or objections. There are two ways to look at this argument: environmentalists viewed this move as bulldozing environment protection norms while the government and a larger part of the population saw this as a national 'priority' to bridge increasing demand and maintain economic 'growth'. Adding to this dilemma is the presence of several tribal groups in these ecologically sensitive regions that comprise a large proportion of India's forest cover.

The Copenhagen Summit in 2009 saw India pledge a reduction in emissions intensity of 25 percent from 2005-2020. In 2015, India reported reductions in emissions intensity to the tune of 12 percent from 2005-2010 (India INDC 2015: 8; Goodman 2016: 186). However, Goodman (2016) argues that emissions intensity reductions do not influence total emissions (which could increase despite reductions in the former). The reductions achieved in emissions intensity in the 2000s were a product of the Kyoto Protocol's carbon credit mechanism, where the UN's Clean Developed Mechanisms (CDMs) funded about 1300 projects in India until it was discontinued in 2012. With nearly US$29 billion in funding from 2002 until 2012 (calculated at US1 = Rs54.85 in 2012) India managed reduction of up to 170 mt Co2e (Goodman 2016).

Concurrently cross subsidies emanating from industrial customers are utilised to cover unpaid dues or low tariffs from agricultural and residential customers. Frequent electricity theft compounds the problem. As a result, State Electricity Boards, that directly sell to end consumers as well as collect dues from them, face severe losses and a retardation of investment into power generation (Shukla et al. 2007).

3.2.1 Curbing power loss after generation still a major concern

Aggregate Transmission and Commercial (AT&C) losses encompass technical losses and commercial losses – subsidies given to the agricultural sector and power theft. During the transmission of power across the electricity grid, some amount of power is lost naturally, but these are minuscule and are merged with other technical glitches that affect supply. Although AT&C losses are not unique to India its extensive reach in all Indian states is a challenging obstacle with socio-political linkages. In March 2016, the overall AT&C losses stood at 20.7 per cent. In other words, almost 21 per cent of the electricity generated in India did not reach its intended consumers (Gupta 2018: 22).

Ideally, the gap between the average cost of supply (ACS) and the average revenue realised (ARR) should be zero. However, the ACS-ARR gap in India in 2015-16 was Rs. 0.59 per unit. Only 5 states – Maharashtra, Rajasthan, Gujarat, Himachal Pradesh and Puducherry – have attained this objective. Socio-economic and political issues in India compel the Central and State governments to subsidise electricity supply to the agricultural sector which has a spill over effect on reducing food prices (and inflation) in the urban areas. In states like Maharashtra, farmers are supplied with free electricity. In 2015, the Central government introduced the Ujwal Discom Assurance Yojana (UDAY) scheme to take over pending debts by the state government. In September 2015, the total debt of discoms amounted to Rs. 4.3 trillion (US$61.99 billion in 2019 value).[22] Of this, approximately US$39 billion or over 60 per cent was converted into UDAY bonds.[23]

One of the conditions of the UDAY scheme is the responsibility of discoms to curb AT&C losses (Kwatra 2018). **Table 3.2** highlights the extensive nature of the challenge. It covers AT&C losses in 10 major states across India. It shows that progress on curbing AT&C losses after the introduction of UDAY has had mixed results. An anonymous interview with the Director of a real estate company in India gives one reason for the failure to achieve the target of restrict AT&C losses to 15 per cent by 2018-19. He says, "The culture of entitlements is strengthening the practice of subsidies that are bankrupting the State Electric Boards (SEBs). Investors in renewable energy projects

[22] Gupta (2018: 22).
[23] Ibid.

are afraid to feed electricity into the grid due to payment issues. (Although) the Smart Grid is an integral concept, nobody deals with (the issue of) Aggregate Transmission and Commercial (AT&C) losses, ATC is a blanket term for theft." (K.G. 2018). It indicates that measures suggested by the Central government like smart and prepaid metering, introduction of the franchise model and feeder replacement etc. will fail if punitive measures against power theft are not undertaken. Furthermore, the process of installing smart meters on rural and urban distribution transformers covered only 1.5 per cent of the target (Gupta 2018: 23).

Table 3.2 Discom-wise AT&C loss performance (percent)

State	Utility	2015-2016	2016-2017	2017-2018
Andhra Pradesh	APSPDCL	11.49	14.42	13.46
	APEPDCL	6.40	4.99	4.93
Assam	APDCL	24.09	25.09	16.60
Gujarat	PGVCL	24.20	19.06	17.89
	DGVCL	9.77	8.00	7.04
	MGVCL	10.50	9.34	10.05
	UGVCL	11.10	8.18	7.76
Jammu & Kashmir	JKPDD	61.60	61.34	57.40
Madhya Pradesh	MP Poorv	24.23	22.58	33.06
	MP Madhya	31.29	35.11	39.15
	MP Paschim	23.65	18.47	18.09
Maharashtra	MSEDCL	19.07	18.88	20.15
Punjab	PSPCL	15.95	17.57	18.21
Rajasthan	AVVNL	25.47	21.95	21.99
	JVVNL	32.49	27.64	19.60
	JdVVNL	22.81	20.71	17.96
Tamil Nadu	TANGEDCO	14.58	14.53	14.23
Uttar Pradesh	DVVNL	44.40	35.08	33.98
	KESCO	22.10	15.61	15.31
	MVVNL	29.40	31.20	28.99
	PVVNL	25.40	24.58	20.77
	PuVVNL	33.10	35.31	31.35

* As of March 2018
Source: UDAY Portal as cited in Gupta, A. (2018), "UDAY Progress", *Renewable Watch*, 8(11): 24.

3.3 Hoping for a longer reign – the case of King Coal in India

Possessing the world's third largest reserves of coal, increasing domestic consumption has compelled India to import about 140 million tonnes of coal equivalent (Mtce) even with domestic production at 340 Mtce in 2013. The generally high ash content and low calorific value of domestically extracted coal results in greater expulsion of carbon emissions to produce the same amount of energy obtained from the burning of high-grade coal. Currently, the coal sector in India, dominated by the government owned Coal India Limited (CIL) observes the safer but environmentally adverse open cast mining (IEA 2015: 31).

The vast distances between the point of production and the areas of maximum electricity, demand involves additional expenditures on fuel and infrastructure. The domestic coal sector is fraught with issues regarding land acquisition and rehabilitation, negative environmental impact, lack of transport and underground mining infrastructure.

More than half of the total numbers of coal-fired power plants in the world were built in the last one decade. This means that the demand for coal will remain constant. It may even increase if new, and super critical coal-fired power plants with larger production capacities replace inefficient old power plants prematurely. Only Bharat Heavy Electricals Limited (BHEL) has super critical technology of boiler turbines (D'Souza 2018). Another important issue relates to the land already in possession by the government. With local opposition to government takeover of land for various infrastructure projects producing a serious obstacle to major infrastructure projects mainly in the power sector, the government would find it more feasible and less acrimonious to build newer projects on land already in its possession (IEA 2015: 88).

Assessments of the gas powered component of the Indian power sector by the IEA have concluded that natural gas cannot break the dominance of coal in the Indian energy mix on account of the fading optimism surrounding the dwindling supply of domestically produced gas. Racked by contractual disputes and geological constraints, the domestic gas sector has failed to provide a stable supply of domestic gas while imports of LNG are too expensive. Rather than incurring steep losses, most Combined Cycle Gas Turbines (CCGT) are being run on severely truncated load factors, which has undermined the ability of this sector in replacing coal as a baseload fuel. Although the IEA predicts that with falling international gas prices of LNG imports will also become cheaper in the medium term, these imports will still be expensive (IEA 2015: 91).

At the current rate of output India's proven coal reserves of 87 billion metric tonnes will last for well over a century. Lying at shallow depths of 300 meters, coal is extracted through open-cast mines. However, population centres and forest land negate surface mining while compelling Indian players to attempt underground mining, for which they lack experience as well as technology (IEA 2015: 101-103).

The average heat content from Indian coal is significantly lower than those found in China, the USA or Russia due to its high ash content.

The production costs for surface mining in India (at $15 per tonne) is much cheaper than that for underground mines ($150 per tonne). Low productivity and low coal prices make underground mining further unprofitable.

Quenching the thirst of coal-fired plants and industry, not profitable returns seems to be the focus of the coal mining sector. 340 Million tonnes of coal equivalent (Mtce) were produced in 2013 (IEA 2015: 103).

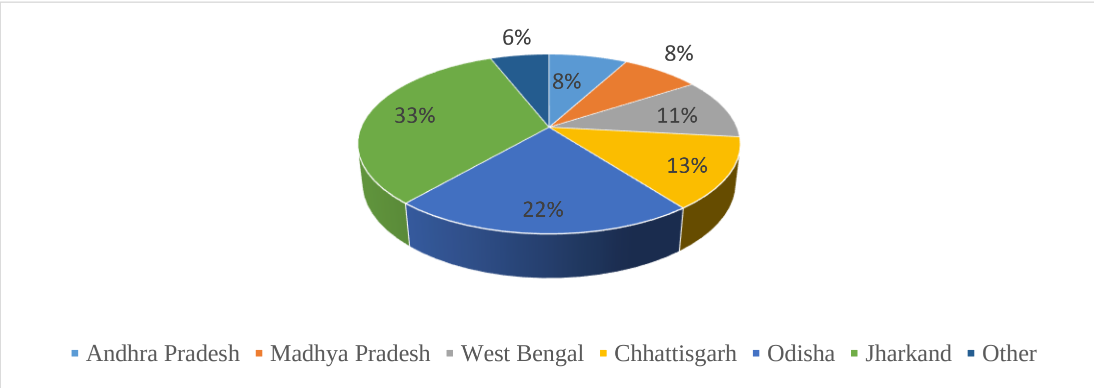
The Indian government's announcement of increasing coal output from 603 million tonnes in 2013 to 1.5 billion tonnes by 2020, if realised will make India completely self-sufficient (IEA 2015: 106). While the coal industry registered an average increase of 4% per year between 2006 and 2013, the ambitious new target seeks an increase of 14% per year. But with delays in the granting of licenses, local opposition to mining projects and additional burden on the Railways, this target seems to be difficult to attain (IEA 2015: 106).

The power generation industry receives more preferential prices for domestic coal than other industrial users. The Indian mining industry, a highly labour-intensive industry, with close to four hundred thousand unionised workers working directly with public sector units who fear streamlining of the workforce and salary cuts.

With coal rich areas located far away from areas of demand, the burden of transporting coal to distances covering more than five hundred kilometres falls on the Indian railways. Over half of India's domestic coal reserves lie in thickly forested areas of the eastern states (**Figure 3.3**). More than 80% of these reserves are found in depths up to 300 metres, making these reserves easily exploitable using surface mining methods (**Figure 3.4**). Surface mining is relatively safer than underground mining, which is more adept for economically extracting coal at depths of more than 300 metres (Lahiri-Dutt 2014). The latter also causes less destruction to the local environment on the surface. India's poor record of mining safety may have played a crucial role in the limited use of underground mining methods. Nevertheless, with the spike in protests against the destruction of forests and land acquisition, it would be wise for firms to explore the underground option.

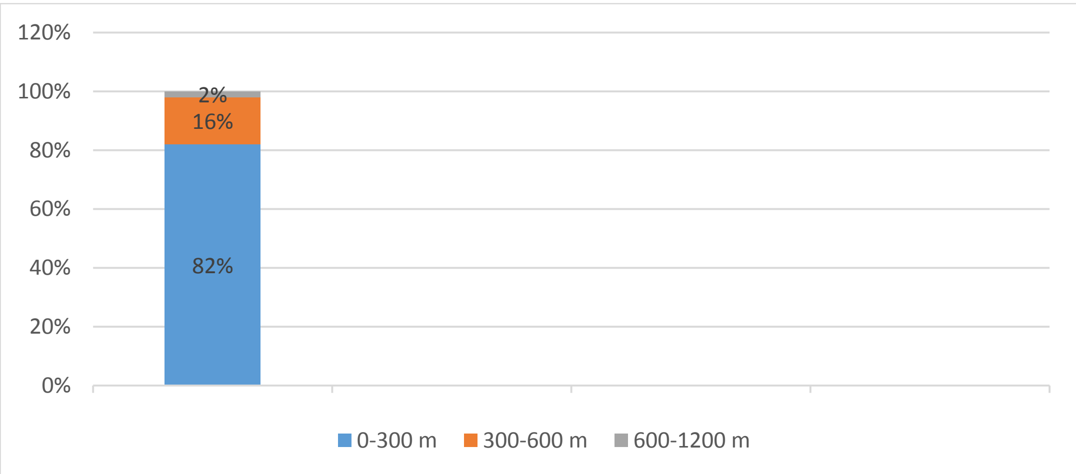
Although equipped with dedicated freight corridors and a closed loop system for coal, the main priority of the railways is passenger traffic, with cross subsidies from goods container traffic paying for lower passenger fares. In 2013, India imported close to 144 Mtce of coal, about 30% of its requirement, mainly from Indonesia but with Australian coal gaining popularity (IEA 2015: 111).

Figure 3.3 Hard coal reserves by state in India



Sources: IEA (2015), *India Energy Outlook*, pg. 102.

Figure 3.4 Depth of hard coal reserves (in metres)



Sources: IEA (2015), *India Energy Outlook*, pg. 102.

3.3.1 Fanning the flames – the clean coal discussion

The introduction of super critical technology in coal-fired plants in India since 2012 has boosted efficiency while reducing the cost on fuel (by way of consuming smaller quantities of raw coal). These developments have offset the high capital costs of the new technology. This development has legal ramifications as the Air Prevention and Control of Pollution Act, 1981 that was amended in 1987 follows standards made possible only with the technology of the 1980s. Improvements in technology have warranted an urgent need to revamp this outdated legislation (Powell 2018).

The utility of coal as a raw material is not bound by its consumption in power generation. It is a crucial player in the manufaturing of commodities like iron, steel, tar, naphthalene, benzole, nylon, synthetic dyes, aspirin, explosives, perfumes, disinfectants, fertilisers etc (Ghosh 1966:1).

Despite the introduction of 'cleaner' fuels like natural gas, nuclear energy and oil, rising demand from the expanding economies of the post-colonial countries, the sheer availability of vast untapped reserves and its ancillary uses, such as in the iron and steel industry, advance its dominance in the energy mix of most countries (Ghosh 1966: 2).

The early Five Year Plans beginning in 1951, promulgating massive industrialisation, steered the development of a large coal industry in India. Massive industrialisation could only be achieved through expanded iron and steel manufacturing capacities; necessitating the use of large quantities of coking coal. However, the poor quality of domestic coal reserves presented an obstacle to the production of high-grade metallurgical coal or 'clean coal' as a reducing agent in the steel manufacturing process. Hence, coal washing in India was first advocated as a measure to improve iron and steel manufacturing processes rather than escalate efficiencies in thermal power generation (Banerjee 2017: 400). *Beneficiation* is the scientific name for mechanically 'cleaning' run-of-mine (r.o.m) coal from impurities like shale, stones etc. The process consists of crushing coal to an optimum size for washing usually with water, without harming its marketability. Baum first invented the coal beneficiation process in Dusseldorf, Germany in 1900. Thus, the clean coal factor is not a new one; it is just a combination of old processes that are being revived due to climatic and economic exigencies (Ghosh 1966: 4-13).

The ability to transport vast quantities of coal across long distances made the railways an integral part of the coal industry. The growth of the railways and the cotton-textile industries simultaneously placed a greater demand on steel production. This demand for high-grade metallurgical coal increased manifold upon the conclusion of the World Wars. The International Coal Preparation Congress of 1950 in France comprising of the

US and Western European countries prioritised coal washing to reduce the demand on good quality coal reserves that were quickly becoming exhausted (Ghosh 1966: 21).

Coal washing in India was recommended by the Coal Washeries Committee in 1953; but the process was delayed as comprehensive studies into the features of the types commonly found in India and their behaviour under various washing processes was incomplete. Domestic private outfits like the Tatas took the initiative to set up the first washeries in India with the Central Government authorising a few more in the Fourth Five Year Plan (1966-71) {Ghosh 1966: 40}.

However, lack of profits, extension of railway connections and comparable cost advantages of manually cleaned coal saw the lethargy continue in the following decades. In addition to these coal producers have not internalised the process, which will benefit end-use consumers like the iron and steel industry and power generation units (Ghosh: 1966: 66). These views have gradually changed – the water used is purified enough for industrial use and the impurities are used as landfills in exhausted mines (Banerjee 402).

In February 2014, the Ministry of Environment, Forest and Climate Change (MOEF&CC) declared that all thermal power stations with capacities of 100 MW and located within a radius of 500-750 kilometres (kms) from the pithead are required to consume raw/blended/beneficiated coal with ash contents of 34 percent or lower (Government of India 2014a). Effective from June 2016, the directive placed the responsibility to adhere to it on the supplier (Powell & Sati 2017: 1-2). With ash contents of more than 40 percent, raw Indian coal had to undergo beneficiaton process at washeries. The 34 percent limit is a hard target to achieve considering high ash content in Indian coal. A significant amount of hard coal will also be lost in the process. Coal rejects after the washing process can only be utilised in power plants with fluidised bed combustion technology (FBC). However, this will lead to incremental costs including additional plants with FBC technology, significant expansion of mining to make up for losses due to coal rejects and, variations in washed coal properties supplied to boilers designed for a specific type could even reduce the efficiency of thermal power stations[24]. Conversely, beneficiated coal condenses additional demand for rail capacity, thereby increasing the profitability of the latter.

The incremental costs in setting up additional washeries with massive capacities overshadow the environmental benefits (Powell & Sati 2017). In addition, the implementation of the Clean Energy Cess[25] will further increase the cost of coal; it will be footed by CIL and indirectly by the Indian public (Nanda 2018). "Clean coal technology is a myth. They are comparable to 'green crackers' that are exploded during Diwali.[26] Super critical technology also reflects increased efficiency but it will further increase coal consumption now that emissions are much less."

3.3.2 Ultra Mega Power Projects – cheap electricity from massive capacities

Conceived in 2005, Ultra Mega Power Projects would possess 4000 MW thermal capacity. The Power Finance Corporation limited (PFC) is responsible for creating a Special Purpose Vehicle (SPV) for every UMPP. This entity manages the bidding process for the state where electricity from these projects is supplied. The tenders insist on a Build Own Operate (BOO) basis of ownership and the adoption of super critical technology. Sites for the projects are selected by the CEA that also acts as the technical liaison. The responsibility to obtain the requisite licenses and clearances lies with the SPV and not with the successful bidder. The SPV is transferred to the winner on the completion of the bidding process along with all the necessary licenses (Power Finance Corporation 2015). Of the planned fifteen projects, only four have been awarded.[27] They were envisioned to reduce power generation costs. "In the early 1990s, energy use (coal-use) was more than 85% in India. It was in this regard that UMPPs of 4000 MW capacity were created. The cost of generation per MW of coal is Rs. 7 crore; to generate the same amount (1 MW) with larger capacities, the cost of generation comes down to 5-5.5 crore per MW. Generation has to be distributed between 4-5 states. The first UMPP at Mundra is built by the Tata's, with an agreement to freeze prices for 25 years. UMPPs have also been given the right to mine for themselves" (D'Souza 2018). Captive

[24] Ibid.
[25] Refer to section 3.4.
[26] In response to a petition proposing a ban of fire crackers in Delhi, the Supreme Court suggested the use of 'green cracker' – with a low explosive content and noise level – to reduce air and noise pollution during the Hindu festival of Diwali. Thus, India's Supreme Court showed cast doubt on the contribution of firecrackers during air pollution in Delhi to appease religious sentiments and concerns of the firecracker industry in India.
[27] Refer to Appendix E for the list of UMPP projects awarded and planned.

mining and the proximity of the project site to the coalmine pithead decreased generation prices that could compete with the lowest solar and wind tariffs.

3.3.3 Trends against increasing coal use

The impending surge in coal output never materialised due to the revelation of a scam involving the sale of licenses to private players through corrupt means. Popularly, known as 'Coalgate', it was brought to light by the Comptroller and Auditor General of India (CAG) in a 2012 report that alleged a nexus between bureaucrats, politicians and private investors in the licensing process for coal mine allocations between 2004 and 2011 (GoI 2012). An estimated 44,440 million tonnes (mt) of coal reserves were sold at 'concessional' rates to private investors through the captive coal mining mechanism (CAG 2012; Goodman 2016). The absence of a competitive-bidding process, according to the CAG, led to the loss of US$3.52 billion (in 2012 dollar value) to the public exchequer due to 'inefficient allocation'{ibid; Indian Express 2017 }. Furthermore, the private owners of these coal blocks did not exploit the coal blocks allotted to them - they chose to hoard their allotments. The failure to conduct physical inspections by the Coal Controller's Organisation (CCO), the main agency promoting private captive mining, resulted in sluggish overall coal output, brownouts and increases in coal imports. Consequently, the Supreme Court cancelled 204 allotments. More importantly, the scam tarnished the image of the Congress-led United Progressive Alliance (UPA) that contributed to a stinging defeat in the parliamentary elections in 2014. The successor BJP-led National Democratic Alliance (NDA) government allocated coal blocks on the condition that mining would commence immediately in these private concessions and, allowed the Indian affiliates of foreign companies to also bid against Indian investors (Goodman 2016). These improved amendments have not yielded expected results i.e. a buoyancy in coal mining. In addition to continued opposition to land acquisition from local residents or environmentalists, the cost of transporting coal from pitheads in eastern India to the major industrial centres in the west are prohibitive. The high ash content and low calorific value of Indian coal – peat – necessitates large infrastructure dedicated towards coal washing and efficient burning of this type of coal.

While the BJP-led government has claimed success in the largest annual capacity expansion and highest generation figures, India is experiencing its lowest plant load factor – 65% - in nearly two decades (Dhoot 2015). Until early 2015, fuel supply shortages worried the power sector. However, the surge in capacity addition is accompanied by concerns surrounding the payment for additional power by financially weak distribution companies (discoms). Demand for power is still high but the ability to pay for that additional demand is doubtful.

Plant Load Factor (PLF) of thermal power stations allows us the ability to gauge amount of power produced from the installed capacity. From April-November 2014, the average PLF of thermal power stations in India was measured at 65.1% (GoI 2015c: 47). **Table 3.3** provides readers with aggregate PLFs from Central, State and Private thermal power stations all over India. It is evident that PLF across all cross-sections have fallen since 2007-08. Among private utilities and state entities, the fallout of the Coal Scam explains this in 2012 when the expected growth in coal production from private captive mines did not materialise. Aging infrastructure also made its presence felt among Central thermal power stations along with coal shortage.

Table 3.3 Plant Load Factor of thermal power stations

Year (%)	Central (%)	State (%)	Private Utilities (%)	Overall (%)
2007-08	86.7	71.9	90.8	78.6
2008-09	84.3	71.2	91	77.2
2009-10	85.5	70.9	82.4	77.5
2010-11	85.1	66.7	76.7	75.1
2011-12	82.1	68	76.2	73.3
2012-13	79.2	65.6	64.1	69.9
2013-14	76.1	59.1	62.1	65.6
2014-15	73.3	59.7	63.4	65.1

Source: Standing Committee on Energy (2014-15), pg. 47.

In the financial year 2012-13, cumulative losses of state distribution companies amounted to Rs. 2.51 lakh crore. In 2015, the total installed capacity in India was 158 GW. About 30 GW capacity is to be added in the coming years. This additional capacity was approved by the previous UPA government before the end of their term in 2014. This is a common pre-election move by all political parties in India to boost their performance in elections. The successor government, led by Prime Minister Narendra Modi, has announced solar and wind capacity expansions of 100 GW by 2022. The no-payment of dues by discoms to power generation firms has led to the latter owing COAL India Limited about Rs. 8000 crore in 2015 alone. There is a difference of 82 paise between generation costs and tariffs charged by discoms. This makes production financially unviable (Dhoot 2015).

The 30 GW capacity addition were envisioned to bridge demand several years ago. These projects were in limbo for long. New projects in the last two years have not been considered. Unclear bidding parameters in the case of ultra mega power projects (UMPPs), with an envisaged 4000 MW capacity, have witnessed low interest in new bids.[28] With utilisation level stuck in the low 60s and poor debt servicing, the profit margins of potential investors in Greenfield projects will be nil. The only solution to this problem was a revision of low tariffs by discoms and strengthening.[29] The government resolved to reform the transmission sector, which needs investments of Rs. 3 lakh crore rather than revising electricity tariffs that are a politically sensitive subject for political parties (Dhoot 2015).

In the end the economic models of thermal power plants have ‘gone for a toss’ considering all the disruptions caused by the introduction of RE into the grid (Pimpalkhare 2018).

3.4 The churnings of renewable energy in a globalising India

India’s expanded RE arget by 2022 is the world’s largest renewable energy capacity expansion.

To put things in perspective, India’s total installed power generation capacity was 327 GW in 2017. The total installed capacity of solar energy in India was 20 MW in 2011; it was 21 GW for wind energy in 2014. As of December 2017, the total installed capacity for solar and wind energy is 17 GW and 33 GW respectively.

According to information released via the Press Information Bureau (PIB), the Ministry of New and Renewable Energy (MNRE) argues for the expansion of renewable energy capacity through focussed ‘thrusts’. This expansion of capacity by primary drivers like the need for increased energy security, climate change mitigation efforts, the need for improved access to energy and plugging high-energy demand (MNRE 2016).

Since 2013, 14.30 GW of renewable energy capacity is grid-connected. Solar power comprises of 5.8 GW; wind power comprises 7.04 GW; 0.53 GW was composed of Small Hydro Power; and 0.93 GW came from Bio-power. The rapid expansion of grid-connected capacity has led the Indian government to give a commitment to the

[28] Refer to section 3.3.2.

[29] These issues were presented to the PM, Finance Minister Arun Jaitley, power and coal minister Piyush Goyal, oil and gas minister Dharmendra Pradhan and transport minister Nitin Gadkari and several senior bureaucrats at a meeting with officials of the NITI Aayog in May 2015, Ibid.

UNFCCC of increasing the share of non-conventional power generation capacity to 40% by 2030. This initiative constitutes India’s Intended Nationally Determined Contribution (INDC). However, to achieve this goal, the government is hopeful of receiving assistance in the form of transfer of technology and finance from the Green Climate Fund.

In order to boost expansion, the government is offering Generation-based Incentives (GBIs). Some of these GBIs include capital and interest subsidies, viability gap funding, concessional finance, fiscal incentives etc. These GBIs improve the cost-competitiveness of renewables vis-à-vis fossil fuel-based generation.

The government’s target of creating one hundred GW of installed solar capacity and 60 GW of wind installed wind capacity of renewable energy by 2022 necessitates the implementation of several policies providing financial assistance (CEA 2016b). Among these policies are Renewable Purchase Obligation (RPO) and Renewable Generation Obligation (RGO) that entail amendments to the Electricity Act of 2003 and Tariff Policy of 2006 (CEA 2016b). In 2006-07, the CERC made RPOs compulsory, but lack of production forced companies to go into RE production themselves; either produce or purchase. The government has created large solar parks and expanded transmission and distribution infrastructure networks through the Green Energy Corridor project. It has also amended rules to accommodate roof top solar installation in housing loans provided by banks or National Housing Boards. Besides these, it has also enforced net metering (D’Souza 2018).

100 GW of renewable energy capacity is to be comprised of solar power. 60 GW is to be sourced from wind power. The remaining 15 GW will come from biomass and small hydropower.

Table 3.4 Three-year Target Predictions

Source	2016-17	2017-18	2018-19
Solar Power	12,000	15,000	16,000
Wind	4000	4600	5200
Biomass	500	750	850
SHP	225	100	100
Grand Total	16725*	20450*	22150*

*(Capacities in MW)

Source: *Government of India (2016), *Year End Review –MNRE*, Ministry of New and Renewable Energy, [Online: web] Accessed 24 February 2017, URL: http://pib.nic.in/newsite/PrintRelease.aspx?relid=155612

The total installed power generation capacity in India, from renewable and non-renewable sources, amounted to 307.27 GW in 2016. At 46 GW, RE comprised 15% of total installed capacity.

In 2015-16, solar and wind comprised 3019 MW and 3423 MW of new renewable installed generation capacity respectively. With 28,279.40 MW of grid-connected installed generation capacity, India ranks fourth behind China, the USA and Germany in wind power generation **(Table 3.4)**.

More than 30,000 solar pumps are operating in 2015-16 out of a total 90,000 pumps, installed since 1991.

Out of the 20,904 MW of solar projects tendered in 2015-16, contracts for 11,209 MW capacity have been awarded.

Until 2016, the total grid-connected installed capacity of solar power in India was 8727.64 GW **(Table 3.5)**.

Some of the major initiatives undertaken by the government include: Power Purchase Agreement (PPA) approved for 10,824 MW; the construction of 34 solar parks with a cumulative capacity of 20,000 MW; the release of Rs. 67.01 crore for the collation of plans and the installation of solar devices (MNRE 2016). All power projects have buyers before establishment, in the form of PPAs (D'Souza 2018).

Table 3.5 Programme/ Scheme wise Achievements in Year 2016 (January-October 2016)

Sector	Achievement (January - October 2016)	Cumulative Achievements as on 31.10.2016
I. Grid Interactive Power (Capacities in MW)		
Wind Power	3191.21	28279.40
Solar Power	3848.77	8727.64
Small Hydro Power	146.47	4323.37
BioPower (Biomass & Gasification and Bagasse Cogeneration)	331.78	4882.33
Waste to Power	7.50	114.08
Total	**7525.73**	**46326.82**
II. Offgrid/ Captive Power (Capacities In MW equivalent)		
Waste to Energy	14.61	161.12
Biomass(non-bagasse) Cogeneration	49.54	651.91
Biomass Gasifiers -Rural -Industrial	0.19	18.34
	15.58	176.30
Aero-Genrators/ Hybrid systems	0.26	2.93
SPV Systems	84.98	373.99
Water mills/micro hydel	1.60	18.81
Total	**166.80**	**1403.40**

III. Other Renewable Energy Systems		
Family Biogas Plants (in Lakhs)	1.014	49.354

Source: *Government of India (2016), *Year End Review –MNRE*, Ministry of New and Renewable Energy, [Online: web] Accessed 24 February 2017, URL: http://pib.nic.in/newsite/PrintRelease.aspx?relid=155612

Only 500 MW of solar rooftop capacity was installed until 2016. Large public buildings were the primary targets for installation. The World Bank, KfW (Germany), Asian Development Bank (ADB) and NDB contributed about US$1.3 billion in funds. These funds are disbursed by government banks and by IREDA with an interest rate of less than 10%.

In 2015, the central cabinet approved the National Offshore Wind Energy Policy to develop offshore wind power along India's vast coastline. Guidelines for onshore wind were approved in October 2016. Similarly, guidelines were issued in October 2016 for setting up 1000 MW Inter-State Transmission System (ISTS) connecting wind power projects. The largest single wind turbines manufactured in India have a capacity of 3 MW. There are 20 registered firms manufacturing 53 kinds of turbines (MNRE 2016).

The scheme for installation of pumps, operational since 1991, has installed 31,472 Solar Pumps in 2015-16 against a target of 100,000 solar pumps.

An array of amendments to the Tariff Policy will enhance the portfolio of renewables in India's energy basket. Some of these amendments include enhancing solar RPOs to 8% by 2022; the inclusion of RGOs for new coal/lignite capacity additions; the exclusion of solar and wind power from inter-state transmission charges or taxes on transmission losses (vital when considering that these are large). The bundling of solar power with unallocated thermal power from coal-fired plants will reduce costs.

The Power Grid Corporation of India (PGCIL) has sought a loan of $1 billion from the ADB to create a 'National Green Energy Corridor', which will also include improving the transmission network between the Western and Southern regions, the creation of

Inter State Transmission System (ISTS) in Rajasthan and real-time monitoring of power transmission.[30]

MNRE's budget was raised to Rs. 9000 crores in 2016-17.

Over 5000 solar photovoltaic technicians have been trained under the 'Surya Mitra' (Friends of the Sun) Scheme until September 2016. Rs. 15 crore is the limit on loans provided to firms for the purchase of solar generators, wind power systems and clean energy-based utilities. The limit is Rs. 10 lakhs for individual households.

The Clean Energy Cess on coal, imposed since 2015, is now Rs. 400/tonne.

The Electricity Act. 2003 has been amended to accommodate Foreign Direct Investment (FDI) up to 100% under the automatic route for renewable energy generation and distribution projects.

3.4.1 Policy Initiatives promoting renewables

The Electricity Act of 2003 and the National Tariff Policy of 2006 form the foundation on which renewable energy in India has developed. They provide the framework for the generation, transmission and distribution of electricity. Over the years, they have been supplemented by public policies like the National Action Plan on Climate Change (NAPCC) of 2008, the Integrated Energy Policy (IEP) of 2006 and finally the five-year plans that have been implemented in the intervening years. The IEP introduced concepts like feed-in tariffs to increase the profitability of renewables and increase confidence among private investors. It also provided for the creation of Renewable Power Obligation (RPOs), and Renewable Energy Certificates (RECs). Unlike the IEP, the NAPCC was India's first international commitment focussing on climate change. Its biggest contribution towards renewable energy growth in India was the inclusion of the Jawharlal Nehru National Solar Mission (JNNSM), which sought to expand solar energy production to 22,000 MW by 2022 (Nagamani 2015: 1207-1208).

3.4.2 India's Incentives for Solar and Wind Power

India's target of developing 175 gigawatts (GW) of renewable energy by 2022 indicates a strong show of official support for the nascent solar and wind sector. Consequently, several tax and financial incentives seeking to make wind and solar energy cost-

[30] PGCIL has received a $1.25 billion loan ($500 from ADB; $625 from KfW Bankengruppe; $100 million from AIIB in 2017. [Online: web] Accessed 14 June 2018, URL: https://www.adb.org/projects/44426-016/main#project-pds

competitive with conventional fuels (mainly coal) were introduced. The renewed target for increased capacity of renewables is merely a 'strong statement of intent' (IEA 2015: 99).

However, the gradual withdrawal of these incentives, which successfully reduced the price of solar and wind power, threatens to make renewable energy (RE) projects financially unviable.

The June 2015 decision preceded the Paris round of climate change negotiations later that year, where India, along with several hundred other nations, agreed to restrict their domestic carbon emissions.

100 GW out of the 175 GW target is to be met through solar power (60 GW through solar photovoltaics and 40 GW through rooftop solar installations). Wind power will contribute 60 GW. The rest of the target is to be met by small-hydro and biomass.

Accordingly, the Ministry of New and Renewable Energy (MNRE) has issued several directives to attract foreign investment in the sector. Renewable Purchase Obligations (RPO) requires power distribution companies (discoms) and large industries to source a fixed percentage of their power requirements from renewables. Each state has set its own RPO requirement, which may usually vary from 2-14% (MNRE 2015a).

On the other hand, 10% of power production from new coal and lignite capacity additions must come renewables according to the Renewable Generation Obligation (RGO).

Incentivising solar and wind power generation to lower their per unit cost follows (grid parity) the federal government's policy to diversify India's energy mix through the introduction of renewables.

3.4.2.1 Tax incentives offered to the wind and solar energy industry:

The government's policy to enhance India's RE portfolio has led to the introduction of a slew of tax incentives to encourage investment (Gonsalves 2018).

- Firms are exempt from the payment of income tax on profits from power generation for the first 10 years of their operation.
- Some imported products are exempt from payment of excise duty. For instance, certain components of wind-energy electricity generators and solar photovoltaic (PV) ribbons are liable for full exemptions.

- Select components for the manufacture of solar modules, solar water heaters and associated systems are granted complete or partial Basic Customs Duty (BCD) waivers.
- Solar and wind power projects are excluded from inter-state transmission charges or taxes on transmission losses for 25 years from the date of commissioning.
- The Goods and Services Tax (GST) on solar and wind energy components is limited to 5%.

3.4.2.2 Financial incentives:

In recent months, several state governments have switched to an auction-based allocation of wind and solar capacity. The lowest wind and solar tariffs now amount to $0.04 (Rs.2.44 for solar and Rs.2.50 for wind). The government offered several incentives as a means to bring down the costs of solar and wind energy (Gonsalves 2018).

- Wheeling charges (power transmission over the grid) are comparable with those offered to fossil fuel–based power. Considering the intermittency of renewables, this is a vital incentive offered to companies.
- Viability Gap Funding (VGF) assistance up to a maximum of $153,846.2/MW through reverse e-auction for ultra large solar power projects of 5000 MW capacity will be implemented by Solar Energy Corporation of India (SECI).
- In addition to a subsidy of 30% of project costs, off-grid solar projects can avail soft loans.
- 40% accelerated depreciation in a written down value (WDV) basis.
- Rooftop solar installation are accommodated in housing loans provided by banks or National Housing Boards.
- To protect against defaults by State distribution companies, solar power has been included in the Tripartite Agreement between the Federal government, State governments and the Reserve Bank of India (RBI) for payment security.

The growth of RE as an alternative to fossil fuels has been characterised by a steadfast interest by successive governments in the form of massive subsidies – a policy tool that has received mixed reviews. An immense burden on a nation's finances, they create monopolies by making private investment seem unprofitable. Intended as a tool for social welfare, they absorb much of the government's finances and affect the very goal of their implementation by leaving scant resources for other social programmes. In 2013-14, $550 billion in subsidies were directed towards fossil fuels globally. Compared to this, renewables received $120 billion in subsidies (Acharya and Sadath 2017: 453).

According to the authors, the paper studies the consequences of reforms in domestic energy subsidies on the social welfare policies of India (Acharya and Sadath 2017: 454).

Increasing incomes within a burgeoning population precedes an increasing demand for more energy resources. With per capita energy consumption measuring a growth of 4.1% in India since the last forty years, financial resources diverted towards subsidies has widened the national fiscal deficit since 2008. In 2012-13, approximately 2.5% of the total GDP catered energy subsidies when the price of crude was over a $100 per barrel.

It is important to note here that subsidies, in India, for petrol were withdrawn in 2010, while subsidies for diesel were withdrawn in 2014 through the deregulation of prices.

Acharya and Sadath (2017: 461) conclude that subsidies targeted towards the poorest often leak into richer groups. They argue for the phased withdrawal of energy subsidies. This move will allow the government to target financially vulnerable groups more specifically through social welfare programmes.

3.5 Investments in Renewables

With no law dealing specifically with RE in India, an amendment to the Electricity Act of 2003 accommodated Foreign Direct Investment (FDI) up to 100% under the automatic route for renewable energy generation and distribution projects. Most companies operating in India do so as Limited Liability Partnerships (LLP), either forming joint ventures or wholly owned subsidiaries.

The combination of favourable policies and incentives has attracted about US$2.05 billion in investments received from April 2014 to December 2016 **(Table 3.6)**.

When asked how is the Indian government planning to induce more investment in RE, Mr. Vijay D'Souza (2017) answered that, "there is already plenty of private investment in the RE". He disagreed that government investment is symbolic. Instead, it was action-oriented, but in need of expanding its focus to tap all other resources.

Table 3.6 Major FDI Equity Inflow in the Renewable Energy Sector (April 2014-December 2016)

Foreign Collaborator	Country	Indian Company	FDI Equity Inflow (USD Million)
MUDAJAYA Corporation Berhad	Malaysia	RKM Powergen Pvt Ltd	77.18
GAMESA EOLICA S L	Spain	GAMESA Wind Turbines Pvt Ltd	66.76
AIRRO (Mauritius) Holdings	Mauritius	DILIGENT Power Pvt Ltd	62.44
Greenko Mauritius	Mauritius	M/S GREENKO Energies Pvt Ltd	59.52
Azure Power Global Ltd	Mauritius	AZURE Power India Pvt Ltd	54.11
ORIX Corporation	Japan	TADAS Wind Energy Private Limited	53.23
OSTRO Renewal Power Ltd	Mauritius	OSTRO Energy Pvt Ltd	45.81
Asian Development Bank	Philippines	Renew Power Ventures Private Limited	44.69
AIRRO Singapore Pte Ltd	Singapore	DILIGENT Power Pvt Ltd	41.07
ORIX Corporation	Japan	LALPUR Wind Energy Private Limited	37.75
ENEL Green Power	Netherlands	BLP Energy Private Limited	32.61

Development B.V.			
DEG-DEUTSCHE-Investitions-Und-Entwicklun	Germany	WELSPUN Renewables Energy Pvt Ltd	32.50
ENERK International Holdings Ltd	Seychelles	RKM POWERGEN Pvt Ltd	32.50
OSTRO Renewal Power Limited	Mauritius	OSTRO Energy Pvt Ltd	32.21
AREVA Solar Inc	U.S.A	AREVA Solar India Pvt Ltd	31.53

Source: Department of Industrial Policy and Promotion (DIPP) and Ministry of New and Renewable Energy (MNRE).

However, in the field of manufacturing where India lacks core manufacturing competenecies, government policies fall far short of supporting the domestic RE industry. The value chain that India has created is not feasible to manufacture even basic solar components. India does not manufacture silicon from sand. The introduction of duties on cheap imports contradicts the government's policy to source the lowest costing panels for government projects (Powell 2018).

3.5.1 Response from Industry

In 2016-17, the installation of 5,400 MW of new wind power capacity surpassed the previous achievement by 1,928 MW set in 2015-16. It brought total installed wind capacity to 32,280 MW. making India the fourth largest country in terms of wind power capacity behind China, the United States and Germany. The wind power sector contributed 4 percent of the total electricity produced by India's entire power generation capacity of 320,000 MW in 2017 (Ramesh 2017).

The phenomenal increase in wind power capacity reflects the positivity experienced after the country's first-ever auctions of 1000 MW of wind power capacity in February 2017. Previously, the state electricity regulatory authorities set static prices that did not reflect market realities. At the auction, the lowest price quoted was a record Rs. 3.46 (US 0.050 cents)per kWh. This auction price, a result of competitive bidding, is the selling price of electricity produced by wind farm owners to electricity distribution companies. Powell (2018) urges caution, arguing that, a comparison at the system level is absent. The low tariffs are only at the plant level and not wholly represent the system level cost. Currently RE is being ‘blended’ with coal and supplied. If the share of RE increases then low tariffs are bound to create socio-economic problems originating from poor financing (Powell 2018). Falling solar prices reflect direct generation costs and not systemic costs (Nanda 2018).

The move to auction wind power capacity by the Central government has created a trend among state governments as well. The purchase of cheap power from wind power projects enables the government to sell it power distribution companies located in different states. Under the Renewable Purchase Obligation (RPO), power distribution companies are mandated to source a part of their supply from renewables. In such a scenario, the Indian government plays the role of a trader. The popularity of auctions has created two distinct expectations. One, wind power installations are expected to further increase in the eight states already possessing substantial wind power capacity. Earlier restricted to Tamil Nadu in the 1980s, wind power capacity has expanded into the southern and western states, excluding Goa. The second scenario could result in unfavourable pricing for sellers. While the government gets cheap power through competitive bidding, the intense competition has pushed down the selling price of wind power, lowering profits and making operations untenable. The low price has also set a standard wherein every government agency is revising earlier fixed prices, which they feel are advantageous only for private wind power developers (Ramesh 2017).

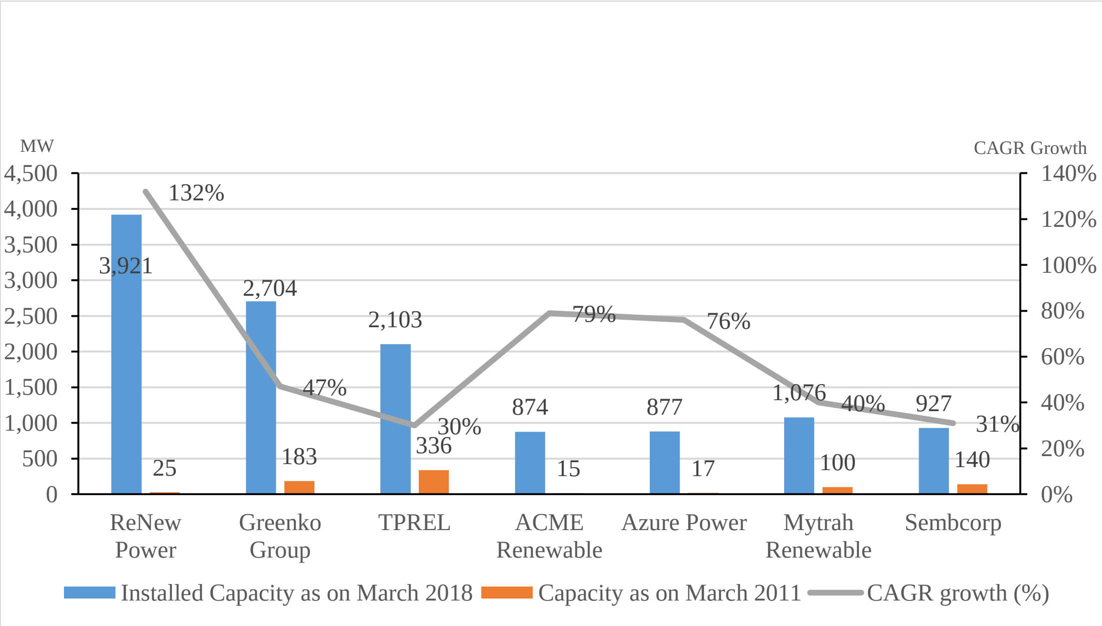
This development (auctions) comes in addition to the termination of the generation-based incentive (GBI) scheme in March 2017.[31] This scheme gave wind power companies an additional 50 paise (US 0.0072 cents) for every kWhr of electricity produced. Furthermore, the central government decreased accelerated depreciation benefits[32] by half form 80% to 40%; and the 10-year tax free benefit on profits were withdrawn. Thus, competitive bidding may benefit large investors like Public Sector Units (PSUs), while smaller investors in wind power projects (those with less than 10 MW capacity) are confronted with low prices and the withdrawal of subsidies that

[31] Mentioned in Chapter III.
[32] Discussed in Chapter III.

promoted small-scale units. This is a cause for concern in a sector where 60 percent of investments are by small investors (Ramesh 2017).[33]

ReNew Power, an Independent Power Producer (IPP), was the first private firm to establish one GW of commissioned capacity of RE in April 2016. **Figure 3.5** indicates that most IPPs in India grew by over thirty percent between 2011 and 2018.

Figure 3.5 Growth in operational Capacities (organic and inorganic) of large IPPs in India from FY2011-FY2018



Source: ReNew Power, CRISIL Research on Outlook on Renewable Energy Market in India (2018). Pg. 2.

3.5.2 Technological developments mating the current Indian power system with advances in modern wind and solar energy infrastructure

With the demand for electricity, especially in the Asian economies, rising steadily, the power generation industry is looking forward to the transformation of electro-mechanically controlled grid to a completely electronically controlled process. This transformation, it is hoped, will result in a market-oriented grid within the next twenty years.

A boon towards an improved quality of life, electricity should not be confused as a fuel; it remains an energy carrier. This engine of modern social progress has increasingly

[33] 'Removal of incentives to hit wind energy projects', *The Hindu*, [Online: web] Accessed 6 April 2019, URL: https://www.thehindu.com/business/Industry/removal-of-incentives-to-hit-wind-energy-projects/article18191688.ece

come to manifest itself into mammoth electricity grid transporting 'wholesale power' across large distances (Amin & Stringer 2008: 399). Their view on 'electricity as a carrier' is similar to that of O'Connor's (2010).

Contrary to what the public believes, the electricity grid not only encompasses the transmission systems moving electricity from the power plant to small substations, but also the facilities that distribute the electricity to the final consumer. Transport of electricity over large distances through long transmission lines could lead to the loss of about 7.5% of the power carried. In India, these losses are termed as Aggregate Transmission and Commercial (AT&C) losses.[34] Heavy congestion also contributes to an increase in these losses (Amin & Stringer 2008: 400-401)**.**

They propose the creation of a 'smart self-healing grid', which involves the placement of a processor into every element of a substation, relaying real-time information of the condition of every component to technicians. However, this is a very expensive proposition. Since 2002, the US has launched a program called Fast Simulation and Modelling (FSM) that provides grid-operators futuristic information much faster than real-time to prevent grid instability (Amin & Stringer 2008: 403-404)**.**

The authors challenge the traditional notion of deregulation – increased competition will gradually lead to reduced prices. They contend that players in a deregulated economy opt to maximise their profits by increasing the efficiency of prevailing infrastructure to their maximum limits possible, instead of spending on innovation (Amin & Stringer 2008: 407)**.**

Ralf Fücks (2015) contends that, "Although the human population is increasing, humans are only consumers but also producers; producers of knowledge and innovation. This knowledge should be channelized into promoting biomimicry." Biomimicry is an approach to model or design technology to resemble the behaviour of organic creatures in order to have a minimal carbon footprint. For instance, tracked solar panels continuously follow the path of the sun to generate stable supplies of electricity. The beginning of the age of renewables must rely on technological superiority to pursue broad national programmes promoting extensive use of renewables.

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[34] Discussed in Section 3.2.1.

3.6 Challenges facing renewables in India

Despite significant private investments, only 58 GW of the 175 GW target has been achieved until December 2017. The withdrawal of incentives like a ten-year tax break and Generation Based Incentives (GBI) last year, compounded with a reduction of Accelerated Depreciation from 80% to 40% has led to a slowdown in sectoral growth.

In fact, the lowest solar bid of Rs. 2.44 ($0.04) per unit at Bhadla in Rajasthan was achieved through a combination of Viability Gap Funding (VGF), a state-backed long term Power Purchase Agreement (PPA) and land acquisition by the government (Gonsalves 2018).

Furthermore, the diversion of $8.3 billion from the Clean Energy Fund, to compensate states for losses incurred due to the implementation of the Goods and Services Tax (GST), is a let-down for investors seeking official funding.[35] The fund is financed by a Clean Energy Cess of $6.2 (Rs. 400) per ton of coal/lignite (imported or domestically mined).

While the government's intends to create a level playing field, the significance of tax and fiscal incentives to industrial growth in a coal-dominated sector with weak transmission and distribution networks cannot be undermined.

With an installed capacity of 23 GW in 2014, India possessed the fifth largest share of global wind power capacity that has seen its fortunes sway between the changes in subsidies offered by the state as well as central governments. Among the slew of measures promoting the use of renewable energy sources, power companies, under renewable purchase obligations, must source a certain share of electricity from alternative power projects; operators of alternative power projects are now paid a generation-based financial incentive that posits a payment for a fixed amount of output. The ramping up of the target for the JNNSM to 100 GW of solar power capacity by 2022 has provided a favourable push to solar power that comprised 3.7 GW in 2014. The solar module forms a smaller chunk of the 175 GW target for renewables by 2022. The JNNSM aims to build 60 GW of grid connected PV arrays with the remaining 40 GW from rooftop PV installations.

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[35] Singh, D. (2018), "Parliamentary panel objects to diversion of clean energy fund to compensate states for GST", *The Economic Times*, 10 December 2018 [Online: web] Accessed 19 January 2019, URL: https://economictimes.indiatimes.com/news/politics-and-nation/parliamentary-panel-objects-to-diversion-of-clean-energy-fund-to-compensate-states-for-gst/articleshow/67019031.cms

Fiscal incentives in the form of subsidies and a favourable regulation policy is necessary for alternative projects to recover most of their high investment costs, but this is resented by distribution companies that have to bear the additional costs of financing these subsidies (IEA 2015: 36). Poor returns for distribution companies have curtailed their ability to invest in upgradation of technology. This in turn also curtails their drive to purchase power from costly renewable energy projects that simply act as peaking plants (IEA 2015: 81).

The inability of solar energy to cater to the Indian power sector's evening peak demand is another hurdle in its application as a baseload fuel. Lacking sufficient storage capacity, solar energy offers fuel saving towards conventional sources during daytime operations but is found lacking when evening peak demand has to be met (IEA 2015: 93).

On the other hand, gas-powered plants offer a more flexible and dependable option. At $10-14 per MBtu from 2012-14 LNG was an expensive proposition for the Indian power sector. Gas was relegated to the role of a peak fuel with severe supply handicaps. With improving supply situations regarding LNG and the falling cost of renewables, coal's dominant position seems to be threatened by a 'renewables plus gas' option, but this depends on the reduction of domestic coal subsidies, low prices of gas in the medium term, falling capital costs and continued government support to renewables (IEA 2015: 129-130). The feasibility of using natural gas as a baseload fuel depends strictly on the relative price of coal in India (Skukla et al. 2009: 3523).

Shortages of domestic coal had resulted in gas replacing coal as a base-load fuel. But at the same time, critical power deficiencies that have led to higher electricity charges have also resulted in an increase of gas based power to enhance plant load factor (PLF) [Skukla 2009: 3533].

India also lags behind China with regard to the pricing of locally manufactured equipment for alternative energy. With production capability of domestically manufactured solar panels standing at 2.7 GW per annum in 2015, the IEA has cast a shadow of doubt on the achievability of the ambitious targets of the JNSSM. China, the world leader in the production of solar panels had, till 2013, managed to reach 11 GW of annual installation capacity. The solar mission faces a series of several challenges that include acquisition of land and the rehabilitation of those displaced, expansion of the network in the face of lagging demand and most important of all the $170 billion necessary for the financing of these projects. The domestic financial sector receives no incentive to offer loans to such projects while foreign financing faces institutional hurdles and currency risks (IEA 2015: 90).

Legislation by the Central government remains largely absent. Instead, an assortment of central and state level schemes guiding the growth of renewable energy in India. Purchase obligations, feed-in tariffs, accelerated depreciation schemes are all part of government initiatives to foster investment in wind and solar energy.

With a potential of approximately 750 GW of potential, estimated by the MNRE sponsored National Institute of Solar Energy, in India's northern, western and central regions. Although about 4 GW of utility scale PVs have been installed till mid-2015, only about 450 MW of rooftop photovoltaics have been installed till 2014.

The hostility of power distribution companies in obeying purchase obligations, the deficiency of financing for the significant initial capital costs, the capacity of utilities in absorbing surplus production and most importantly land acquisition issues form the crux of the challenges facing the mass deployment of solar capacity. The popularity of rooftop solar cells is derived as a solution to address land acquisition issues but its employment has been sluggish at best. Commercial and industrial consumers have adopted rooftop solar as a means to avoid overdependence on invertors or diesel powered generators during power cuts. However, as tariffs for conventional power, the decreasing generation costs of solar along with measures like net metering for industrial users generating surplus power receiving payment from the grid may spurn a boom in the adoption of rooftop solar.

The IEA 2015 report investigates the plausibility of renewables surpassing coal as the dominant fuel to create a low carbon conduit for the electrification of India. The report cites several reasons that make this scenario improbable. Even with a massive influx of infrastructure and funding, renewables cannot sustain increasing demands for power. Secondly, the reliance on foreign imports of solar panels, wind turbines as well as other technology threatens India's energy security – the main reason why India opted for coal in the first place.

Renewables, be it wind or solar, are highly susceptible to weather conditions with supply being highly intermittent. Its inability to cater to the evening peak in electricity consumption and a weak transmission network punch further holes in the reliability of renewables. In the case of wind power, there is a preference for solar power due to the possibility of setting up of solar infrastructure in proximity to centres of demand. Offshore wind farms offer a solution to land acquisition but these are expensive and high maintenance undertakings.

3.7 The Renewables plus Gas Option

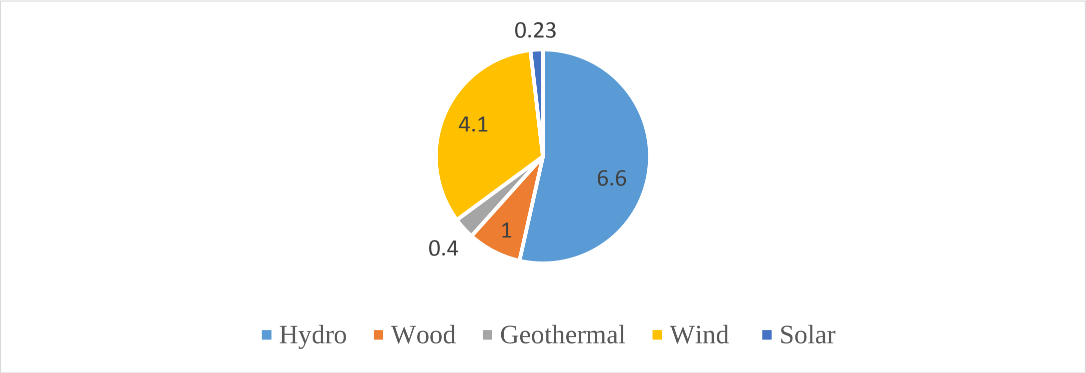
The negative attributes of coal use is recognised as a serious challenge to climate change mitigation. However, its wide availability across the developed and developing world make it an vital segment of industrialisation and overall economic development. Variations in quality are overcome by technological factors. Therefore, if the share of coal in the primary energy mix is targeted for withdrawal can RES fill the vacuum left by a stable domestic source of energy? The 'Renewables plus Gas option' is progressively being analysed to form the baseload capacity vacated by coal (IEA 2015). In this section we examine the 'option' to assist the development of RES in the medium term or until they can overcome intermittency-related issues. We start off by an analysis of the US energy sector as it presents us with a variety of issues to consider before the wide implementation of the renewables plus gas option.

Apt (2015) makes a pitch for the implementation of a 'renewables plus gas option' into the US electric supply system to tide over intermittency issues plaguing renewable energy;looking into the expansion of the contribution from RE, from the current 4%, within US power generation. He lists out three vital points for discussion. Firstly, intermittency, or variability as the author terms it, is the major hurdle in the large scale integration of utility-scale wind and solar electric power. Secondly, the addition of multiple interconnected wind plants reduces profit margins. Third, storage of excess solar or wind electric power is implementable only on small scale projects. Intermittency could be defined as variations in weather patterns preventing the effective generation of power from renewables. Unlike fossil fuels, RES are unable to cater to 'power on demand'.

Issues related to land-acquisition will prevent the expansion of wind and solar energy generation to not beyond the forecasted twenty or thirty percent. Utilities in the state of California managed to meet compulsory purchase obligations of energy from renewable sources, to the tune of 20%, successfully in 2012. In 2013, wind energy and solar energy contributed 4.1% and 0.23 % to the total renewable electric net generation of 12.4% **(Figure 3.6)**. Components for wind power production are much cheaper and widely available than their solar counterparts. The author contends that a method to create a histogram, among other statistical methods, simulating variations in power output for an extended period of time could assist experts in predicting periods of intermittency. While the interconnection of multiple wind plants, called aggregation, to tide over intermittency issues, does seem logical, this action only works for a few hours. Also, the addition of more interconnected wind plants will reduce returns as well as cost as much as a new combined-cycle gas plant (Apt 2015: 2-4).

Wind and solar related intermittency fluctuations may take place over several hours or days, thus imposing the need for fast-ramping gas plants which generate power at a faster pace than coal or combined-cycle gas plants. However, the recurrent use of fast-ramping plants generates high emissions that undermines the purpose of renewables. The author argues that the siting of solar or wind production facilities should be undertaken in dense polluting areas of the mid-Atlantic, in contrast to the vast open spaces of the south-west. Renewables have a much better chance at reducing air pollutants in areas with dense populations (Apt 2015: 7-8).

Figure 3.6 US Net Renewables Generation 2013 12.4% of total electric net generation



Source: Apt, J. (2015: 2).

As of 2014, India had acquired stakes in projects abroad that produced nearly 6.1 bcm/d (IEA 2015: 117). Natural gas at the Reliance-owned KG-D6 bloc, located between 700 and 1700 meters, is a challenging play with technical issues affecting well performance. However, future investment in gas exploration depends on the price offered by the government to domestic producers of gas. At $4 MBtu, down from a previous $5.6

MBtu after revisions, the current rate is a balancing act between the demands from gas dependent sectors and the minimum incentive required towards industry for further investment. Gas prices in India are referenced against international energy prices due to the absence of a domestic trading hub to peg the market price of gas in India. This consists of a slanted average of prices in the US, Canada, the UK and Russia among others. An ad hoc solution like this ignores the ground realities in India while discouraging further investment (IEA 2015: 120).

Only a fraction of India's vast coalbed methane reserves have been exploited (0.2 bcm till 2013). **(Table 3.5)** The existence of large reserves of shale gas have been speculated but its heavy dependence on water, a sensitive issue given India's agricultural woes, compels policy makers to go slow with the corresponding legislation (IEA 2015: 122).

Table 3.7 Natural gas resources by category in India, end-2014 (bcm)

	Ultimately recoverable resources	**Cumulative production**	**Remaining recoverable resources**	**Remaining % of URR**	**Proven reserves**
Conventional onshore	1 570	280	1 280	82%	290
Shallow offshore	1 810	500	1 300	72%	340
Deep offshore	1 480	70	1 400	95%	770
Coalbed Methane	1 230	0	1 230	100%	20
Shale gas	2 720	0	2 720	100%	0
Total India	**8 810**	**850**	**7 930**	**90%**	**1 420**

Note: URR = ultimately recoverable resources.

Source: IEA databases; BGR (2014); USGS (2012a, 2012b); OGJ (2013); BP (2015); Rystad Energy AS; India Ministry of Petroleum and Natural Gas. As quoted in *International Energy Agency (2015), *India Energy Outlook*, World Energy Outlook Special Report, Paris. Pg. 115.

Although located near West Asia, the transport costs of LNG to India are not significant but this has not depreciated the price of LNG that is available to power companies. At $6 MBtu, LNG is much more expensive than even coal imported from abroad. Added to this is the distance of the main areas of demand from the LNG terminals on the coast and the lack of infrastructure in the eastern and southern regions of the country to transport LNG. Hence, price differences and infrastructural lacunae relegate LNG to the role of a peak fuel to meet peak demand for electricity that cannot be met by coal alone (IEA 2015: 123).

On the other hand, the Turkmenistan-Afghanistan-Pakistan India (TAPI) and the Iran-Pakistan-India (IPI) initiatives have run into stalemates for two reasons- commercial and political (IEA 2015: 124). Pricing and financing contribute to the first while the instability in Afghanistan and tensions between India and Pakistan are part of the latter (IEA 2015: 124).

3.7.1 The Complexities of Natural Gas use in India

The power sector in India received priority subsidised gas under the Administered Price Mechanism (APM), which governed gas extracted by PSUs. The APM for oil was phased out in 2002 but it still exists in the case of gas. In 2010, APM prices were raised from $1.8/Mbtu to $4.2/Mbtu and PSUs were permitted to market gas extracted from new fields allocated to them at market prices (Corbeau 2010: 5). In 2009, the IEA forecasted that natural gas demand, if it continued to grow at 5.4% per year, would reach 132 bcm by 2030. The New Exploration Licensing Policy (NELP) of 1998, which unlocked the Indian petroleum and natural gas sector to foreign and private players, resulted in significant gas finds in the Krishna Godavari basins in the east coast. With production beginning in early 2009, the consumption of natural gas increased by 16 billion cubic meters (bcm) to touch 59 bcm in 2010 (Corbeau 2010: 5).

Earlier the majority of natural gas in India was diverted towards the heavily subsidised fertiliser industry, and the power sector through the Administrative Price Mechanism (APM). However the price reforms in 2010 that did away with the pre-determined (and often reduced) prices set by the government created rendered natural gas more receptive to market forces (Corbeau 2010: 5).

Prolonged hostilities with Pakistan have prevented the construction of overland gas pipelines from Central Asia and Iran. As an alternative, India has established large-scale facilities on its western coast to re-gasify LNG imported from West Asia (Corbeau 2010:6)..Infrastructure for gas is located on the Western coast or in the north western region on India (Only 1 pipeline connecting eastern India exists – GAIL 2016). As of 2014-15, there were four LNG terminals located at Dahej, Hazira, Kochi and Dabhol.[36]

According to Corbeau (2010: 8), India lacks wide foreign private participation in its energy sector due to the interference of the government in issues regarding gas pricing, allocation and transparency in governmental regulation.

Gas Authority of India Limited (GAIL), Reliance Gas Transportation Infrastructure Ltd (RGTIL) – a subsidiary of RIL – and Gujarat State Petronet Ltd. – a subsidiary of GSPC – are some of the important players in the gas transportation sector. Ending the monopoly of GAIL in 2006, the entry of RGTIL led to the construction of the East-West Pipeline (EWPL) in just two years.

The gas supplies allotted to the power sector under the APM have been gradually declining and total subsidies afforded by the power sector over a five year period stood at $16.6 billion in 2008-09. Artificially low APM prices discourage investment in upstream projects and financially burden PSUs (Corbeau 2010: 18). To tide over an increasing supply-demand gap India has been compelled to opt for contracted LNG supplies from the global market or spot cargoes, whenever these are available. India contracts LNG for its terminals on the western coast through long-term contracts, short-term contracts as well as spot cargoes (Corbeau 2010: 19).

Gas-operated power stations located close to gas transmission networks and coal-fired power plants at a distance from coalfields or dependent on imported coal; make the former an attractive competitor against coal.

The losses experienced by ONGC resulting from under-recoveries from the power sector and fertiliser industry amounted to $1 billion in 2008-09.

As of 2009, the proven and potential reserves of gas in India was 1074 bcm. Domestic production in 2009-10 touched 46 bcm[37]. India lacks a complete geological survey of sedimentary basins with a mere 20% of the sedimentary basins being fully explored (Corbeau 2010: 21). Licensing delays and retail price caps have always been traditional hindrances to new foreign investment in new exploration. The National Exploration and Licensing Policy (NELP) which included among its clauses, tax breaks for seven years

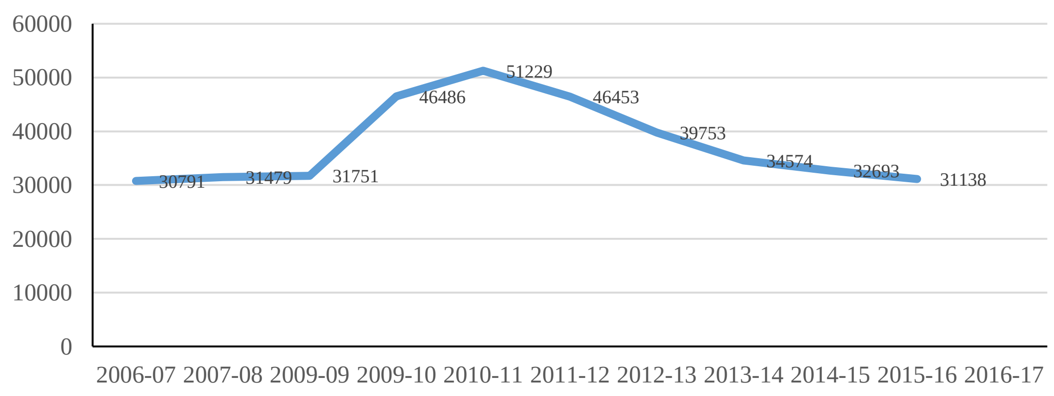
[36] Ministry of Petroleum and Natural Gas - Demand For Grants (2014-15), First Report. Pg: 80.

[37] Domestic natural gas production peaked at 51 bcm in 2010-11.

beginning from the onset of production, or an exemption from customs duty imports on petroleum products, has been unable to meet targets either. Investors could sell their products after discussions with the government relating to price. However, the government's continuing policy of capping domestic prices has deterred the bigger international private players (Corbeau 2010: 23).

Expecting increased supplies from the RIL operated KG-D6 off-shore field, several gas-based power projects were envisaged and built, but erratic offtake of gas supplies from KG-D6 have disturbed stable production from this field. Another important point to bring here is the government's intervention in the dispute between the Ambani brothers. The stand of the government that the price of natural gas, a national wealth, could not be argued by private players, was backed by the Supreme Court. This has cast doubt on the strength of the Production Sharing Contract (PSC) based NELP and the willingness of the GOI to abide by commercial agreements (Corbeau 2010: 26). **Figure 3.7** demonstrates the spike in natural gas production from the KG basin from 2008-09 onwards. It peaked in 2010-11 and gradually tapered off in the subsequent years. The decline from 51,229 million metric standard cubic feet per day (mmscmd) in 2010-11 to 32,693 mmscmd in 2015-16 showed a forty percent decline in natural gas production. The ingress of sand and water were blamed for declining production in fields that were expected to possess reserves lasting up to fifteen years.[38]

Figure 3.7 Net Production(in MMSCMD)



Source: Gupta, Ankit (2017), 16(3): 39.

[38] In September 2018, Reliance Industries Limited (RIL) shut down its single oilfield in the KG basin. BP owned thirty percent of the joint venture along with NIKO Resources' ten percent. Pathak, Kalpana (2018), "Reliance Industries shuts its only oilfield in Krishna Godavari basin", *Livemint*, [Online: web] Accessed 14 October 2018, URL: https://www.livemint.com/Home-Page/26cYvl37yfAhuVudBjUoDK/Reliance-shuts-down-Krishna-Godavari-oilfield.html

In 2004, India, lacking pipeline connectivity, began to import LNG. Several other factors contributed to the expansion of India's efforts at securing LNG. The fall of spot prices for LNG, spike in the prices of naphtha, declining domestic production from older fields like Bombay High and contractual problems surrounding the Krishna-Godavari fields are some reasons why India opted for acquisition of LNG supplies (Corbeau 2010: 31).

India and Qatar entered into a long term contract for the supply of LNG in 2004. India has contracted spot cargoes from Russia, Australia, Trinidad and Tobago, among several other countries that it trades with **(Table 3.7)**. LNG is increasingly being seen as an attractive option due to falling spot prices stemming from low demand in East Asia, rise in the prices of naphtha, declining output from older domestic fields and multiple issues plaguing supply from the KG-D6 field. As of 2014, contracted supplies of LNG amounted to 18 bcm. LNG regasification terminals at Dahej, Hazira – both located in Gujarat - and Dabhol in Maharashtra have been constructed, among others, to cater to growing imports (Corbeau 2010: 32).

Table 3.8: India LNG imports by country (bcm)

	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Abu Dhabi			0.09	0.08	0.13	0.16
Australia			0.09		0.16	1.11
Indonesia						0.08
Malaysia			0.09	0.09	0.08	0.25
Oman			0.27	0.27	0.41	0.35
Qatar	3.49	6.98	8.24	9.43	8.34	7.95
Algeria			0.09	0.55	0.53	0.16
Nigeria			0.09	0.77	0.38	0.32
T&T				0.24	0.23	0.68
Egypt			0.62	0.09	0.24	0.33
E. Guinea					0.42	0.25
Norway					0.08	
Russia						0.68
Others					0.17	

Total	3.49	6.98	9.59	11.52	11.16	12.31

Source: IEA, Natural Gas Information 2010. As quoted in Corbeau (2010): 32.

India's Ministry of Petroleum and Natural Gas (MoPNG) estimated that domestic consumption of natural gas in 2009-10 amounted to 59 bcm. According to the India's 11th Five Year Plan (2007-12), the consumption of natural gas was set to increase ceteris paribus between 37% and 58% (Corbeau 2010: 37).

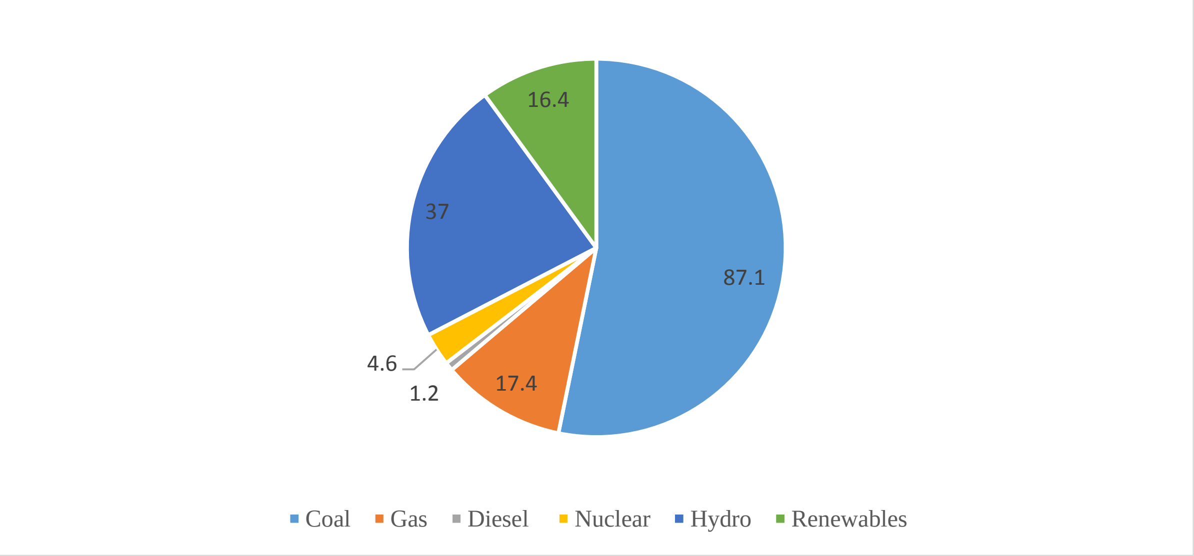
Table 3.9 India's gas use (Mcm)

	2004/05	2005/06	2006/07	2007/08	2008/09
Energy purposes					
Power generation	12 099	11 878	11 963	12 037	12 603
Industrial fuel	3 569	3 780	3 205	3 324	5 912
Tea plantation	142	151	170	160	154
Domestic fuel	343	75	443	39	102
Captive use/LPG shrinkage	4 944	5 048	5 034	5 618	5 706
Others	231	1,120	40	1258	1535
Non-energy purposes					
Fertiliser	8 173	7 762	8 497	9 822	9 082
Petro-chemicals	1 236	1 175	1 377	1 432	1 105
Others	38	36	639	638	6 761
TOTAL	30 775	31 025	31 368	34 328	42 960

Source: Ministry of Petroleum and Natural Gas of India. As quoted in Corbeau (2010: 38).

The shortfall in gas supply compelled gas-fired plants to run on naphtha, and remained idle when naphtha grew too expensive. This situation improved gradually with the decline of spot prices and increasing supply from the KG-D6 field that has improved plant load factor (PLF) considerably **(Table 3.8)**. The spike in electricity prices, a result of the shortfall in coal and electricity supply, has led to the adoption of non-APM gas as a base fall to tide over shortages (Corbeau 2010: 39).

Figure 3.8 Generation capacity in India (July 2010) (GW)



Source: Central Electricity Authority. As quoted in Corbeau (2010: 39).

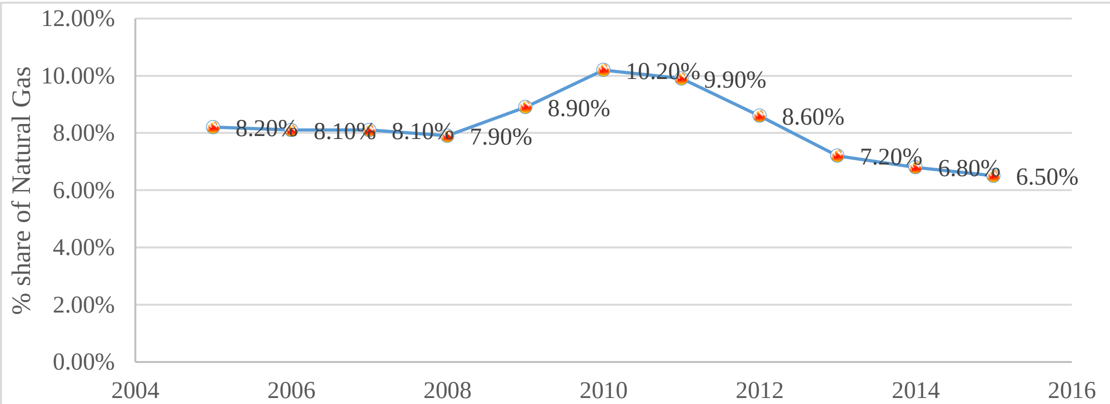
In order to measure the competitiveness of gas over coal for use as a base-load fuel the Corbeau (2010) examined short-run marginal costs (SRMC) that focusses on operational plants. After considering several factors like distances from coal mines till power plants, increased price of APM gas, cost of contracted LNG as well as spot cargoes and transport through domestic pipelines the SRMC approach concludes that coal is a much cheaper option than gas (Corbeau 2010: 40).

A second approach that scrutinises generation costs for new argues that although newer gas-fired power plants offer more efficiency, modern coal-fired power plants offer a PLF similar to the levels observed in gas-fired power plants **(Figure 3.8)**. When fed with domestic coal, these coal-fired plants are a better alternative to their gas-fired competitors. However, in cases where imported coal is being used or when the distance from mine to plant is great, gas could pose a credible threat to coal as base-fuel (Increasing production of coal and reforms in the coal industry could decrease imports of coal n further threaten gas' position) [Corbeau 2010: 41].

Corbeau (2010) concludes that apart from the construction of gas-based infrastructure, the government's policy regarding APM gas as well as domestic production will not only impact India's ability to attract crucial foreign investment but also the profitability of domestic upstream companies.

India has a target of achieving fifteen percent natural gas share in the energy mix by 2020. However, until 2018-19 it had barely reached eight percent of the total energy mix due to supply shortages (Sengupta 2019). **Figure 3.9** represents the progress of natural gas in India's primary energy mix (Gupta 2017). The share of natural gas mirrors the progress of net production shown in **Figure 3.7** previously. Domestic production from the KG fields coincided with the availability of greater LNG capacity from countries like Qatar, which, had begun to come online. The decline in natural gas share shows the effects from diminishing domestic supplies and also from increasing demand from China, which was in the throes of replacing coal in power production in the northern regions resulting in a spike in prices in the spot market. At 6.5 percent in 2016, India's natural gas consumption was considerably lower than the global average of approximately 25 percent (Gupta 2017).

Figure 3.9 Natural Gas in Prime Energy Mix (%)



Source: Gupta, Ankit (2017), 16(3): 39.

In light of this scenario, rising supplies of shale gas from the US is making its presence felt gradually in the international market. The availability of large shale gas volumes could re-ignite the interest in natural gas use in the power sector in India. It has proved to be the lynchpin for pushing down energy prices despite increasing demand from economies picking themselves after the Recession of 2008. Let us examine the diverse issues influencing the growth of shale gas within the power sector.

3.7.2 The impact of shale gas extraction in the United States

Macmillian et al. (2013: 3-4) examine the implications of decreasing production costs of shale gas in augmenting the affordability of gas-fired plants when compared to coal. Fuel price, the phasing out of old coal-fired power plants, the construction of new Combined Cycle Gas Turbines (CCGT) and changes made to power regulations are the factors considered for this study. The US is the world's leading consumer of natural gas and the second largest consumer of coal. Its gas consumption totalled 690 bcm in 2011. The dramatic drop in natural gas prices to under $3/Mbtu in 2012 was almost entirely absorbed by idle gas-fired plants while slowly eroding coal's dominance over gas in the US power sector. Ninety five percent of total coal demand in the US was absorbed by the power sector. The authors examined the many ramifications of the US's "quasi-independence" from LNG imports (Macmillian et al. 2013: 4). The first effect is the increasing amounts of LNG on the open market because of US dependence on domestic production as well as its plans to export shale gas. Secondly, stagnant gas prices in Europe have compelled the import of US coal for power generation that could undermine Europe's efforts at retarding its levels of emissions, while the largest emitter of GHG enjoys lower emissions.

They attempt to elucidate the meaning of the term 'fuel-switching' in the short term, by observing that fuel switching is an option available for transient fuel costs while leaving open to expand, convert, retrofit etc. (Macmillian et al. 2013: 5). Sixty percent of the US' demand for additional power was met by gas plants between 1990 and 2011. Coal, while still having a large base, its role as a peaking fuel is gradually declining. Although gas-fired plants outnumber coal-fired plants in the USs, the former is unable to displace the latter because of geographical compulsions like the proximity of the plant in relation to the source of its fuel, fuel prices at the state level, technical factors, the duration of coal contracts etc. This is similar to the Indian scenario where LNG has to be imported and is much more accessible to coastal areas. Between 1990 and 2019, a massive 184 GW of gas-fired capacity was constructed (Macmillian et al. 2013: 6).

Besides involving a lower input of capital, CCGT plants attract a lower degree of opposition compared to nuclear or coal-fired plants. Natural gas prices fluctuated rapidly in the late 1990s and 2000s. This encouraged several players to opt for CCGT due to favourable prices, but this cannot be attributed as the main reason behind the growth of CCGTs in the US as coal prices during the same period were low too (Macmillian et al. 2013: 7).

By 2011, natural gas entailed a built up capacity of 415 GW, possessing a 100 GW surplus than that possessed by coal-fired generation (Macmillian et al. 2013: 8).

Fluctuations in regional gas prices (exacerbated during the winter months when demand peaks) is a weak indicator of coal-to-gas switching when compared to the take-or-pay clauses that define long term contracts for coal supply, which might deter any inclination towards fuel switching (Macmillian et al. 2013: 10)**.**

Competing on a technical basis CCGT's of a newer vintage possess a definitive edge over older coal-fired power plants when factors like start-up rates, ramp rates, range, efficiency and output are considered. Coal-fired power plants of a recent vintage are a tough competitor to their gas-fired counterparts (Macmillian et al. 2013: 14). In states with regulated pricing, the incentive to reduce electricity prices may not exist due to already low electricity prices. If CCGT's are located at a distance from electricity distribution networks (which are highly independent of each other) it may serve as a deterrent to fuel switching in states with a dominant coal-fired base (Macmillian et al. 2013: 17)**.** Tightening of licenses to open new coal-fired power plants keeping in mind the portrayal of coal as a 'dirty fuel' may give impetus to fuel switching among older coal-based power plants even in cases where economic profit is tough to source (Macmillian et al. 2013: 19)**.**

Even with the introduction of shale gas into the market, new capacity for accommodating gas, is unlikely to expand greatly due to apprehensions that there is a significant excess of gas-fired capacity already in the market. The report concludes that switching will not gain traction in the US electricity market on account of fluctuating prices of gas in the US as well as the prevalence of long term coal contracts (Macmillian et al. 2013: 22-23)**.**

Venkatesh et al. (2013) argue on similar lines. They claim that when the average price of gas dropped to $1.5 per MMBtu, consumption within the power industry rose somewhere between 8-20%. The tripling of US natural capacity from 60 to 200 GW in the late 1990s and early 2000s was a product of lower gas prices (below $5 per MMBtu), but this expansion acted as peaker plants when prices soared above $5 per MMBtu. If the US begins to trade coal with Asia because of lingering natural gas prices in the domestic market, this could also lead to the transfer of emissions outside the US and not necessarily a cut in GHG emissions globally (Venkatesh et al. 2013: 6-7).

On the other hand, Cullen & Mansur (2014) examine the effect a carbon price would have on carbon emissions originating from the electricity sector. According to them, a combination of a carbon tax and low natural gas prices, ushered in by the shale revolution, are more adept at reducing carbon emissions. Their study concluded that a carbon price amounting to $20 would subsequently reduce carbon emissions by 6% (Cullen & Mansur 2014: 31). The market price of natural gas and coal was the most important factor in determining the success of carbon taxes.
While several regions within the US have implemented carbon prices, federal support to implement direct taxation on carbon emissions, instead of enforcing emission caps, remains elusive. At 65%, accounting for one third of all US carbon emissions, the electricity sector may opt for fuel-switching where underutilised natural gas capacity may be used to reduce emissions to 42%. Implementation of a carbon price could be as effective as reduced costs of natural gas vis-à-vis coal in the adoption of switching (Cullen & Mansur 2014: 1).

Extraction of shale gas led to a glut in the North American market where export options were limited, with prices falling by $10 to settle at below $2 in 2012 (Cullen & Mansur 2014: 2). A switch to natural gas gives way to a marginal increase in emissions stemming from gas-fired plants by one percent if a $20 carbon tax was imposed on per tonne of carbon emitted. Besides switching, conservation and efficiency measures that do not pass on additional costs to the consumers are encouraged. Producing most of the electricity generated in the US, the most distinct advantage possessed by coal-fired power plants is their relatively low operational costs. There are two types of gas-fired power plants – gas turbine peaker plants and CCGTs. The former operate during peak demand. Although lower gas prices are a good incentive encouraging switching, considerations like electricity demand, plant capacity, ramping rates, intra-day fluctuations, start up rates among others also have to be taken into account. With regard to power transmission, the three grids or 'interconnections', as they are termed in the US, are characterised by the absence of any interconnectivity (Cullen & Mansur 2014: 2-7)**.**

The market price of gas in the US may be low now but the threat of environmental regulations against the process of fracking could spike the prices further (Cullen & Mansur 2015: 28). The authors argue that the possibility of exports and an economic recovery could spell the end of cheap natural gas prices in the US (Cullen & Mansur 2014: 31).

Brehm (2015) argues that with the dramatic fall in natural gas prices, beginning in 2007, switching from coal generation to natural gas generation has been more prevalent (65-85% of new capacity) while also leading to a decrease of 14,700 tons/hour of carbon emissions amounting to US$5.1 billion.

The spread of the practice of fracking within the US natural gas sector has resulted in a depreciation of natural gas prices by over 65% since 2008. Total natural gas production in the US stood at 30 TCF (trillion cubic feet) in 2013. The decline of more than 31 thousand tons/hour of carbon emissions in 2013 from a high of 284.7 thousand tons/hour in 2008 is mainly attributed to the economic slowdown and the slight increase in the share of renewables rather than the increase in the use of natural gas in power generation. The author examines the short term implications of low natural gas prices on regional carbon emissions stemming from the power industry. Secondly, the author aims to focus on the implications of falling natural gas prices on carbon emissions resulting from the "unanticipated" expansion of gas-fired capacity. Low gas prices have induced the electricity industry to bring online additional gas-fired capacity. He contends that the addition of this expanded capacity will reduce carbon emissions even when natural gas prices begin to rise (Brehm 2015: 1-2).

Brehm (2015: 5) criticises Cullen and Mansur (2014), arguing that their study does not account for the further decline of gas prices neither does it minutely examine the expansion of additional capacity for electricity generation. He states that a dearth of infrastructure increased the transportation costs of natural gas, which handicapped its export outside the US, and pushing regional prices further down. Low marginal costs, a result of decreasing prices of natural gas, could induce switching, which can be underway in a matter of hours. Contrary to expectations of low capacity additions between 2010 and 2013, a period of reduced gas prices, 25.9 GW of gas-fired capacity was added (Brehm 2015: 9).

The expansion of natural gas production facilities can be attributed to governmental non-intervention in the fracking process, while lower gas prices have been less of a contributing factor (Brehm 2015: 38)**.** The shale revolution in the US – be it in gas or crude oil – had a profound influence in the overall energy sector. Cheap gas supplies in the early 2010s threatened the development of the global renewables industry, at a time when the latter had overcome initial technical, capital and systemic hurdles. Decreasing the share of coal in the primary energy mix of the nation is target of every nation since the emergence of the climate change issue. Filling the vacuum left by coal with gas encompasses several complications of its own. First, when accounted for in tandem with available gas reserves in Russia and West Asia, US gas reserves enlarge the available pool of reserves that could see nations opting for gas instead of renewables without the near-term threat of high gas prices. Second, low emissions from gas will show immediate results in the ambient environment[39] and meet the short-term goals of the nation, while satisfying the immediate visible and perceptive demands of the electorate. Collective action in the form of the adoption of natural gas to stave away climate change in the end will postpone the transition to renewables. The respite provided by large reserves to policymakers is only temporary given the finite nature of the fuel in the first place.

However, all the arguments regarding shale gas miss one vital issue – shale oil had a stronger effect on global crude oil prices. It was the primary reason for the fall in international prices when OPEC decided to slash prices and increase production in a bid to undersell its American counterparts in 2014. Cheaper oil supplies will mainly be absorbed by the global transport and manufacturing sector thereby abrogating any climate-related improvements experienced because of the switch to renewables. Supplies of cheap crude oil from shale extraction have already entered the Indian market. In 2017, a group of Indian national oil companies consisting of Indian Oil Corporation (IOC), Bharat Petroleum (BPCL) and Hindustan Petroleum (HPCL) ordered a total of 7.85 million barrels of US crude oil. A Very Large Crude Carrier (VLCC) transported the first shipment of 1.6 million barrels. It was received in the port of Paradip less than two months after it left its port of embarkation in the US Gulf Coast. It indicates the predominance of energy security in the form of diversification of energy sources for both consumer and supplier. Climate change imperatives cannot be rejected

[39] The city of Beijing China is experiencing some the cleanest air in a decade. Of the seven cleanest months since 2008, five belong to the summer of 2018. In a bid to reduce the recurrence of the 'airpocalypse' of 2013 when particulate matter in the prevailing smog was more than 35 times the safe limit, the federal government compelled a switch to natural gas in industry and residential heating. The move pushed up global LNG prices but at the same time made a strong visible impact in the air around Beijing. Bloomberg News (2018), "Beijing Enjoys the Bluest Skies in a Decade", 19 August 2018, [Online: web] Accessed 22 September 2018, URL: https://www.bloombergquint.com/global-economics/xi-s-clean-energy-drive-paints-bluest-sky-over-beijing-in-decade

outright as these may be fulfilled by concentrating on established competencies like efficiency measures prevalent in the Indian market. However, given the widespread availability of domestic coal supplies in India and the limited capacity for the expansion of LNG infrastructure globally in the medium term, there is clearly not enough gas supply available to overcome the dominance of thermal power generation (Natarajan 2018).

Inference

India's commitment to coal is based on massive entrenched capacities. This finding answers the third research question: *what explains India's commitment to coal as the dominant source of fuel in the production of electricity?* The use of clean coal technology and the possibility of large capacity additions by UMPPs threaten both the climate element of the transition and ignore the threat of future shortage. The cost of solar power is less than Rs 2.5 per unit; it is lower than non-UMPP production. Better absorption materials could increase capacity utilisation factors of installed capacities. Furthermore, the study observes that lower the initial cost of commissioning, greater the savings and profit to be extracted from RE projects, which have no fuel requirement anyway.

The chapter observes that the renewables plus gas option to displace coal from baseload capacity to balance intermittent supply from RE is not realistic as the supply of gas is low, in need of massive infrastructure support and sensitive to international gas pricing.

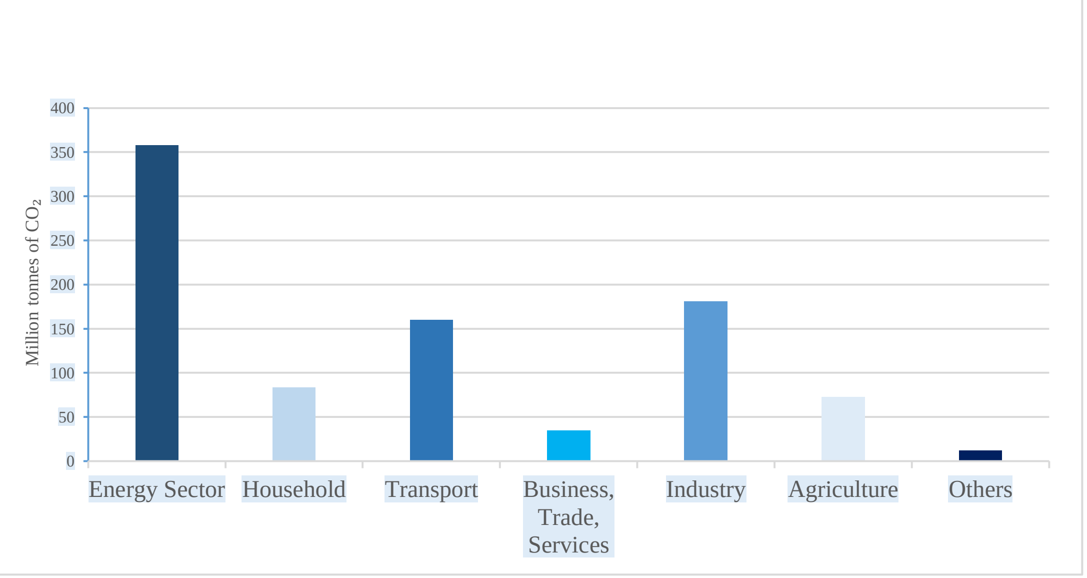
CHAPTER IV

Understanding Energy Transition through Germany's *Energiewende*

The *Energiewende* entered the public consciousness in the 1990s when support for the initiatives of the German Green Party began to gain traction at the political level. Two decades on, the initiative to decommission all nuclear power stations in Germany and reduce the dependence on other fossil fuels possesses 'broad political consensus' (Kerr et al. 2017: 215). Today the energy transition or energy turn around has led to the creation of two overlapping targets – the reduction of all carbon emissions by 80-90 percent and slashing primary energy consumption by 50 percent by the year 2050.[40]

Although the introduction of the Electricity Grid Feed Act of 1991 obligated utilities to purchase electricity from RE at higher tariffs than conventional fuel sources, it was the Renewable Sources Act in 2000, which strengthened the process to expand RE in power generation. The Act of 2000 proposed three concepts – assured fixed feed-in tariffs for all RES, a surcharge scheme that spread out additional charges equally among the consumers and, prioritised power evacuation by the grid (Federal Foreign Office 2018: 10).

Figure 4.1 Who emits greenhouse gases in Germany (2014, Million tonnes of CO_2)



Source: The German Energiewende, Federal Foreign Office, Berlin, pg. 14.

[40] Ibid.

Figure 4.1 shows that the energy sector emitted the largest share of greenhouse gas emissions. It indicates that more than one third of all emissions originate from Germany's power plants. If Germany must meet its targeted INDC of 35 percent reduction in per capita emission by 2030 then the energy sector must be at the forefront of the government's efforts.[41] However, the *Energiewende* is focussed only on electricity generation (about 20 percent of the energy sector), which restricts its impact (Heinrich Boll Foundation 2018).

These novel concepts proved to be the catalyst for the massive expansion of Germany's RE potential well before any country undertook the challenge of bringing RE into mainstream power generation. However, there are several other issues that have contributed to the early expansion and establishment of RE in Germany. Germany has the most aggressive plan to tackle climate change. This plan makes massive commitments to reengineer Germany's economy. It is this aggressiveness that makes it a worthwhile comparative study despite the glaring differences in demography, resources, technological ability, wealth and socio-political challenges that face India and Germany. First, we shall outline the factors that created a consciousness among Germans to attempt an overhaul of their power generation framework. Second, the study will examine the policies and the actors that provided the early fillip. Next, challenges to *Energiewende* shall be analysed with a direct comparison between India and Germany concluding this chapter.

4.1 Development of Germany's renewable energy industry

At the outset, Singh (2018) questions the heavy reliance on coal for power generation even with the abundance of community-owned and corporate renewable energy plants in Germany.

Germany is the pioneer in community-owned 'energy cooperatives'. Local organisations arrange capital by themselves to create infrastructure for mainly wind and solar energy generation. Approximately 150,000 individuals are involved in the citizen-owned energy cooperatives. Citizen-owned and community-owned plants may follow several models of ownership - private, cooperative or even shareholder-based. In 2013, 55 percent of the total installed renewable energy capacity in Germany was citizen-

[41] The University of Melbourne, [Online: web] Accessed 21 June. 2019 URL: http://climatecollege.unimelb.edu.au/files/site1/factsheets/Germany_INDCFactsheet_UoM-PRIMAP_GWPAR4.pdf

owned, with renewable energy solely powering the homes of over 20 million of the German population.

Predominantly rural communities, with the active involvement of the local protestant church, led this grassroots movement. These communities had borne the brunt of mining and diversion of resources to power the energy-intensive cities of Germany. With most rural communities consuming possessing lower energy levels than their rural counterpart's do, excess electricity produced by the local resource is sold to nearby towns for a profit.

This practice of local energy generation by communities or individual citizens is known as *bürgerenergie* or 'citizen energy'. The German scenario is hence a case study of a greater opposition to the NIMBY phenomenon.

RE development has overcome the scepticism of the 1980s to reduce Germany's greenhouse gas emission levels by 27 percent over the 1990 levels in 2016. However, the 40 percent reduction target over 1990 levels by 2020 seems unattainable even with the progress achieved so far. As the only country with an active national policy oriented towards greenhouse gas reduction, Germany's failure to reach the 40 percent target by 2020 will have significant repercussions on the success of the Green Party.

Singh (2018) questions the failure of Germany's aggressive policies in reducing its greenhouse gas emissions. He argues that coal-based power production has actually increased despite the growth of RE. Secondly, with RE being far more cost-competitive than natural gas, coal use has grown in the absence of a carbon tax. Thirdly, the initial call to expand RE infrastructure was in opposition to nuclear power generation. The latter, the lowest emitter of greenhouse gas emissions[42], has witnessed a 52 percent decline in production capacity since 2002.

Singh (2018) argues for an aggressive stance towards coal. Accurate weather predictions could assist utilities in arranging for adequate 'baseload electricity' or backup during intermittent weather. With the withdrawal of nuclear energy and the threat of intermittency looming, coal-fired systems have increasingly formed baseload capacity.

[42] Singh (2018) argues that the life-cycle emissions from nuclear power is much lower than most resources. He defines life-cycle emissions as 'emissions from the production of (components)'.

The author uses the concept of 'levelized cost of energy' (LCOE) to explain the 'economics of energy'. LCOE is described as the cost per unit of electricity from any resource, and including manufactured components, land, labour, minerals etc., in addition to the expected power production from the entire lifetime of the plant. LCOE allows analysts to study the differences in energy costs across several different energy sources. He presents readers with illustrations from the US power market. Until a few years ago, the LCOE of solar and wind energy was much higher than coal and even nuclear energy; they are now cost-competitive.

Current energy storage systems, which are mechanical or battery-powered, are incapable of storing huge amounts of energy. Singh (2018) suggests a modification of energy consumption patterns and the inclusion of several energy resources within the grid to cope with intermittent energy.

4.1.1 Opposition to Nuclear Energy

The word *Energiewende*, encapsulating the process of weaning energy systems away from a high carbon emission structure, has grown in popularity in recent years. Singh (2018) disagrees with popular opinion when he argues that Germany's transformation from coal and nuclear-based energy systems to those powered by the wind and sun is not the world's most aggressive. What makes Germany unique is its large domestic manufacturing capacity and the focus on nuclear energy, the fuel with the least carbon emissions. The historical transition from wood to coal helped conserve forestland. The second transition to petroleum helped preserve the sperm whale population. Germany's first nuclear power plant was built in 1969. It was envisaged that the growth of nuclear energy would decrease the rampant destruction of land due to coal extraction.

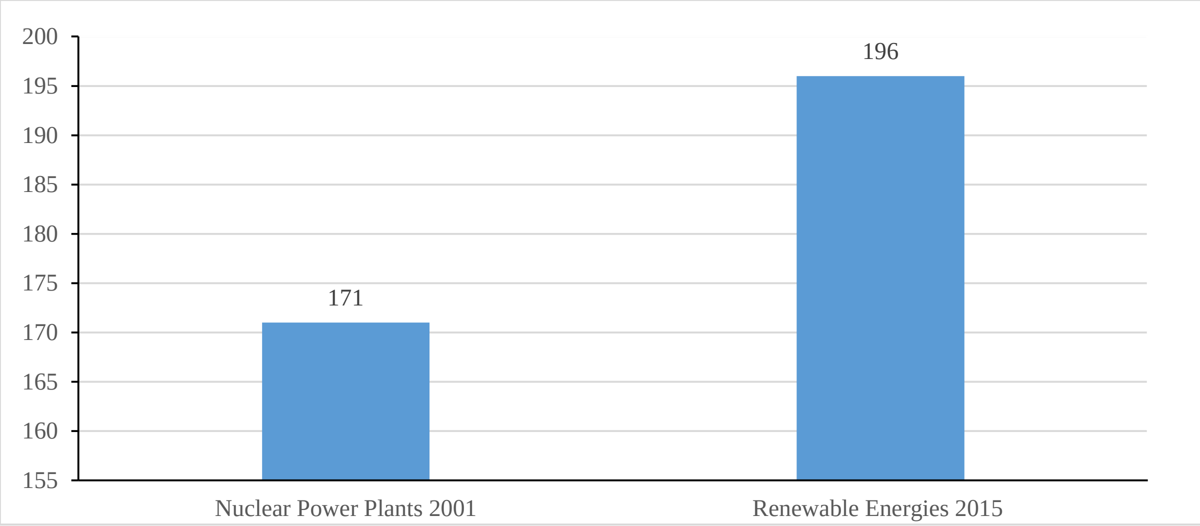
Radioactive fallout after the Chernobyl nuclear accident gave rise to a local citizen group called the 'Power Rebels' (Singh 2018). The group challenged public utilities by taking over the local power company in order to reduce power consumption. The idea was that the reduction of energy usage would trigger a winding down of processes to experiment with unstable forms of energy like nuclear power. Simultaneously, the oil shock of 1973 compelled the then West German government to create a 90-day strategic stockpile much before the IEA advised it to do so. In a larger sense, it brought home the hazards of relying on foreign energy imports.

An expected turn to nuclear energy, with its repute for zero-emissions, shockingly did not materialise. The siting of nuclear weapons on either side of the Cold War border made Germany exceptionally susceptible to nuclear holocaust. The birth of Green Party in West Germany in the 1970s was initially an outcome of the threat of nuclear war – not an outright rejection of electricity produced from nuclear plants. The nuclear accident at Chernobyl in 1986 underlined the fragility of the safety-centric nuclear industry; it shattered public confidence all over the world and introduced a new element of opposition within the German Green Party. Simultaneously, the NIMBY factor came into play during the disposal of nuclear waste in Germany. A site for the disposal of low and medium-level waste is set to open at the Konrad repository by 2022. Appropriate sites to store nuclear waste with longer shelf life are still being examined, with the process expected to be completed by 2031.[43] The opposition grew so intense that Germany continues to search for an appropriate site to dispose waste from its eight functioning nuclear power stations (Federal Foreign Office 2015: 17)[44]. A new national consciousness around renewables, at a time when the industry was still in its infancy, was being developed. Five years after the Chernobyl disaster, the German legislature approved the first incentives dedicated towards renewables. Feed-in tariffs along with an assortment of other supporting tariffs and subsidies were introduced in 1991. The Renewable Energy Act in 2000 solidified tariffs for twenty years to prevent pushback from the entrenched energy majors that began in the late 1990s (Heinrich Böll Stiftung 2016). The implementation of feed-in tariffs and supporting policies provided impetus to an industry struggling to find its footing in a competitive market. The share of coal in power generation fell by 8 percent from 51 percent between 2000-05; the share of nuclear energy fell by 3 percent from 29% in the same period. Meanwhile, the share of renewables in German power generation touched 9 percent in 2005 against a targeted 12.5 percent (Goodman 2016: 189).

[43] Ibid.

[44] Refer to Appendix D for further information on operational and decommissioned nuclear power stations.

Figure 4.2 Largest Amount of Electricity Generated in a year in Germany (in terawatt- hours)



Source: *The German Energiewende*, Federal Foreign Office, Berlin, pg. 17.

The decision to withdraw nuclear power from the German electricity generation system in 2011-12 increased scepticism regarding the ability of RE to bridge the gap in stable and continuous supply of electricity to the grid. **Figure 4.2** above sows that the combined electricity production from renewable energy was higher than that produced by nuclear power – at its peak – in 2001.

4.1.2 Reinvention of the renewable energy sector in the face of rising global energy prices

Neuhoff (2005) attempts to identify the economic and non-economic obstacles which impede the large-scale dissipation of renewables. He tests the versatility of individual renewable technologies in acquiring larger roles in electricity generation.

Rather than the energy conservation measures, energy efficiency is easier to implement in sectors like transportation which is untouched by renewables.

Transmission infrastructure, built to compensate for the sudden shutdown of fossil-fuelled plants, can easily withstand slowdowns in power production from intermittency issues plaguing renewable energy. He suggests that older conventional energy plants may be retained to fill in the vacuum during intermittent weather.

Subsidies, originally intended for economically weaker sections of society, are always usurped by the upper classes which increase their consumption of resources on account of cheap domestic prices.

It is also important to note that even if emissions are restricted to well below the threshold, they are nonetheless still emissions. The indirect costs of healthcare are not accounted for in the price of resources like coal.

Miser (2016: 20) details the impact of battery stored energy systems on supplying electricity during peak demand, in areas prone to seasonal migration.

He argues that the conventional electric supply system is designed to cater to peak demands, with capacity over and above the peak demand added to act as a safety-cushion. However, such a large installed capacity could lie ideal during periods of low demand.

Energy storage systems, acting as stand-alone systems, augment a utility's ability to supply electricity during a spike in demand. This prevents the overloading of transmission lines. It is the costs and accompanying risks that deter them from investing in research. Instead they turn to private innovators. Contemporary energy storage systems are built on lithium-ion equipment. Besides technical issues, an ambient temperature is required for their optimum utilisation (Miser 2016: 22).

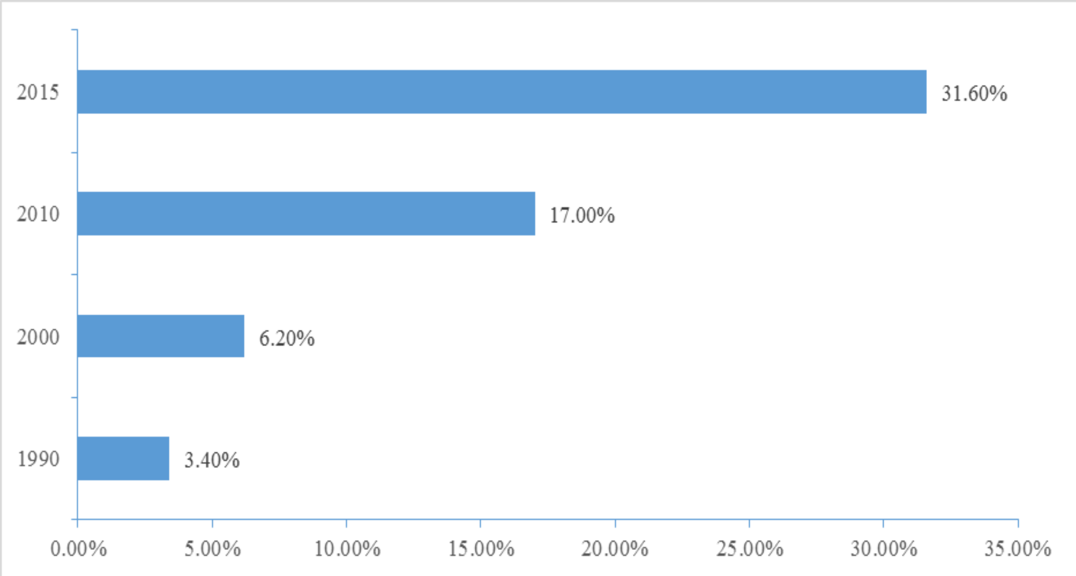
The pruning of peak demand during the summer goes against what is assumed to be the energy system's primary role – a backup for renewables during inclement weather. The author claims that grid instability, because of intermittency, will occur only after high market penetration by renewables is achieved. He goes on to add that energy storage systems are an alternative to the expensive construction of additional capacity that may encounter low demands frequently.

According to Alba et al. (2016: 1) the introduction of utility-scale photovoltaic plants (USPVPs) into the conventional grid system includes the responsibility of fulfilling minimum technical requirements (MTRs). The application of a battery energy storage system (BESS) contributes to system stability.

Unlike non-renewables sources, using electro-mechanical systems, USPVPs operate on electronic systems, but their intermittent nature makes them non-synchronous in the power production process.

Transmission lines, linking the power plant to the sub-station, are generally high-voltage, while distribution lines' proceeding from sub-stations to households and industries, are low voltage lines. Weak grids are those that have very limited sources of electricity and smaller loads than the national grid. The authors recommend installation of BESS to maintain output (and grid stability) during unfavourable weather conditions (Alba et al. 2016: 19).

Figure 4.3 Share of renewables in gross electricity consumption



Source: *The German Energiewende* (2018), Federal Foreign Office, Berlin, pg. 10.

Figure 4.3 traces the growth of renewables in German gross electricity consumption across twenty five years. It is a remarkable testimony to the fact that Germany led the way at a time when speculation around the success of the German plan was rife. From barely four percent during reunification, RE now supplies one third of Germany's electricity needs. It is a remarkable achievement given that Germany was emerging out of the Cold War and plunging into the problems accompanying reunification with East Germany.

4.1.3 The German Green Party and its efforts to increase public consciousness around renewables

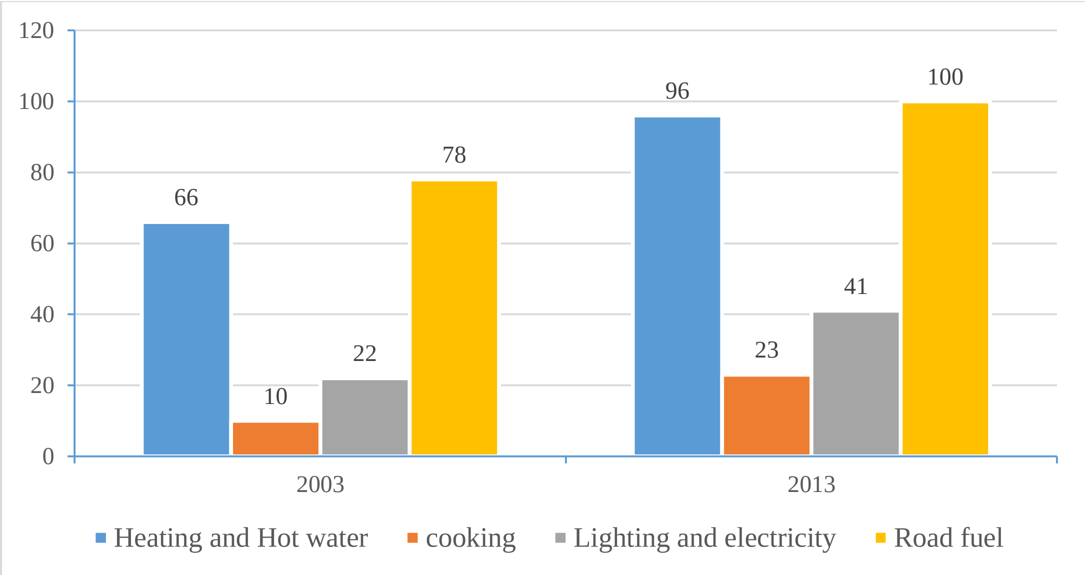
Unlike the transition from coal to oil in the previous century, the contemporary disruption from coal-led energy use in the power sector to that of renewables has been driven by an emphasis on climate change concerns.

In the case of Germany, the failure of the latest nuclear safety protocols during the Fukushima nuclear accident in 2011 led to, what is often described, as a 'U-Turn' in the nuclear policy of Germany. The initial opposition to the closure of nuclear plants in Germany stemmed from concerns surrounding the loss of jobs and import of nuclear power from abroad. The stunning decision – the systematic closure of all nuclear facilities by 2022 - was expected to curry favour among the German Green Party by the Merkel-led Christian Democrats (Singh 2018b).

Singh (2018) explains Germany's aversion to coal mining through the high casualty figures that the activity entailed. He argues that nuclear energy is misconstrued as the most unsafe source of electricity. A collation of data regarding deaths per unit of electricity reveals that more nuclear accidents have led to far lesser death than coal or even hydropower. Citing a 2002 study on the impact of electricity, Singh (2018) argues that coal-related fatalities amounted to between 2.8 and 32.7 people per 10 billion killowatt-hour. The figures for nuclear energy were between 0.1 and 1.2, and that for hydropower was between 1 and 54.7. The most serious nuclear accidents at Three Mile Island, Chernobyl and Fukushima had far fewer fatalities than coal and hydropower. However, he states that the long term deaths due to related illnesses could be significant.

The consumption of fossil fuels carries with it inherent externalities; such externalities are defined by Singh (2018) as 'a consequence of an activity that affects an entity that has not chosen to be party to that activity.' It is difficult to collate deaths caused by coal or petroleum. It is agreeable that these deaths are fairly large in number. Here again, coal is most deadly fuel, with nuclear energy the least dangerous fuel. The reactive and myopic scrutiny on nuclear safety has allowed other fossil fuels to slip under the radar. The lack of scrutiny has allowed them to function in a Germany, anxious to phase out 'unsafe' nuclear energy. Negative public perception has compelled nuclear energy to be compared with the position of air travel. Although both are the safest in their respective fields, they are both vilified by the public on account of concerns surrounding public safety. Germany's position as an erstwhile Cold War battleground and unsafe mining practices in the former East Germany led to the growth of the Green Party, first in the 1970s. Ralf Fücks (2015), the President of the Heinrich Boll Foundation and a prominent leader leader of the Green Party claims that Germans are prepared to endure marginal increases in electricity costs considering that RE does not pollute the local surroundings. He adds, "This (the expansion of RE) would require a comprehensive application of smart grid technology and community projects. Future generations are being held hostage because of storage of nuclear waste. In fact, most civil-nuclear treaties have an agenda of opening up their nuclear option" Fücks (2015). Germany is recovering money through the consumers. The system is choice-based unlike India where costs are passed on to the industrial consumers (Powell 2018). **Figure 4.4** shows the monthly expenditures of German households on the four largest components of the energy bills of German households. The increase from 2003 to 2013 reflects the high oil prices in the international market. Therefore, ordinary Germans support the RE initiative even if it translates to higher overall energy expenditure in the short-term.

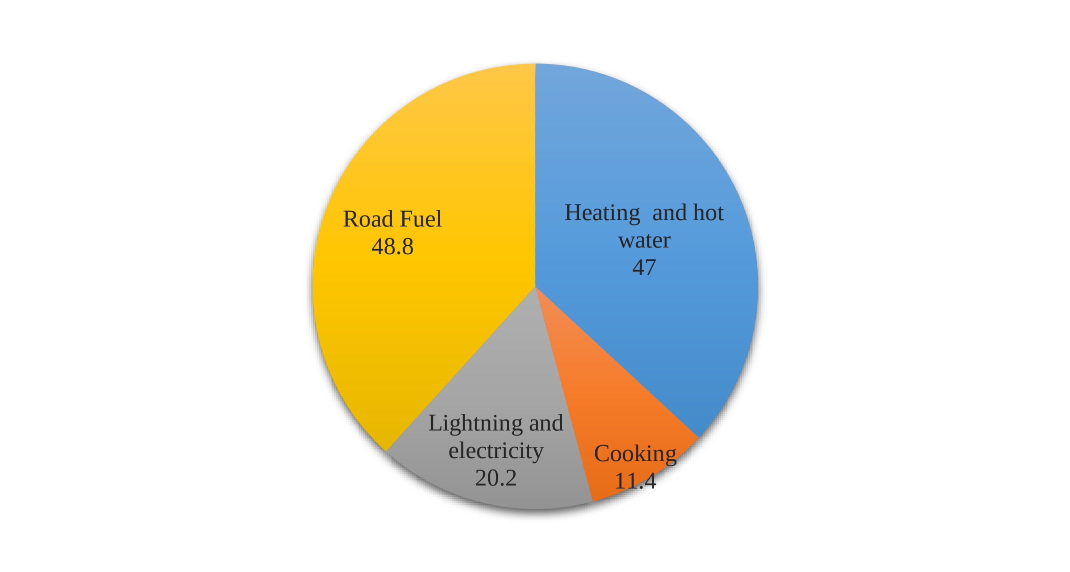
Figure 4.4 Comparison of monthly expenditure in 2003 and 2013



Source: *The German Energiewende*, Federal Foreign Office, Berlin, pg. 12.

The commitment to RE will require billions to fund the necessary infrastructure. This funding originates from the surcharge stemming from the Renewable Energy Sources Act of 2000. In 2007, German consumers were paying an average of 21 eurocents per kWh. This had increased to 29 eurocents per kWh in 2015. This expense was spread across consumers and in reality, the consumer was paying an average 6.9 eurocents per hour (Federal Foreign Office 2015: 13; IRENA 2015). These low prices have kept overall electricity charges stable. On the other hand, energy intensive industries are exempt from paying the surcharge provided they use these savings to invest in energy efficiency measures. In 2013, German households spent a total of €127,4 billion on energy **(Figure 4.5)**. A major share of their expenditure is on fuel for transportation and heating where both these sectors are dominated by the petroleum industry; where the effect of RE has been minimal. Hence, minimal increases in electricity bills do not face an adverse reaction from a population paying more for fossil fuel use in other sectors.

Figure 4.5 How much do German households spend on energy in 2013 (Billion €)



Source: The German Energiewende, Federal Foreign Office, Berlin, pg. 13.

4.2 Feed-in Tariffs – the catalyst for the early expansion of renewables

A feed-in tariff (FIT) is a fixed amount (tariff) paid to producers of renewable sources of energy for every kilowatt-hour of electricity supplied to the grid. These tariffs are higher than what is paid to producers of conventional sources of energy like coal or natural gas. It was first introduced through the Electricity Feed-in Law in 1991, which guaranteed grid-connectivity. The tariffs are adjusted every year according to match decreasing the inputs of initial capital of wind and solar energy. "FITs are the progenitor of large efficient RE capacity that enabled them to be ready to compete with non-renewables sources of energy" (Sawyer 2018). Firms still gain an estimated 5-7 percent return on investment (Heinrich Boll 2018: 46). The popularity of FITs can be gauged from the large presence of small private players – ordinary citizens – involved in power generation all over Germany. It also guarantees priority power evacuation over conventional sources of energy. Since 2016, solar and wind capacities over 750 KW are no longer receiving FITs; instead, this large capacity is included in an auctioning process conducted by the government. The gradual withdrawal of FITs for capacity under 1 MW benefits large organisations and edges out small power producers who cannot cope with increasing competition and the need to maintain stable supply (optimum operationalisation) [Heinrich Boll 2018: 47].

The large costs incurred from adjusting the flexible output of non-renewables, both economic and environmental, are not included while calculating the cost of emission-reducing electricity in the UK. A traditional 'cost of a generating unit divided by amount of units produced' method is followed while calculating the cost of RE. Yet the damage caused to fossil-based power plans from operating on low plant factors, the threat to stable fuel supplies and the environmental effects of running non-renewables inefficiently are not taken into account when the grid parity of RE is debated. Grimston (2014) suggests a 'system level parity' while analysing the amount of financial resources dedicated toward each fuel source.

Difficulties related to the storage of electricity translate into a very fine margin of error between over-generation and under-generation. Baseload is defined as, 'the power demand that never goes away' (Grimston: 2014: 359).

The variability of wind power plants reduces their output to an average of 30% of its rated capacity. For example if a plant has a capacity of 100 MW, the average output would be calculated between 25-30%. Excess power, generated during favourable weather conditions, could damage transmission systems. This may compel producers to shut down renewable power generation; or producers of non-renewable power to halt power production, impacting their profitability. However, in addition to large subsidies paid to RE producers, the government has to compensate natural gas plants to be on standby during intermittencies.

In Germany, grid operators have to compulsorily absorb all power produced from RE at any time, at any cost. RE operators receive subsidies in two ways, through FITs and an obligation by the government to absorb all renewable power. The copious supply of renewables in the grid has forced the closure of several gas-based power plants in Germany. Compensation to keep them online became too much of a financial burden. The export of excess energy produced by the German renewable energy industry has exported to its neighbour, the same problems experienced by the Germans (Grimston 2014: 364).

The necessity of ensuring stable and secure electric supply in systems heavily ingratiated with renewables requires the construction of fossil-based energy systems. This is a reversal of the motive behind the introduction of renewables in the first place. The achievement of 'grid parity' i.e. the becoming economically competitive with other sources of electricity, does not take into account the economic and environmental impact that renewables have. A 'system-level parity' is encouraged to lower electricity bills, taking into account that renewables may not always deliver on their promise of clean energy (Grimston 2014: 366).

4.3 Pushing forth *Energiewende*

In a clear departure from the previous government-backed financing of conventional energy projects, additional taxes paid by consumers, provides critical financing for the implementation of REs in Germany. This has accompanied a slew of legislations that have opened up the domestic energy market, encouraged the deployment of RES and founded a system to trade carbon emissions.

The supporting legislations that back the Integrated Energy and Climate Change Programme' are known as the '*Erneuerbare Energien Gesetz*' or EEGs. Translated as the RE Acts, they have been promulgated five times. Successive RE Acts encompass legislations dealing with the deployment of incentivised grid-connected RE services and designates the prices of feed-in tariffs applicable to particular RES, distributed as well as utility-scale. First formulated in 1991, the EEGs have come to form of the pillars of RE in Germany.

Some of the provisions include the connection of RE facilities to the grid, with the grid operator bearing most of the expenses, and the payment of FITs on a per kWh basis based on electricity supplied. As FITs, fixed for a period of twenty years, show a declining trend, after each successive EEG, due to the economies of scale, RE operators are encouraged to get their facilities online as soon as possible (Sturm 2017: 42).

Another feature of the EEGs is the continued payment of FITs even during closure of the grid on account of the grid being unstable, by the grid operator.

The addition of more RE capacity has lowered the market price of power in the last one ten years, from 60-80 euros per mWh to 20-30 euros per mWh. However, this reduction in the wholesale prices of electricity has not translated into a reduction of tariffs for individual and small industrial consumers. The surcharge for covering additional generation of power from RES has increased from 0.2 cents per kWh in 2000 to 6.88 euros per kWh in 2017 (Sturm 2017). The surcharge foots almost 23 billion euros of the Energiewende costs - approximately 34.1 billion euros in 2016.

With climate change coming to the fore of international debates, Chancellor Merkel amalgamated Germany's energy and climate policies to include a reduction of 80 percent of carbon emissions from 1990 intensities by 2050. A roadmap, delaying the mothballing of nuclear plants by 14 years, was unveiled in 2010. The delay, argued the government was climate related. Nuclear power emitted almost no carbon dioxide, solved the problem of power storage due to the intermittency of RE, and shouldered 60% of the base load power generation. However, this move was shelved in the wake of the Fukushima disaster in 2011 (Sturm 2017). The phase-out by 2022 is back on schedule with GHG emission targets remaining unchanged.

The vacuum left by the withdrawal of nuclear power has compelled grid operators to aggressively incorporate intermittent RE into the power system. RE systems, with an installed capacity of 97.4 GW produce significantly less power when compared to the 96.7 GW of installed capacity of all fossil fuels. Conventional power plants are compelled to act as ‘power back-ups’, operating on very low and uneconomical plant load factors (PLF), to bridge the wide gap in full load hours. Full load hours may be described as the annual total power produced divided by the installed capacity. In the case of conventional sources, it amounts to 8000 hours. Solar energy accounts for 800 hours; and on-shore wind about 2000 hours.

The paper states that for every megawatt (MW) of power generated by conventional sources, 10 MW would be needed in solar power and four MW in wind. Complicating matters further, peak production in RE may not match weather-determined demand patterns. Intermittent power makes the grid unstable, necessitating the need for conventional sources, most of which are coal-fired, and with faster ramp up rates.

At the same time, several actors are engaged in taking advantage of several grey areas within RE legislation to increase profits. Three examples are shared. The EEG of 2009 allowed traders with an assortment of 50% RE to sell 100% of their electricity without the additional EEG surcharge. By selling tax-exempted power at reduced prices, and maintaining a 50% RE portfolio and 50% conventionally sourced power, traders made a profit

Another example refers to the exemption from EEG surcharges for companies deriving their own power. Leasing of a conventional power plant allowed savings in EEG surcharges which were divided with the owners of the power plant. The third example deals with an age-old trick. Since boilers with a capacity of 20 MW or more were taxable, the trade in boilers with a maximum capacity of 19.9 MW and using cheap, but polluting lignite as a fuel, increased. However, most actors are not directly to blame. Recalibrating their businesses to reflect the changing geopolitical complexities in Germany in 1990 and in Europe in 1992, several actors have had to cope with increasing production costs and fluctuating prices, a forced reliance on intermittent energy sources and technologies which are incompatible with current energy systems.

The deregulation of the energy market in the 1990s compelled several utilities into mergers to stave off increasing hostility in the domestic market, and begin to diversify into the international market.

Utilities have withstood the worst of the impact of the entry of RE into the market. A positive change in the attitude of utilities towards renewables was witnessed, with some even making forays into the business (Sturm 2017: 45). But increasing competition, high operating costs, complexities of owning unprofitable conventional plants and low market prices for electricity have forced them into cutbacks.

The demonstration of 15 May, 2016, when more than 70% of the electricity requirement of Germany was met by RE (in summer, with low demand for power), although impressive, fails to impress the author.

Although the level of GHG emitted by Germany has reduced by 27% over 1990 levels, this has been the result of industrial efficiency measures enforced by the EU after the ratification of the Kyoto Protocol. The 80% reduction of emission levels by 2050 appear to be bleak as gas and coal-fired power plants have come online since 2009, to fill the vacuum left by nuclear power.

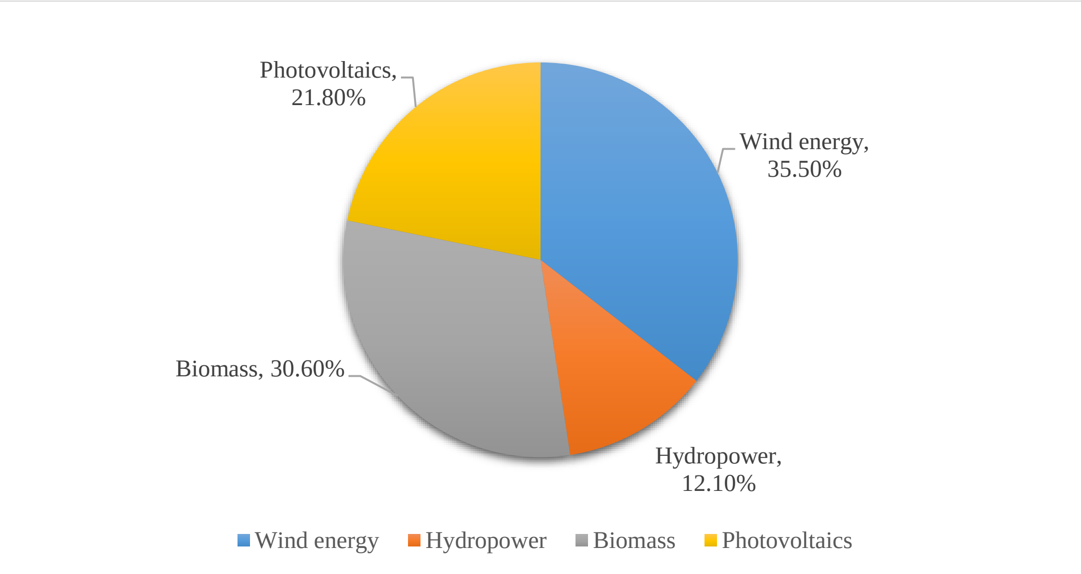
According to the US' Energy Information Agency (EIA) 19% growth in RE generation in Germany has been witnessed since 2005. This growth translated into 32 billion kWh of electricity generation out of a total of 194 billion kWh recorded in 2015. RE generation contributes 31% of Germany's gross electricity generation.

As of 2015, the German power system was dominated by coal power generation at 44% of total capacity; 15% came from nuclear energy sources and 11% from other sources. Germany's energy transition or *Energiewende* plan calls for a reduction of the country's carbon emissions by 80-95% of 1990 levels by the year 2050 (Hoff 2016). It also seeks to phase out nuclear energy by 2022. In a much larger framework, Germany hopes to reduce import dependencies through a largescale adoption of RE sources at the cost of conventional energy sources.

Solar PV and wind energy make up 20% of electricity generation while hydropower and biomass contribute the remaining 11% of Germany's RE-sourced power generation. Preference for the former two has translated into a commitment of a *"fixed, above-market price for every kilowatt hour of energy generated by solar PV or wind and delivered to the grid"* (Hoff 2016, USEIA). This is the US EIA's definition of feed-in tariffs. The preferential tariffs, enforced by federal law, have pushed back the expansion of other energy sources, including hydropower.

Figure 4.6 shows that wind energy is dominant in Germany's RE sector. A large majority of this capacity comprises of offshore wind. Biomass comprising of wood pellets and firewood form one third of RE-based power generation in 2015.

Figure 4.6 Share of total renewables generation in 2015



Source: *The German Energiewende*, Federal Foreign Office, Berlin, pg. 10.

The prioritisation of RE over other energy sources has had a deep impact on the German population. Capacity expansions and favourable prices have led to the decline of wholesale electricity rates but it is the German taxpayer who foots the cost of this expansion of RE in the form of increasing residential retail prices. Renewable energy surcharges comprised 17% of the residential electricity bill in 2013. It was 8.8% in 2010. The average retail electricity price in Germany was 35 cents/kWh. It was only 13 cents/kWh in the US.

The capacity expansion has also led to the generation of surplus power, especially on windy days. Germany's neighbours, Poland and the Czech Republic, until recently, lacked the necessary systems to prevent blackouts. As a net energy exporter Germany has also found itself in need of infrastructure to transport surplus electricity from the north to the more densely populated south. However, the need for approximately 3300 kilometres of transmission lines have run afoul of NIMBY-style local opposition.

The surplus power has also led to closer integration of the European power market. The excess power has compelled the government to do a rethink on feed-in tariffs. If capacity expansion targets continue to be exceeded, feed-in tariffs will not be offered to producers so as the maintain price stability. In, fact feed-in tariffs may soon give way to auction-based tariffs.

Sims et al. (2003) conducted a study investigating the operational expenditure involved in the generation of electricity and the subsequent carbon emissions produced by commercial technologies available then and those expected to be mass produced in the years to come. Barring carbon sequestration and solar power, the production costs and levels of carbon emission were reduced considerably through fuel switching, wind energy and hydro power. The paper presents itself as a brief dissecting a report on the Third Assessment Report of Intergovernmental Panel on Climate Change (IPCC) that in itself is bereft of any policy analysis or critical observations. By 2020, the global power sector is expected to emit 4000 MT of carbon dioxide per year. In 2002, carbon dioxide emissions from this sector comprised 37.5% or 2100 MT of global emissions. Their consolidated geographical locations make power generation facilities the primary target of governments in their drive to curb global GHG emissions.

The authors compare the feasibility of efficient conversion of fuels, fuel switching (from coal to natural gas), carbon sequestration, nuclear power and renewable energy sources (Sims et al.: 1316). Coal (38%) is still the dominant fuel in the global power generation scenario, followed by renewables (of which hydropower forms the largest share) at 20%. Blessed with abundant coal reserves, China and India will continue to invest heavily in the coal sector. Hydropower would also continue to develop within these two regions. Western Europe would grow increasingly dependent on natural gas, while the US would record steady growth figures for coal as a power source. Nuclear energy would record flat growth figures taking into consideration the retirement of old reactors in developed despite new takers in the developing world. Modern Combined Cycle Gas Turbine (CCGT) can achieve efficiency rates of 60% as compared to the 40% achieved by new age coal fired units. In the year 2000, the operational cost of the former was between \$450–500 per kilowatt-electric (kWe). The latter clocked \$1300 per kilowatt-electric (kWe).

Irrespective of public concerns regarding safety issues, emissions from nuclear units are almost zero (comparable with renewable energy sources) but the operational costs per reactor range between \$1700 to \$3100 kWe. Compared to coal fired power stations, nuclear-based power stations, while generating the same amount of power, can avoid emissions amounting to 600 MT of carbon emissions per year.

Renewable energy sources, being spasmodic in nature, are in constant need of support systems as well as storage capacity to guarantee a stable supply of electricity. Hydro-electricity, which retains the largest share among renewables, has in recent years witnessed hostility from environmentalists as well as displaced populations. High capital and transmission costs deter fresh investment in a market where coal and gas offer cheaper higher rates of return.

In 2003, although the installed capacity of wind power was 0.3% of global capacity, it supplied barely 0.1% to meet global electricity demand. Global capacity for wind power in 2000 was 13,000 MWe. In 1997, the installed costs for wind power was \$1000 with operating costs varying greatly depending on areas with differing wind patterns.

In 2003, the installation costs of photovoltaics was a massive \$5000 per kWe whereas the cost of generation ranged between 20-40 c/kWh. Negation of transmission losses and supply costs are one of its biggest advantages. The authors promote off-grid use of solar electricity to bridge the gap between the source of power generation and far off rural areas. In 2000, the installed capacity of solar cells reached a mere 300 MW. However, the conversion efficiencies of silicon cells were between 12-17%. Geothermal sources and wave technology was not considered during the course of this study.

This study evaluated the installation and operational costs of alternative technologies while also comparing their effects on the mitigation of carbon emissions. This was divergent from past studies were only the economic aspects of these new technologies were studied. Whereas mitigation of carbon emissions depended on the nature of fuel used (coal or gas) and the availability of RETs, operational costs of various ventures may differ based on regional and countrywide variations that encompass differing infrastructure requirements, balancing capital costs and productivity. Furthermore, variations may also occur due to the pressure on baseloads and the exigencies of fuel supply (Sims et al. 2003: 1320).

The authors contend that under ideal conditions, alternative technologies could reduce emissions by 660 Mt C from the estimated 4000 Mt C that emissions levels are expected to reach by 2020. However, taking into account technical, financial and socio-political limitations, the authors estimate that emissions would be reduced by a mere 350–700 Mt C by 2020.

The operating costs of several alternative technologies surpasses that of the CCGT.

Sims et al. (2003: 1325) conclude that the ‘geographical location’ of a fossil fuel based power production facility or a project for alternative power production influences its operational costs as well as emission reduction targets mainly on account of efficiency concerns.

4.4 The German Energy setup – spearheading the transition

Germany’s *Energiewende* encompasses three main goals – enhancing energy security, climate change mitigation and industrial growth. The German Federal Ministry for Economic Affairs and Energy or *Bundesministerium für Wirtschaft und Energie* (BMWi) is the most recent avatar of the Ministry of Economics and Technology.[45] Like the MNRE of India, it is the nodal agency implementing the transition to renewables. It is charged with the responsibility to achieve a balance between the earlier stated goals of the *Energiewende* ‘without compromising German industries’ competitiveness’ (Federal Ministry for Economic Affairs and Energy 2019). As a highly industrialised country Germany has ensured 100 percent access to energy to all its citizens. Thus, the Ministry aims to ensure that the *Energiewende* will maintain affordable and secure energy supply that is environmentally benign.

It has six departments that deal with different aspects of the energy transition such as in the heating and mobility sector. Three departments include renewable energy in their brief. On the other hand, thirteen departments are dedicated towards issues surrounding

[45] https://www.bmwi.de/Redaktion/EN/Artikel/Ministry/structure.html

energy efficiency, especially in buildings and heating. Federal Network Agency for Electricity or *Bundesnetzagentur* (BNetzA) is the national regulator for electricity. BNetzA must confirm all decisions with the European Commission. Each of Germany's 16 states also has their own regulators at the provincial level. Licenses for new power projects go through the Federal Cartel Office or *Bundeskartellamt* (BKartA), which falls under the ambit of the Federal Ministry of Economic Affairs and Energy. The Energy Industry Act or *Energiewirtschaftsgesetz* (EnWG), 2005[46] is the equivalent of India's Electricity, 2003. It covers the main aspects of the electricity sector.[47]

Federal Minister for the Environment, Nature Conservation, and Nuclear Safety or *Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit* (BMU) has directorates covering policies regarding climate, the environment, nuclear safety and sustainability.

4.4.1 Contribution of private players

The composition of the German renewables' industry is characterised by ownership of over fifty percent of capacity by individual households, community initiatives and local governments. The pushback from the four large distribution companies and their lobby groups has been strong. To counter the criticism from these big players, likeminded citizens and civil society organisations have come together to form organisations like the German Association for Renewable Energies and the Klima-Alliance. They have millions of members who compete with the fossil fuel lobby to gain favour at the policy level (Goodman 2016).

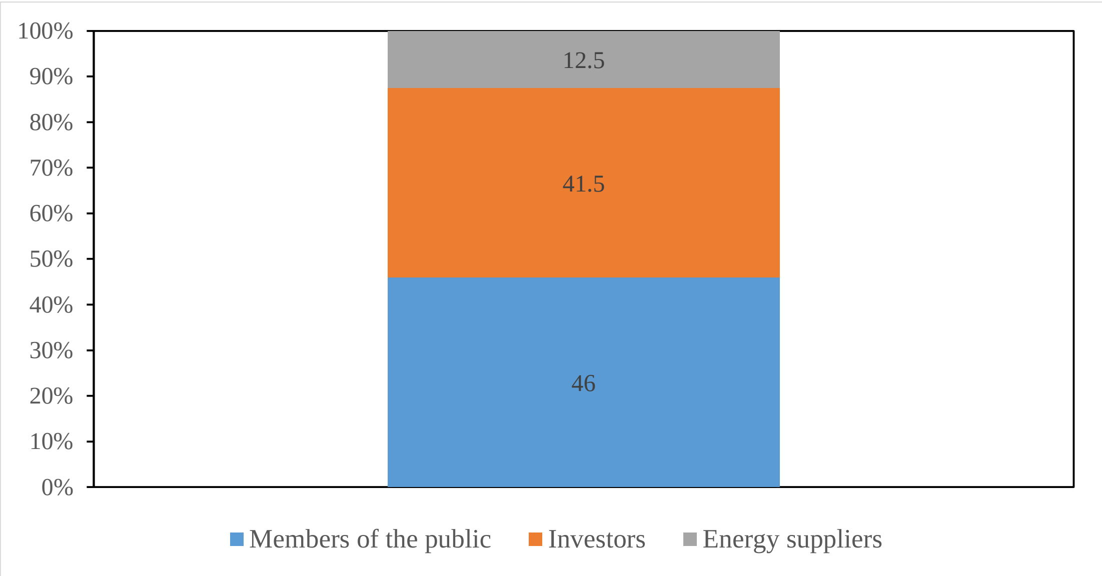
Singh (2018) argues that the current trend of citizen-owned renewable energy infrastructure has its roots in the 1970s with Dietrich Koch. Koch challenged the monopoly of the central grid-connected utilities. He argued against the continuation of monopolies, which were rooted in the Nazi-era policy of fiscal spending toward a strong war economy. Such monopolies were now redundant. He also argued for the delinking of monopolies and the opportunity to supply excess power back to the grid. His actions led the establishment of the first independently owned wind turbine/s that could supply excess power to the grid.

[46] Amended in 2016.
[47] Refer to Appendix B and C for more information on the legislations and strategies covering Germany's power industry.

The monopolies challenged independent connections to the grid by charging high tariffs for grid-connectivity. Koch, in the court that decided the case in favour of independent power producers in 1983, challenged this. The compensation paid for supplying excess electricity to the grid is now called feed-in tariffs. Feed-in tariffs, that incentivised independent power generation, were introduced in an almost surreptitious manner amidst the tumult of German unification in 1990. The popularity of renewable energy is evident from its contribution of 38 percent to the German energy mix in 2018 – far outstripping the 4 percent propounded by the monopolies in the 1980s.

Figure 4.7 reveals ownership patterns of Germany's installed electricity generating capacity in 2015. Among the 46 percent of public investors, 25.2% were individual owners. 9.2 percent was owned by energy cooperatives and members of the public who had made investments in different projects owned 11.6 percent (Federal Foreign Office 2015: 28).

Figure 4.7 Installed Energy Generating Capacity by Owner Group



Source: *The German Energiewende*, Federal Foreign Office, Berlin, pg. 28.

4.5 Challenges to the implementation of the German *Energiewende*

High energy prices, providing an impetus for clean energy development, proved deceiving to German lawmakers. Expecting a favourable turn towards their renewable energy-run competitive industry, low global energy prices have left German industries footing a much more expensive electricity bill than their competitors in the US (Johnson 2014).

The surcharge on residential and small-medium industrial consumption of electricity, funding the successful expansion of renewable energy capacity, had grown to 23 billion euros in 2014, from 18 billion euros in 2012 (Johnson 2014). The surcharge, limited by the government to 35 euros per MWh, has now touched 60 euros per mWh (Johnson 2014). Exemption of large industries from paying any surcharge has given rise to allegations of illegal state subsidies in the European free market.

Scaling back the programme to more conventional and achievable goals is favoured over licensing domestic hydraulic fracking or even imports of natural gas from the US. Huge domestic support for the programme has continued to prop up the development of the alternative energy sector (Johnson 2014).

Contrary to fears of power shortages following the closure of almost half of its's nuclear power plants, Germany avoided the predicted blackouts, and even exported power abroad in 2012. The decrease in power prices and surprisingly impressive production figures for solar and wind energy led to speculations surrounding the future of nuclear power plants but also those running coal and gas (Boisvert 2013). Much of this speculation arose out of reports that renewables formed the largest source of electricity generated in the last weekend of May 2012.

However, Boisvert's (2013: 62) arguments viewed against the supposed 'high level of security of supply', forwarded by Häseler (2014: 155), casts a shadow over increasing capacities of renewables in Germany's power system. Intermittency-related issues continue to plague the German power system. The exponential rise in capacity has not translated into reliable generation figures. Lethargic generation by renewables has compelled Germany into opting for a larger share of coal and gas-fired capacity. The greenhouse emission figures for these sources, especially coal, far exceed those exhaled by the nuclear industry; thus, turning the German transition to renewables on its head.

Boisvert (2013: 62) goes further by adding that Germany has created a workable concept from the utopia surrounding renewable energy. The supporters of renewables have managed to sideline a low-carbon source on the basis of its extremely high capital costs (including land and safety) and health risks. With renewables, the threat to human health like that posed by nuclear energy is eliminated.

Bosivert (2013) attempts to assure readers that arguments related to nuclear safety by anti-nuclear groups do not hold water when the likelihood of those affected by the

Fukushima nuclear accident in 2011 developing cancer is slim.[48] Anti-nuclear groups often cite the nuclear accident in Japan as the main reason why Germany should switch to renewables. However, Boisvert (2013) argues that this stance is a fallout from the alarmism emanating from the response of emergency services.

Boivert (2013) then follows up his argument into the alarmism of anti-nuclear groups by emphasising the advantages of substituting coal and gas-fired capacity with nuclear energy. Like Sims et al. (2003) and Singh (2018d), Boisvert (2013) argues that the reductions in greenhouse gas emissions, a particularly grave health risk in urban areas, are much more apparent through expansion of nuclear capacity. Unlike gas and coal-fired power plants, nuclear reactors have a very low emission rate of greenhouse gases.

Furthermore the author argues that the much-vaunted reliance on renewable to take up the slack is unfounded, solely due to their negative attributes. Difficulties in grid-integration, high costs of technology, over-dependence on subsidies, supply fluctuations and the necessity to have fossil fuel backup comprise the negative attributes of renewables.

Boisvert (2013) argues that the benefits to health and climate change far outweigh safety concerns around innate with safety-related tunnel vision.

Following the Fukushima accident in 2011, the share of nuclear power in the German power system decreased in favour of renewables and fossil fuels. However, electricity from fossil fuels became "dirtier" because renewables supplanted gas-fired power, which is much more expensive than carbon-laden coal power. The consequent displacement of nuclear power generation saw in the overall national greenhouse emissions by 1.6 percent in 2012 (Boisvert 2013: 64).

In 2012, hydropower, biomass and garbage incinerators contributed 9.9 percent of Germany's electricity production. Although stable, they are restricted by infrastructural constraints. This leaves room for the expansion of solar and wind capacity. However,

[48] Boisevert (2013) cites the World Health Organisation's (WHO) report titled, *Health risk assessment from the nuclear accident after the 2011 Great East Japan earthquake and tsunami, based on a preliminary dose estimation (2013).* The author argues that the report underlines only a small proportion of nuclear plant workers stand an increased chance of developing cancer directly attributed to their exposure to nuclear fallout – so small that "they will probably not be discernible against the normal background incidence of cancer" (Boisvert 2013: 63). Online link: http://apps.who.int/iris/bitstream/handle/10665/78218/9789241505130_eng.pdf;jsessionid=7EB1D5ABEE3F1C8E90665110FAA18DFF?sequence=1

the phenomenal expansion of total capacity, with an average of 30 GW for wind and 29 GW for solar, has not led to a large rise in the share of electricity generated (Boisvert 2013).

The capability of the total installed capacity for solar panels was 254 TWh in 2012. In 2012, only 28 TWh of electricity was sourced from solar panels. Thus, the capacity factor of solar energy in 2012 was a mere 11 percent of total electricity produced. Boisvert (2013) defines capacity factor' as 'the amount of electricity a generator produces in a year divided by the amount it *would* produce if it ran at nameplate capacity for all 8,760 hours' (Boisvert 2013: 64). Similarly, wind energy had a capacity factor of 17 percent in 2012.

On the other hand, with 99 TWh of power coming from 12 GW of nuclear capacity, Germany's nuclear reactors had a capacity factor of 94 percent.

Even in terms of average capacity (installed capacity multiplied by capacity factor) solar and wind energy had an average capacity of 1.24 GW in 2012 when 10 GW of installed capacity for both sources together was added. The author cites the example of the Brokdorf nuclear plant in northern Germany; with an installed capacity of 1.37 GW the average capacity of this plant alone was 1.28 GW in 2012.

Such poor average capacity figures for solar and wind means that it could take almost two decades to replace the existing nuclear capacity of Germany. A long gestation period targeting only nuclear energy will hardly leave any room to expand against fossil fuel capacities in the future.

4.5.1 Intermittency – the constant thorn

Better ramp-up and ramp-down rates of gas, coal, nuclear, hydro and biomass, a vital feature for producing electricity on a moment-to-moment basis, have earned these fuels sources the label of "dispatchable" generators. "Intermittent" generators like wind and solar energy are in constant threat of "common-mode failures" – when weather patterns prevent the efficient generation of power (Boisvert 2013: 65).

Expansion to prevent such a scenario is unfeasible, as it would lead to an expensive, excessive and sensitive network. The shuttering of nuclear capacity leaves only coal and gas capacity to fill the gap. The author posits the creation of a "second grid" as an alternative to the *Energiewende*. It would be centred on nuclear power, supplemented by low-carbon dispatchable renewabels like hydro, and geothermal (Boisvert 2013: 66).

The author stresses on a false narrative created by the *Energiewende*, which targets a 35 percent share of total power generation by 2020. Instead, the share of "low-carbon generation" by renewable and nuclear energy should be the point of focus.

The safety net provided by the German government in the form of Feed-in Tariffs (FITs) assures renewables of above market prices for a limited period. In the case of onshore wind, FITs will be withdrawn in five years. Subsidies targeting offshore wind will be withdrawn in twelve years. Photovoltaic solar will benefits for twenty years.[49]

The author fears the creation of a "Frankenstein's monster", largely funded by a public surcharge, that is set to explode with the increase in renewables with Germany's power sector (Boisvert 2013: 67). Boisvert (2013) is unsure of support for a surge in power tariffs from a population that has been largely accommodating towards renewables.

Cheap German electricity, funded by FITs have flooded the wholesale market in the EU, often to the chagrin of Germany's neighbours. Excess power is dumped into the EU's common grid, particularly during the mid-day summer hours. These threaten the profits of neighbouring power producers like the French nuclear industry. It also requires the creation of a capacity market consisting of backup fossil fuel capacity.

At 8.5 billion euros per reactor, Germany could construct 43 reactors of French design at a total cost of 367 billion euros (the annual cost of FITs for 18 years) by 2030 [Boisvert 2013: 69]. These could be supplemented by nuclear capacities existing in 2010. The 91 GW of peak capacity will be able to meet the 85 GW of peak power demand, even if operated at 75% capacity. This would be far cheaper, and much more cleaner, than the 1 trillion euros required for creating a 50% renewable energy capacity by 2030. The author, however, fails to recognise the immense problems with nuclear waste disposal that such a large boost in capacity is bound to create.

In conclusion, Boisvert (2013: 69) argues that, Germany has transformed into a symbol of change – reorienting traditional demand-supply oriented energy policy. The *Energiewende* is a gradual process representing realistic calculations that leaves the

[49] The author was unable to find the exact year when fee-in tariffs to solar photovoltaics will cease.

power generation system open to major blackouts that will raise their heads when balancing fails and storage solutions do not deliver their promise.

4.5.2 Countering Intermittency through Flexibility

If Germany must achieve its goal of sourcing 80% of its electricity from renewables then it must overcome intermittency issues. To bridge the gap between varying supply and steady, but increasing, demand huge investments into a slew of technologies that enhance flexibility are necessary. Häseler (2014) outlines the steps taken by German legislators to address this challenge. Flexibility should earn more incentives rather than mere generation. Feed-in tariffs should be replaced by investment subsidies. More importantly, variable electricity tariffs will generate positive responses from consumers.

A transition in Germany's profile is perceptible given that the closure of nuclear power plants has already begun and the accompanying scaling up installed capacities will allow the country to hit its first target – 35% of electricity generated by renewables by 2020[50] (Häseler 2014).

Increasing renewable energy capacities carry negative externalities that find their source in the challenge of intermittency. Current electricity systems with base load capacities sourced from fossil fuels are extremely stable and have faster ramp-up rates catering to sudden spikes in power demand. Unlike renewables, they are immune to changes in weather patterns. The introduction of renewables into grid-connected supply increases the pressure on current technologies to adapt to supply variations. The technical ability of technologies to adapt to challenges posed by intermittency is known as 'flexibility' (Häseler 2014: 152). An emerging field like renewables encompasses several regulations that must quickly adapt to transformations in demand and supply. The onus of creating a suitable environment for investments in flexible technologies falls on the German legislator. The German legislator must thus manage to achieve adequate technical flexibility while preventing an additional tax burden on the consumer. The paper questions regulations that have been introduced to expand flexibility among renewable energy technologies.

Despite its energy import dependency, Germany has created a stable supply of energy from abroad. It is essential that the energy transition does not disturb this balance. Prior

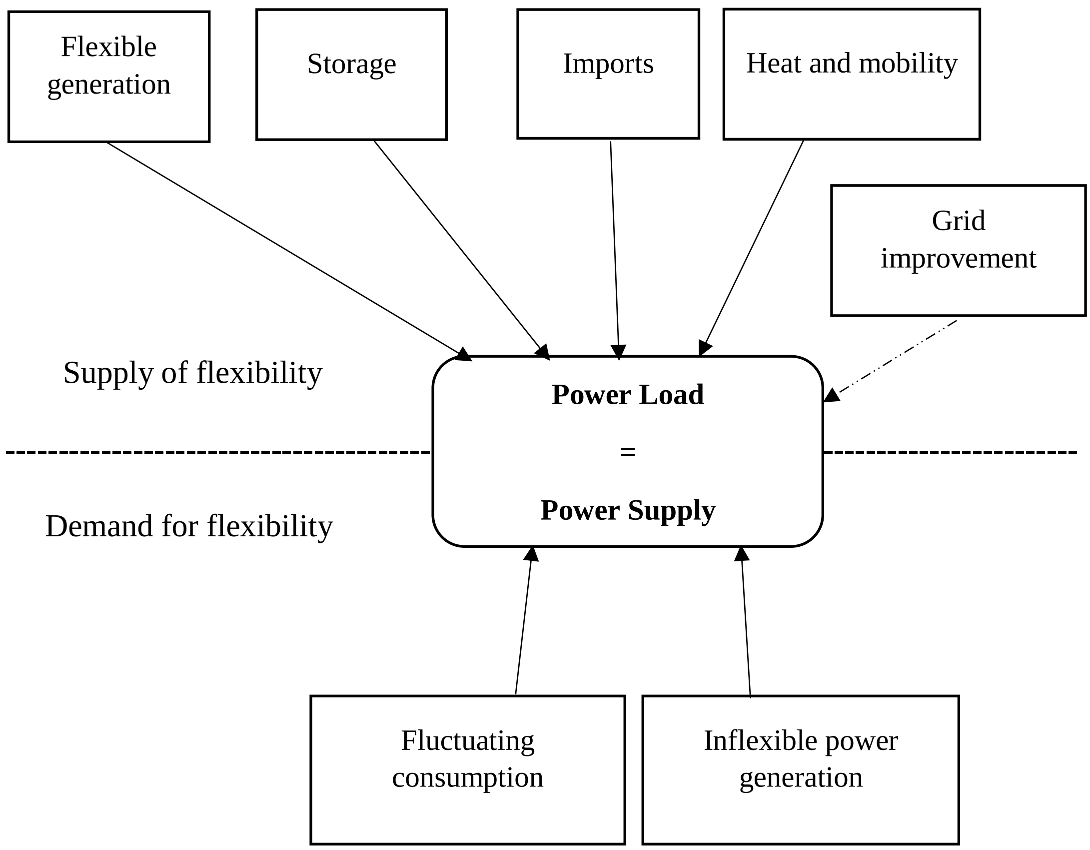
[50] Art. 1(2) of the Renewable Energy Act.

to the introduction of renewables, the electricity grid was balanced by adjusting the output of conventional power plants to match predictable patterns in power demand on a daily, weekly or seasonal basis.

This negative attribute (intermittency-related inflexibility) has no impact on their productivity costs vis-à-vis fossil fuels, as the marginal cost of production is very low. Renewables are unsuitable as back-ups in case of demand fluctuations. Instead, renewables are in need of back-ups themselves. These attributes are major elements of the 'demand for flexibility' (Häseler 2014: 152). Demand for flexibility not only includes renewables but also some fossil fuel power plants like coal-fired ones where boilers are best left lit.

As the capacities for renewables increase, the burden on fossil fuel power plants to supply flexibility will also increase. However, this flexibility will diminish once renewables gain a massive quantitative edge over their conventional counterparts. Such a scenario will lead to a growing dependence on the market and the grid. **Figure 4.8** states that every component of the power system will respond to a demand for flexibility with a supply of flexibility according to prevailing market conditions. This dependence on extra sources for flexibility includes storage, the electricity grid, global power trade interconnectivities encompassing thermal energy and transport sectors. The grid, the most vital and inexpensive source of additional flexibility is limited by fixed capacity and is immune to price fluctuations in the power markets; and hence cannot respond as quick as the other sources of flexibility.

Figure 4.8 Demand and supply of flexibility



Source: Häseler 2014: 153.

The addition of flexibility to RE systems through other sources involves large investments of capital. Further complicating this scenario, the social marginal cost of delivering this flexibility and the marginal cost incurred from non-usage of all additional flexibility should not exceed that of non-renewables. It must also satisfy the requirement of efficiency.

Häseler (2014: 153) outlines three approaches thorough which governments may secure adequate flexibility within their electricity systems.

1. **Power Markets**: Here, the demand and supply sides of the market involve only private actors. Prices are based on the marginal cost involved in the dispatch of electricity from the last power plant. These are energy-only markets where high consumption is penalized and high generation rewarded. High demand endangers security of supply and hence provides an incentive to invest in flexible technologies. In Germany, the Energy Industry Act 2005 (Energiewirtschaftsgesetz, EnWG) regulates private actors, in energy-only

markets. The Act presupposes the prominence of security of supply over other regulations surrounding the players.[51]

On the other hand, the output from renewables, especially during the mid-day peaks, has decreased electricity price levels (spreads) in the previous 5 years. Falling spreads also affect electricity storage plants, which hope to profit from the sale of electricity during peak demand. They affect power generation from flexible sources on stand-by during peak hours. These developments introduce volatility and unpredictability in previously predictable time slots.[52] Profit margins of old, new and established conventional projects have suffered due to the competition from renewables, capacity reduction, compulsory purchase of efficiency permits and a 70% rise in operating costs over the past 10 years. These scenarios could also indicate a surplus of flexibility.

Another take on investments into flexibility and the market's ability to deliver enough of the former argues that if the power generation system is facing a crisis due to the introduction of renewables it indicates inherent shortcomings in the present system. The author (Häseler 2014) agrees this view, arguing that even countries with minor renewable energy targets dole out subsidies for the maintenance of flexibility; what happens when larger targets for renewables are set? The shortcomings of the energy-only markets are apparent under three circumstances – political opposition to high power prices, uninterrupted supply of electricity is a 'public good' and, incorrect forecasting and the inability to plan for the long-term.[53]

2. **State Markets**: In this situation, legislation exclusively creates demand, with supply embracing only private players. Under the 2012 amendment to the Energy Industry Act, Transmission System Operators (TSOs) are in-charge of maintaining security of supply, an objective espoused in Art 1(1).[54] Providers

[51] Article 1(1) of the Energy Industry Act.
[52] Dwindling demand for flexibility during peak hours has led to the closure of at least two gas power plants in July 2013 and threatened the future prospects of at least half of the conventional power plants in North Rhine-Westphalia alone.
[53] This is especially important given that power projects usually have a minimum shelf life of 25 years.
[54] Article 12 of the Energy Industry Act.

of grid stability services are guaranteed additional markets created by TSOs. Services are auctioned, with costs passed on to consumers through transmission charges. State markets intend to bridge the ‘flexibility gap’ created by the shortcomings of the energy-only markets by creating additional capacities. The highly stable German grid is evidence of the competence of TSOs in creating adequate flexibilities (Häseler 2014: 155). However, criticism of this method include that TSOs cannot guarantee performance after the creation of additional capacities. Next, additional capacities could translate into load shedding by large electricity consumers to show extra capacities and ‘guaranteeing markets’ for new entrants.

3. **Market Intervention**: The major difference between private markets and market intervention is that in the case of the latter government policies are created before market outcomes are realized. Any action threatening the security of supply may be prohibited in an unplanned manner i.e. through directives and not through legislation. Here, the isolation of threats to stability is the focus of legislators. Market interventions in Germany are carried out by the TSOs. The Energy Industry Act allows TSOs to command power plants of over 10 MW capacity to increase or decrease generation[55]; compensate plants in return for their commitment to serve as ‘grid reserves’ for 5 years[56]; accept/reject the closure of plants over 50 MW capacity for up to 1 year[57]; and, instruct gas-powered plants to change fuels[58]. This is the least inefficient method in creating flexibility since TSO’s have the tendency to ignore the social costs in favour of maintaining grid stability.

Private markets deliver qualitative incentives in the form of cost variations. State markets create quantitative flexibilities by accurately measuring flexibility through auctions and tenders.

[55]Article 13 (1a) of the Energy Industry Act.
[56]Article 13 (1b) of the Energy Industry Act.
[57] Article 13a of the Energy Industry Act.
[58] Article 13c of the Energy Industry Act.

Häseler (2014: 156) discourages the implementation of additional cesses that tax the negative externalities of fossil fuels. They are vital in maintaining grid stability if a massive renewable' capability is to be realised.

The amendment to Renewable Energy Act (*Erneuerbare-Energien-Gesetz, EEG*) in 2012 introduced major changes to the renewables support scheme. Under the 'market premium model'[59], electricity from renewables should be promoted among third parties and the power exchange. The returns from any sale as well as the difference between the average wholesale value and feed-in tariff, known as the 'market premium' go to the operator. Producers are also paid a 'management premium'[60] to cover marketing risks. The model incentivises renewables, making them more receptive to electricity demand (Häseler 2014: 157). However, this model is more suited towards biogas plants which are more flexible. In 2012 alone, 80% of Germany's wind capacities converted to the market premium and gained a considerable share of the 460 million euros that the German government had invested in flexibility.

As an alternative, the EEG should reorient itself to reward producers consuming less flexibility and risking the price variations in the market. Moreover, every unit of capacity installed should be rewarded with a consolidated infusion of capital, which depreciates through time to encourage the introduction of new technologies (Häseler 2014: 158). Investment subsidies allow operators to produce power based on their capacity and not on the expectations of large feed-in tariffs. They also wean operators off their dependence on FITs in determining the lifecycle of the plant. They will also encourage operators to design plants with more flexibility based on market demand. It will emphasise quality i.e. the lack of flexibility consumption, rather than simply enlarging capacities. With almost negligible maintenance costs, investment costs comprise the largest share of lifetime costs (for 20-year plant life). A 20-year feed-in tariff is adequate to cover maintenance costs and provide a small profit. However, it is insufficient to cover upgrades in technology, especially flexibility. With only one-third of the 2050 target for RE capacity attained, the German RE sector is ripe for the replacement of feed-in tariffs by investment subsidies.

[59] Article 33g of the amended Renewable Energy Act, 2012.
[60] Article 64f(3) of the amended Renewable Energy Act, 2012.

Häseler (2014) suggests that consumers, excluding household consumption and small users) must be made aware of the social cost of the lack of flexibility consumption. To reduce the burden on flexibility, large-scale users may negotiate a lower network charge (under the Load Shedding Directive) with the TSO for low load consumption.[61]

The use of the private market could encourage consumers to shift peak loads to periods with low prices. Accessibility to short-term price risks can be encouraged through the availability of the applicable electricity tariffs in the market. Real-time metering will aid consumers in analysing demand patters and in making an informed choice. Lastly, real-time pricing and smart metering should be complemented with demand control and efficient technologies. Currently, large industries with large power demands sign contracts with power producers based on their maximum power demand.

The increasing share of rigid supply from RE and the falling share of conventional, but dispatchable, sources of energy threaten Germany's security of supply; and in a larger framework jeopardise the energy transition. The "ad-hoc applications of stick and carrot" may only increase the cost of the transition to be achieved by 2050 (Häseler 2014: 160).

Ex post interventions in power markets by their very nature are very disruptive. The paper suggests investment subsidies, variable tariffs along with an active role in the market to reduce this dependence. A 'market for flexibility' is posited to overcome qualitative deficiencies (Häseler 2014: 161) **(Table 4.1)**.

Table 4.1 Future economic framework for the power supply: Markets and schemes available to each group of actors

<table>
<tr><th>Renewables</th><th>Storage</th><th>Fossil Power Generation</th><th>Consumption</th></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Investment Subsidy</td><td rowspan="3">Market for flexibility</td><td></td><td>Electricity market</td></tr>
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Source: Häseler 2014: 161.

[61] Art. 14a of the Energy Industry Act.

Climate change-induced external disruptions are far more serious to German energy security than its domestic impact. The potential rise in sea levels will affect areas having fewer inhabitants than Germany's neighbours. The strength of Germany's federal structure will allow it to create comprehensive responses that take into account the national rather than localised impact (Kraemer 2011: B-1).

The incorporation of renewables and stricter energy efficiency measures facilitate a clear transition to environmentally benign sources of energy and fill the vacuum left by the future withdrawal of nuclear energy from the power generation setup. Germany's historic association with domestic coal is already on its last leg. The last vestiges of a 200-year old industry are gradually being disbanded as mining activity has literally reached the bottom of a hole from which it cannot pull itself out. In short, coalmines have reached depths so deep that they have lost their competitive edge over cheap imported supplies.[62]

Soft coal, also called lignite or brown coal is still in use as a fuel for local power generation. Unlike hard coal reserves, lignite can be mined using open mines on the surface. Surface mining, as already stated before, causes visible environmental destruction to the surface. This has brought lignite mining in conflict with local environmentalists.

The federal Renewable Energy Act enabled the synergy with Germany's power generation sector through the introduction of 'attractive' feed-in tariffs. Designed to depreciate over time and dissipate after grid parity is achieved, feed-in tariffs offer developers of wind and solar energy projects higher prices than those paid to other sources of energy (Kraemer 2011: B-2). Together with net metering, feed-in tariffs bolster the creation of decentralised power generation systems. With a turnover of 36 billion euros in 2009, renewables were one of the few profitable industries in Germany in the aftermath of the Global Recession of 2008. Germany also had lower CO2 emissions in 2008, but this could be a result of the Recession.

The establishment of a **'combined renewable power plant'** consisting of intermittent sources like wind and solar energy and dispatchable sources like biogas-to-power,

[62] In December 2018, the Prosper-Haniel coalmine, the last operating hard coal mine in the coal-rich Ruhr river valley and indeed Germany, shut operations. Over 150 years, the mine had reached depths in excess of 600 metres.

pumped storage and hydropower is capable of maintaining grid stability (Kraemer 2011: B-2).[63] Several scholars like Häseler (2014) have put forward this idea of the combination of intermittent and dispatchable renewables. However, the sheer volume of demand and the inability to bridge sudden demand spikes makes this suggestion unfeasible. Of course, such a complicated setup will not only require real time monitoring of demand, but also a close watch of supply of dispatchable energy. Organic residues are not compatible with power demand, while hydropower is susceptible to low water levels.

4.5.3 Increasing dependence on cheap imported gas supplies

Schmid (2014: iv) forwards the expansion of Europe's renewables capacity to counter the threat of costlier Russian gas imports. The independence from the effects of Russia's volatile relations with neighbouring transport hubs like Ukraine and Poland will strengthen European self-reliance and stymie, at least temporarily, its obsession around energy security. Energy independence will spill over on to tougher stances against aggressive Russian pricing and Russian support for Crimean independence. In short, energy independence guarantees political independence, making Europe's transition to renewables essentially a 'security project'.

Unlike Boisvert (2013) and Häseler (2014), Schmid (2014) argues that Germany's forays into the large-scale transition of her energy sector assures its citizens and industries of affordable access to energy and, in a broader sense enhances energy security. Fears of intermittency-related power outages are unfounded as these are restricted to an average of less than 30 minutes annually. A large gas-based system provides a solid footing for the expansion of renewables capacity towards ultimately achieving a transition to cleaner energy sources. It also provides flexibility to cover the shortcomings in renewables, mainly intermittency (Häseler 2014). In 2013, only one-fifth of Germany's gas consumption came from domestic sources (11%), with the balance imported from Russia (31%), Norway (24%) and from the EU (34%). The withdrawal of nuclear-based electricity has compelled Germany to rely on mainly gas-fired plants to provide flexibility to the power generation setup. However, the need for flexibility endangers the security of supply, a core precept of Germany's energy policy.

[63] Kraemer (2011: B-2) gives an example of an experiment with 36 'plants' (of unknown source of fuel) that maintained stable supply of electricity. However, this is unverified.

Citing a June 2014 study by the Fraunhofer Institute,[64] Schmid (2014) believes that a combination of alternative technologies in the heating sector and the substitution of imported natural gas by biogas and power-to-gas technology could terminate the dependence on foreign gas imports by 2050. Improved efficiency is the key to attaining German energy independence. The creation of a target – 25% electricity consumption reduction by 2050 – is a step in the right direction.

The accommodation of dissipated production and consumption forming a flexible energy structure goes against the traditional fulfilment of baseload through centralised power production. This 'paradigm shift' (Schmid 2014: v) in the energy system forms the conceptual backbone of the Green Party-led contemporary debate on energy transition in Germany. The expansion of decentralised power generation through community-based projects is already underway in Germany (Schmid 2014; Singh 2018). These 'prosumers' produce and consume electricity produced by them; surplus power is sold to the grid.[65]

Schmid (2014: vi) argues that the inclusion of prosumers and utility-scale renewables in the German power generation system creates a buffer against external threats to energy security – in effect, creating 'energy islands'. 'Energy islands' emphasise sizable investments in smart grid technologies, energy efficiency measures and modern energy services. The 'paradigm shift' in the energy system embodies a strong element of security within it. Domestically, Germans will reduce their dependence on a centralised grid with the creation of a new industry that has already led to reduced prices in the wholesale market. Globally, the independence from Russian gas imports gives it plenty of manoeuvring room in diplomacy. The Fukushima nuclear accident in 2011 clouded the debate surrounding the nuclear phase-out. Leaving behind the immediate cause of the phase-out, the long-term benefits towards environmental protection, increased domestic economic capacities and reduced external dependencies should

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[64] This report is available only in German. [Online: web] Accessed 1 April 2019, URL: https://www.gruene-bundestag.de/fileadmin/media/gruenebundestag_de/themen_az/energie/PDF/Erdgassubstitution_final.pdf

[65] In 2008, there were 147 registered energy cooperatives; in 2010 there were 380; in 2012, 751; in 2014, 974; and in 2016 there were 1024. Kahla et al. (2017), 'Development and State of Community Energy Companies and
Energy Cooperatives in Germany', *Working Paper Series in Business and Law*, No. 27, Luneberg University. [Online: web] Accessed 3 April 2019, URL: https://www.buendnis-buergerenergie.de/fileadmin/user_upload/wpbl27_BEG-Stand_Entwicklungen.pdf

ultimately convince other European countries to overcome their dependence on nuclear energy to create stable power systems.

Schimd (2014) conveniently leaves out increased flexibilities that maintain stability within Germany's electricity system after the introduction of intermittent sources of energy (Häseler 2014). Secondly, the author fails to take into account the impact of the under-sea Nord Stream gas pipeline from Russia to Germany, bypassing any third country. It eliminates the influence of Russia's disputes with her neighbours on gas supplies to Germany.[66] Finally, her emphases on the security aspects of the energy transition also ignore the shifting of production capacities to Asia, mainly China. Thus, the dependence on Russia is replaced by a new dependence on China.

4.5.4 Entrenched thermal power capacity

The complete focus on nuclear phase-out highlights tunnel vision among German lawmakers. The production of hard coal in Germany contributed a measly 12 mt in 2011; lignite production touched 171 mt. Yet the Federal government was committed to shutting down all mines extracting hard coal by 2018. The decision was made after the EU's refusal to subsidise inefficient coalmines in 2007. The failure of the EU's Emissions Trading System (ETS) in 2012, larger electricity exports to the EU and the inability of renewables to bridge the gap left by the withdrawal of nuclear capacity led to the ascendance of lignite. These factors led to coal [from both source] capturing a share of 45 percent of German power generation by 2015 (Goodman 2016). Coal's dominance has cast serious doubts on Germany's ability to reduce emissions by 40% over 1990 levels by 2020. These doubts renewed the focus on the dirtiest fossil fuel when the Federal government agreed to pay production companies to suspend generation from coal-fired power plants indefinitely in 2015. These decommissioned plants would form a 'carbon reserve'.

Initially, investments in thermal capacity were strong considering that the ETS favoured it in the early 2000s. The reliance on thermal created very broad caps and surplus allowances in the market, due to which the prices of these allowance fell sharply (IRENA 2015: 26). New thermal capacity was chosen over increasing in natural gas imports to replace aging thermal power stations.

[66] Construction of the Nord Stream 2 pipeline began since May 2018. Running along the same course as its predecessor, the second direct pipeline to Germany will double gas exports to Russia's largest customer in Europe.

Furthermore, high capital costs of renewables and lack of familiarity discouraged utilities from investing in renewables.[67]

4.6 Comparison of the Indian and German scenario

The prominence of the climate dialectic expanded concurrently with the growth ('popularisation') of climate science as a subject in academia, culminating in the formation of the Intergovernmental Panel on Climate Change (IPCC) though a convergence of corporate, non-governmental and UN-led effort in 1988. This convergence of understandings of climate change by multiple actors in society promoting a distinct climate change narrative is called 'climate agency'. Climate agency has ascribed biophysical qualities to anthropogenic emissions dominated by large-scale fossil fuel use. These biophysical features, with their encompassing deleterious effects violate the biophysical parameters (global warming) set by the climate agency. The hazards of GHG emissions challenge the business-as-usual (BAU) by side lining suggestions of 'management' or 'co-optation' through an emphasis on emissions-reduction. Challenges to mainstream economic activity provide climate agency with political attributes - to influence official policy to do more than simply manage climate change (Goodman 2016: 185).

Goodman (2016: 186) accentuates the importance of establishing a comparative framework integrating the distinct historical contexts of India and Germany to shed light on the climate-energy nexus. India's experience with British colonialism and Germany's post-Cold War unification have shaped their own distinct forms of industrialism, which touch one common agenda: emissions reduction.

Goodman (2016) presents five policy recommendations with regard to the climate dialectic. First, he cautions against the inclusion of a managerial approach in energy policy; it can only work within the accounts of demand/supply dynamics and, could strengthen the permanency of climate change impacts. Second, the role of key entrenched players along with their self-centred interests must be appreciated. Third, awareness among the general population could improve the legitimacy of what is essentially a grassroots framework. Fourth, a mid-way approach between the supporters and opponents of the climate dialectic to pacify the interests of the larger section of the population will surely lead in the failure of the compromise reached. Finally, the author

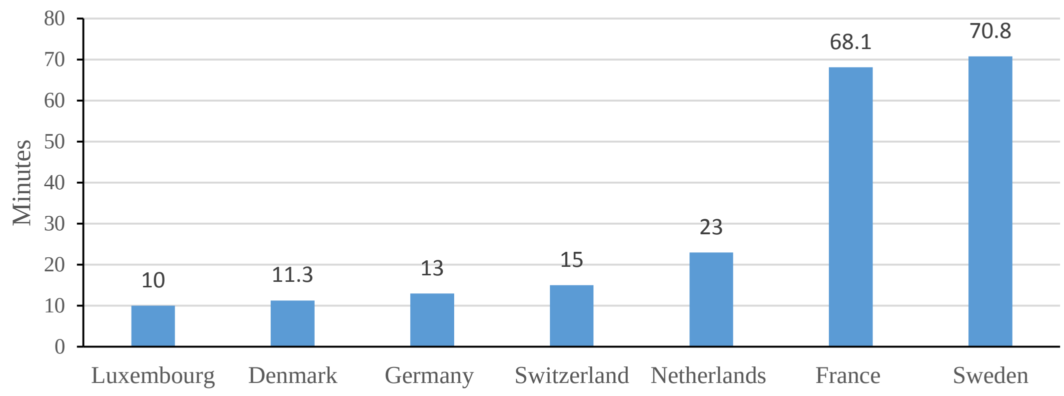
[67] Ibid.

recommends willingness to introduce and adapt to changes in societal and political processes based on the endorsements on climate science.

Table 4.2 highlights specific regulatory policies present in both these countries. It also shows various financial and fiscal incentives offered for the development of their domestic capacities. Both India and Germany have national renewable energy targets in place. One glaring difference is the absence of compulsory obligations for utilities in Germany. The large numbers of community and individual projects contribute a substantial part of Germany's electricity from renewables. Another glaring difference in the fiscal policies of these two countries is the absence of tradable Renewable Energy Certificates in Germany. RECs are a recent addition in India. German producers do not feel the need for RECs because of the large and established renewables' capacity already in Germany. Furthermore, efficiency measures are very strong in German industry negating the need for added emissions reduction.

Despite the criticism that the inclusion of intermittent RES into the German grid could exacerbate power shortages, Germany has one of the most stable and reliable power system in the world. In 2013, Germany suffered only 13 minutes of power cuts over 8,760 hours per year. France, which has a large nuclear industry, suffered an average of 68.1 minutes of power cuts in 2013 **(Figure 4.9)**. The last major blackout in 2006 occurred due to complications from routine maintenance. Germany has sufficient back up capacity to tide over any power shortages arising out of fluctuations. In fact, the winter months are some of the most productive for wind power generation; at a time when power generation from solar PV is low (Maue 2018).

Figure 4.9 Average lengths of Power cuts in minutes in 2013



Source: The German Energiewende, Federal Foreign Office, Berlin, pg. 24.

Germany had the largest engagement with the Kyoto Protocol's CDM among the European countries before the system's 'collapse' in 2012 (Goodman 2016: 190).[68] Between 2008 and 2012, German power companies contributed to the reduction of 179 mt CO2e of Germany's total CDM-induced reduction of 303 mt CO2e. Political criticism from the coal lobby in India compelled the contracting of German involvement in CDMs dedicated toward India's coal industry.[69]

Lagging behind its greenhouse emissions reduction and efficiency targets, Germany plans to invest about US$40 billion to strengthen the transmission grid as more than forty thousand kilometres of lines need to be upgraded. This would also enhance German capabilities to manage intermittency (Ney 2018).

Inference

Germany's stronger transmission capabilities make the transition to renewables more robust than that in India. In the case of India, the Green Corridor will play a vital role in expanding RE supply. The expansion of RE in Germany has acted as a confidence booster in other countries – while fossil fuels fostered competition RE fostered cooperation and knowledge sharing. The low incidents of power cuts and the absence of prolonged power cuts demonstrate the success of Germany's power management capabilities. The ability to balance intermittency and low utilisation factors through optimum power management in a market dominated by small and independent operators that serves as example from which India could successfully stave off any competition from thermal power. The fourth and fifth research questions: *What lessons can India learn from Germany's Energiewende?*; and, *How can grid-connected wind and solar energy challenge other major fuel sources for a larger share of the national electricity grid in both India and Germany?* are answered by observing Germany's initiatives in flexibility and synchronisation.

[68] By 2012, more than a billion credits were sold. Valued at US$20 at their peak, carbon credits were just under US$3 in 2012. The federal governments in countries like China and India refused to implement compulsory emissions reduction targets. Instead, CDM-financed projects focussed on small targets, which did contribute greatly to global emissions reduction. This defeated the main objective of the system. The failure of the CDM system pushed countries to adopt voluntary targets through the INDCs under the 2015 Paris Climate Agreement during the COP 21 Summit. Also refer to section 5.4.

[69] Ibid.

Table 4.2 Renewable energy promotion policies: India and Germany

COUNTRY	REGULATORY POLICIES							FISCAL INCENTIVES AND PUBLIC FINANCING					
	Renewable Energy Targets	**Feed-in tariff/premium payment**	**Electric utility quota obligation/ RPS**	**Net metering**	**Biofuels obligation/ mandate**	**Heat obligation /mandate**	**Tendering**	**Tradable REC**	**Capital subsidy, grant, or rebate**	**Investment or production tax credits**	**Reductions in sales, energy, CO2, VAT, or other taxes**	**Energy production payment**	**Public investment, loans, or grants**
Germany	o	R			o	o			o	o	o		o
India	o	o	o	●	o	●	o	*	o	o	*	o	o

o – existing national (could also include state/provincial), ● – existing state/provincial (but no national), * – new (indicates state/provincial),

R– revised (*indicates state/provincial)

Source: KPMG 2015: 10.

CHAPTER V

Political Economy of the Global Energy Transition process

The association between politics and electricity outcomes – in this case, renewable energy generation - is a broad area of interest that juxtaposes the modern day of element of climate change mitigation with economic prerequisites. "Most countries deconstruct their energy-climate policy by including their energy security goals. India is currently in a period of resource boom, where emission reduction is a secondary priority" argues Prof. Akhisa Mori.

The previous chapters have focussed on conceptual issues and analysed the renewable energy scenarios in India and Germany amidst a continuous need to reassess and adapt to changing conditions. This chapter shall analyse the exigencies of the 'global' aspect of implementing policies that will eventually contribute to the overall transition of the power generation sector to a low-carbon framework.

5.1 Prevailing trends in the global climate change arena

The energy policy of every major country, which previously sought to only secure stable supplies of energy to fuel the domestic economy to one that seeks to reduce import dependency through efficiency, considers climate change issues and lastly, attempts a smooth transition from fossil fuels to renewables (Deutch 2011).

According to Deutch (2011), conceptually, transition is a response to complications created by long-term anthropogenic activity. It is not only sensitive to issues of climate change, but also receptive to ideas like independence from foreign energy imports, or restraining the prices of oil and gas while lesser energy sources are exhausted.

When the penetration of solar PV or wind is less than ten percent of the grid, adjustments to intermittency are undemanding (Deutch 2011: 92). Nevertheless, in cases when grid penetration is more than ten percent, the entire system has to make several adjustments to maintain grid stability. Some of these adjustments may include an alternate source of electricity, the transmission of excess electricity from other parts of the grid and tapping into electricity storage. The massive public pressure to adopt renewable technologies notwithstanding, government policies are determined by the technological capabilities of these unfamiliar technologies.

Likewise, the core theme of Bradshaw's (2010) paper examines the fine balance that must be achieved to initiate a transition to low carbon energy systems, in the face of what every government is striving to achieve – a stable and cheap supply of energy. According to him, "The energy system is the single largest source of anthropogenic greenhouse gases, therefore it is no surprise that decarbonising the supply of energy services is a key element of climate change policy" (Bradshaw 2010: 275). The paper studies three elements – climate change policy, global energy security concerns and the global energy system.

It seeks to answer the problem, through a geographical perspective, whether the global economy will be able to sustain itself at the same rate, even if energy consumed will be curtailed by a transition to a low-carbon economy.

The IEA defines energy security as 'adequate, affordable and reliable supplies of energy'.[70] The nation-state has gradually come to guarantee energy security. The IEA also views end-use energy efficiency as the most effective form of carbon dioxide mitigation. A global low-carbon energy revolution, mitigating anthropogenic carbon emissions, would require a level of technological change that has never been witnessed throughout history (Bradshaw 2010). Immense hope was placed on carbon capture and storage (CCS) by the IEA, even though it continues to remain inconclusive. Although endowed with plentiful energy resources, even the United States, a leading energy importer and a non-signatory to the Kyoto Protocol, has seen its carbon emissions increase by 19.9% between 1990 and 2005.

5.2 Financial mechanisms governing the international trade in renewables

Jorgensen (1986: 2) attempts conciliation between two discerning views; that world energy prices *may* or *may not* have a defining impression on economic growth. Engaged in a continuous cycle of falling prices and economic slowdown and, rising prices accompanying rapid economic growth, it is hard to determine the role fluctuating energy prices, particularly in the aftermath of the two oil crisis in the 1970s, play in determining economic growth.

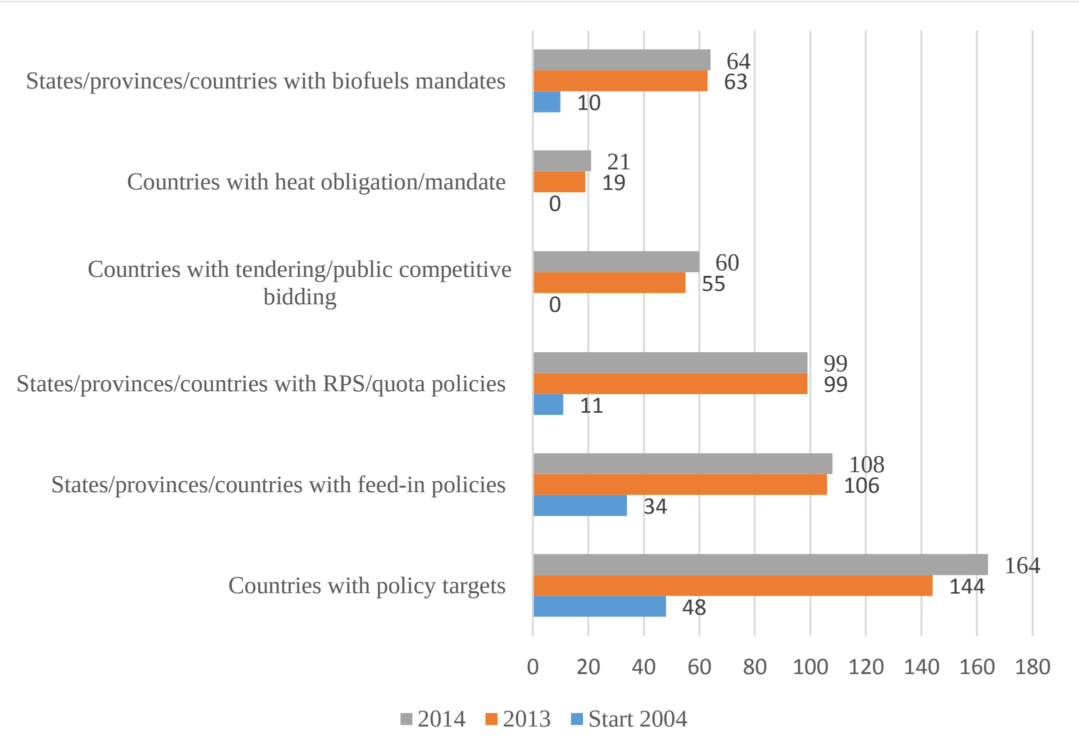
The economic growth of the Organisation for Economic Co-operation and Development (OECD) countries, the emphasis of this article, recorded high figures in

[70] International Energy Agency. As quoted in Bradshaw (2010: 276).

the 1960s, a product of low oil prices. Jorgensen (1986: 13) concludes that the highly elastic nature of world energy prices, if increasing, negatively affects economic growth as well as global demand for energy.

Figure 5.1 indicates that the renewables sector picked up strength only in the early 2010s. It is an amalgamation of financial and policy-based incentives encouraging development in this sector. Twenty countries introduced renewables capacity targets in 2013-14 alone. The spread of countries was not restricted to high-income countries alone; neither is it restricted to countries induced with geographical advantages for the establishment of a specific technology (KPMG 2015: 2). The sector was dedicated almost wholly towards power generation with FITs and RPS comprising the most widely used mechanisms. The massive expansion of capacities reflects the fall in the pricing of solar PV panels since 2008.

Figure 5.1 Growth in taxes and incentives for renewable energy, 2004 to 2014



Source: REN 21 Renewables 2015 Global Status Report. As quoted in KPMG (2015: 2).

5.2.1 Funding mechanisms for renewable energy projects in India

Krithika and Mahajan's (2014) working paper analyse issues of governance, technical competence, regulation, finance and legal frameworks that have risen after the government's aggressive implementation of enhanced grid-connected RE targets. This study is 'technology-neutral'.

According to the CEA (2013), 12.3 % of total installed capacity was from renewables. The inclusion of specific targets is testimony to the support renewables have received from policymakers.

The Electricity Act of 2003 forms the bedrock from which RE in India has sought recognition as a viable alternative source of electricity Krithika and Mahajan (2014: 10). Under the act, SERCs were directed to actively pursue grid-connectivity for renewables. The National Tariff Policy, 2006, maintained a minimum share of renewable power to be purchased compulsorily by grid operators.

The MNRE is the core central agency spearheading the growth of renewables in India. Central funding for R&D stems from here. Departments within the state governments receive centralised funding, through the Indian Renewable Energy Development Agency (IREDA), and are responsible for its disbursal at the local level.

A competitive bidding process for long-term encompassing grid-connected renewable energy was begun in 2012-13. "India is a large but very young market and RE is vital to the climate change agenda. India is doing away with FITs by pushing for reverse auctions. (However), the industry is not convinced of the strength of RE infrastructure or market; but reverse auctions are the law of the land" contends Soma Banerjee (2018).

In order to fulfil its obligations to compulsorily source renewable energy output, the NTPC created a process called 'bundling', where unsold electricity originating from NTPC coal-fired plants would be clubbed with renewable energy, and sold to distribution companies. The intention was to reduce the cost of solar power (Krithika and Mahajan (2014).

The entry of amateur players quoting low prices during bids compelled the government to maintain a 12-month deadline for the commissioning of solar PV projects. Failure to do so would attract fines and a cut to their generation-based incentives.

Grid-connected renewables fall under the purview of the CERC and the SERCs, the central and state electricity regulators. For example, while the CERC set out the parameters for feed-in tariffs, the SERCs determine the rates payable for the various renewable technologies. They also set RPOs.

Since 2013, feed-in tariffs and generation-based incentives are applicable for both wind and solar PV. The domestic manufacture of solar PV modules has failed to take off owing to the import of cheaper modules from abroad.[71] A majority of domestic capacity is idle, while some manufacturers have shut shop.

The integration of renewables with grid-connectivity, especially in states with large capacities for renewables is a challenge due to the over-production of electricity in peak summer months.

It is the responsibility of the developers to obtain the required clearances from the state nodal agencies (SNAs). Although a single window process was planned, this is rarely implemented with procedures for land acquisition alone taking one year. The release of the NAPCC in 2008 did not attract additional funding from the government for renewables, unlike its conventional counterparts. The total budget for the sector continued to stagnate below 1% of the total budget.

The objectives of the National Clean Energy Fund (NCEF), funded through a cess[72] on domestic as well as imported coal, to finance world class R&D into renewables, have remained elusive due to financial misallocation. The additional funds have been directed to bridge the deficits (budgetary allocations) of several ministries involved in financing off-grid and small-scale renewable technologies. As such the NCEF has failed to increase the scope of renewables into the larger[73], and more polluting, urban framework. Transparency is the need of the hour

The compulsory purchase of Renewable Purchase Obligations (RPOs) by distribution companies has not been strictly adhered to. Several states have cited low installed capacity of renewables and high costs that will have to be borne by consumers. In most cases, the regulator has permitted defaulters to carry forward the backlog into the next financial year. The absence of fines has encouraged non-compliance. The authors cite the example of Haryana, which appealed to CERC in 2013 for relaxation of RPOs for the aforementioned reasons. However, Haryana was informed that these targets had accounted for the renewable potential of the state and were at their minimum.

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[71] Refer to section 5.5.

[72] The Clean Energy cess was first imposed in 2010 when every metric tonne of coal sold was levied with a cess of Rs. 50. In 2017, the Clean Energy cess amounted to Rs. 400 per metric tonne sold.

[73] As of Jan 2017 an estimated Rs. 9000 crore, from a total of Rs. 54-56,000 crore, has been spent on clean energy project. The NCEF is now known as Clean Environment Fund.

Only Tamil Nadu, from a group including Maharashtra, U.P., Punjab, Haryana and Gujarat, has fully complied with RPO targets in the fiscal year 2011-12.[74] Non-compliance in fulfilling RPO targets has led to low demand for REC certificates.

Renewable energy projects are often exempted from Environmental Impact Assessment (EIA) conducted by the Ministry of Environment and Forests (MoEF). The dedication of sparse water resources towards the increasing number of renewable energy projects in drought prone states like Gujarat and Rajasthan may face social backlash.

The authors acknowledge that the weak financial ability of distribution companies makes it difficult for them to fulfil targeted RPOs, much less pay fines for their non-compliance. At the same time all data relevant to RPOs must be made available to regulators so as to assess the success of renewable energy penetration They conclude that the NCEF must be re-oriented towards its original objective of funding state-of-the-art technical research into renewables (Krithika and Mahajan 2014).

According to the Make in India website (2016), India's dependence on foreign imports of oil and natural gas makes it vulnerable to price increases. In 2016, it was the fourth largest importer of oil and the fifteenth largest importer of LNG and other petroleum products.

The government of India has introduced several incentives like generation-based incentives (GBIs), capital and interest subsidies, viability gap funding (VGF), concessional finance, fiscal incentives etc. The Reserve Bank of India (RBI) has issued guidelines to treat bank loans for the installation of rooftop solar systems as home loans, which are eligible for tax breaks. As the nodal agency, the MNRE has issued several directives to attract foreign investment in the sector. Firms are exempt from the payment of income tax on profits from power generation. They are exempt from the payment of excise duty. They may receive certain concessions on custom duties for the import of specific vital components. They are also entitled to 80% accelerated depreciation.

Wind power projects may opt either for inducements in the form of GBIs, which are limited to $153,846.2/MW, at a rate of $0.007/unit, or payments in the form of 80% accelerated depreciation.

[74] Detailed records of RPO compliance remain unavailable.

Several states offer preferential tariffs for the purchase of power from wind-generated projects.

Pig Iron (SG grade) and ferro-silicon-magnesium, used to cast components of wind-energy electricity generators, are liable for full exemptions from the payment of excise duty. Round copper wire and tin alloys for use in the manufacture of solar PV ribbon are also included in excise duty waivers.

Select components for the manufacture of solar water heaters and associated systems are granted complete Basic customs duty (BCD) waivers.

Solar power projects receive a ten-year tax break.

Wheeling charges are similar to those offered to conventional sources of electricity. In order to protect wind and solar power producers from non-payment of dues by state distribution companies (discoms), various payment security mechanisms are in place.[75]

In addition to a subsidy of 30% of project costs, off-grid solar projects can avail soft loans. The Indian Renewable Energy Development Agency (IREDA) is a 'dedicated financial institution' offering financing for RE and energy efficiency projects **(Table 5.1)**. The five-year period from 2012-13 to 2016-17 saw a dramatic rise in funding for all sectors, eclipsing the twenty-five year funding from 1987-12.

Table 5.1 Sector-wise financing disbursed by IREDA (Rs Crore)

Sector	1987-12	2012-13	2013-14	2014-15	2015-16	2016-17	Total
Wind	4874	1207	1173	1355	873	2535	12017
Solar	562	151	274	576	1519	1524	4606
Energy Efficiency & Conservation	273	59	0	0	0	6	338

Source: Compiled from IREDA Annual Reports. As cited in *State of Renewable Energy in India*, pg. 162.

[75] For several years, State Electricity Boards (SEBs) have been riddled with debt. Much of this debt is blamed on cheap power supplied to the residential sector. However, the larger blame is assigned to the free power schemes offered to the agricultural sector, often to garner votes during state and national elections. Another aspect of this financial situation is the inability of regulators to curtail transmission losses.

In 2011, the total installed capacity of solar energy in India was 20 MW. This has grown to 8.062 GW as of July 2016.

The report was based on reviews of the MNRE as well as 24 states stretching from 2007-14. Released in December 2015, the report reviewed the performance of the renewable energy sector in India. More specifically, it evaluated the portfolio of RE within the energy mix of India.

The Performance Audit of the CAG of India (2015) states that the existing target for the purchase of electricity sourced from renewables was 3.5% in 2008. The NAPCC which was released in the same year increased this to five percent. The target would be increased by 1% every year subsequently, so that renewables would comprise 15% of the total energy mix by 2020. However, the RPO in 2012-13 was 8%, but only 4.28% was met. Similarly the RPO target in 2013-14 was 9%, but only 4.51% was achieved (MNRE 2015: viii).

Barring Himachal Pradesh and Tamil Nadu, the rest of the 24 states failed to synchronise their commitments with those laid down by the NAPCC. A little more than 95% of RPOs were met through direct purchases of power. The rest were purchased through RECs.

RECs to the tune of 93.64 lakhs, costing Rs. 1500 each, were unsold due to unstable environmental policies and half-hearted enforcement of RPOs (CAG 2015).

As the leading co-ordinator in the field of renewables, the MNRE has to formulate clear policies to dispose of unsold RECs and create awareness to attract Clean Development Mechanisms (CDMs). In 2007 no grid-connected solar capacity existed in India. By 2014 however, 2656 MW of grid-interactive solar capacity was installed in India. Also, in 2007 there was an installed capacity totalling 7091 MW of wind power in India. Wind power definitely had a head start over solar power. Generation Based Incentives (GBI) and Accelerated Depreciation policies had been withdrawn in 2012 causing a drastic drop in the creation of additional wind capacity.

With regard to wind power, the CAG reported that the grid due to inadequate transmission services, uncoordinated power generation and the inability to make accurate weather forecasts did not absorb wind energy produced satisfactorily. These factors caused losses amounting to Rs. 2040 crores between 2012 and 2014 (MNRE 2015: xi).

Even high-potential states like Gujarat and Rajasthan had tapped barely 2.56% and 0.51% of their total solar potential. Another recommendation was that tariffs should remain flexible to mirror any increase or decrease in costs.

The re-modelling of older wind turbines, comprising about 1.6 GW of total capacity, with the latest technology was behind schedule. India's total potential for small hydro was 19.749 MW. Grid-connected biomass potential was 17.981 MW. However, many schemes were suffering from poor siting. Forty seven percent of decentralised solar PV systems had fallen into disrepair due to non-maintenance of off-grid systems.

The MNRE has applied a three pronged approach to increase the share of renewables within the energy mix. First, it has aided research and development in the form of financial support and provided a platform to demonstrate breakthroughs. Second, it has mobilised financial support from several institutions. Third, and most importantly, it has provided several incentives in the form of tax holidays, depreciation allowances, fiscal incentives in the form of Grid Based Incentives (GBI). Grid-connected systems could be defined as comprising of energy systems feeding electricity into the centralised grid. Grid-connected renewable energy comprised of solar, wind, biomass and small hydro power (MNRE 2015: 3).

The State Nodal Agencies (SNAs) lead policy discussions for development of renewable energy in the state. Besides these, there are the NTPC Vidyut Vyapar Nigam Limited (NVVN) and Power Grid Corporation of India Ltd. (PGCIL). The former is the main agency that purchases electricity from renewables' operators. The latter deals with grid-connectivity issues and the construction of transmission infrastructure for conventional and non-conventional power projects.

The Electricity Act of 2003 delegated the State Electricity Regulatory Commissions (SERCs) with the responsibility to ensure the smooth evacuation of electricity sourced from renewable energy sources to the gird. The National Tariff Policy of 2006 also emphasised the responsibility of setting targets for inclusion of electricity from renewables with the various SERCs (MNRE 2015).

Renewable Energy Certificates (RECs) along with Renewables Purchase Obligations (RPOs) are policy mechanisms designed by the MNRE to provide indirect financial incentives to developers. Another issue addressed was the inability of several states to fulfil RPO targets due to fewer RE potentials , like that of Delhi state. By virtue of producing electricity from grid-connected renewable sources, developers are also able to reduce the levels of greenhouse gas (GHG) levels. RECs allow developers to sell these "environmental attributes" to distribution companies or other industries that are obligated to fulfil RPO targets. One megawatt hour (MWh) of electricity equals one certificate. In 2015, one REC was valued at Rs. 1500 or roughly $22. As of 2017, these certificates are valued at Rs. 1000 or $15.55. They are valid for three years. They are sold at Indian Energy Exchange and Power Exchange of India Limited.

In 2014, only Mizoram, Tamil Nadu, Himachal Pradesh and Karnataka achieved their RPO targets. In many states the State Nodal Agencies set RPO targets much below the benchmark set by the MNRE, keeping in view the NAPCC's goal. Even in states with lower RE potential, the purchase of RECs was very low. The absence of penalties for non-compliance in meeting RPO targets is one of the reasons. From 2008-2012, Generation Based Incentives (GBI) under the Demonstration Programme amounting to Rs. 12 per kWh, payable for 10 years, were offered to approved projects. This scheme expired at the end of the eleventh Five Year Plan.

Accelerated Depreciation (AD) is another scheme that was introduced to encourage a faster addition of grid-connected solar and wind projects. AD envisaged a payment of eighty percent of total the block on the basis of depreciated value. In turn, their tax burden decreases. The industry is highly susceptible to destruction from new technologies. In such an environment, without financial incentives developers would be reluctant to open projects.

Developers may either avail either GBI or AD, but not both. Both schemes were discontinued in 2012 as they were initiated during the eleventh five year plan. The move was not popular and figures fro addition of new capacity plummeted. They were both re-introduced in 2014. The government plans to withdraw these schemes gradually.

The record low prices secured for per unit of solar and wind energy during capacity auctions in 2017 signal the end of expensive prices for renewables in India. This is indicative of the increasing confidence players have in the government policies. The promise of evacuation of the electricity produced from renewable sources to the centralised grid is a major reason for the price drop. The author claims that prices will further decline if developers are permitted to construct facilities anywhere in India, while placing no restrictions on choice of clients, under the "inter-state open access system" (Ramesh 2017).

With the high cost of renewable energy falling rapidly, the focus will soon move on to managing the other problem that is innate within the nature of renewables – intermittency. The author argues that the increasing footprint of the software interface within grid management infrastructure will make intermittencies manageable. In the coming years, strides made in the development of storage technologies will reduce the dependence on coal in India. Although a dominant source of fuel in India coal use will soon mirror the declines of 11% and 6.7% as witnessed in the US and China respectively (Ramesh 2017).

5.3 Ecological Modernisation – killing two birds with one stone

Early renewables, beginning with solar energy in the 1970s, promised to neutralise geopolitical threats to Western energy supplies and satisfy concerns regarding environmental degradation rising from the necessity to find alternative sources of fossil fuel reserves in the West. The two oil shocks in the 1970s led to hydrocarbon exploration in the Western hemisphere. Simultaneously, the fallout from the Three Mile Island accident in 1978 brought to the fore the danger to the immediate neighbourhood instead of some distant uninhabited desert. President Jimmy Carter of the US targeted a share of 20 percent of power generation from solar energy alone by 2000. Despite federal funding and public interest, the technologies could not overcome technical hurdles to achieve the target (Yergin 2011). Instead, Japan and Germany, the former heavily dependent on West Asian oil and the latter influenced by its Cold War past, backed research into renewables.

Lovins (1976) emphasised the adoption of the 'soft path' consisting of a combination of energy efficiency and renewables to induce a sustainable transition to a low-carbon economic system.[76] Energy efficiency is also known as the 'fifth fuel' and similar to energy conservation (Yergin 2011: 1078). It should not be confused with cost cutting. Traditional efficiency worked towards reducing costs, enhancing energy use and

[76] Refer to section 2.1.1

environmental sensitivity. Contemporary efficiency seeks to incorporate climate change issues and reducing consumption of resources that experience high demand by the industrialisation of the emerging Asian economies. For instance, China's 13th Five Year Plan (2016-2020) emphasised energy intensity reduction of fifteen percent by 2020. The EU carries a twenty percent efficiency target by 2020. Russia has an ambitious forty percent intensity reduction target by 2020. Yergin (2011) argues that efficiency induces more confidence that renewables because of the targets already achieved after the 1973 oil crisis. "It takes less to produce per unit of GDP – showing an improvement in energy intensity" Natarajan (2018). Efficiency has moved from encompassing only industry and transportation to include the household sector. With rapid urbanisation, the construction of new residential spaces must include efficient use of the electricity supplied. The advent of Heating, Ventilation and Air Conditioning (HVAC) into developing countries, marginal increases in household incomes and the popularity of household appliance –'gadgiwatts' - has increased the demand for electricity (Yergin 2011: 1209). While industrial efficiency has been the traditional focus of efficiency measures, the shortcomings of retrofitting old housing stocks with efficient technology is a concern directly related to the power industry with an overall impact on a nation's efficiency target (Kerr et al. 2017). Efficiency measures include behavioural changes in energy use and regular maintenance of machinery – best practices – as well low-power lighting, temperature control and power management systems. It is necessary to initiate several wide-ranging policies to create a successful efficiency programme (Yergin 1213). The 'smart grid' concept is an extension of energy efficiency. It involves the transfer of electricity from the power plant to the consumer in an optimum manner using technological inputs. It is an amalgamation of several technologies. One of these is the smart meter, a real-time monitoring system, allows grid managers and discoms to adapt to fluctuating demand. A dynamic pricing programme may accompany smart meter installation to increase the latter's effectiveness e.g. consumers will be charged less for managing their individual demand during peak hours of demand.

The latest challenge is the integration of variable power loads from intermittent sources of with a grid historically dependent on stable power generation. The rising demand for efficiency will reverse conventional practices like passing on savings to customers. This role reversal moves efficiency away from direct cost saving for customer benefit to an intangible concept like emissions reduction. Electricity savings from low-cost indoor lighting comprise the ‘low hanging fruit’ where efficiency measures have a smoother acceptance (Grueneich 2015: 47). However, changes in building codes have blunted their impact while compelling greater engagement from builders. Sources for energy conservation should be diversified to include building operation efficiency measures governing equipment use. Introducing smart meters and their real-time inputs sidesteps the dependence on projections. The following section shows the combination of initiatives essential for the success of energy efficiency measures.

5.3.1 Choosing the alternative of the cheapest fuel – energy efficiency

India has one of the lowest energy consumption rates in the world. Indian efficiency measures are restricted to industry, appliance and transport efficiency standards. These measures can create lasting reductions in residual load, which is very important when the availability of residual load is high (Green Paper 2014: 17).[77] Vehicle emission standards are very strict. Bharat Stage IV (the equivalent of Euro 4 norms) was introduced in 2010.[78] In fact, the Central government is planning the implementation of stricter Stage VI norms by 2020.[79]

In the Indian context, utility-scale renewables resemble a sector in perpetual need of mollycoddling and micromanagement by policymakers. The constant need to adapt and a failure to establish a tranquillity through high performance shows heavy reliance on what scholars call ecological modernisation or the integration of energy efficiency to create a sustainable economic system.

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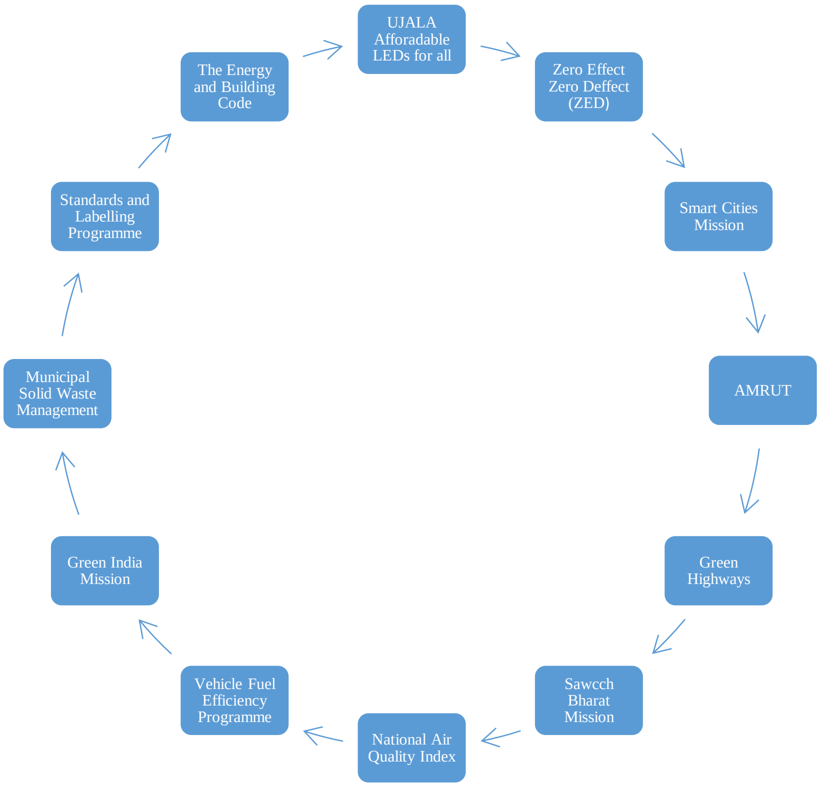
[77] Residual load is defined as the remaining capacity under which conventional sources of power can operate after supply from intermittent sources are accounted for.

[78] It was implemented only in April 2017.

[79] *The Economic Times*, “Bharat Stage VI norms: Know how they will impact you”, [Online: web] Accessed 28 June 2019 URL: Bharat Stage VI norms: Know how they will impact you Read more at: //economictimes.indiatimes.com/articleshow/66362907.cms?from=mdr&utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

Figure 5.2 Major programme initiatives of India in climate change mitigation



Source: Federation of Indian Petroleum Industry, *Voice of Indian Oil and Gas Industry* (2017), 16(3): 28.

Figure 5.2 denotes all the initiatives launched by the Central government to curb energy intensity through a combination of energy efficiency measures, afforestation actions and pollution control programmes. Efficiency is more vital to industry. In fact, efficiency measures (energy saved in energy generation) are adopted by all discoms, more than other streams (D'Souza 2018).

The failure to implement a standardised building code in India is the principal hurdle to the overall success of efficiency measures. In response to the question, 'have initiatives to increase energy efficiency subsumed efforts to expand the use of RES in India/Germany?' Dr. Bhaskar (2018) replied that "The consumption of solar/wind energy will increase if electric apparatuses are not changed. LEDs have to be installed too; India's solar rooftop target will be a complete waste if energy efficiency practices will not be followed through." Energy efficiency is more realistic than RE capacity expansion (Pimpalkhare 2018).

5.3.2 Decentralised renewable energy and the Power Distribution Sector

Sen et al. (2016: 25) argue that the importance ascribed to energy, as the building block of a strong developed economy, may be gauged through the term, 'strategic commodity', which has come to define it. A Decentralised Distributed Generation (DDG) scheme contributes to the Remote Village Electrification (RVE) programme. It entails the setting up of systems for both solar and conventional sources, whichever is applicable, in locations where the extension of the centralised power grid is not feasible. Under the JNNSM, the Ministry of New and Renewable Energy (MNRE) provides a subsidy covering 30% of the capital costs for installation of solar PV systems. When the on-site generation of electricity is considered, wind energy is much cheaper than solar energy.

Import duties on solar cells, from any source, have been absent since 2013.[80] A Generation Based Incentive (GBI) providing 50 paise for every unit produced by wind energy projects (with a maximum of Rs. 1 crore per MW) has been instituted to evoke private sector interest (Sen et al. 2016: 30). They note that 17% of the 31% of the RES that supplied electricity to the German power grid came from wind and solar energy during the first half of 2014 (Sen et al. 2016: 31).

D'sa (2015 : 74) explores the obstacles preventing the inclusion of integrated resource planning by power distribution companies in India. With the Bangalore Electricity Supply Company as a case study, she classifies the barriers based on operational, financial and technical hurdles, and proposes solutions to overcome these. She criticises the outdated practice of utility planners merely fulfilling supply targets by choosing between several options. Instead, a combination of demand-side management, efficiency measures and systems upgradation will assist in meeting India's growing need for power.

A product of the US, Integrated Resource Planning (IRP) was developed to avoid the creation of over-capacity and mitigate environmental effects of power generation. One of the main features is diminishing the size of the peak load to reduce expenditure of constructing peaking facilities. According to D'sa (2015), IRP has not been taken seriously in India, especially in the wake of serious restructuring of the Indian power

[80] A 25% safeguard duty on solar panels imported from Malaysia and China has subsequently been reintroduced in July 2018, to the consternation of private renewable energy developers. The safeguard duty has disrupted market mechanisms as standards for panels remain absent in India.

sector with vertical divisions between production, transmission and distribution. Corporations have now replaced State Electricity Boards (SEB). The National Tariff Policy of 2006 insists that discoms must fulfil minimum renewables purchase obligations at prices beneficial to renewable energy producers. Even though discoms serve non-paying or low-paying consumers, they are assured of only recovering supply costs, and receive no incentive for long-term planning.

Nathan (2014: 60) questions the logic of introducing a distributed system of energy led by solar PV when essential maintenance of this technology is not prioritised in rural India. Distributed solar PV has largely failed to make an impact in rural India due to the delineation of the power needs of rural and urban India. Only 55% of rural India is grid connected compared to 93% in urban India in 2011. Nathan (2014) argues that electricity from renewables may, at times, be more expensive than conventional sources. He also argues that rural customers are willing to pay for reliable grid-connected electricity. Payments towards decentralised lighting schemes are done only due to the lack of other options. The concept of off-grid electric systems catering to rural areas is several decades old. Divided into remote and non-remote categories, rural village electrification since 2013 targets the former as a prime target for off-grid connections.

High per unit costs, high costs of replacements, the lack of skilled technicians and spares are the main reasons for the gradual failure of solar systems and a reversion to kerosene in rural areas. Nathan (2014: 64) investigates the ‘remoteness’ factor in the devolution of off-grid solar. The author claims that the cost of per unit of electricity delivered to a rural community 5 kilometres away from the grid is Rs. 26. While this may be expensive, the population in remote areas may number approximately 2 million. This does not explain why are 73 million people in non-remote areas still without electricity? The author also punches holes into the ‘subsidies’ argument. He claims that capital subsidies would be more effective on improving the supply situation in rural India. He emphasises the need for urban areas to undertake greater responsibility of climate change mitigation initiatives as they are more polluting than rural areas. The argument indicates a greater emphasis on the predominance of grid-connected systems catering urban areas over their decentralised rural counterparts. By developing solar initiatives in the urban areas, rural economies would subsequently benefit from the increase in scale of production.

Sharma (2012: 24) on the other hand, criticises the exaggerated demand projections made by government agencies that lead to the creation of excess production capacity. The creation of the large ecosystem that would cater to the large amounts of domestic natural gas from the eastern coast is a case in point. Unrealistic targets that are unachievable to reach are projected. This is a hazard for players in the power industry who go by these projections to create additional power capacity.

The author criticises the creation of a façade of equitable energy access, and improved HDI, as the reason for a predicted rise of average annual per capita consumption of power to 2000 kWh, a serious jump from the current average of 800 kWh. The average annual per capita consumption of power in developed countries is 10,000 kWh. The urban-rural electric divide (where urban consumption is much higher than the national average) means that additional capacity created will largely cater to urban consumers, rather than those for whom it was intended to serve (Sharma 2012: 25). He suggests that energy efficiency measures targeting industries, commercial enterprises, power production facilities and agriculture could reduce power demand on the network by 30-40%. The author thus supports the wide dispersion of off-grid solutions in rural India. Conversely, FITs will work well in decentralised projects (Pimpalkhare 2018).

Subranya and Raghavan (2015: 19) support the off-grid measures of electrification on account of the failure of the centralised grid in providing reliable power to rural India. Refuting Nathan's (2014) argument about the cost of transmission lines connecting rural households and industries, Subramanya and Raghavan (2015: 21) argue that the aggregate transmission and commercial (AT&C) losses are recorded as 25% of total supply from utility scale power plants to urban areas.[81] Off-grid systems have recorded much smaller figures. The per unit cost of on-grid supply of electricity is Rs. 4, whereas it is Rs. 10 for off-grid systems in rural areas. The authors state that the government, through the use of smart metering and prepaid payment options, continue their monitoring of off-grid renewables project. Capital subsidies may be misused through the installation of sub-standard equipment by operators who asses that rural areas do not provide sufficient incentive for continuous operations. The authors suggest that capital-based subsidies should be replaced by generation-based tariffs in the case of decentralised electricity.

[81] Refer to section 3.2.1.

Powell (2018) adds that, "the cost of decentralised RE is prohibitive. It cannot sustain itself without external funding and overall rural households do not value clean electricity for lighting." Vaibhav Chaturvedi (2016) further comments that, "the key elements of Indian energy policy are access, affordability and security. The government defines rural electrification in terms of an electricity pole in a village with ten percent of the village consuming electricity." This flawed definition has invited much criticism for its parochialism.[82] The Central government's claim of one hundred percent electrification in April 2018 was soon withdrawn. The earlier definition of electrification meant limited expenditure to establish supply infrastructure. Under these circumstances, rural inhabitants prefer grid-connected supply, which is reliable and most importantly stable in adverse weather (Pant 2016).

5.4 German motivations surrounding renewable energy and climate change

Unlike India, German commitment to the decarbonisation of the national economy stemmed from the financially draining experience of its post-Cold War history. The euphoria of unification in 1990 soon gave way to the despair of East Germany's failing industrial vigour. The Soviet-dominated infrastructure was jostling with declining output and competition from the modern industrial setup in the western part of Germany. A slowing economic growth rate of 1.5% (prior to the global economic meltdown of 2008) and the implementation of strict energy efficiency measures saw total GHG emissions from Germany contract from 1040 mt of carbon dioxide equivalent to 944 mt CO2e between 2000-10 (Goodman 2016: 188). It echoed a fall in electricity demand at a time when electricity demand in India was rising rapidly. With a population of just over 80 million, a large majority of whom belong to a high-income category, Germany has an obvious edge over India in transitioning to a low-carbon economy. This economic edge gives it the ability to cope with climate change even though its impact is less adverse than in other countries. Nevertheless, its Cold War experiences have indirectly led to a deliberate strategy to decarbonise its economy. This collective 'self-consciousness' towards decarbonisation is unique to Germany (Goodman 2016). It has seeped into the larger European mind-set by imploring the region's responsibility to mitigate the effects of GHG emissions from its industrial past.

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[82] D'Cunha, Dutt Suparna (2018), "Modi Announces '100% Village Electrification', But 31 Million Indian Homes Are Still In The Dark", *Forbes*, [Online: web] Accessed 27 June 2019, URL: https://www.forbes.com/sites/suparnadutt/2018/05/07/modi-announces-100-village-electrification-but-31-million-homes-are-still-in-the-dark/#78ab83a063ba

Opposition to the disposal of nuclear waste compelled the government to gradually withdraw nuclear energy from power production – a move discontinued in 2010 by the release of the 'Energy Concept'. The Fukushima nuclear accident n 2011 saw a reversal of the Federal government's reliance on nuclear energy as an intermediate between renewables and other conventional fuels. The *Energiewende* proposed the complete withdrawal of nuclear energy by 2022. This was the primary goal of *Energiewende*. Although it foresaw the massive development of renewables lignite (brown coal) became the go-to energy source of Germany's power industry. Both the Energy Concept and *Energiewende* predicted the rise of renewables; they contradict each other based on their preferred 'transitional' fuel (Goodman 2016). Fifty percent of German RE falls under distributive grids (Gaebler 2018).

Figure 5.3 shows the reductions in GHG emissions since 1990. After the signing of the Kyoto Protocol in 1997, Germany undertook to reduce emissions by 21 percent over 1990 levels. In 2014, Germany had achieved reductions of 27.7 percent. The EU has collectively achieved reductions of 24.40 percent in the same period (Federal Foreign Office 2018). Currently, every unit of industrial output from Germany worth one billion euros emits half the share of GHG compared to output in 1990. Germany has adopted the Climate Action Plan 2050 to reduce emissions by 80 percent by 2050. The Plan focusses on energy efficiency measures to reduce GHG from industry, transport and agriculture with fixed long-term reduction targets.

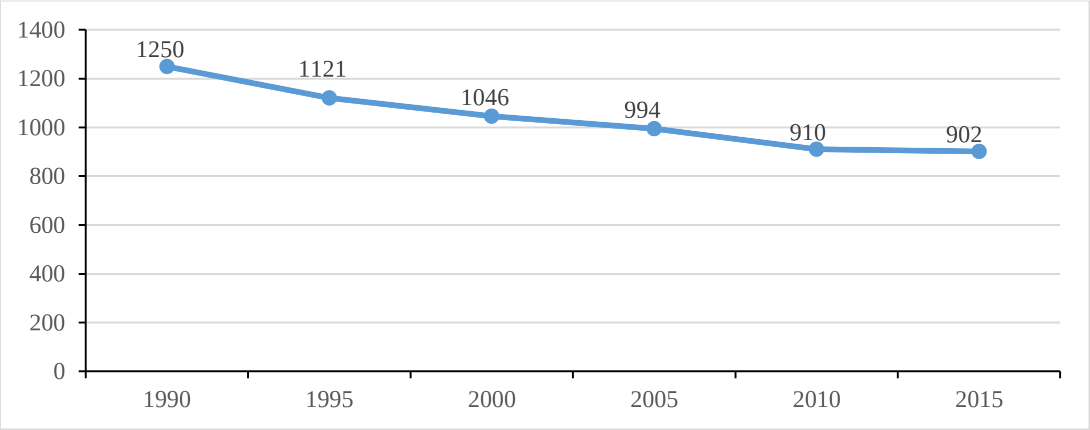
Germany's commitment to limit emissions below the 2 degree Celsius target is implemented under the EU's Emissions Trading System (ETS). Under the ETS, the total permissible emissions for every participating country are fixed. Large-scale industries with high emissions intensity are obligated to participate in the ETS programme; this way they do not have to pay additional surcharges that may be applied to other consumers.[83] According to the scheme, every firm has a fixed share of emissions that they must adhere. This cap is gradually reduced over time. If they emit

[83] For instance, the surcharge as part of the Renewable Sources Act 2000 are not applied to large-scale energy intensive industries that are part of the ETS programme.

However, despite the strides made in emissions reduction, Germany's ideological commitments ignore issues of political economy and governance (Powell 2018).

more than the targeted cap then they must purchase emissions allowances that can be traded. Alternately, firms can purchase international credits from projects dedicated to emissions reduction. The numbers of emissions allowances are limited, creating a monetary value. At the end of the fiscal year, firms must have enough allowances to cover their emissions or they are heavily fined. The EU ETS is the only functioning system after the failure of the CDM process (Harvey 2012). It targets the cheapest form of emissions.

Figure 5.3 Germany's Reduction in Greenhouse Gas Emissions (Million tonnes of CO_2 equivalent)



Source: *The German Energiewende* (2018) Federal Foreign Office, Berlin, pg. 15.

5.5 Rise of the Green Lobby and its impact on global transition patterns

The power sector is highly understanding of the needs of conventionally fuelled plants while acting highly suspicious of the intermittent character of renewables; which provide the peaking ability when conventional plants are out of operation (Neuhoff 2005). This position of renewables as a peaking fuel is not as well compensated as their non-renewable counterparts.

According to Neuhoff (2005: 97), ‘technology lock-out’ occurs when the deployment of new renewable technology on a larger scale is restricted to maintain high revenues. The processes associated with incumbent technologies, like decreasing revenues from wider deployment, deter investment in new technologies.

As electricity is the common product produced by all technologies in the electricity sector, most existing technologies compete on prices. This furthers the aversion to R&D in new technologies. Even with the high expectations surrounding them, renewables receive far less funding for R&D than its fossil-fuelled counterparts (Neuhoff 2005).

Konopko (2015) explores the linkages between the relatively new smart grid technologies and decentralised energy systems which could expand the reach of locally available renewable energy to isolated societies. According to Konopko (2015: 1), 'a decentralised energy system is characterized by locating of energy production facilities closer to the site of energy consumption.' While no clear definition of the term smart grid exists, it is generally thought to envisage the interconnection of traditional centralised energy systems consisting of a widespread distribution network, with a renewable energy sources supplying off-grid areas. Variability from a dispersed network of renewables can be integrated with traditional power sources, catering to several groups of consumers, only through a smart grid.

In the US, decentralised generation systems are known as 'embedded generation'; 'decentralised generation' takes place in Asia and Europe, while in other parts of North America, it is known as 'dispersed generation' (Konopko 2015: 2). A smart grid could negate the need for expensive peaking plants by moving some of the peak demand to time periods where the cost of power is relatively less.

Assessments of the environmental impact of solar energy projects include the evaluation of solar land use energy intensity (LUEI). In simple terms, LUEI defines the amount of land used per megawatt hour (MWh) of electricity generation. When compared with the per square meter generation of electricity by conventional fossil fuelled plants, solar power plants lag far behind. This increases their on-site LUEI. The paper investigates the off-site LUEI of three variants of solar power - silicon photovoltaic (Si-PV), cadmium-telluride (CdTe) PV, and parabolic trough concentrated solar thermal (Murphy et al. 2014: 1).

Prevailing studies, only account for the "on-site" infrastructure requirements of a project while ignoring "upstream" uses of "off-site" land for the assembly of production machinery and the mining of fossil fuels at the source. The "downstream" use of land is devoted to the disposal of by-products (like fly ash) and equipment. This study therefore examines off-site LUEI from a lifecycle perspective (Murphy et al. 2014: 1). The study concludes that both the upstream and downstream off-site LUEIs of the various solar technologies was approximately one percent. In such a case, using on-site LUEI figures was sufficient to gauge the environmental impact of solar power infrastructure. This equalled on-site LUEI measurements. Coal on the other hand has a large off-site LUEI (Murphy et al. 2014: 8).

Ozturk (2013: 309) argues that energy efficiency and renewable energy share the same benefits. They reduce import dependency, increase diversification of resources, and induce environmental sustainability and savings in fuel. Several energy importing countries have released strategies to reduce domestic energy consumption. China aimed to reduce energy intensity by sixteen percent by 2015; the EU seeks to reduce energy demand by twenty percent by 2020; while Japan is aiming for a ten percent cut in energy consumption by 2030. However, while the paper is a study on both renewable energy and energy efficiency, the discussion tilts largely in favour of energy efficiency. Ozturk (2013) argues that RE is a fairly indigenous source of power; he fails to take into account the import of RE technology.[84]

The reduction of energy intensity through energy efficiency measures and fuel-switching had been very successful in the 1970s and 1980s. The increase in carbon emissions in the 1990s and 2000s can be attributed to the increase in energy demands stemming mainly from the post-Soviet developing world. The high energy prices of 2008 compelled both developed and developing nations to opt for carbon intensive coal to reduce expenditure on the import of foreign energy sources. Technological improvements in both efficiency and plant load factor (PLF) that have created, in the case of coal, the moniker, ‘clean coal’ have further challenged the adoption of RE technology.

The reduction for energy used for the completion of any particular process may be termed as energy efficiency (Ozturk 2013: 311). Energy conservation on the other hand has more to do with behavioural patterns – the use of less energy, based on personal preferences, to complete a particular action. Heavy volumes of natural gas, destined for Europe through several proposed pipelines may reduce the reserves of gas feeding countries like Azerbaijan’s domestic power generation system. Energy efficiency measures and the introduction of RES in power generation go a longway in addressing

[84] Which may also the entry of foreign labour, which may hurt domestic moves to indigenise their labour forces.

the 'Energy Trilemma'[85], with its three vital dimensions – energy security, energy equity and environmental sustainability (Ozturk 2013: 329).

In this context it is vital to analyse the RE manufacturing segment. With the installed capacity of solar energy increasing from 5.1 GW in 2005 to 227 GW in 2015, the global solar industry comes second only to hydroelectricity in the renewable energy sector. During this decade the fulcrum of the renewable energy market moved from Germany, which pioneered a large-scale and long term renewables policy, to China, where a reliable manufacturing ecosystem was created **(Table 5.2)**. This period also witnessed China, with 30 percent capacity additions until 2015, gaining a strong foothold in the solar industry. The entry of Chinese manufacturers led to the expansion of the global supply chain (Hughes & Meckling 2017).

Table 5.2 Capacities for Solar Module Production

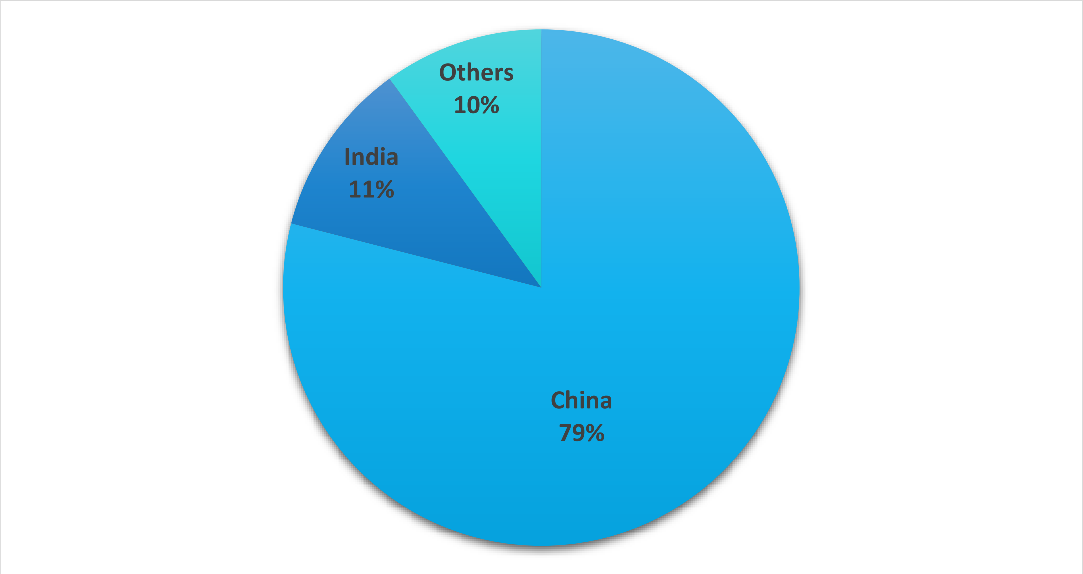
Country	**2007**	**Relative Share of Global Module Production (2007)**	**2013**	**Relative Share of Global Module Production (2013)**
Germany	747 MW	18.5%	1.7 GW	4.2%
Japan	713 MW	17.7%	2.4 GW	6.1%
United States	353 MW	8.8%	943 MW	2.4%
China	1.34 GW	--	25.6GW	<60%

Source: Hughes and Meckling (2017).

Today, the lobbies in RE follow strong national lines with several countries filing cases at the WTO to benefit their domestic RE manufacturing sector. Chinese modules were ten percent cheaper than Indian modules. This made all the difference when firms had to choose between suppliers. "Cheap modules from Taiwan and China have wiped out nearly eighty percent of the domestic manufacturing capacity in India" (Maithani 2017). **Figure 5.4** confirms this statement. Similarly , Germany failed to increase models of scale (Pimpalkhare 2018).

[85] Refer to Chapter II.

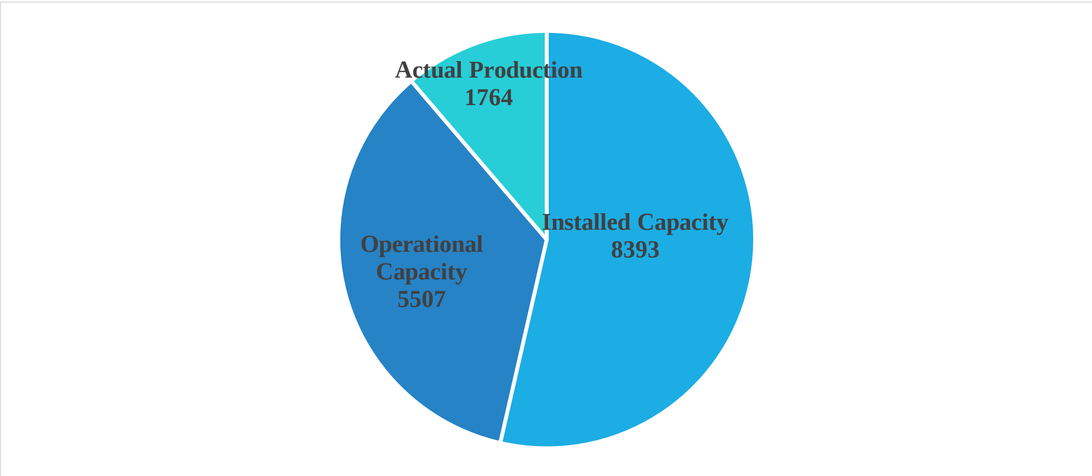
Figure 5.4 Source of Modules used in Indian utility scale projects



Source: BRIDGE TO INDIA Research. As cited in SOLAR TODAY (2018), 4(1): 21.

Indian manufacturers have repeatedly asked for the imposition of an anti-dumping duty (ADD) targeting Chinese imports.[86] Indian manufacturers rely on foreign technology and raw materials, especially silicone derivatives. The imposition of ADD does not guarantee the recovery of Indian manufacturing capacity, which is considerably smaller than the Chinese economies of scale **(Figure 5.5)**.

Figure 5.5 Capacity and Production of Modules in 2016- 2017 (in MW)



Source: BRIDGE TO INDIA research. As cited in SOLAR TODAY (2018), 4(1): 21.

[86] In March 2018, India imposed an ADD on a specific solar cell manufacturing element from China, Thailand, Saudi Arabia and Malaysia to protect domestic manufacturing capacity. The move did not go down well with project developers in India.

In addition, Chinese companies are expanding globally, routing manufacturing through countries considered trade-friendly by India. The ADD will surely be challenged in the WTO. It will raise the capital costs of projects being set in India and endanger employment generation in construction.

5.5.1 Job Creation

When efficiency measures were first introduced in industries, they were perceived as threats to employment opportunities. This notion compelled governments to educate their populations about the 'big picture'. These were the beginnings of the first Departments/Bureaus/Ministries of Energy Efficiency. The 'big picture' has transformed from a focus on energy security and fuel poverty to climate change mitigation. It moved from inducing changes in individual behaviour to a much broader approach focussed on institutions (Kerr et al. 2017: 217). On the other hand, the retrofit policy provides employment opportunities and develops economic activity when these measures are subsidised by the government, as is the case in Germany (Kerr et al. 2017: 218). One of the promises of the ruling BJP government was the creation of jobs for the educated unemployed. Jobs for the youth are a significant electoral issue and India's expansion of its renewables' capacity is a trump card for the incumbent government, making this issue an important associated topic of interest in this study.

The expansion of India's solar programme to 100 GW by 2022 is expected to generate at least 300,000 jobs by 2020. Prime Minister Modi put forward this estimatein 2015 at the COP21 conference in Paris. Job creation is a vital election issue in India. The absorption of thousands of technically qualified youth in India by the renewable energy sector could bolster the chances of the re-election of the National Democratic Alliance under PM Modi. India's education sector has responded by introducing several courses to familiarise graduates with the operation and management of the country's booming renewables infrastructure (Ram 2017). India has already launched the Skill India Programme under the Ministry of Skill Development and Entrepreneurship to impart vocational skills and diploma courses to young adults.

The transfer of carbon-intensive industrial production processes to mainly China and India play an important role in the reduction of Germany's emissions intensity from the manufacturing process. Imports of manufactured goods have effectively transferred potential German emissions abroad. To elucidate, Germany reduced emissions by 8 percent (154 mt CO2e) of its total emissions comprising 1251 mt CO2e in 1990; this rose to 20% (196 mt CO2e) of Germany's total emissions of 994 mt CO2e in 2008 (Goodman 2016: 190). Essentially, by outsourcing these carbon-intensive manufacturing processes during this period, Germany slashed its target of 40 percent intensity reductions over 1990 levels to 28 percent.[87] The author clarifies that outsourcing is outside the purview of domestic climate change targets. However, by suggesting this outsource-offset relationship, the study is advocating a 'look on the bright side' approach.[88] It ignores other fundamental issues like job losses and a reduced industrial capability.

In 2015, around 8.1 million individuals were employed by the global RE industry in various capacities (IRENA Annual Review 2016). The majority of employment opportunities were located in China, Brazil, the United States, India, Japan and Germany. The extension of the EU's twenty percent efficiency target by another ten percent could create 400,000 jobs (Gonzales 2017). Until 2014, Germany had created more than 370,000 jobs in renewables (IRENA 2015). Expanding solar PV capacities mainly in Asia led to the creation of more than two million jobs. In fact, sixty percent of the total new RE jobs were created in Asia **(Figure 5.6)**. However, a large share of these jobs was situated in construction (installations) and operations, and not necessarily manufacturing or design. Automation has made its presence felt in solar PV manufacturing which resulted in slowing job growth in Asia.

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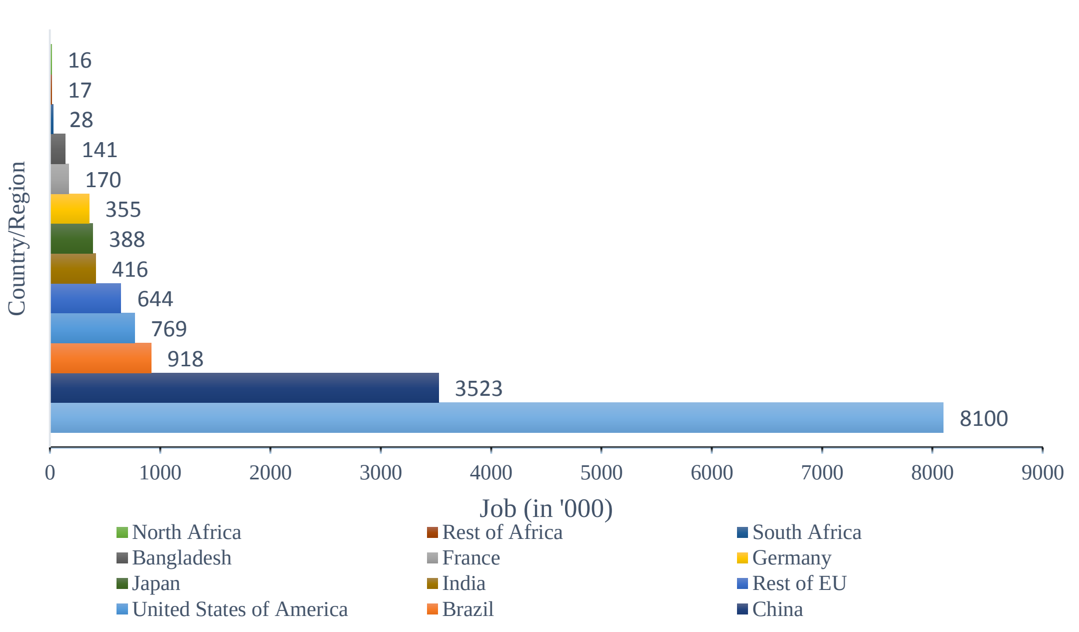
[87] Ibid.
[88] Ibid.

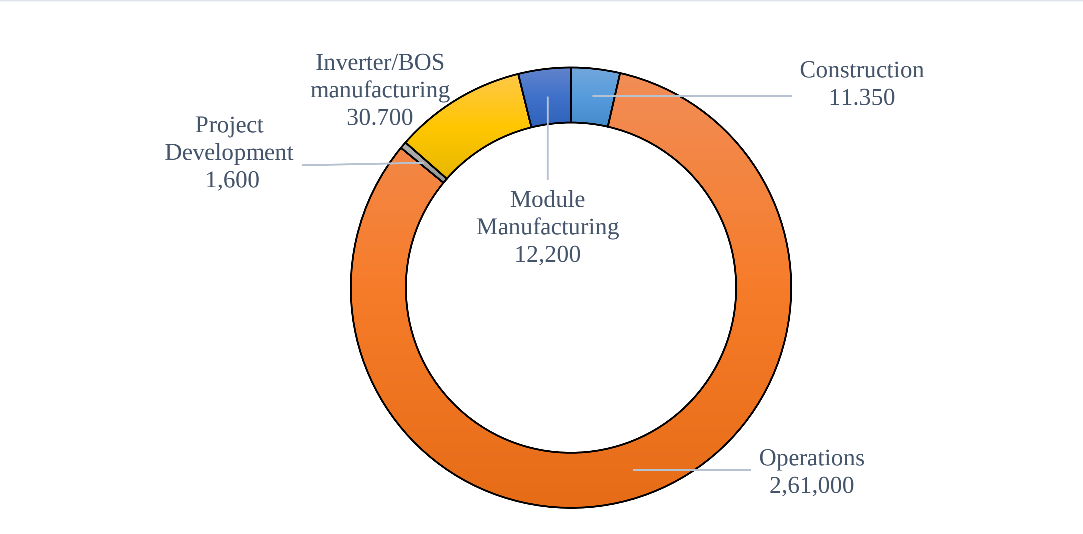
Figure 5.6 Renewable Energy Employment in Selected Countries and Regions (2015)



Source: IRENA Annual Report 2016, pg. 11.

Utility scale solar is less labour intensive than rooftop solar. **Figure 5.7** shows that the upstream value chain consisting of component and module manufacturing creates employment equivalent to 429 man-years for 100 MW solar capacity (Kamat 2018).

Figure 5.7 Employment Generation across value chain for 10,000 MW of project capacity, man-years



Source: BRIDGE TO INDIA Analysis. As cited in SOLAR TODAY (2018), 4(1): 16.

The downstream value chain comprises of construction, project development and operations; eighty percent of employment is created here. These domestic employment opportunities are available in the remote locations in which the projects are sited.

However, the expansion of employment opportunities does not necessarily indicate development of human capital. Interviews conducted by the author with several *Suryamitra* trainees highlighted a lack of overall job satisfaction.[89] The unscheduled interviews were held at the second ReInvest Conference at Greater Nodia in October 2018. *Suryamitra* - Friends of the Sun – is a skill development programme led by the National Institute of Solar Energy (NISE) under the MNRE. It is a technical training programme. Majority of the trainees are low-skilled individuals like electricians etc. The programme focusses on imparting technical training to individuals who can then be employed by government or private companies at project sites. The author learned that the training is sub-standard with trainees requiring further instructions by their employers. The location of the remote sites are not endearing to the youth who undergo training. They are devoid of entertainment facilities and located in regions with extremely high temperatures, such as in Rajasthan. Furthermore, trainee supervisors complain that trainees often left the programme mid-way after absorbing basic skills to find employment in urban cities where they may earn a higher salary under better living conditions.

Despite the burgeoning employment opportunities in RE, India is stuck in a 'legacy hangover' (Pimpalkhare 2018). It continues to indulge in big projects, a reminiscence of the large hydropower projects of the 1960s and 1970s. Capacity building, especially in government departments, in human resources is a challenge.[90]

5.6 The impact of geopolitics and climate consciousness on the development of renewables

Fischhendler et al. (2015) study the linkages between geopolitics and renewable energy through their analysis of solar farms in Israel. The European Union, as outlined by its document titled, 'Roadmap for EU-Russia Energy Cooperation until 2050', has identified the renewable energy sector as a 'geopolitical opportunity for energy cooperation'.

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[89] https://suryamitra.nise.res.in/info/About-Suryamitra.html

[90] Ibid.

The authors seek to construct an understanding of linking renewable energy technology (RET) with geopolitics. They also seek to identify the core participants in this debate and their impact on the decision-making process of marketing RETs.

The authors argue that the term ‘energy security’ is heavily influenced by geopolitics, with a rapt fixation on the availability of energy sources within a nation’s sphere of control. It is this feature that endears it to the realm of foreign affairs (Fischhendler et al. 2015: 100). The authors also argue that RET seems to offer an opportunity to establish a greater degree of energy independence.

The article relies heavily on the independence offered by dissipated renewable energy i.e. reduction of dependence on the centralised grid. However, these refuse to make a dent on energy dependence, as they may still be dependent of external forces.

Bereft of a cross border transmission and fuel transport network with the neighbouring states, the lack of energy connectivity makes Israel an ‘energy island’. Israel’s energy basket underwent major change when offshore gas from Egypt in 2005. In 2010, natural gas contributed 36% of Israel’s energy requirement. Frequent violence led to the closure of the gas pipeline between Egypt and Israel in 2010. This had led to an increase on the dependence of coal (62%). However, this situation is only temporary since the discovery of offshore gas field, which could cover up to 73% of Israel’s energy needs.

Here, the authors (Fischhendler et al. 2015) argue that the discovery of offshore gas and the coming online of gas reserves has been cornered into the sphere of security. In 2008, the Israeli government granted tax benefits to PV projects. It also created a 10% target for renewable energy production by 2020. A 20% carbon dioxide emissions reduction target is also is place. It would also assist in land acquisition for projects in the Negev Desert. The desert, which comprises nearly 60% of Israeli land, would prove to be an ideal location for PV facilities. However, over 90% of the desert is occupied by the military, reserved for national parks and used for agriculture. The government’s initiatives to implement feed-in tariffs were rejected by the Ministry of Finance and the Public Services Authority due to the availability of cheaper gas from domestic sources. Citing these reason, the authors cast doubt on Israel’s ability to achieve its emissions and RET targets.

The authors examine three rationales vital to the understanding of the solar energy discourse in Israel. The first, the ‘energy independence rationale’, targets a stable energy supply devoid of the trappings of external factors like the hostility of neighbouring states. The second – cooperation rationale – promotes interlinkages and cross-border energy trade using PV projects as a platform for cooperation. Finally, the 'land-safeguarding rationale' propagates that PV projects may undermine or strengthen the sovereignty of the Jewish state. A fourth rationale, the 'counter politics rationale', questions the ability of technologies to adapt to climate change and the links between RET and geopolitics (Fischhendler et al. 2015: 105).

The authors also sought to identify the major players promoting each of these rationales. By connecting the sensitive political scenario of Israel with the development of RET to geopolitics – the spatial relation – the importance of the latter is evident. The authors show that the 'energy independence' and 'energy cooperation' rationales were alternatively fovoured by major players like energy regulators and politicians (Fischhendler et al. 2015: 113).

For instance, the land rights of Bedouins are cited as an impediment to the development of RET. The land-safeguarding rationale thus, connects a localised issue like land rights with the geopolitics of RET. Similarly, the hazard of fuel import dependency and its influence on Israel's political narrative places the importance of developing RET in close proximity to Israel's geopolitical concerns. This template is expanded through the opportunity for cooperation with Israel's neighbours. Thus, the authors seek to highlight the importance of geopolitics with RET. They conclude that the current academic literature has a narrow focus on the environmental and economic aspects of RET.

5.6.1 International Solar Alliance – the Global South stretches its muscle

The International Solar Alliance (ISA) represents the efforts of the Global South, under the aegis of Indian diplomacy, to reduce the cost of financing and technology to further the dissemination of solar energy. It aims to mobilise more than US$1 trillion of investments needed by 2030 for the 'massive' deployment of solar energy on a global scale. It also seeks to influence the evolution of forthcoming technologies, which could be easily adaptable to the energy-starved countries (MNRE Working Paper). Historically, there is no precedence of an institution-based formal transfer of technology on such a large scale.

Inaugurated on the first day of the UN Climate Change Conference in Paris (COP21) by PM Modi and ex-President Hollande of France in November 2015, ISA

Headquarters established its headquarter in Gurugram, India in January 2016. The Framework Agreement was presented during the COP22 in Marrakech, Morocco in November 2016. Until January 2019, 71 nations signatory to Framework Agreement; 48 countries have ratified it.[91]

With the introduction of mega solar parks, countries with large solar capacities have witnessed a dramatic fall in solar tariffs. In India, low tariffs and the shortcomings of energy storage continue to discourage participation from major solar developers. In this regard, the ISA faces an uphill battle to manage national interests and improve profitability for private players.

The ISA has stated five programmes it intends to focus on, ranging from expanding solar in the agriculture sector, financing, storage options etc (MNRE Working Paper[92]; Kulkarni 2018).

However, an analysis of primary sources from the ISA and expert interviews has found that the role of the ISA may not be feasible as financing is in doubt (Powell 2018). The total Indian contribution so far is US$67 million; France ha promised a further 700 million euros. India has also realigned US$1.4 billion in lines of credit originally intended as humanitarian aid to 27 solar projects in 15 countries, mainly in Africa (Aggarwal and Bhaskar 2018). No unique mechanism to facilitate the ambitious objective of effecting a generous transfer of technology is in place. There is inadequate financial mechanisms to reduce capital costs with the 2030 target looking nigh impossible to achieve. Under such circumstances, the ISA is playing the role of a mediator.

The ISA is a political gimmick of the ruling BJP; it has not garnered any credible achievement. India's own achievements are leading the ISA's but its shortcomings are also apparent (Nitya Nanda 2018). The ISA is a "means to a larger diplomatic stage, showing a commitment to the Paris Climate Change talks" (Kulkarni 2018). The ISA's focus on decentralised solar outweighs utility-scale solar, which is the need of the hour considering that GHG emissions largely originate from centres of extensive economic activity. Pimpalkhare (2018) agrees with this assessment while adding. "the ISA is just a nametag as domestic manufacturing is poor; R&D is poor in the Indian Institute of

[91] *Documents from the ISA website – www.isolaralliance.org
[92] https://mnre.gov.in/file-manager/UserFiles/ISA-Working-Paper.pdf

Technologies (IITs) and more importantly the infrastructure for research parks focusing only on renewable sis lacking". These indicate that multiple objectives of the ISA are being ignored. Indeed an analysis of the responses from these personal interviews indicates that the ISA is still trying to find its footing. An anonymous interview with an official from the Ministry of External Affairs confirms this, but the official also claimed that the ISA should be given more time (B. C. 2019). It must also distinguish itself from other IRENA, Renewable Energy and Energy Efficiency Partnership (REEEP), IEA and Renewable Energy Policy Network for the 21st Century (REN21). However, for a government organisation to take four years to find itself is confusing and the constant need to adapt to changing scenarios in renewables threatens to push the ISA to a long and unsustainable gestation period.

5.7 Challenges to renewable energy-centred global energy transition

Ekka et al. (2016: 1780) argue that GHG mitigation measures have repeatedly failed to include rural development. This is in violation of the social dimension of the IPCC's 2007 policy.

Under the UNFCCC's Kyoto Protocol, three GHG mitigation mechanisms were put into place – joint implementation, clean development mechanism and emissions trading. The first and the last fall under a term called 'flexibility mechanism.' Under this, developed countries may invest in developing countries to outsource their emissions reduction target. The last mechanism involves the trade of the savings made 828 out of the 894 CDM projects in India cater to energy industries. Reinforcing Nathan's (2014) argument, Ekka et al. (2016) argue that it would be more efficient to regulate urban pollution, as the corresponding sources are far more dangerous over the long term. Agriculture contributes 14% of the world's total anthropogenic GHG emissions annually (Ekka et al. 2016: 1782). Yet not much is done to regulate agriculture related emissions or encourage the use of bioenergy in India. However, the authors fail to analyse the rapid pace in which the government has introduced LPG cylinders.

Dubash (2017) argues that in light of U.S. President Donald Trump's reversal of his predecessor's climate change initiative through an executive order in March, 2017, it would be in India's interests to prove its commitment carbon mitigation efforts. The order promoted U.S. energy independence, bereft of a majority of its international environmental commitments. The Clean Power Plan, that aimed to reduce carbon emissions from the power generation sector, is under review. At the same time, the moratorium on new allotment of land for coal mining has been revoked. The proponents of the latter claim that reduction of the prices of wind and solar energy, and the dominance of domestic shale gas, eliminates coal's chances of a comeback (Dubash 2017).

India's pledge at the Paris summit echoes its prudence while committing to an agreement that relies on 'pledges' instead of binding commitments. Accordingly, India's push towards transitioning to renewables reflects other localised concerns like controlling air pollution it its cities and improving its import situation. As the third largest emitter of GHG, India, now emerging as a 'swing player', has an opportunity to remind the developed world of their international commitments (Dubash 2017).

The capacity utilisation factor (CUF) of solar energy is not more than twenty five percent i.e. if the total capacity of a solar plant is 100 MW, then only 25 MW of power can be generated. The capacity utilisation for wind is thirty five percent (D'Souza 2018). Even if intermittency can be managed through flexibility, low CUF can only be addressed by improving absorption rates or enhancing installed capacity (hampering daily operations and increasing maintenance costs. Here, fossil fuels and especially coal carry an advantage. Coal is available in plenty and utilisation factors are higher than fifty percent. The UMPPs follow this principle by enhancing scales. For instance, Reliance Energy (taken over by the Adani Group) at Sasan has agreed to freeze prices for 25 years at the rate of Rs. 1.2 paise; captive mines; it played an important role in the reduction of price per unit. There are two major costs involved – fixed cost (salaries etc.) and variable cost (raw materials). The cost of electricity at new power plants is between Rs.3-3.5 per unit, but the sheer scale of the UMPPs provides better economies of scale (Dsouza 2018). However, opposition to large thermal projects like the UMPPs is widespread due to their environmental costs. Furthermore, capital costs themselves act as a deterrent for such a scale.

Inference

The study has observed that the failure to account for political economy is costly to India. So, *Is renewable energy still being viewed as a substitute conciliating global climate change mitigation efforts?* The limitations of energy efficiency are apparent.

Alternative sources of energy do just that – they present an alternative unlike efficiency, which tweaks the demand for non-renewable sources of energy. Target oriented goals based on technology have encouraged the RE sector in India but the expansion of scale excludes domestic manufacturing capacity. Solar technology in India is not cost effective as the price of electricity is high. The production of solar panels is also an energy-intensive process where efficiency measures can balance the scenario. The chapter also shows that initially wind power was promoted by government incentives, which are now majorly diverted towards the development of solar energy. However, falling solar prices threaten technological lock-in i.e. cheap panels will dominate a developing market like India until the end of their shelf lives.

CHAPTER VI

Conclusion

The analysis of the conceptual origins of energy transition in Chapter II exposes convoluted factors that shaped the early national frameworks around which renewable energy was expected to prove itself. An issue like energy geopolitics and burgeoning demand from the industrialising world was interspersed with renewed interest in the diversification of energy sources and the prerequisite for prudence in energy use. The study traced the early beginnings of the transition in the world's most advanced and competitive energy market. The introduction of the climate change narrative failed to create a deeper impact within a region possessing vast energy reserves. Its failure to create a place for itself in the US did not affect its popularity in countries with poor domestic energy reserves. The growing acceptance of renewables in the national frameworks of a diverse range of countries indicates their versatility in adapting and creating a symbiosis with the limited capacities of these countries.

The chapters on India and Germany demonstrate the resurgence of emissions-heavy thermal power generation amidst the expansion of an industry struggling to reconcile national aspirations with global optimism. The previous chapter studied challenges from within the RE sector and seeks to bring about a clarity in balancing energy security and equal access with climate change objectives. The final chapter shall summarise the broad issues continuing to influence the global energy transition. It shall draw inferences from the previous chapters to analyse the two hypothesis regarding intermittency, import dependency and climate change. It shall also delve into supplementary issues like energy efficiency and the present the limitations experienced during the course of this investigation.

6.1 Limitations of the study

The primary limitation of this study is its inability to delve extensively into the technical and financial aspects of renewable energy. The field of energy has gradually come to be dominated by individuals from a technical or financial background. Although the study incorporates simple quantitative analysis by examining secondary data produced by research organisations and primary data by government departments, its scope its restricted largely to the qualitative skill and experience of the author. To compensate for this shortcoming, the author of this study conducted personal interviews and attended related conferences/seminars to gain a detailed understanding related to public policies in India. Data collection or ‘theoretical sampling’ involved the preparation of a broad questionnaire. However, individuals from varying professional backgrounds could only answer a few questions based on their professional experience.

Likewise, personal interviews had to be tailored according to the narrow experiences of the interviewee. The winter of 2016 witnessed mass student protests in Jawaharlal Nehru University, New Delhi – on an issue that received negative reviews from the broader Indian population. The issued debated the accepted version of nationalism based on differing political ideologies. Although the study was in no way related to these protests, the author encountered several difficulties based on the reputation of the university. For instance, interviews scheduled for thirty minutes yielded few results because the interviewees often discussed the student protests. In such a scenario, the author learned to adapt to the change by adapting ‘elevator pitches’ to gain valid answers. Another challenge was the bureaucracy involved in seeking interviews with government officials. The author instead chose to attend seminars or conferences with government officials or senior industry leaders in attendance. Comments made during breaks were open although concerns surrounding their application were addressed appropriately. The study followed a n interview style to answer the questionnaire rather than simply mail it because the former provided better inputs and the latter was often ignored.

Second, the lack of financial resources to conduct extensive fieldwork, especially in Germany, compelled the author to rely largely on literature – both primary and secondary – and personal interactions with individuals having a keen interest on RE issues. This application of the Grounded Method allowed the author to incorporate responses from interviewees and discussants (in seminars/conferences). These interactions have added immense value to the study. For instance, although the construction of UMPPs has not proceeded as scheduled it poses a continuous threat to grid-connected renewables. Its cost advantage aside, the siting (close to the pithead), large production capacity, the adoption of clean coal technology and the availability of large coal reserves is a threat that cannot be underestimated by scholars based on the NIMBY factor in involved.

Similarly, the author has also observed the prominence of solar energy vis-à-vis wind energy; there is a paucity of recent literature focussing on the expansion of wind energy, especially in India. Fieldwork conducted at an investor's meet in Greater Noida in October 2018 revealed that analysts assume that the wind sector has reached saturation due to the unavailability of suitable locations for project sites. I. S. Jha, Chairman and MD, Power Grid Corporation of India Ltd. claimed that, 'grid integration is the primary challenge of every large energy target. Huge intermittencies witnessed in the wind sector exacerbates the challenge of integrating an intermittent source of energy with the centralised grid. For example, approximately 3600 MW of electricity was produced in Tamil Nadu on 21st September 2018; less than 34 MW was generated the next day' (Jha 2018). This statement once again proves that intermittency is the critical issue threatening the further development of RE (in this case, wind) and casting doubt over India's ability to achieve its 160 GW target for solar and wind energy.

Collation of data was not formalised; rather inputs were added wherever appropriate. For instance, inputs from Mr. Vijay D'Souza, an engineer and manager with a discom in Maharashtra provided inputs regarding the challenge posed by UMPPs to renewables proved valuable. However, his knowledge was restricted to the Indian scenario.

They study shall now outline the conclusions and inferences based on the analysis of the data gleaned from literature, seminars and interviews.

6.2 Economic Growth or Climate Change – the perpetual debate

In recent years, the threat of war and pandemics has abated, only to be replaced by climate change as the greatest threat to humanity. It possesses the one common trait found within all existential threats – physical borders do not restrict it. It has compelled countries of all levels of economic development to adjust their energy policies to accommodate climate mitigation initiatives. Alterations in energy policy have a trickle-down effect on society and politics. Putting forward the concept of 'climate dialectic' in energy policy issues, Goodman (2016: 184) analyses the energy policies of Germany and India to find a shared approach to climate change irrespective of economic influence. With both countries showing a high dependence on coal for power generation, the inclusion of climate change mitigation is leading to widespread socio-political changes.

This investigation must again clarify that pollution reduction and climate change mitigation are concurrent but distinct approaches. Industries discharging effluents into a water body are required to treat their wastes before discharge. The goal of climate change mitigation is the reduction of GHG emissions into the atmosphere. To this end, an industrial unit or a coal-fired power plant should install industrial-strength scrubbers to absorb air pollutants.

The evolution of climate science subsequently led to the acceptance of the hazards of climate change mainly by communities vulnerable to its local effects. However, stakeholders with political and business interests in the community are threatened by financial setbacks or loss of political power, and may seek to influence the state to restrain /temper climate change mitigation. Governments, be they federal or provincial, may be compelled to ignore the larger interest by 'denying, managing or displacing' any linkages to climate change (Goodman 2016: 184). Ignorance of a seemingly benign threat, one often attributed to climate variations or unsatisfied pollution control norms, reduces it to a likeness of an economic downturn. Unlike the former, economic downturns are cyclical and respond faster to corrective measures in an economy.

Mitigation initiatives focus on the reduction of GHG emissions from fossil fuel use from anthropogenic activities. The advent of the Industrial Revolution increased the rate of anthropogenic emissions since 1750, much quicker than in the last twenty thousand years. The use of the 'climate dialectic' in policy-making 'socialises' an abstract concept, in becoming a readily acceptable and tangible development with large-scale effects (Goodman 2016: 184).

As the most industrialised country, pursuing an aggressive and extensive transition in its power sector, and the economy as a whole, Germany has distinguished itself from its peers. Its Federal government has taken the lead in international climate change negotiations by leading with example. It has diverged from the Indian case of putting the economic needs of the country first. It has gained international prestige and recognition in attempting to prove that sustainability is achievable without compromising the economic goals of the country through the integration of high technology with fresh innovations (Goodman 2016).

Varying levels of economic development between India and Germany have one common element between them: a high demand for power. The intertwining of high power demand - dominated by large fossil fuel capacities - with intermittent systems strongly supported by a utopian demand for climate change mitigation is evidence of combining sensitive national goals with pan-continental idealism. In short, the incorporation of climate-based and ecological discussions within the broader energy spectrum demonstrates an inclusion of societal aspirations to create dynamism in national energy policies.

The climate change narrative reflects ecological changes perceived by society; a narrative when further developed transforms society's conceptualisation of climate. The development – rather creation - of this climate change narrative gradually influences societal thinking in return, compelling its members to choose between 'emissions dependency' and 'climate stability (Goodman 2016: 185).

The popularity - the possibility of expansion - of renewables in India's power industry is dependent on the role of coal in power generation. Large domestic reserves not only make it more viable than nuclear energy but also offer stiff competition to renewables mainly based on coal's higher capacity utilisation factors (CUF). The introduction of super critical technologies along with enhanced pulverisation and coal washing (provided the latter could overcome chronic water shortage) enhance the efficiency coal. Enhanced efficiency in coal-fired power plants overcome the natural deficiencies of the type of coal largely found in India; and thus, allowing for greater exploitation of domestic coal reserves. The augmentation of coal-based generating capacities by new plants threatens the development of renewables by entrenching huge coal-based infrastructure – it establishes a 'lock-in' for the corresponding technology. The Central Electric Authority (CEA) expects a fall in the growth of renewables in India and has consequently expanded thermal capacity. As of September 2018, around 70 GW capacity of thermal power plants is under construction in India (CSE Report 2019).

The expanded renewable energy target of 100 GW by 2022 and India's commitment at the COP21 to enhance power generation from non-fossil fuel based sources to 40 percent of total power generation are a combination of global commitments and domestic change. If successful, the expanded renewables target will comprise one-third of the country's electricity supply, similar to the coal and gas capacities in 2016 (Goodman 2016: 188).

Goodman (2016) argues that a climate narrative first entered the Indian political sphere following the introduction of CDMs in India's energy setup in 2002. The Indian government was compelled to clarify its stance vis-à-vis its climate policy. The understanding of the impacts of climate change creates a need to the energy policies of a country. With time, the incorporation of a climate element in mainline policy constructs a diversified energy mix reflecting enhanced renewables capacity. Developing countries always prioritise energy need – in this case coal – against an idealistic requisite like climate change. Growing competencies allow for gradual expansion of renewables at the cost of dirtier fuels like coal. Goodman (2016: 188) summarises this argument by claiming that, 'developmentalist rhetoric is deployed to manage and maintain coherence, but overtime the policy direction is substantially recast'.

Goodman (2016) argues that policy documents released by India coincide with a periodic shift in prevalent attitudes within the government. The Integrated Energy Policy (2006), the National Action Plan on Climate Change (2008), the Five-Year Plans [specifically the 12th Five Year Plan (2012)], the Low Carbon Report (2014) and the Intended Nationally Determined Commitments (2015) reflect a great change in priorities – at the national as well as international level. However, within all these documents, climate change and mitigation measures are seconded to India's primary aspiration - the achievement of high economic growth for poverty reduction initiatives. The levels of development achieved primarily by the Western nations have always been the envy of the developing countries, chiefly those struggling with their colonial past. With this development-oriented perspective laid out in the heart of India's energy-climate policies, 'climate dialectic' according to Goodman (2016), ecological modernisation – in the form of energy efficiency measures – gains the upper hand over energy transition. While this study agrees that India has every right to pursue its development goals, it must address growing evidence of climate change impacts on its population and the land it inhabits. Annual droughts in varying parts of the country have seen a dramatic fall in the local water table. The expansion of India's coal-based ecosystem will only exacerbate the water shortage. The Low Carbon Report (2014) and India's INDC (2015) are measures in the right direction. They bring forward an urgency in policy discussions by supporting the development of renewables in an economy entrenched with mature systems, which are viable recipients of improved efficiency initiatives.

The focus of the debate should enlighten policy makers about the inherent shortages waiting to happen in the medium term instead of the climate change angle, which struggles to gain a foothold over economic compulsions in a nation like India.

6.3 The unending struggle with coal

Setting aside the rhetoric of sustainability trumping economic exigencies, Germany's tryst with coal continues to remain as strong as that in the Industrial Revolution. Both India and Germany seek to strike a balance between economic development and climate change mitigation. The growth of the climate dialectic in policy has come to focus itself explicitly on broadening traditional views on energy policy. Both these narratives create strong adherents competing for mainly financial resources within the official framework and, attempting to gain greater awareness about the importance of their own specific goals. In recent years, demands to include softer components like emissions reductions and the assimilation of renewables within harder and enduring domains like energy policies have compelled governments to form inclusive energy policies against the 'common threat'. Both India and Germany follow their lines of thought within the broader framework of developmentalism. In the case of India, the burden of aggressively combating climate change lies with the post-industrial countries who have progressed at the expense of vast GHG emissions. On the other hand, Germany presents an alternative approach by advocating the importance of technological competences. Each represent opposite spectrums of industrialisation. However, both approaches are criticised for their overt idealism and unrealistic attitudes towards approaching their goals (Goodman 2016).

Entrenched conventional fuel sources in India and Germany, indeed all around the world, promote a status quoist approach on the premise that a 2 degree Celsius limit is unattainable given mounting energy demand. They suggest an extension of the upper limit to 4-6 degree Celsius in the Earth's temperature with the implementation of changes in the global economic processes. However, they do not forward a plan for implementation. As climate change impact becomes more pronounced, initial short-term measures are replaced stronger long-term measures to deal with the effects with more dynamism. The initial familiarity ushered by the climate dialectic on the formulation of policy and subsequently to the aforementioned short/long term measures showcases its ‘cascading effect’ (Goodman 2016: 191).

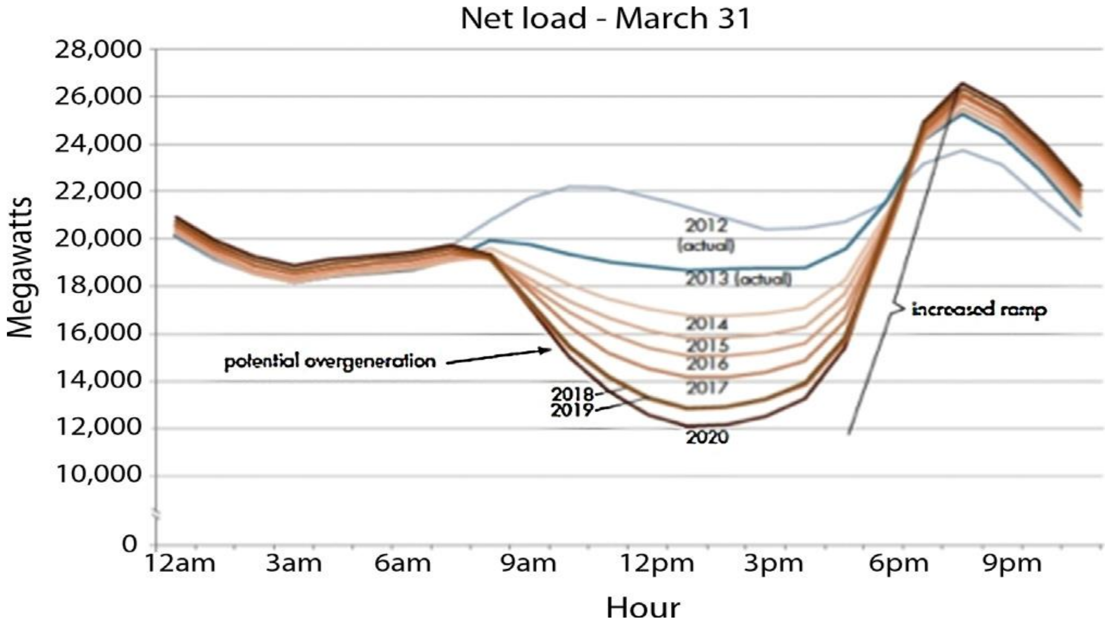
The study concludes that coal beneficiation and super critical technology could work in tandem to decrease GHG emissions and improve PLF (and thereby overall efficiency) but these initiatives will also increase the consumption of coal that will defeat the climate aspect of the global energy transition {Nanda 2018}. Secondly, the continued use of clean coal technology will give lend citizens false hopes surrounding the consumption of smaller proportions of coal while ignoring future supply shortages.

The presence of coal in Indian electricity generation for a long period is a given. Its ability to cater to varying demand compels renewables to explore energy storage solutions to meet consumer expectations. Rather than worrying about the challenge from clean coal or the financial and technical strength of UMPPs, RE should focus on enhancing stability features.

6.4 Applying power management to curb intermittency – is it a chimera?

In 2012, the California Independent System Operator (CAISO) calculated the total demand for power and highlighting the disparity in power generation from solar energy in favourable weather **(Figure 6.1)**. It was found that electricity from solar energy was concentrated during the non-peak hours of the day. It tapered down towards the evening when demand peaked. The result of this disparity in demand and supply was in the shape of a duck and hence the term ‘duck curve’ was coined and associated with intermittent solar-based power and its inability to perform during peak demand hours like conventional sources of electricity (Grueneich 2015: 51). Several conclusions can be derived from CAISO’s study. Excess generation during non-peak hours damages the grid infrastructure and requires extensive backup capacity with quick ramp-up rates during peak hours. Varying ramp-up patterns considerably lower the shelf life of the boilers in thermal power plants. Furthermore, a variation of 15-18 percent in supply during daytime can damage transmission components (Powell 2018).

Figure 6.1 Duck Curve indicating disparity in solar energy generation during peak hours of demand



Source: CAISO's 'Duck Curve' (Note: CAISO. Fast Facts: What the Duck Curve Tells us About Managing a Green Grid. http://www.caiso.com/Documents/ FlexibleResourcesHelpRenewables_FastFacts.pdf.). As cited in Grueneich (2015: 52)

Energy efficiency measures can step in here; they can be tailored to reducing peak electricity demand during the night hours (Grueneich 2015: 52). Efficient lighting -like CFLs, appliance standards and behavioural changes are effective in allowing solar energy to adjust to with peak hours of demand. The integration of renewables and their consequent contribution to efficiency are excluded from policy initiatives. An alternative view is to measure the savings in ramp-up rate reductions (Grueneich 2015).

This study concludes that efficiency measures should be assimilated within a carbon emission control mechanism where intermittent RES are adapting to form a vital segment of grid-connected power. The inability to assimilate efficiency with major renewables initiatives will lead to the failure of human decarbonisation actions.

"The uncertainty of renewable energy is the most concerning challenge. Non-seasonal energy sources are another challenge. That is why energy storage is the focus, but again only in decentralized power set-ups" (Natarajan 2018). Dr. P. C. Maithani confirms this concern when he adds, "The problem of energy storage is also significant. Japan's Mitsubishi company is in the process of establishing a 15 megawatt (MW) storage plant near Delhi; it will cost around Rs. 6 crore per MW and should be operational within 2-3 months" (Maithani 2017).

The 175 gigawatt target will contribute in a long way in spurring R&D. The necessary technology will arrive in 3-4 years. The main issue is how to improve the reliability for predicting solar energy; error margins will come down to 5%. As of now, it is 10% (Bhaskar 2018). Once RE increases capacity utilisation, managing variation will become much easier until storage solution mature. The 160 GW target for solar and wind in India is a united target and although regulations are moving fast, the implementation of standards should also tighten.

The German energy transition is more successful as the EU's grid is more robust than India's. It also has better forecasting support, an aspect ignored by Indian policy until recently. Although forecasting is now compulsory in India, compliance is standards is weak (Nongpiur 2017). RE should do away with the kid gloves. It should do everything what conventional sources can achieve. For instance, better ramp-up rates could challenge coal's ability to perform as baseload. Furthermore, a limit of only 100-150 MW of coal capacity to balance the grid should be imposed in the future. Similarly, getting consumers onto 'time of day' pricing is a challenge that should be taken up grid operators to optimise demand management scenarios.

The comparison with Germany shows that power management through flexibility and synchronisation can successfully manage to balance the challenge of intermittency. Thus, with regard to the second hypothesis - *intermittency remains the primary issue inhibiting the wider adoption of wind and solar energy into the centralised grid system* – the study concludes that yes intermittency is the primary challenge but attaches a caveat to it. Rather than energy storage solutions, elements like flexibility and synchronisation play a vital role in managing variation.

6.4 Import dependency or climate change?

Natarajan (2018) claims that "Coal-based power stations have to consume oil for generating power which is expensive. Renewable energy is in demand in the southern states to curtail the operations of coal-fired power stations."Germany is pursuing a large-scale transition to reduce its dependence on imported fuel. The transition has reduced Germany's energy import bill. The Heinrich Boll Foundation expansion of renewables within power generation has not made strong dents in German emission levels. The entry of RE into a field dominated by overcapacity led to the generation of a surplus of nine percent in 2016 (Heinrich Boll Foundation 2018). This surplus, exported to Germany's neighbours through the common grid, is an indication that RE must now focus on reducing emissions from the estimated 100 coal-fired power stations.[93] The successful decommissioning of twelve nuclear power plants since 2000 demonstrates the possibility of RE shouldering the burden through optimum use of power management systems. This partly answers the research puzzle regarding the reduction of coal-dominated power generation by RE. However, the accommodation of coal to replace nuclear power in electricity generation has not led to the increase of GHG emissions from Germany but also saw the withdrawal of an energy source with almost no emissions after entering operations. This failure in targeting thermal power generation will leave Germany's objective of a forty percent emissions reduction by 2020 unfulfilled. In fact, the US has reduced carbon emissions through market mechanisms. Several plants can switch from coal to gas, in a market where gas is chaeap. Biofuels and EVs have failed to take off in Germany (IRENA 2015). This only proves that a transition is only complete only if it includes end-use applications in transport and industry.

Given the above arguments, this study can conclude that neither India's nor Germany's import-dependency has changed or improved. Instead, this stagnancy in the energy import scenarios will continue unless the imported fuels are substituted by electricity. A holistic look at transportation is missing. An ecosystem for RE like that established for manufacturing fossil-fuelled vehicles in both India and Germany is absent in both countries. Although RE is no longer a show of symbolism, leapfrogging in electricity cannot mirror the strides made in the telecom sector.

Fears of replacing import of fossil with RE components are unfounded as these are technological and modular imports are less expensive than the former anyway. Capital costs of RE projects have fallen rapidly so imports of panels and components only comprise a marginal share of the total cost of the project. Additionally, the cost of non-renewable fuels, comprising the largest expenditure of imports in both India and Germany, is negated by the use of renewable sources of energy.

[93] Ibid.

Thus, with regard to the first hypothesis the literature based on the Germany suggests that both import reduction and climate change mitigation are the reasons behind the German transition. In the case of India, the growth in overall energy demand negates the element of import reductions within the transition to renewables in India. However, the climate change element is accompanied by the diversification of energy sources to cultivate a healthy balance of sources and offset any supply shortages.

6.5 Energy efficiency and restriction to power generation

India is committed to the introduction of Bharat Stage VI emission standards (the equivalent of Euro VI) but despite pushing for EVs the huge automotive industry in India will face severe losses if it must recalibrate established functions to produce EVs.

Efficiency cannot guarantee larger results as it has led to larger consumption of electricity. It is an application added to existing designs and processes. To put it more succinctly, overconfidence in the abilities of the seatbelt could encourage drivers to engage in rash driving. Likewise, consumers may use more electricity when naively trusting the ability of low-voltage appliances to reduce end-use bills. Efficiency is not about and either-or choice. It is more cost effective but electricity demand is also increasing. Strict efficiency measures have brought tremendous improvement in transport. Its limited applications work best in the industry where basic technical remain the same.

The enhanced technical abilities of RETs in supplying a greater share of electricity since the mid-2000s was carried by a rising public consciousness on climate change mitigation and future energy shortages. The convergence of these three elements has created the perfect condition to cultivate a resilience to fossil fuels. This study finally concludes that renewables are constantly in a *state of flux*. The industry is flooded with ideas for new technologies and new processes. The last ten years have been a disruptive period for renewables (energy technology). No projections regarding generation and distribution can be made. They are adapting to intense competition from conventional sources of energy. RE cannot be viewed in binaries that are state-centric. Retrofitting technology is expensive, the impact of energy efficiency is blunted by growing demand; instead aligning technology to policy is critical. The massive growth of renewables in a developing market like India signals the country’s commitment to alter the dominant energy framework.

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Appendices

Appendix A. Questionnaire for personal interviews

Question 1. What are the major steps taken by the India/Germany to reach its Intended Nationally Determined Contribution (INDC) of thirty five percent carbon emissions reduction by 2030?

Question 2. Who are the major stakeholders in the renewable energy sector?

Question 3. What is the current operational capacity of Renewable Energy Sources (RES) in India/Germany? Who are the major consumers?

Question 4. Does India/Germany envision renewable energy as stand-alone systems, mini-grids or as grid-connected systems?

Question 5. What are the significant issues challenging the expansion of renewable energy in India/Germany?

Question 6. What are the major steps taken to increase the competitiveness of Renewable Energy Sources (RES) vis-à-vis conventional sources of electricity?

Question 7. How does India/Germany plan to induce more private investment in the renewable energy sector?

Question 8. How has India/Germany promoted domestic R&D, along with manufacturing capacity?

Question 9. What has been the contribution of international financial and environmental organisations in India's/Germany's renewable energy sector?

Question 10. Is government investment in renewable energy a showcase of symbolism?

Question 11. Have initiatives to increase energy efficiency subsumed efforts to expand the use of RES in India/Germany?

Question 12. How has the general population viewed government efforts to increase renewable energy capacity in the power industry?

Question 13. Why has renewable energy failed to reduce the dependence on other sources of fuel in India's power production industry?

Appendix B. Overview of legislation governing Germany's energy supply system

Key strategies, acts, directives, and regulations/ordinances

EUROPEAN LEVEL

EU Climate and Energy Package (20/20/20/) Targets @ # $ *

2030 European Energy and Climate Framework @ # $ *

Internal Electricity Market Directive (Directive 2009/72/EC) @ # *

Emission Trading Directive (Directive 2009/29/EC) @ #

Energy Efficiency Directive (Directive 2012/27EU) @ #

Energy Consumption Labelling Directive (Directive 2010/30/EU) @

Regulation (EC) No 715/2009 on Access to the Natural Gas Transmission Networks $ *

Renewable Energy Sources (RES) Directive (Directive 2009/73/EC) # $ *

Internal Market in Natural Gas Directive (Directive 2009/73/EC) # $ *

Environmental Impact Assessment (EIA) Directive (Directive 2011/92/EU) @ # $ *

Habitats Directive (Directive 2011/92/EU) and Birds Directive (Directive 2009/147/EC) @ # $ *

Ten-Year Network Development Plan *

Connecting Europe Facility Regulation # $ *

Critical Infrastructure Protection Directive (Directive 2008/114/EC) # *

Ecodesign Directive (Directive 2009/125/EC) @

Regulation (EC) No714/2009 on Cross-Border Trading @ *

Regulation on Guidelines for Trans-European Energy Infrastructure *

Inter-TSO Compensation Mechanism Regulation (EU) No 838/2010) $ *

Regulation EU No 994/2010 on Safeguarding a Secure Supply of Natural Gas $ *

Directive for a Secure Supply of Electricity (Directive 2005/89/EC) # *

CCS Directive (Directive 2009/31/EC) # *

Industrial Emissions Directive (Directive 2010/75/EU) # $ *

EU Energy Performance of Buildings Directive (Directive 2010/31/EU) @

Planned Investment in Energy Infrastructure # *

KEY
@ Consumption
# Generation
$ Storage
* Transmission and Distribution

Yellow: Strategies
Green: Regulations/Directives
Blue: Reports/Guidelines

Source: Federal Ministry for Economic Affairs and Energy, [Online: web] Accessed 6 October 2016, URL: https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/gesetzeskarte.html

NATIONAL LEVEL

Appendix C. Overview of legislation governing Germany's energy supply system

THE ENERGY CONCEPT OF THE FEDERAL GOVERNMENT @ # $ *

Key strategies, acts, directives, and regulations/ordinances

Appendix D. Decommissioned and Operational Nuclear Power Plants of Germany

POWER PLANTS	OPERATIONAL PLANT	DECOMMISSIONED PLANT	SCHEDULE YEAR OF DECOMMISSIONING	YEAR WHEN DECOMMISSIONED
Tsar1		✓		2011
Tsar 2	✓		2022	
Gundremmingen B	✓		2017	
Gundremmingen C	✓		2021	
Neckarwestheim 1		✓		2011
Neckarwestheim 2	✓		2022	
Obrigheim		✓		2005
Philippsburg 1		✓		2011
Philippsburg 2	✓		2019	
Grafenrheinfeld		✓		2015
Biblis A		✓		2011
Biblis B		✓		2011
Muhlheim-Karlich		✓		2001
Wurgassen		✓		1994
Grohnde	✓		2021	
Lingen		✓		1977
Emsland	✓		2022	
Unterweser		✓		2011
Brunsbuttel		✓		2011
Stade		✓		2003
Brokdorf	✓		2021	
Krummel		✓		2011
Rheinsberg		✓		1990
Greifswald		✓		1990

Source: *The German Energiewende* (2018), Federal Foreign Office, Berlin, pg. 17.

Appendix E. List of Awarded and Planned Ultra Mega Power Projects in India

UMPP Name	Awarded	Identified
Bihar Mega Power Ltd, Bihar UMPP, Banka District, Bihar		✓
Coastal Tamil Nadu Power Ltd., Cheyyur UMPP, District Kanchipuram, Tamil Nadu		✓
Coastal Maharashtra Mega Power Ltd. Maharashtra UMPP, District Sindhudurg		✓
Coastal Karnataka Power Ltd., Karnataka UMPP, Karnataka		✓
Coastal Gujarat Power Limited, Mundra UMPP, Gujarat	✓	
Coastal Andhra Power Ltd., Krishnapatnam UMPP, Andhra Pradesh	✓	
Deoghar Mega Power Ltd, Jharkhand 2nd UMPP, District Deoghar, Jharkhand		✓
Ghogarpalli Integrated Power Co. Ltd., Orissa 2nd Additional UMPP, District Kalahandi, Odisha		✓
Jharkhand Integrated Power Ltd., Tilaiya UMPP, Jharkhand	✓	
Orissa Integrated Power Ltd., District Sundargarh, Odisha UMPP		✓
Sasan Power Limited, Sasan UMPP, Madhya Pradesh	✓	
UMPP in Uttar Pradesh		✓
2nd UMPP in Gujarat		✓
2nd UMPP in Tamil Nadu		✓
UMPP in Uttar Pradesh		✓

Source: Power Finance Corporation Limited [Online: web] Accessed 18 June 2019, URL: http://www.pfcindia.com/Home/VS/22

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