Global Subsidies Initiative

International Institute for Sustainable Development / Institut international du développement durable

RESEARCH REPORT

Assessing Green Industrial Policy
The India experience

Karthik Ganesan
Poulami Choudhury
Rajeev Palakshappa
Rishabh Jain
Sanyukta Raje

March 2014

Council on Energy, Environment & Water

www.iisd.org/gsi

Published by the International Institute for Sustainable Development.

About IISD

The International Institute for Sustainable Development (IISD) contributes to sustainable development by advancing policy recommendations on international trade and investment, economic policy, climate change and energy, and management of natural and social capital, as well as the enabling role of communication technologies in these areas. We report on international negotiations and disseminate knowledge gained through collaborative projects, resulting in more rigorous research, capacity building in developing countries, better networks spanning the North and the South, and better global connections among researchers, practitioners, citizens and policy-makers.

IISD's vision is better living for all—sustainably; its mission is to champion innovation, enabling societies to live sustainably. IISD is registered as a charitable organization in Canada and has 501(c)(3) status in the United States. IISD receives core operating support from the Government of Canada, provided through the International Development Research Centre (IDRC), from the Danish Ministry of Foreign Affairs and from the Province of Manitoba. The Institute receives project funding from numerous governments inside and outside Canada, United Nations agencies, foundations and the private sector.

Head Office

161 Portage Avenue East, 6th Floor, Winnipeg, Manitoba, Canada R3B 0Y4
Tel: +1 (204) 958-7700 | Fax: +1 (204) 958-7710 | Website: www.iisd.org

About GSI

GSI is an initiative of the International Institute for Sustainable Development (IISD). GSI is headquartered in Geneva, Switzerland and works with partners located around the world. Its principal funders have included the governments of Denmark, the Netherlands, New Zealand, Norway, Sweden and the United Kingdom. The William and Flora Hewlett Foundation have also contributed to funding GSI research and communications activities.

International Institute for Sustainable Development
Global Subsidies Initiative
International Environment House 2, 9 chemin de Balexert, 1219 Châtelaine, Geneva, Switzerland
Tel: +41 22 917-8373 | Fax: +41 22 917-8054

Assessing Green Industrial Policy – The India experience
Written by Karthik Ganesan, Poulami Choudhury, Rajeev Palakshappa, Rishabh Jain and Sanyukta Raje
Council on Energy, Environment and Water

March 2014

About CEEW

The Council on Energy, Environment and Water (http://ceew.in/) is an independent, not-for-profit policy research institution. CEEW addresses pressing global challenges through an integrated and internationally focused approach. It does so through high-quality research, partnerships with public and private institutions, and engagement with and outreach to the wider public. In June 2013, the International Centre for Climate Governance ranked CEEW 15th globally in its first ranking of climate-related think-tanks and number one in India. In January 2014, the Global Go To Think Tank Index ranked CEEW first in India in three categories.

Table of Contents

GSI Global Subsidies Initiative

iisd International Institute for Sustainable Development / Institut international du développement durable

List of Tables

List of Figures

List of Acronyms

AD	Accelerated Depreciation
AMSC	American Superconductor Corporation
APIIC	Andhra Pradesh Industrial Infrastructure Corporation
CAGR	Cumulative Annual Growth Rate
CDM	Clean Development Mechanism
CEA	Central Electricity Authority
CEEW	Council on Energy, Environment and Water
CERC	Central Electricity Regulatory Commission
CII	Confederation of Indian Industry
CIGS	Copper indium gallium selenide
CUF	Capacity Utilization Factor
C-WET	Centre for Wind Energy Technology
DCR	Domestic Content Requirements
DGAD	Directorate of Anti-Dumping
DIPP	Department of Industrial Policy & Promotion
DNES	Department of Non-conventional Energy Sources
DST	Department of Science and Technology
EC	Environmental Clearances
EEZ	Exclusive Economic Zones
EIA	Environment Protection Act
EPC	Engineering, Procurement and Construction
EPO	European Patent Office
ESDM	Electronics System Design and Manufacturing
FDI	Foreign Direct Investment
FEMA	Foreign Exchange Management Act
FIPB	Foreign Investment Promotion Board
FTE	Full Time Equivalent
FYP	Five Year Plans
GBI	Generation Based Incentive
GDP	Gross Domestic Product
GERD	Gross Expenditure on R&D
GHG	Greenhouse Gases
GMAC	Green Manufacturing Committee
GoI	Government of India
HRD	Human Resources Development
IACS	Indian Association for the Cultivation of Science
IEGC	Indian Electricity Grid Code
IEP	Integrated Energy Policy
IIT	Indian Institute of Technology

IMG	Inter-Ministerial Group
InWEA	Indian Wind Energy Association
IPC	International Patent Classification codes
IPO	Indian Patent Office
IPP	Independent Power Producers
IPR	Intellectual Property Rights
IREDA	Indian Renewable Energy Development Agency
ISES	International Solar Energy Society
ISMA	Indian Solar Manufacturers Association
IWPA	Indian Wind Power Association
IWTMA	Indian Wind Turbine Manufacturers Association
JNNSM	Jawaharlal Nehru National Solar Mission
JV	Joint Venture
LNG	Liquid Natural Gas
MIST	Metal and Intrinsic layer Semiconductor Technology
MNRE	Ministry of New and Renewable Energy
MoEF	Ministry of Environment and Forests’
MoP	Ministry of Power
M-SIS	Modified – Special Incentive Scheme
NAL	National Aerospace Laboratories
NAPCC	National Action Plan on Climate Change
NCE	National Council of Research
NCEF	National Clean Energy Fund
NCPRE	National Centre for Photovoltaic Research and Education
NISE	National Institute of Solar Energy
NLDC	National Load Despatch Centre
NMEEE	National Mission on Enhanced Energy Efficiency
NMIZ	National Manufacturing and Investment Zones
NOWA	National Offshore Wind Energy Authority
NRDC	Natural Resources Defense Council
NTPC	National Thermal Power Corporation
NVVN	NTPC Vidyut Vyapar Nigam
OECD	Organisation for Economic Co-operation and Development
OPIC	Overseas Private Investment Corporation
PAT	Performance, Achieve and Trade
PFC	Power Finance Corporation
PLFs	Plant Load Factors
PPA	Power Purchase Agreement
PPP	Public-Private Partnerships
PRIS	Performance Related Incentive Scheme
PWPL	Pioneer Wincon Private Limited

RBI	Reserve Bank of India
RCA	Revealed Comparative Advantage
RD&D	Research Development and Design
REC	Renewable Energy Certificate
RPO	Renewable Purchase Obligation
RPSSGP	Rooftop PV and Small Solar Power Generation Programme
RRD	Renewable Resource Development
RRF	Renewable Regulatory Fund
SECI	Solar Energy Corporation of India
SECI	Solar Energy Centre
SEMI	Semiconductor Equipment and Materials International
SERC	State Electricity Regulatory Commission
SERIIUS	Solar Energy Research Institute for India and the United States
SESI	Solar Energy Society of India
SEZ	Special Economic Zone
SIPs	Special Incentive Package Scheme
SLDC	State Load Dispatch Centre
SME	Small and Medium Enterprises
SRISHTI	Science, Research and Innovation System for High-Technology led path for India
SRRA	Solar Radiation Resource Assessment
STI	Science, Technology and Innovation
TADF	Technology Acquisition and Development Fund
TANGEDCO	Tamil Nadu Generation and Distribution Corporation
TAPS	Type Approval – Provisional Scheme
TOE	Tonnes of Oil Equivalent
TTRC	Tradable Tax Rebate Certificate
UI	Unscheduled Interchange
VGF	Viability Gap Funding
VOSL	Value of Statistical Life
WBGEDC	West Bengal Green Energy Development Corporation
WEDM	Wire Electric Discharge Machining
WGEEP	Western Ghats Ecology Expert Panel
WIPO	World Intellectual Property Organization
WIPPA	Wind Independent Power Producers Association
WTO	World Trade Organization
WWIL	Wind World India Limited

Summary

The report in brief: This analysis addresses a topic that is seldom the focus of discussion in policy circles or the popular press: India's Green Industrial Policy. In reality, it is a blend of steps taken to address market failures in promoting green/clean energy technologies and solutions, and other more classical policies to promote industrial development in India. Specifically, we analyze the domestic political motivations for policies that target the solar photovoltaic (PV) and wind energy sector in India. We find that the support offered to the industry has come at a relatively low cost, but has also resulted in a slow pace of development—growth has not been sustained, and many policies have been found wanting when evaluated against the originally proposed goals. We find clearly visible impacts of RE in the pursuit of energy security and access, avoided health costs for the local environment and in the abatement of GHG emissions. The industrial policy element, in comparison, has fared poorly. The impacts on job creation are unclear, and there are large variations in the estimates. There is also much work to be done in spurring domestic R&D and in ensuring long-term manufacturing competitiveness domestically and their ability to compete in the growing global marketplace for RE. Despite the early beginnings of RE in India, these two sectors are very much a "work in progress,"' and many of the lessons from the experience so far can positively influence growth in the years to come.

Domestic context and motivations: India's renewable energy aspirations and actions are driven by multiple objectives, including greater energy access, energy security, responding to local environmental challenges and addressing climate change risks. Broader industrial policy objectives also play a large role in driving policies that support RE. They include the desire to create a vibrant manufacturing base for RE technologies, creating additional jobs, and other ancillary activities such as R&D, which requires strong relationships with other countries. This study's analysis should be read in that context, namely how these different drivers have resulted in the evolution of policy regarding RE. The policies, in turn, should be evaluated in terms of whether they have indeed delivered results in line with the premises on which they were initially formulated. This is a complex set of interacting variables that cannot be strictly separated, but the framework and impact categories used help set some markers for how green industrial policy in India should be studied and analyzed.

The policies: This study focuses on policies that may broadly be categorized into overarching, direct and indirect policies. Recognizing the vulnerability of the country to energy price shocks and the inherent state of energy poverty, India was the first country to set up a ministry dedicated to RE (1992). The enactment of the Electricity Act, 2003 (and the subsequent National Electricity and Tariff Policy) laid out the principles that would incentivize and enable a rapid scaling up of RE. While the Integrated Energy Policy (2006), was not very bullish about the prospects of RE, it certainly highlighted the demand-supply gap that would prevail with regard to conventional energy sources. The declaration National Action Plan on Climate Change (NAPCC) is yet another watershed moment for RE, as it formally recognized the role of RE in mitigating climate change and laid the foundation for the Jawaharlal Nehru National Solar Mission (JNNSM). The direct policies that were the focus of the study include **financial incentives** (mainly feed-in tariffs[FiTs] and generation-based incentives [GBI]), **preferential tax treatment** (accelerated depreciation [AD], tax holidays and duty exemptions), **incentives to promote R&D, demand stimulation** (renewable purchase obligations [RPOs], renewable energy certificate [RECs]) and finally, **manufacturing-linked incentives** (domestic content requirements [DCRs], technology transfer and investment promotion schemes). Conspicuous by their absence are incentives like interest rate subvention, extended credit lines for export purposes and working capital provisions. Little attention has been paid to these instruments, even though there is agreement that low-cost financing is the key requirement for promotion of the sector. Other support mechanisms were also studied, such as the establishment of the National Clean Energy Fund (NCEF), the Performance, Achieve and Trade (PAT) scheme and the Renewable Regulatory Fund (RRF). In addition, there are programs in place to improve the quality of human resources available to the sector, projects underway to strengthen the power evacuation infrastructure and an overarching policy to promote the ecosystem for science and technology in the country.

A costing exercise undertaken to evaluate the extent of support (in monetary terms) provided to green industries reveals only a low level of outlay thus far. A bulk of the outlay (more than 50 per cent) was by way of preferential tax treatments (AD and income tax holidays). Financial support by way of FiTs was the single largest outlay and accounted for nearly 28 per cent of the provisions (evaluated). The overall level of support (both in terms of revenue and foregone fiscal revenue) when compared to the cost of supplying electricity across all utilities of the country is (approximately) a mere 1 per cent.

The impacts: The impact categories that were used as metrics to evaluate the success of the policies were: Energy Access and Security, Competitiveness of Domestic Firms, Competition in the International Market, Employment Generation, GHG Emissions, Local Environmental Impact and Technology Advancement in domestic entities.

Energy access and security: *An analysis carried out on the role of wind energy in Tamil Nadu proves beyond doubt that RE certainly supports energy security and a decreased reliance on conventional energy sources. With few market principles at work in the Indian electricity sector, large distortions through subsidies and cross-subsidies mask the true impact (on consumer prices) of any novel policy instrument and concomitantly, on energy security. Nevertheless, an analysis across major states (with RE potential) is necessary to illustrate the benefits derived from the deployment of RE and to reaffirm the understanding that RE has the potential to lower electricity procurement prices for large utilities. While off-grid solar systems and community solar PV plants have catered to demand from a few sectors, there is a long way to go. Determining the impact of grid-connected RE on energy access is a difficult task given the numerous bottlenecks in the delivery of electricity to the poor through the grid. Energy access and the means to provide minimum consumption to households are still debated in policy circles.*

Competitiveness of domestic firms: *In the past decade, both the wind and solar sector have seen many ups and downs. From being highly competitive, the sectors have lately been unable to meet global expectations in terms of price and quality, leading to a decrease in exports and the increasingly visible presence of foreign manufactured products even in domestic installations. While Indian wind manufacturers are able to meet domestic expectations, the solar sector faced an onslaught of cheap imported products. Neither industry invested effectively in research and development and thus had to rely largely on their overseas suppliers/ tie-ups. This dependence on foreign players for technological transfer led to a lag in the adoption of technology and a continued reliance on legacy systems. Manufacturers complained that the high cost of finance, lack of working capital and an insufficient export credit line also put Indian manufacturers at a disadvantage. Also, it has been noticed that while the Indian wind sector has been the more competitive of the two as a result of its maturity, the solar sector has been propped up by creating a demand through the DCR clause in the policy. Having witnessed competition from imported products, Indian solar manufacturers have started to diversify their business models, and some sort of consolidation of the sector is expected. Also, it has yet to be seen how the wind sector will react to the entrance of Chinese wind turbine manufacturers into India.*

Competition in the international market: *Indian manufacturers have not had a significant impact on the international market. While wind companies were competitive in the global market for a few years, their presence is declining. Other than Suzlon, no company (wind or solar) has any major international presence—at least no export from their Indian manufacturing base. The Indian solar industry has not yet reached a scale of production where it can contribute significantly to the global manufacturing pool, and no real analysis can be made of its impact on international competition.*

Employment generation: *Our analysis reinforces the need for comprehensive studies that could clarify the full impact that myriad RE policies such as the JNNSM, domestic content requirements, GBI, AD and so forth have had on employment generation. The impact on jobs is indirect, through the commissioning of projects and the associated activities. The influence of policies such as the GBI and AD on employment in the wind sector can only be deduced by anecdotal evidence that indicates companies having downsized their operations and cut back on their workforce, following the rollback of these incentives. Employment in the wind sector has received a boost with government's customs and excise duties' guidelines that make imports of wind turbine components (such as nacelles) and their domestic assembly more attractive than imports of assembled turbines. A large portion of the employment in the solar energy* *value chain is in the project development and maintenance phases, and India certainly stands to gain in the years to come, even if the solar manufacturing industry is slow to take off.*

Impact of GHG emissions: *The impact of RE on the country's overall greenhouse gas (GHG) emissions is not very significant today. This illustrates the immense scale of the effort necessary to scale up RE to seriously dent the emissions profile of the country (both energy and non-energy uses considered). Though much of the emissions reduction has happened without the support of a carbon price, a functioning carbon market could provide the right incentive, and the small number of projects that accessed the Clean Development Mechanism (CDM) in the first commitment period (2008–2012) of the Kyoto Protocol certainly benefited from the additional revenue stream associated with it. RE can certainly play a role in achieving India's voluntary target of reducing emissions intensity by 20 per cent to 25 per cent by 2020.*

Impact on local environment: *Analysis of the immense impact of conventional coal-fired power plants on human health indicates that their emissions result in hundreds of thousands of premature deaths and negative health outcomes. Conventional analyses that evaluate the costs and benefits of RE do not monetize these, and their inclusion further supports the case for RE financing. In addition to the impact on human health, there are many impacts on local agriculture, forest productivity, and urban buildings that are not analyzed here. Studies suggest that RE power in itself has an environmental impact that must be accounted for through proper planning and execution.*

Technology advancement in domestic entities: *Current policies do not mandate or incentivize continuous technological advancement in the solar and wind sectors in India; however, institutes like the Centre for Wind Energy Technology (C-WET) have played an important role in ensuring standardization and monitoring of quality for wind turbines, and institutes like National Institute of Solar Energy (NISE) and the National Centre for Photovoltaic Research and Education (NCPRE) are working on making solar technologies more affordable, while customizing the technology to local conditions. Demonstration projects have been pivotal in early-stage deployment of RE technologies, especially in the wind sector: their importance cannot be overstated. Low patent numbers indicate there is a lack of effort towards translating research into commercially viable technology/products in both the solar PV and wind sectors, mainly due to a low level of private sector investment and a weak intellectual property regime that does not promote patent filing.*

Lessons for Policy-Makers

What have the policies addressed?

The notion of a green industrial policy is not a significant part of public discourse in India, nor is it widely discussed in policy-making circles. In attempting to bring together the two elements of "green" technologies (in response to market failures) and industrial policy (to promote the more traditional goals of manufacturing or job creation), it is inevitable that only one of these broader motivations can claim victory, even if marginally. In the case of India, the emphatic victory, surprisingly, is for the green story. The green argument supports three pillars—energy access and security, local environmental benefits, and climate change mitigation—all of which are public goods in their own right. The strides made in these areas are there to be seen, as India is seen as leader (and rightly so) in augmenting RE capacity, though at a less-than-desirable pace.

The more classic industrial policies aimed at creating a thriving domestic industry that is competitive on its own strength, generating much-needed employment and establishing significant domestic R&D, have delivered to a lesser extent. Despite the targeted industrial policies over the decades (which focused on specific industrial activities with a view to attaining self-sufficiency in the manufacture of goods deemed critical for the economy) the manufacturing sector has not flourished in India. At no point in the last 20 years did manufacturing contribute more than 16 per cent of GDP (RBI, 2013). What ails the manufacturing sector at large also affects the ability of RE-related manufacturing to take off in a meaningful way.

Have the policies worked?

While the conclusions around the success of the "green" element may be seen as generalizations, it is necessary to investigate policies under the specific umbrellas to understand their efficacy. Financial incentives such as FiTs and GBI have met with much less success than have the preferential tax treatments given by AD and income tax holidays. With no guarantees on the procurement of power from RE generating stations and the financial insolvency of many public sector utilities, developers believe that the relatively assured returns associated with tax breaks is far more effective than financial incentives. This attests to the poor enforcement of contracts and a lack of commitment on the part of the utilities towards honouring them. Measures to stimulate demand for RE, through RPOs and RECs, have not been well-received, and have resulted in rampant non-compliance from many quarters with no penalties to check the rise in such cases. Manufacturing-linked incentives have not delivered as expected. In order to have a thriving manufacturing sector, two prior existing conditions must be satisfied—a great degree of backward integration for sourcing the necessary components domestically (and the necessary infrastructure to promote manufacturing such as roads, power, etc.) combined with the overall ease of starting and running businesses in the country. India is not ideally placed when viewed through the lens of these prerequisites. One could argue that the complementary policies to make manufacturing attractive in India are missing, a lack that goes well beyond the realm of "green industrial policy." A focus on R&D is lacking, and investment from the private sector is not forthcoming. However, the focus on making RE technologies more affordable and tailored to the needs of the country is certainly a step in the right direction. The SEC and C-WET need to play a more active role in ensuring that the lessons from the many pilot/ demonstration plants that they commission filter down to large-scale installations and enable a move up the learning curve.

Whither Green Industrial Policy?

Policies cannot persistently be seen as supporting either the evolving notion of "green" or just the classic industrial policy goals. In a world of geopolitical uncertainties and major barriers in the areas of trade and technology transfer, it is difficult to envision a scenario where India would pursue capacity augmentation in RE while solely relying on external providers of the technologies and manufacturing capabilities, while at the same time focusing its own manufacturing in other favourable domains. RE has implications for long-term energy—and concomitantly national—security. Both must be given their due in order to ensure that there are no adverse impacts on the economy in the long run. The two can positively reinforce each other: an efficient domestic manufacturing base will push the envelope of possibilities when it comes to achieving green goals through affordable technologies, while enjoying popular support of the public on account of the economic and environmental benefits.

Introduction

For much of the last decade (2000 to 2010), the Indian economy witnessed growth rates in excess of 8 per cent in terms of overall GDP and nearly 6 per cent in GDP per capita terms (World Development Indicators, 2011). The burgeoning Indian economy is being primed to grow at an average rate of 8 to 9 per cent over the next two decades. Two crucial elements in determining the fate of the economy will be the performance of the manufacturing sector and the availability of energy to supply the needs of the growing aspirations of the population. The renewable energy (RE) sector straddles both elements and has the potential to give a much-needed impetus to both. It is thus imperative for policy-makers to be aware of the role the sector has played and reflect on the success of existing policies and their relevance in the years ahead.

India's renewable energy aspirations and actions are driven by multiple objectives, including greater energy access, energy security, responding to local environmental challenges and addressing climate change risks. The analysis in this study should be read in that context—namely how these different drivers have resulted in the evolution of renewable energy policies. And the policies, in turn, should be evaluated in terms of whether they have delivered results in line with the premises on which they were initially formulated.

Section 1 of the report provides the rationale and the motivation behind the pursuit of a "green industrial policy" in India. We then document the current status of the solar photovoltaic (PV) and wind sectors in India with an emphasis on key players and trends.

Section 2 outlines the key policies used to stimulate the RE sector in India—both project development and domestic manufacturing of RE-related goods and services. Policies are split into overarching, direct and indirect policies.

Section 3 seeks to highlight the impact of various policies on specific outcomes chosen for the study, including: Energy access and security; competitiveness of domestic firms; increased competition in the global market; impact on employment generation; impact on the local environment and greenhouse gas (GHG) emissions and lastly, technology advancement made by local industry.

Section 4 reflects on the lessons for policy-makers and to what extent key policies have worked.

The paper provides a broad overview of the state of affairs of the RE sector in India with a focus on solar PV and wind, and seeks to draw lessons from a work that remains very much in progress.

1. Background

Despite rapid strides in power capacity addition, India remains an energy-poor country. The energy demand/supply gap and peak shortage are on the order of 7 per cent, and 80 million households have inadequate access to electricity. Although significant headway has been made in extending the electricity grid across India, there remains a persistent problem of intermittency in supply. Energy access is an overarching priority for India, whether to raise human development outcomes for poor and non-electrified households or to increase prospects for more robust economic growth across the agriculture, industrial and commercial services sectors (Ghosh, 2012a). This means that efficiently maximizing the utilization of energy sources while ensuring energy access has become the need of the hour (Census of India, 2011) (CEA, 2013a).

The role of renewable energy in India must be viewed in the context of fulfilling energy demand. Unlike many developed countries, where energy demand might have flattened out in recent years, the development of renewable energy in India is not a question of substituting for other energy sources but adding to the existing stock of energy supply. In other words, while a number of countries are seeking to chart a transition away from fossil fuel-based power generation, India's energy policy is primarily focused on bridging ongoing supply and demand gaps. Renewable sources (excluding large hydro) currently form 12.2 per cent of the installed base capacity (Ministry of Power, 2013) and contribute in the range of 5 to 6 per cent to the total energy mix (Figure 1.1). The government aims to increase the share of renewable energy in the electricity mix to 15 per cent by 2020 (PIB, 2012).

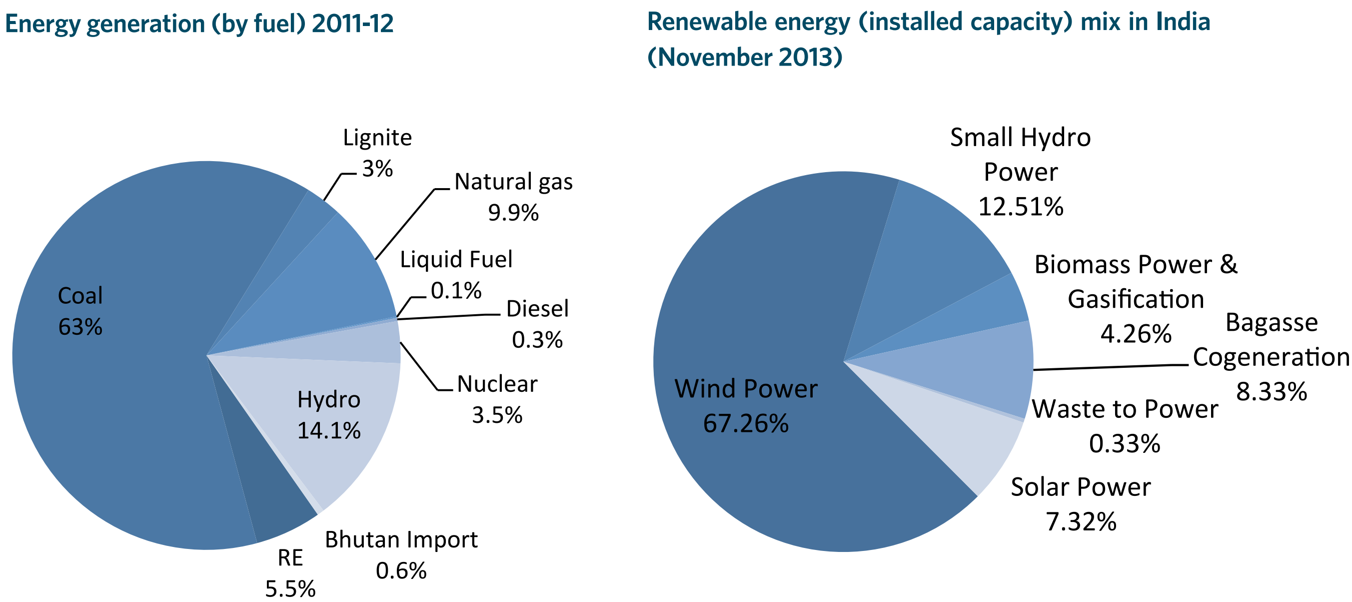


FIGURE 1.1: ELECTRICITY GENERATION MIX IN INDIA

Sources: CEA (2012a) & MNRE (2013d).

1.1 Domestic Context and Motivations

At around 5 per cent of total electricity generation, renewable energy has yet to make a dent in the share of fossil fuel-based electricity generation. Over the last 15 years a number of policies and programs have been developed by central and state governments in India to provide a framework to support renewable energy, stimulate investments in alternatives to thermal power generation, and bring together diverse parties to support the implementation of renewable energy. This has included efforts to establish the wind and solar sectors (including non-electricity-driven uses of solar), efforts to effectively use biogas and national efforts to extend the reach of the electricity grid to evacuate power and distribute it to those in remote locations. Decentralized energy provision by tapping locally available renewable energy sources has also seen a big push in the last decade.

Several questions arise from this experience. Is enough being done to build confidence in the renewable energy market to entice investors? To what extent does progress in renewable energy in India demonstrate a strategic willingness on behalf of policy-makers to promote this sector? If not enough has been done, what policies could be adjusted, abandoned or introduced to make these levers more effective? And, in the context of this study, does the totality of policies, measures, regulations and investments from the government amount to what could be considered a "Green Industrial Policy" in India?

It is important to note that the term "Green Industrial Policy" is not prevalent in Indian policy discussions. As one stakeholder we interviewed remarked, "Are you asking me about Green Industrial Policy, or policies to support Green Industry – because that I can talk about" (V. Subramanian, personal communication, July 9, 2012). In reality, India's "Green Industrial Policy" is a mix of steps taken to address market failures in promoting green/clean energy technologies and solutions, and other, more classical, policies to promote industrial development in India.

Responding to Market Failures

The provision of energy services through market mechanisms has many benefits in terms of lowering marginal costs, increasing efficiency and improving consumer choice for energy services. However, if some households are too poor to pay for energy services, or are located in inhospitable and inaccessible areas, then relying entirely on the market could result in a degree of energy exclusion for the poor. Similarly, if only the direct costs of thermal power were considered, without accounting for the impact on public health or global environmental change, then there would be little reason to challenge the dominance of coal or other fossil fuels. Again, the security of supply of even fossil fuels is dependent on the broader public goods of national security and protection of sea lanes of communication. In other words, one broad motivation for promoting renewable energy in India is to respond to a series of real and potential market failures, in energy access, energy security, climate change, and local environmental challenges.

Energy access and security are focal points in India's energy policy and seek to address latent demand for energy services to underserved populations, as well as catering to India's large demand-supply gaps. Even under an aggressive scenario of global climate stabilization, India would consume around 60 per cent more energy in 20 years than it does today (Ghosh & Steven, 2013). Dwindling output from domestic fuel sources, large spikes in prices of imports and the uncertain geopolitical conditions in the Middle East and elsewhere, form the foundation of growing concerns about predictability of supply (Dubash, 2012). The household sector in India consumes about 39 per cent[1] of the total energy supplied in the country, a large share (~ 77 per cent) of this is through traditional biomass-based fuels like firewood, dungcake, charcoal etc., and not accounted for in the official statistics. This forms the backbone for the imperative of increasing access to modern energy sources for millions of Indians.

[1] CEEW analysis based on a combination of commercial fuels data from (CSO, 2013) and NSSO 68th Round Survey on Household Expenditures.

The pursuit of energy access and energy security enjoys considerable political support, and is recognized in the Integrated Energy Policy (Planning Commission, 2006a), which states that India is energy secure when its citizens have lifeline energy—irrespective of their ability to pay for it. This is backed by a history of policies and programs aimed at enhancing rural electrification that go as far back as 1969.[2] Unlike other major economies, all of the major sectors in India—agriculture, industry, services—will have to grow simultaneously, underscoring the importance of energy security for the economy. And yet, India is one of the few major economies that has limited resources of its own and is not geographically contiguous to major sources of supply, thereby making it vulnerable to geopolitical and geo-economic shocks (Ghosh & Steven, 2013). If renewable energy can even partially mitigate some of this pressure, it could offer a double advantage of promoting energy access for the poor and increasing options for domestic sources of energy supply from an energy security perspective.

Climate change mitigation: India's desire for energy security also serves as an important driver for actions that have the co-benefit of climate mitigation and, indirectly, the pursuit of renewable energy aspirations. Within India, the many measures to address climate change, notably promoting end-use energy efficiency and pursuing renewable energy supply, are consistent with decreased greenhouse gas emissions. In June 2008, India launched a National Action Plan on Climate Change (NAPCC), which set out eight "Missions" to support action on climate change: the most prominent among these missions have been the National Solar Mission and the Mission for Enhanced Energy Efficiency. One of the important considerations behind the plan was suggested by the then-Finance Minister: "It is because we recognize the linkages between climate change and energy security that we have adopted a National Action Plan on Climate Change" (Pranab Mukherjee, 2008). Moreover, senior Indian diplomats recognized the links between energy and climate change mitigation. The first report on India and global governance emphasized that India offers a vast market for future investments in clean technologies and, as a consequence, the need to deepen bilateral relations to develop and secure access to energy and climate-related technologies (Ghosh, et al., 2011).

Local Environment: For a country greatly reliant on coal-based thermal power, the local environmental consequences in terms of air pollution, respiratory diseases and water use and pollution are real concerns, even if the challenges of climate change were not severe. Renewable energy development could be considered as one response to growing opposition to the local environmental impacts of coal-based power. The practice of Environmental Impact Assessments (EIA) has been prevalent in India since the late 1970s, and the Environment Protection Act (1986) has been in force for over 25 years. In a 2006 amendment to the Act, wind and solar projects were exempted from EIA requirements. This approach was intended to accelerate the implementation of projects, but may have imposed additional costs and ended up shifting the burden on to companies, namely the need for strong intra-firm practices to gauge and address the potential environmental impacts of their renewable energy projects.

Promoting Industrial Policy

A second major motivation for promoting renewable energy could draw upon more classical arguments of industrial policy. Manufacturing has potential benefits for increasing domestic value addition, creating jobs, promoting innovation, improving the trade balance and improving resource security (Gupta, Ganesan, Raje, Ahmed, & Ghosh, 2013).

Manufacturing: The National Manufacturing Policy (2011) seeks to increase the contribution of manufacturing in GDP to 25 per cent (from around the current 15 per cent) within the next decade and help create 100 million jobs (PIB, 2011a). Among the priorities that the policy has outlined is the focus on "greener and cleaner" technologies. The policy recommends that a Green Manufacturing Committee (GMAC) would apply objective criteria to identify such technologies, consistent with the National Action Plan on Climate Change. The GMAC is also tasked with operating, monitoring and reviewing a newly proposed Technology Acquisition and Development Fund (TADF) (GoI, 2011).

[2] The establishment of the Rural Electrification Corporation.

Job Creation is another major driver for India's policy-makers, and renewable energy policies are no exception. MNRE seeks to have 100,000 solar jobs by 2022, and the wind industry seeks to add 25,000 over the next five years. Unlike other developed countries, where a transition to renewables may mean job losses in the fossil fuel sector, the renewable energy sector in India would be likely to add new jobs. In both these cases subsidies could a play an important role in affecting a shift. For example, subsidized clean energy in developed countries may lead to increased clean energy jobs, but may also be balanced out by job losses in the fossil fuel sector. However, in developing economies government subsidies would likely drive down renewable energy prices and could encourage job creation across the value chain (manufacturing, installation, financing, after-sales service, etc.), without affecting existing jobs in the fossil fuel sector (Ghosh, 2012b).

Support for new technologies: New energy technologies provide an opportunity for countries to display technological leadership and support ecosystems development, which could support the development of new sectors of the economy (Ghosh, 2012b). In the early stages firms rely on government support to access technologies and patents. The Government of India has been proactive in developing international collaborations to enhance transfer of clean technologies to India. In addition, the Ministry of New and Renewable Energy established a Research & Development Department in 1994, and continues to seek out research and technology transfer collaborations. There are also public–private partnerships. The Joint Clean Energy R&D Center (focusing on solar, second generation biofuels, and energy efficiency in buildings) is a $100 million initiative, half financed by the Indian and U.S. governments and the remainder by research consortia comprising firms and laboratories in both countries (the Council on Energy, Environment and Water and the Natural Resources Defense Council facilitated this process) (see Council on Energy, Environment and Water (CEEW) & Natural Resources Defense Council (NRDC), 2012). However, there continue to be challenges to developing a vibrant R&D ecosystem in India. Public sector entities drive R&D spending which, in the case of wind and solar, is largely focused on applied research i.e., adapting existing technologies to Indian conditions and driving incremental efficiency gains and lowering cost. Fundamental research in these areas is largely absent due to a lack of the necessary funding and expertise.

A Balanced, Inclusive Approach to Renewable Energy Development

The two decades since liberalization have seen a move away from a planned economy, with policies, rather than mandated targets and resource allocation, largely driving the machinery of the state. The Planning Commission, through its Five Year Plans (FYPs) and Working Group Reports (developed in the process of formulating each FYP) continues to be a guiding beacon for the various industrial sectors and development in the country. Though renewable energy finds mention in earlier FYPs, it is only recently that a broad vision for a more environmentally sustainable economy has been elucidated. The 12th FYP (2012-2017), sets out a vision for "Faster, More Inclusive and Sustainable Growth" (Planning Commission , 2013). The 12th Plan also establishes a goal of 30,000 megawatts (MW) of renewable energy capacity additions, with wind power providing 15,000 MW and another 10,000 MW from grid-connected solar (Planning Commission, 2013b). The Plan document goes on to state the need for "broad-based improvement in living standards of all sections of the people through a growth process which is faster than in the past, more inclusive and also more environmentally sustainable" (Planning Commission , 2013, p.10).

Continued growth is necessary, but there is also recognition that this needs to be done in a manner that is not at an absolute cost to the environment. Internationally, a desire to measure gross domestic product (GDP) in more than just financial terms and to account for the environmental costs of production activity (as well as the cost of resource usage such as water, forests and minerals), has led to a growing interest in Natural Capital Accounting (World Bank, 2013). The Government of India first announced that it would publish natural capital accounts in 2010 (Jowit, 2010), but it is only now that traction is developing for such an approach. An Expert Group was convened to prepare a framework to understand the environmental cost of production (Planning Commission, 2013a). The findings were released in April 2013 and a draft framework for "Green Accounting" has been announced.

Addressing India's wide-ranging needs and multiplicity of objectives can make for a complex balancing act where different ministries and levels of government are required to act in concert to ensure robust policies and outcomes. A good example is India's National Solar Mission, which has energy generation, job creation, a vibrant manufacturing ecosystem and effective financing channels laid out as objectives in the Mission document, and attempts to deliver on all these objectives through one policy (CEEW & NRDC, 2012). This multiplicity of objectives is exacerbated by India's Centre-State relationship (being a federal republic), which further complicates not only legislative authority but how policies are expected to be enforced. For example, although India's Renewable Purchase Obligation (RPO) is a Central scheme to stimulate the renewable energy market, State Electricity Regulatory Commissions (SERCs) have established State-level RPO regulations, which may not act in concert with other states, or fulfill the objectives of the scheme as planned (MNRE, n.d. a). Furthermore, responsibility to enforce RPOs rests with SERCs—with limited success to date (Ramesh, 2013a).

To be sure, the motivations outlined above should not be interpreted as emerging from a singular policy process or the outcome of a nation-wide consensus to give strategic priority to renewable energy. In fact, the different drivers (aspirations for access to energy, concerns about energy security, pressures of climate change, need to promote domestic manufacturing and create jobs, etc.) emerge from a diversity of stakeholders, interests, levels of government and international diplomatic and negotiation dynamics. In other words, a "Green Industrial Policy" in India is more a combination of "green" concerns and ambitions (in response to several market failures) and more traditional drivers of industrial policy. The analysis in this study should be read in that context, namely how these different drivers have resulted in the evolution of policy regarding renewable energy. And the policies, in turn, should be evaluated in terms of whether they have indeed delivered results in line with the premises on which they were initially formulated. This is a complex set of interacting variables, which cannot be strictly separated, but the framework outlined above helps to set some markers for how green industrial policy in India should be studied and analyzed.

In the following sections we provide a picture of the actions being taken to increase the share of renewables in the energy mix, the policies which have been used to support the transition towards renewable energy, and, where possible, an analysis of the impacts of these policies.

1.2 Solar and Wind Energy in India: Key players, technologies and trends

Realizing the goal of 30 gigawatts (GWs) of renewable energy capacity by 2017 will require involvement and alignment of several government ministries, departments and agencies. Some of the key government bodies that have a role to play in India's transition to a renewable energy driven economy are described in Table 1.1.

TABLE 1.1: OVERVIEW OF GOVERNMENT PLAYERS

GOVERNMENT INSTITUTION	BRIEF DESCRIPTION
Ministry of Finance	It is concerned with taxation, financial legislation, financial institutions, capital markets, centre and state finances, and the Union Budget. Its Department of Expenditure oversees allocation of budgetary resources to various ministries.
Ministry of Power	It deals with planning, monitoring of the implementation of power projects; also responsible for the administration and periodic amendments to the Electricity Act, 2003, the Energy Conservation Act, 2001.
Ministry of New and Renewable Energy (MNRE) and State Nodal Agencies	Nodal Ministry of the Government of India for all matters relating to new and renewable energy. MNRE also oversees several autonomous institutions including the Centre for Wind Energy Technology (C-WET) and National Institute of Solar Energy (formerly the Solar Energy Centre).
The Indian Renewable Energy Development Agency (IREDA)	Non-banking financial institution under the administrative control of MNRE for providing term loans for renewable energy and energy efficiency projects.
Power Finance Corporation (PFC)	Public financial institution which provides financial assistance for grid-connected solar power projects for which a Power Purchase Agreement (PPA) has been signed and finances equipment manufacturers for the power sector.
Central Electricity Authority (CEA)	A statutory body functioning under the Electricity Act 2003 responsible for promoting and assisting the timely completion of the programs/schemes for improving and strengthening the electricity system.
Central Electricity Regulatory Commission (CERC)	A statutory body functioning under the Electricity Act 2003 responsible for regulating the tariff of generating companies; interstate transmission of electricity; determining price range for renewable energy certificates (RECs) etc.
Solar Energy Corporation of India (SECI)	Solar Energy Corporation was set up in 2011 as an implementation and facilitation institution for solar energy. It is responsible for development of solar technologies and works towards inclusive solar power development throughout India. In the second phase it is also charged with signing long-term PPAs with project developers and takes on the role played by NVVN.

Source: CEEW compilation

1.2.1 Solar Industry in India–The new kid on the block

India's first grid-connected solar power plant was commissioned in 2009 under the Generation Based Incentive Scheme. Situated in Asansol, West Bengal, the plant had an installed capacity of 2 MW and was financed by the Power Finance Corporation (WBGEDC, n.d.). In January 2010, Jawaharlal National Solar Mission (here on referred to as the Mission or JNNSM) was launched and has driven investment in solar, taking India from cumulative installed capacity of grid-connected solar photovoltaic (PV) of nearly of 10 MW in early 2010 to more than 1,800 MW in July 2013 (MNRE, 2013d). Although the solar market in India has garnered a lot of attention domestically and internationally (and implementation is rising), the sector in India is very much in its infancy.

The JNNSM is divided into three phases and aims to deploy 20,000 MW of grid-connected solar power and 2,000 MW of off-grid power by 2022 (Table 1.2) (MNRE, 2010b). The states of Gujarat (>850 MW) and Rajasthan (>500 MW) (GEDA, 2013a), (RRECL, 2013) have the largest share of national installations, largely due to high irradiance and favourable business conditions.

TABLE 1.2: JNNSM TARGETS FOR GRID-CONNECTED SOLARSOURCE: MNRE (2010B).

PHASE 1 (2010-2013)	PHASE 2 (2013-2017)	PHASE 3 (2017-2022)
1,000 MW - 2,000 MW	4,000 MW - 10,000 MW	20,000 MW

Key Players in the Solar PV Sector

The JNNSM generated a lot of interest within the Indian business community. The nascent PV solar sector has witnessed the entry of a large number of new players seeking to explore the market. This includes small-scale entrepreneurs, established power producers exploring the solar sector, and a number of companies seeking to diversify activities into solar. The capital-intensive nature of solar plants means that as the size of allocated projects increases, only large and serious players are attracted to the market. Several firms, especially those small firms without a track record of project executions, or a plan for future growth in the solar market, have already exited the sector. Table 1.3 illustrates some of the key players operating at different levels of the solar sector

TABLE 1.3: KEY PLAYERS IN THE SOLAR PV SECTOR

ROLE	KEY PLAYERS
Strategic	Ministry of New and Renewable Energy (MNRE); Indian Renewable Energy Development Agency (IREDA); State Renewable Development Agencies; Central Electricity Regulatory Commission (CERC); State Electricity Regulatory Commission (SERC); National Thermal Power Corporation Vidyut Vyapar Nigam (NVVN); Ministry of Power (MoP),
Project Implementation (Manufacturing, Installation and O&M)	Manufacturers (cells, modules, balance of systems) – e.g. Moser Baer, Tata Power Solar, EMMVEE Project Developers—e.g., Azure Power, Green Infra, Mahindra, Welspun EPC contractors—e.g., Lanco Infratech, Mahindra EPC, Tata Power Solar Financiers—e.g., Axis Bank, ICICI, U.S. Ex-Im Bank, OPIC
Support	Industry Associations—Solar Energy Society of India (SESI), Indian Solar Manufacturers Association (ISMA) MNRE R&D Centre—Solar Energy Centre (SEC); National Centre for Photovoltaic Research and Education (NCPRE)

Source: CEEW & NRDC (2012); CEEW Compilation

Strategic Players

The role of various government ministries in charting policies and plans for the growth of renewables has been a vital pillar of support for the solar industry. As the nodal ministry of the Government of India for all matters relating to renewable energy, the MNRE formulates policies and programs (such as the JNNSM) for harnessing solar power; developing skilled manpower for the industry, and supporting research, design and development of solar technologies. Effective implementation of MNRE's programmes and objectives requires it to coordinate effectively with other functional ministries such as the Ministry of Power (MoP) on matters such as grid integration of solar power. The central and state-level electricity regulators—CERC and SERCs—are involved in fixing of renewable purchase obligation

(RPO) targets and feed-in tariffs for solar power. IREDA is the public sector financing arm providing concessional financing for solar projects. Under the JNNSM, NTPC's Vidyut Vyapar Nigam Ltd (NVVN) has been designated as the nodal agency for procuring solar power by entering into a Power Purchase Agreement (PPA) with solar power developers and selling "bundled" power to utilities. The National Load Despatch Centre (NLDC) is the central agency responsible for operationalization of the renewable energy certificate (REC) mechanism.

Project Developers

Project developers are, by design, key stakeholders in the project implementation process, bidding for projects under the NSM (and state-level initiatives). However, given the inexperience of some players, Engineering, Procurement and Construction (EPC) contractors are emerging as central players in the JNNSM. Project developers often rely heavily on their EPC contractors to support their projects and support in arranging financing.

Financiers mainly include Indian commercial banks, Indian non-banking financial institutions and international funding channels which provide financial assistance to the project developers in the form of debt, loan guarantees, and risk insurance in order to commission the solar plant (CEEW & NRDC, 2012).

The manufacturing capacity of photovoltaic cells and modules in India has steadily grown over the past decade. Local manufacturers were largely export-focussed, catering to the then-burgeoning European market (Figure 1.2). Some local manufacturers anticipated greater local demand due to the announcement of the JNNSM (Down to Earth, 2012), but due to the unintended distortionary effects of the domestic content requirements (DCR), demand for domestically manufactured crystalline panels all but vanished. Stakeholders we spoke to noted that they were operating at very low capacity utilization, until FY 2011 – 2013. The European market has started to pick up once more following EU anti-dumping measures against Chinese products.

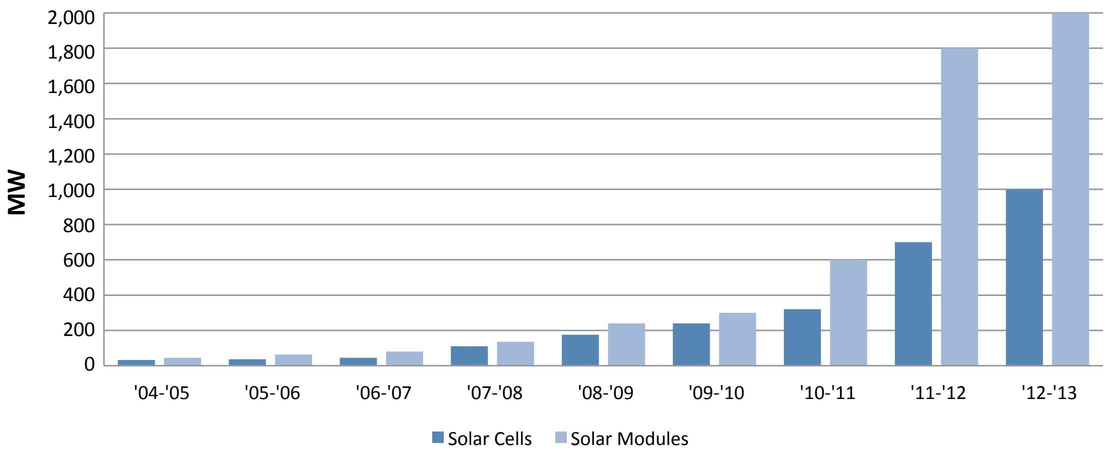


FIGURE 1.2: MANUFACTURING CAPACITY OF SOLAR CELL AND MODULE IN INDIA

Source: CEEW compilation

The solar panels used in projects constructed so far and those under construction are chiefly supplied by international players, with a combined share of over 80 per cent. First Solar, a U.S.-based provider of thin film technologies, has the largest share of approximately 22 per cent, followed by Canadian Solar and Trina Solar with a share of about 6 per cent each—this is a fragmented market with no significant concentration of market share. Vikram Solar, an Indian enterprise, has the highest share among domestic manufacturers (3.5 per cent); other leading domestic suppliers are Moser Baer, Tata Power Solar and Lanco in order of their market shares (PVTECH, 2013; Bridge to India, 2013). Figure 1.3 illustrates some of the major Indian solar PV manufacturers operating at different segments of the manufacturing value chain.

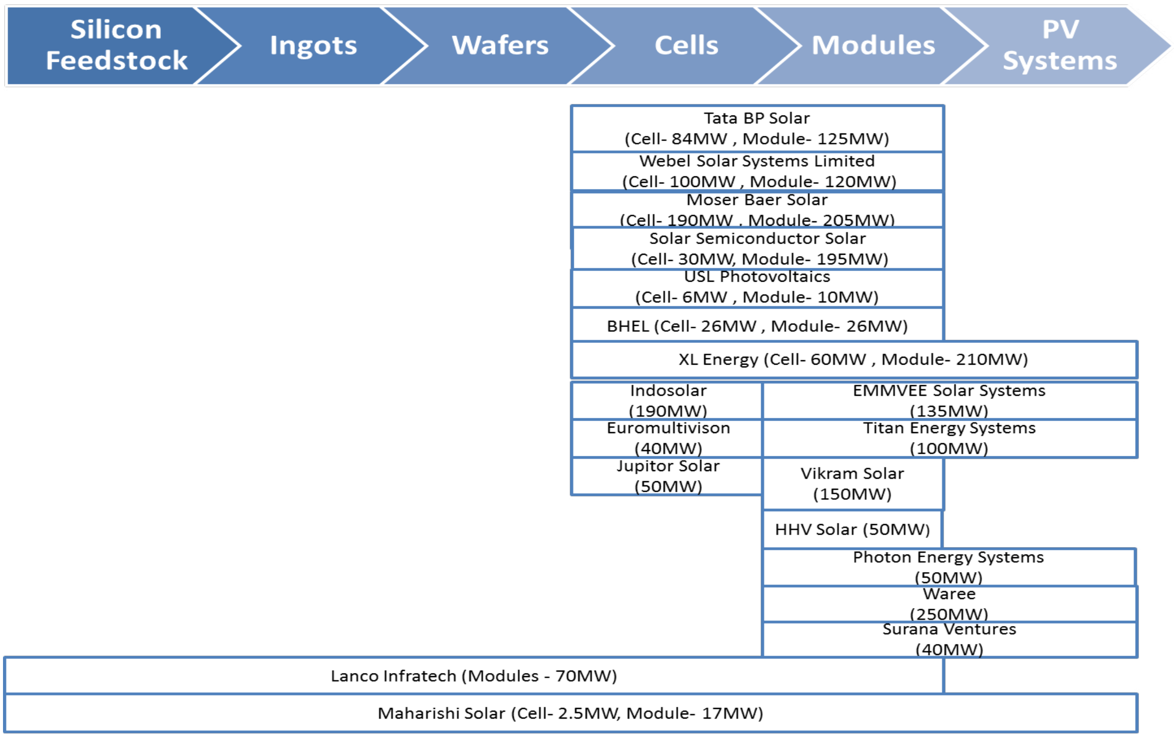


FIGURE 1.3: SEGMENTS OF THE SOLAR PV VALUE CHAIN AND MAJOR PLAYERS

Source: CEEW compilation

Support

Industry Associations

Industry Associations in India attempt to bring together disparate stakeholders to present a common voice to government. Two of the most prominent industry associations in India are the Solar Energy Society of India (SESI) and the Indian Solar Manufacturers Association (ISMA). SESI was established in 1976, and is the Indian chapter of the International Solar Energy Society (ISES). On the other hand, the Indian Solar Manufacturer's Association (ISMA) is a relatively new association of domestic manufacturers of solar cells and modules. It was constituted in 2011. ISMA comprises 25 members including Lanco Solar, Moser Baer and Indo Solar. ISMA has been pushing for domestic content legislation and anti-dumping duties against imported products (Sethi, 2013).

1.2.2 The Wind Industry in India: Progression and maturity

India's wind potential assessments have been found to vary widely, from 80 GW to over 2,000 GW.[3] Such wide variations signal the need for ground-level assessments to ensure a realistic measure of India's wind potential, which in turn can lead to well-informed policy decisions and planning (C-WET, n.d. a; WISE, 2011). As per C-WETs estimation, Gujarat (35 GW), Andhra Pradesh (14.4 GW), Tamil Nadu (14.1 GW) and Karnataka (13.5 GW) are the states with the highest wind energy potential in the country (C-WET, n.d. a).[4]

> **Mechanisms to stimulate investment in wind and solar**
>
> **Accelerated Depreciation:** enables investors to write off 80 per cent of the project asset values within the first year of installation as depreciation.
>
> **Generation-Based Incentive:** A top-up provided to RE power producers in addition to the tariff approved by various state regulators; applicable only to those who do not receive the benefit of accelerated depreciation.

The early years (1985 to 1990) of the wind industry in India were driven by demonstration projects sanctioned by government and implemented by private companies mostly with collaborations with the Danish International Development Agency (DANIDA) (GWEC-IRENA, 2013).

Post-liberalization (1991) and after the success of demonstration projects, many Indian entrepreneurs who were interested in captive usage or wanted to access accelerated depreciation benefits entered into joint ventures with foreign firms. A series of licence agreements with European, Japanese and American firms (for example, Enercon, Nordex, DeWind, Sudwind GmbH, Mitsubishi and Kenetech) laid the foundation for domestic manufacturing.

BOX 1: COLLABORATIVE EFFORTS IN THE WIND SECTOR

- Suzlon entered into a technology collaboration agreement with Sudwind Energiesysteme GmbH in 1995, and acquired the company in 1997.
- American Superconductor Corporation (AMSC), a U.S.-based company, has been a key licensor of technology in India. AMSC has helped Inox Wind Ltd. expand their installation base with 2 MW turbines tailored for areas with low-wind conditions.
- Vestas RRB India Ltd was a joint venture between Vestas and RRB India Ltd. The company now operates as RRB Energy Ltd., following the withdrawal of Vestas in 2006.

A Renewable Resource Development Project (RRD) was implemented by the World Bank through IREDA from 1993 to 1999. The project had a significant impact on the wind sector in India, with wind energy capacity deployment increasing from 40 MW in 1993 to over 1,000 MW in 2000 (World Bank, 2000).

The earlier part of the decade (1990 to 2000), saw a great deal of technology transfer between Indian and foreign companies, but the scenario changed after 1998, when most of the foreign collaborators had exited the market. The late 90s and early 2000s witnessed resistance from foreign collaborators in sharing their latest technology. Modifications of wind turbines according to Indian conditions were also limited due to restricted business agreements.

[3] C-WET estimates the potential of 103 GW at 80 metres and 2 per cent land availability and Lawrence Berkley National Laboratory's estimate of 2006 GW at 80 metres (GWEC, 2012a)

[4] C-WET estimates the state-level wind potential at 80 metres height.

Installation rates began to fall from 1997 onwards, and the annual capacity additions exceeded the 1996–1997 level only in 2003–2004 (Giri, 2010). This was mostly due to reductions in tax benefits, increase in interest rates (financing costs), poor performance of installed plants, poor financial conditions of state electricity boards, which started to resist third-party sale of power, and due to increase in capital costs associated with installations (Mizuno, 2011; Rajsekhar, van Hulle, & Jansen, 1999).

The Indian manufacturing sector also faced challenges when approaching the global market. Despite increases in indigenization in the manufacturing of small-capacity turbines (nearly 80 per cent in 1997), domestic manufacturing of complex components was—and remains—low. Manufacturers struggled to meet high quality standards and were slow in adapting to the latest technologies due to limited experience. These problems negated the benefits of low labour costs. From 1992 to 2003, turbine efficiency increased only 1.6 times in India, whereas it had increased over 3.9 and 6.4 times in Denmark and Germany respectively. Though companies had started to open their R&D centres in India, crucial R&D activity was still housed in Europe. This had led to an increase in technological differences and innovation between Indian and European manufacturers (Mizuno, 2011; B. Rajsekhar, 1999).

The Electricity Act of 2003 de-licensed electricity generation, enabling a larger group of players to enter the electricity market. Supported with policy measures like accelerated depreciation and open access, coupled with options of wheeling and banking attracted many players to enter (and re-enter) the sector.

Installations of wind energy have increased at a cumulative annual growth rate (CAGR) of 26 per cent in the last decade, with annual installations of over 1,000 MW every year since 2004 (Giri, 2010). The projects are concentrated in the states of Tamil Nadu, Karnataka, Maharashtra, Gujarat and Andhra Pradesh, accounting for over 85 per cent of the total installed capacity, broadly reflecting wind-resource potential (Figure 1.4).

Backed by an enabling policy and regulatory framework, wind power installations have grown in the past few years and are widely accepted to have achieved "grid parity" in many instances, depending on the costs, efficiency and wind speeds. The introduction of the generation-based incentive (GBI) in 2009 marked a new phase of development that led to emergence and increased participation of independent power producers (IPP), such as, Mytrah Energy and Regen Powertech. Their share has grown from 35 to 40 per cent in the past two years from almost nil in the fiscal year 2010 (ICRA, 2013).

BOX 2: THE SPREAD OF WIND POWER GENERATION—NEW TERRITORIES

Gujarat has registered the highest growth in wind power generation in the past four years. Its share of India's total wind generation had risen to 17 per cent in 2012, making the state second only to Tamil Nadu. Rajasthan is also a favourable destination, on account of the FiTs on offer and power transfer infrastructure. In the past year, there has been a significant fall in capacity addition and investments in Tamil Nadu on account of continued delays by the state utility in payments to generators, besides other issues such as inadequate power transfer infrastructure and a hike in banking charges (ICRA, 2013).

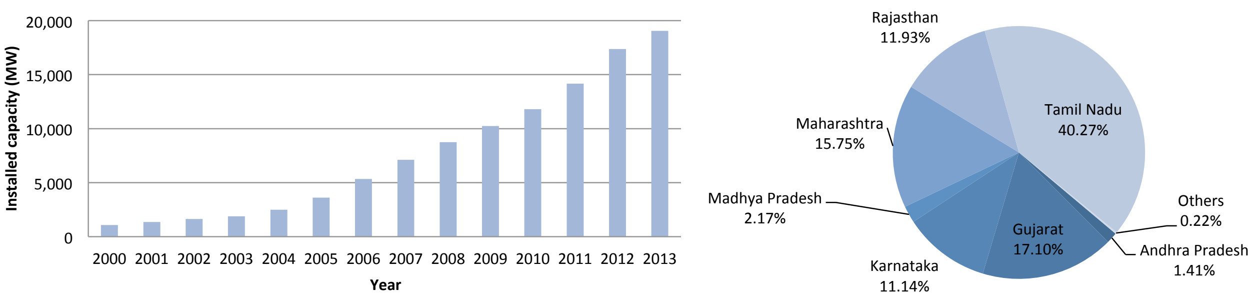


FIGURE 1.4: INSTALLED WIND POWER CAPACITY (MW) AND STATE WISE DISTRIBUTION OF INSTALLATIONS (2012)

Sources: GWEC (2012b); Indian Wind Energy Association (InWEA) (2012).

India was the third-largest wind power market in fiscal year 2011–2012 and fifth globally (after China, the United States, Germany and Spain), in terms of total wind power installed capacity. The withdrawal of AD and GBI, coupled with uncertainty over the new wind tariff announcements in the last fiscal year (2012–2013), saw annual wind installations plummet drastically between 2012 to 2013 (GWEC, 2012a).

Key Players in the Wind Sector and Industry Dynamics

It is possible to broadly consider various stakeholders in the wind industry within several levels of operation: strategic (e.g., policy-makers and implementing agencies), project implementation (including leading manufacturers and Independent Power Producers), and support infrastructure (e.g., banking and research & development) (Table 1.4).

TABLE 1.4: KEY PLAYERS IN THE WIND POWER SECTOR

ROLE	KEY PLAYERS
Strategic	Ministry of New and Renewable Energy (MNRE); Indian Renewable Energy Development Agency (IREDA); State Renewable Development Agency; Central Electricity Regulatory Commission (CERC); State Electricity Regulatory Commission (SERC); National Load Despatch Centre (NLDC)
Project Implementation (Manufacturing, Installation and O&M)	Wind turbine manufacturers; Independent Power Producers (IPP) such as Mytrah Energy and Renew Power Financiers including private equity players, Non-Bank Finance Corporations
Support	Industry associations—Indian Wind Turbine Manufacturers Association (IWTMA), Indian Wind Energy Association (InWEA), Indian Wind Power Association (IWPA), Wind Independent Power Producers Association (WIPPA); R&D institutions: Centre for Wind Energy Technology (C-WET), Private R&D Facilities;

Source: CEEW compilation

Strategic Players

MNRE laid the foundation of wind power development in India back in 1980s with its wind assessment and demonstration program. Since then it has played a crucial role in furthering the growth of the wind sector by providing a host of fiscal incentives, including tax concessions; generation-based incentives; tax holidays; customs and excise duty relief; and so forth. The Ministry has also established C-WET to carry out wind resource assessments; develop standards for wind turbines, conduct testing and certification of turbines; and undertake training and other wind energy-related R&D activities. As in the case of solar power, the SERCs are responsible for reviewing preferential tariffs and setting RPO targets for wind power. Apart from operationalization of the REC mechanism, the NLDC is also responsible for maintaining and operating the renewable regulatory fund (RRF) mechanism aimed at generating better prediction of wind power using weather forecasting tools. Public finance support to wind power developers is routed through IREDA.

Project Implementation: Domestic manufacturing

India has emerged as a major wind turbine-manufacturing hub, with major overseas and domestic manufacturers in the process of bolstering their local operations. In 2012, 16 manufacturers cumulatively had an annual production capacity greater than 9.5 GW. Since 2012, three new manufacturers have entered, bringing the C-WET list of certified manufacturers to 19 (Appendix A). It is expected that by the end of the financial year 2013-2014 the annual production capacity may reach 10,000 MW. Data from the Indian Wind Turbine Manufacturers' Association reveal that the top five manufacturers controlled 90 per cent of the market last year because small manufacturers were compelled to halt production due to a decrease in installations (Pearson, 2013).

Indian turbine manufacturers operate either through (i) joint ventures under licensed production or with technology transfer arrangements, or (ii) as subsidiaries of foreign companies, or (iii) as Indian companies with their own technology (Table 1.5). The most prominent domestic firm has been Suzlon Energy, which was established in 1995 as a result of the owners' desire to address energy shortages being faced at a family-owned textile business. The company went on to establish itself as one of the leading turbine manufacturers within five years of incorporation. Other prominent players present in the Indian market include Gamesa Corporation, Vestas and Wind World India (formerly Enercon). In the prevailing market for wind energy solutions, a number of wind turbine manufacturers such as Suzlon, Vestas, RRB Energy, Gamesa, and Inox Wind provide turnkey solutions through their domestic production centres. For example, Suzlon has a complete ecosystem in place and offering solutions ranging from design, construction and commissioning to long term operation and maintenance of systems (Suzlon, n.d.).

TABLE 1.5: OWNERSHIP/MODE OF OPERATION OF MANUFACTURING COMPANIES (APPROVED BY C-WET) IN INDIA

NATURE OF OWNERSHIP	NO. OF MANUFACTURERS
Joint venture/technology transfer agreements	9
Subsidiaries of foreign companies	6
Indian companies with own technology	4

Source: CEEW compilation

Capitalizing on the low cost of manufacturing turbines in India, Indian companies started to export their products to Europe, Australia, Brazil, and the United States (GWEC, 2009). Central and state incentives, increased domestic demand, a growing acceptance for "India-built" wind turbines in overseas markets and expansion of the in-house manufacturing capacity of the Indian wind industry have managed to attract many new manufacturers into the Indian market (GWEC, 2012a). Companies in India make turbines in the range of 250 kilowatt (kW) to 2.5 MW. The International Electrotechnical Commission specifies three turbine types to cater to varying wind conditions. Class I turbines cater to areas with higher wind resource, such as Tamil Nadu. Considering that low-wind regimes prevail in most other parts of India, manufacturers have increased production of Class II and Class III turbines with newer technologies and higher power capture capabilities in low- and medium- wind conditions in the country.

Figure 1.5 illustrates the top six Indian wind turbine manufacturers and their sales (in capacity terms) in fiscal year 2011–2012 and fiscal year 2012–2013. In fiscal year 2012–2013, Wind World (India) Ltd.[5] displaced Suzlon to become India's leading turbine supplier ("Suzlon loses top spot," 2013). Inox and General Electric (GE) made significant gains to figure in the top five that year. Inox Wind witnessed an almost five-fold increase in installations. This may be attributed to their turbine designs, which were tailored for Indian low-wind conditions and also entail lower operation and maintenance costs (American Superconductor [AMSC], 2012; Energy Next, 2013b).[6] This is a good example of collaboration in developing solutions tailored to local requirements. GE's installations surged more than six-fold to 122 MW, the biggest jump among its counterparts. The company's gain in orders may indicate a shift away from turnkey project development, as GE has a presence only in the manufacturing value chain, in contrast to its competitors, which include land acquisition and permitting as part of supply deals.

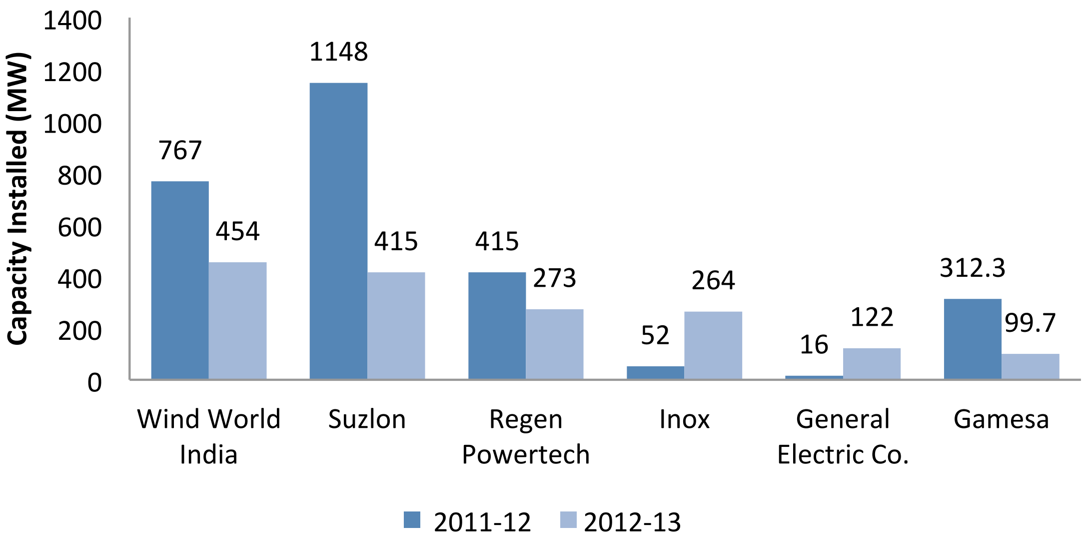


FIGURE 1.5: TOP SUPPLIERS OF WIND POWERED SYSTEMS IN INDIA

Source: CEEW compilation.

[5] Formerly the Indian subsidiary of Enercon

[6] Inox collaborated with American Superconductor Corporation (AMSC), headquartered in the United States, which specializes in power system design and manufacturing.

Support

Industry Associations and Representation

The Indian wind power sector is well represented by independent industry associations that act as a focal point for government interaction and lobbying. This includes the Indian Wind Turbine Manufacturers' Association (IWTMA), Indian Wind Power Association (IWPA) and Indian Wind Energy Association (InWEA). The Indian Wind Power Association (IWPA) was established in 1996 and has worked closely with several national industry bodies towards removing barriers to wind power development and creation of an enabling regulatory and policy environment for investments in this sector. The Indian Wind Energy Association (InWEA), established in 2002, is the central body representing all stakeholders associated with wind energy in India. In addition to organizing events and disseminating information, InWEA also offers advisory services to stakeholders interested in investments in wind sector (InWEA, n.d.). IWTMA is an association of wind turbine manufacturers in India that has actively advocated reinstatement of government incentives that were withdrawn in 2012, such as GBI and AD.

The Wind Independent Power Producers Association (WIPPA) is a newly formed association (in 2013) of wind independent power producers (IPPs). Since its inception, WIPPA has actively opposed competitive bidding and has advocated enforcement of renewable purchase obligation (RPOs) (Ramesh, 2013c).

R&D—Building confidence in wind technologies

MNRE norms for installation of wind turbine models at any wind farm site in the country require manufacturers to obtain a valid type certificate from an internationally accredited certification agency or C-WET. MNRE, through C-WET, has also developed a localized wind turbine certification scheme, based on the IEC system for conformity. The "Type Approval – Provisional Scheme (TAPS 2000)" aims to ensure quality, safety and reliability of the wind turbine and increase confidence amongst financiers and support bankability. (MNRE, n.d. a; CEEW & NRDC, 2012).

BOX 3: OFFSHORE WIND AND REPOWERING – UNTAPPED POTENTIAL

Off-shore wind: MNRE issued its draft policy for development of offshore wind energy in 2013, which aims to deploy wind farms within territorial waters (12 nautical miles). Preliminary assessments have indicated that the coastlines of Tamil Nadu (Rameshwaram and Kanyakumari) and Gujarat have reasonably high offshore wind potential. A recent study conducted by WISE estimates Tamil Nadu's offshore wind potential at 127 GW at 80 metres height, although this is yet to be corroborated by other studies (MNRE, 2013e). A separate study also estimates that India has the potential to develop 350 GW of offshore wind energy in the long term (PIB, 2013c).

Repowering: Repowering low-capacity and aging wind turbines can lead to improved efficiency, grid integration and higher energy yield. At present, Germany, Denmark, the United States and the Netherlands are at the forefront of the repowering movement. India's current repowering potential is estimated at approximately 2,760 MW (GWEC, 2012a), but there are numerous practical challenges (involving land ownership, lack of supporting state policies or economic incentives), which hinder realization of this potential. Tamil Nadu, having several aging wind farms (older than 15 years) located in wind-rich districts, is a state with high repowering potential. Gamesa was the first company to implement a wind repowering project in India—"Project Avatar" in Tamil Nadu in 2011 (MNRE, 2011a).

2. The Policies

Recognizing the vulnerability of the country to energy price shocks and the inherent state of energy scarcity, India has a long history of efforts to promote RE: for example, in 1992 India was the first country to set up a ministry dedicated to RE. Section 2 classifies India's extant RE policy framework into three categories: overarching, direct and indirect policies. Overarching policies are those that may address broad issues related to various forms of energy and are not confined to the solar or wind energy sectors. Among other things, overarching policies provide a direction for the power sector in the country and set broad goals in line with the optimal use of the country's energy resource endowments. Direct policies are designed to address the needs of the RE energy sector by assisting the relevant manufacturing entities and parties involved in project development. Indirect policies refer to those that help strengthen the supporting environment for these technologies and revolve around broader initiatives for R&D in science and technology, human resource development and financing—or project development and R & D.

Figure 2.1 (pg. 23) captures the timelines of the various policies discussed below in chronological order, within the context of the broader developments in the Indian economy and commensurate growth in RE capacity in the country.

2.1 Overarching Policies

The Electricity Act, 2003 paved the way for regulatory interventions which supported and accelerated the development of renewable energy. Section 86.1(e) of the Act mandates SERCs to fix quotas (in terms of the percentage of electricity being handled by the power utility) to procure power from renewable energy sources. It requires SERCs to determine the tariff for all renewable energy projects across the state and ensure connectivity to the grid for project sites that are generally in remote locations and away from major load centres (Ministry of Power, 2003). The Electricity Act necessitates the preparation and notification of a National Electricity Policy, Tariff Policy and Grid Code periodically, for the optimal utilization of various energy resources within the country. These are periodically amended and updated to ensure their continued relevance in a constantly changing energy portfolio.

The National Electricity Policy calls for a better utilization of non-conventional energy sources including solar and wind for additional power generation capacity (PIB, 2005). The policy recognises the need to reduce capital costs of renewable energy projects by promoting competition.

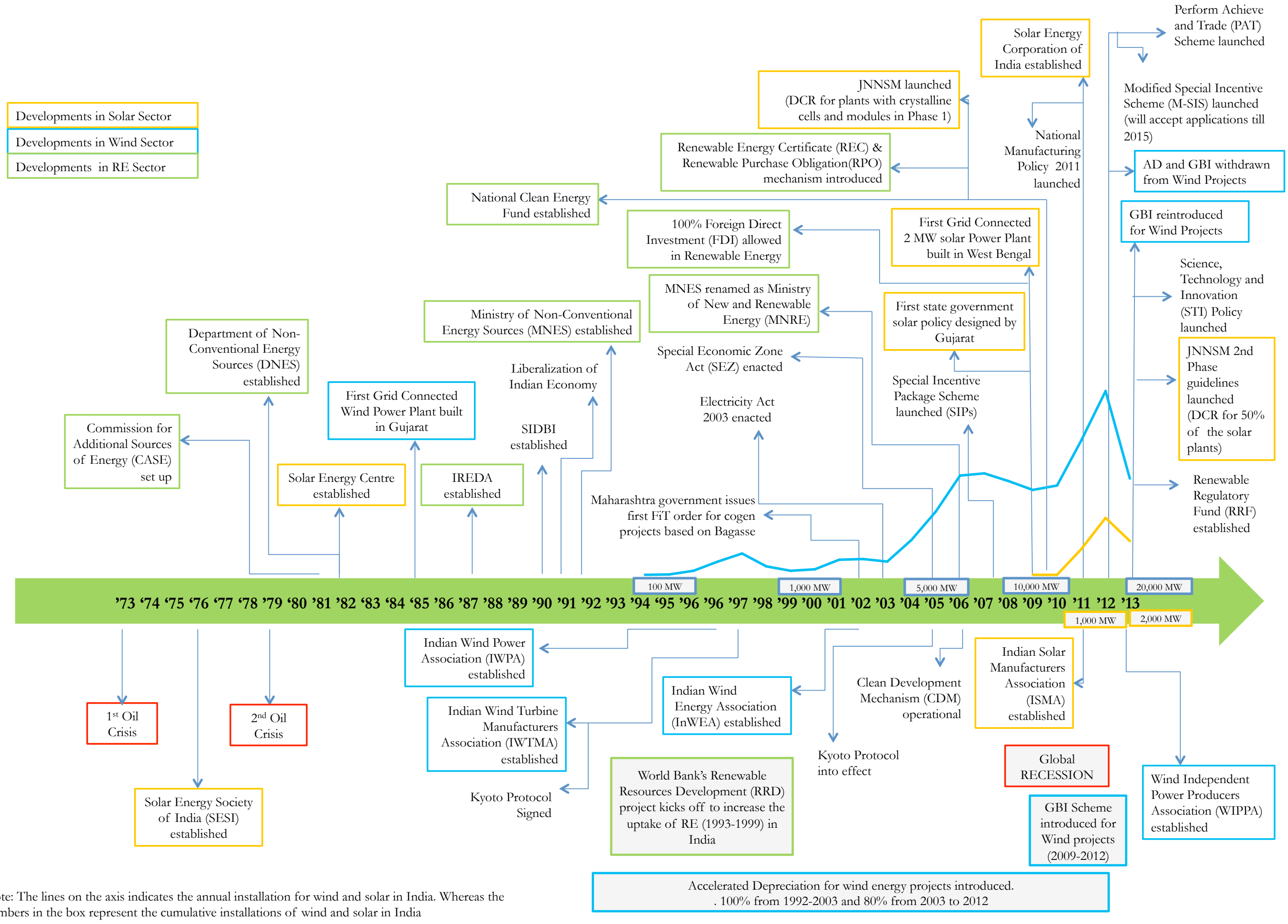
The National Tariff Policy (2006) mandated SERCs to fix a minimum percentage of Renewable Purchase Obligation (RPO) from RE sources taking into account availability of such resources in the region and its impact on retail tariffs and procurement by distribution companies at preferential tariffs determined by the SERCs (Ministry of Power, 2006). The policy was amended in January 2011, prescribing that the solar-specific RPO be increased from a minimum of 0.25 per cent in 2012 to 3 per cent by 2022 (PIB, 2011b).

The Indian Electricity Grid Code (IEGC) 2010 is a regulation developed by CERC, which lays down the methodology for scheduling wind and solar energy and a basis for compensating the states with a large wind and solar energy potential for dealing with the potentially large degree of variability in generation. This was done through a renewable regulatory charge operated through the renewable regulatory fund (RRF) mechanism. IEGC stipulates that power system operator (state/regional load dispatch centres) shall make all efforts to evacuate the available power from RE sources (CERC, 2010a).

The Integrated Energy Policy (IEP), formulated by the Planning Commission in 2006, provides a broad framework for all policies governing production, distribution and use of different energy sources. The policy emphasized the need to step away from capital subsidies towards performance incentives, for example, in the form of tradable tax rebate certificate (TTRC) that could be based on actual energy generated. IEP also suggested that power regulators create alternative incentive structures such as mandated feed-in-laws or differential tariffs to encourage utilities to integrate power from RE sources into their systems. The IEP envisions a limited role in power generation for renewable energy sources, with only 5 per cent to 6 per cent of renewables based electricity in the grid even by the year 2032. The policy suggests that renewables would only prove a crucial component to India's energy independence beyond 2050 (Planning Commission, 2006a).

Finally, although not a policy in itself, the *National Action Plan on Climate Change (NAPCC)*, announced by the Government of India (GOI) on July 30, 2008 outlined eight national missions for achieving a low-carbon growth path (PM Council on Climate Change, 2008). These include National Missions on Solar Energy, on Enhanced Energy Efficiency, on Sustainable Habitat, on Conserving Water, on Sustaining the Himalayan Ecosystem, on creating a "Green India", on Sustainable Agriculture and finally, on establishing a Strategic Knowledge Platform for Climate Change. A bio-energy mission; clean coal mission and wind mission are also reportedly under consideration.

As one of its strategies to combat climate change, NAPCC envisages renewable energy to constitute approximate 15 per cent of the energy mix of India by 2020. In order to achieve the target, NAPCC pegged the minimum share of renewable energy in the national grid at 5 per cent, starting 2009-10. This share is slated to be increased by 1 per cent per annum to reach 15 per cent by 2020. Note that the NAPCC targets are not in alignment with the IEP which envisages contribution of renewables in the total energy mix to be in the range of 5 per cent to 6 per cent by as late as 2032. The JNNSM was launched under the NAPCC in 2010 to create an enabling policy framework for increased solar power in the country. One of the initiatives for clean energy under NAPCC includes promoting trade in Renewable Energy Certificates (RECs) across states in order to comply with RPOs (PM Council on Climate Change, 2008).



Note: The lines on the axis indicates the annual installation for wind and solar in India. Whereas the numbers in the box represent the cumulative installations of wind and solar in India

FIGURE 2.1: TIMELINE OF POLICY DEVELOPMENTS

2.2 Survey of the Various Direct Policies

This section describes the various direct policies and incentives that have catalyzed the growth of solar PV and wind power sectors in India. The direct policy framework has been classified in five broad categories: direct financial transfers; preferential tax treatments; R&D support; demand stimulation and manufacturing linked incentives (Figure 2.2).

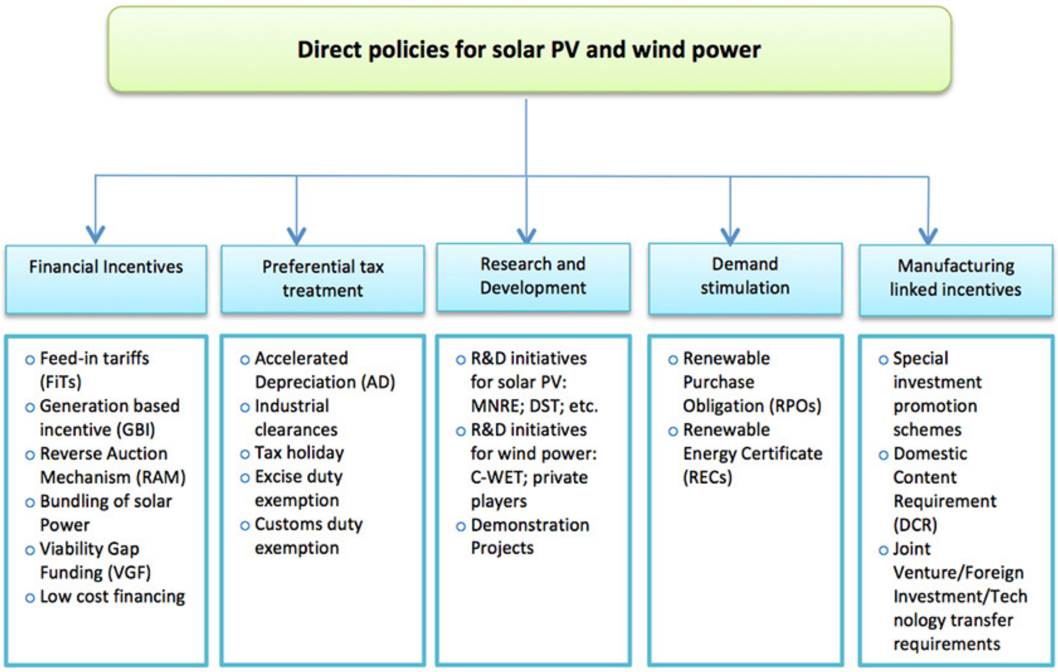


FIGURE 2.2: OVERVIEW OF VARIOUS RE ENABLING DIRECT POLICIES

Source: CEEW compilation, (Ghosh 2012b).

2.2.1 Financial Incentives

Direct Financial Transfers: Feed-in Tariffs, Generation-Based Incentives

General Policies

Feed-in-tariffs (FiTs) were first adopted in India by states such as Maharashtra, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, and Karnataka in the early 2000s (Institute for Building Efficiency, 2010). These were later introduced on a national level to increase the contribution of renewable energy to the energy mix for which CERC issued guidelines for fixing the tariffs. CERC determines the tariff on the basis of the following fixed-cost components: a) return on equity; b) interest on loan capital; c) depreciation; d) interest on working capital; e) operation and maintenance expenses. The tariffs determined under CERC regulations are also based on some technology specific parameters, such as capital costs, interest on working capital etc. The tariff is determined using the discount rate, which is the average weighted cost of capital (CERC, 2009). While the CERC issues generic tariff regulations that provide a guiding benchmark for SERCs to set their tariffs, the actual prevailing rates in the states are determined by the SERC. They typically interpret the CERC specified FiT as a reference figure but may declare tariffs that are higher or lower, depending on the resource endowment and cost implications to the utilities. A detailed listing of FiTs across solar and wind available to project developers in various states can be found in Appendix B: **Solar and Wind Energy FiTs**.

The tariffs are representative of the levelized cost of electricity, and are derived from the specific useful life of each technology. The feed-in tariff period for most renewable energy technologies is 13 years, extended to 25 years for solar PV. The tariff would be revised periodically, taking into consideration the escalation of normative operation and maintenance expenses at the rate of specified rates (CERC, 2012a). Prior to the roll out of the JNNSM (in its current form) CERC set the tariff at Indian rupee (INR) 17.91 per kilowatt-hour (~ US$0.30) for solar PV projects whose power purchase agreements (PPAs) were signed on or before March 31, 2011 and INR 15.39 per kilowatt-hour (~ US$0.20) for solar PV projects whose PPAs were signed after that date, expecting a downward push on prices going forward. Though these were the tariffs that were set, the Reverse Auctioning Mechanism (detailed in a later section) resulted in much lower tariffs ranging from INR 7 to INR 12.[7] Over the last year, SERCs have raised the wind FiTs in a range from 4 to 34 per cent across the six key Indian states with the greatest wind energy potential (see Appendix B).

A Generation-Based Incentive (GBI) scheme[8] was introduced for the first time in 2008, for solar projects of less than 1 MW and for a total of 50 MW of capacity, on a first-come, first-served basis (PIB, 2008). The scheme was continued under the national solar mission as "Rooftop PV & Small Solar Power Generation Programme" (RPSSGP) for projects (each) with capacity less than 2 MW, connected to a distribution network at voltage levels below 33 kV. The scheme was only available for the first 100 MW of capacity that was installed, and is merely to spur the rooftop and small-PV market. The Indian Renewable Energy Development Agency (IREDA) is responsible for the disbursement of GBI. For solar power, a project developer is required to be pre-registered with the state-designated agency and then register online with IREDA. Projects registered with IREDA are eligible for the GBI; however, there is a cap of 100 MW (with a project capacity range of 100 kW to 2 MW each, connected to a high-tension grid below 33 KV); allocated on a first-come, first-served basis. The project developer is also required to meet the technical requirements on performance and grid connectivity of the solar power plant. (PIB, 2011c). As per the CERC draft tariff order for determination of levelized tariff for solar PV technology, in 2013–2014 it has been revised to INR 8.75 (~US$0.15) per kWh.[9] The difference between the levelized tariff and the base price[10] is the GBI (INR 2 to 3 per unit) and is provided by MNRE (MNRE, 2012e). This is substantially lower than the GBI provided during Phase 1. This is a result of the lowering of the levelized tariff, which in turn was driven down by aggressive price reductions in the auctioning for Phase 1 of the NSM. However, there are currently no further projects being accepted under the GBI scheme.

The GBI scheme for grid-connected wind projects was implemented in December 2009 as part of the 11th FYP (MNRE, 2009). For wind projects, while there are no capacity requirement specifications, a fixed GBI of INR 0.50 (~US$0.01) per kWh that is supplied to the grid, is provided for a period not less than four years and a maximum period of 10 years, with a cap of INR 6.2 million (~US$112,000) per MW of installed capacity. For wind power projects, developers could either access the GBI scheme or AD, but not both (PIB, 2011c). Both AD and the GBI were withdrawn in 2012, which contributed to a 50 per cent drop in capacity additions in the last fiscal year (2012–2013).

Low-Cost Financing: In an effort to alleviate barriers arising from high cost of finance for renewable power projects, GoI has decided to provide low interest bearing loans (through IREDA) to viable renewable energy projects (Ministry of Finance, 2013). This scheme, introduced during budget of 2013 to 2014, has a lifespan of five years and will serve to attract more investors in renewables (including both solar PV and wind power sectors) (Budget 2013, 2013).

---

[7] The average cost of power supply in the country is INR 4.87 per kWh (Planning Commission, 2012)
[8] GBI is a top-up provided to RE power producers in addition to the tariff approved by various state regulators.
[9] INR 7.87 (~ US$0.14) per kWh after considering the benefit of accelerated depreciation (AD).
[10] Normatively fixed at INR 6 and corresponds to the average pooled price of electricity.

Solar Policies

Under JNNSM Phase1, the government selected projects through a reverse auction mechanism (RAM) under which the project developers bid at a discount to the tariff ceiling set by CERC (CEEW & NRDC, 2012). Projects were selected based on lowest cost, which resulted in huge discounts over the initial FiTs (IDFC, 2011). Under Phase 1 – Batch I, the average tariff for selected PV projects was INR 12.16 per kWh, which was 32 per cent lower than the CERC approved benchmark tariff of INR 17.91 per kWh. Under Batch II, the average tariff came down to INR 8.77 per kWh, which was 43 per cent lower than the CERC-approved benchmark tariff of INR15.39 per kWh (MNRE, 2012e).

A **"Bundling of Solar Power"** scheme was introduced, whereby the NTPC Vidyut Vyapar Nigam (NVVN), a power-trading company, was approved as the nodal agency to sign PPAs with project developers and sell it on to electricity utilities/DISCOMs. In order to share the burden of the increased cost of solar power among all utilities, NVVN bundled power from solar generation with unallocated[11] conventional coal-based power. The bundled price would work out to approximately INR 5 (~US0.09) per kWh (CEEW & NRDC, 2012).

For Phase 2, MNRE has proposed to fund solar projects through a **viability gap funding** (VGF) mechanism due to the limited amount of unbundled power available. The VGF mechanism subsidizes the capital cost of accessing infrastructure provided through the PPP framework to make economically essential projects commercially viable. Under Phase 2 of JNNSM, bidders would bid for VGF requirement in INR/MW and the selected bidder would be the one with the minimum VGF requirement. To meet the requirements of funding through VGF, MNRE has requested the Ministry of Finance to disburse between INR 15 to 20 billion (~US$272 million) from the National Clean Energy Fund. Under VGF, the Solar Energy Corporation of India (SECI) would pay a tariff fixed at INR 5.45 (US$ 0.10) per kWh, which will remain firm for a project period of 25 years. This tariff would get reduced to INR 4.95 (~US$0.09) per kWh (i.e., by 10 per cent) in case the benefit of accelerated depreciation is received (MNRE, 2013f).

2.2.2 Preferential Tax Treatment and Trade/Investment Restrictions

In order to promote RE (specifically wind and solar energy) in India, several other direct incentives in the form of preferential tax treatment and trade/investment are offered by the GOI. They include:

- Accelerated depreciation.
- Waiving of industrial clearances.
- Waiving of clearances required from the Central Electricity Authority (CEA) for generation projects up to INR 1 billion (~US$ 18 million).
- Tax holiday.
- Excise duty and customs duty exemptions/reduction.

Accelerated Depreciation (AD): Under section 80(I)(C) the of the Indian Income Tax code, a company (commercial or non-commercial) is allowed to claim 80 per cent of the project cost under the AD scheme in the first year of installation leading to savings on income tax and overall profit. . Prior to its withdrawal in April 2012, AD drove a third to half of annual wind energy installations (Pearson, 2013).

Also, under section 80(I)(A) of the Income Tax Act, the central government offers a **10-year tax holiday** within a block of the first 15 years during the lifecycle of all infrastructure projects, which also includes renewable energy power generation projects.

[11] Power from central government owned generation facilities that does not get allocated to states as part of their share

Other tax benefits include **excise duty exemptions** and **concessions** on specified renewable energy devices, reduction in customs duty by 5 per cent (Energetica India, 2013) on equipment for solar photovoltaic, and wind power machinery.

Ten states in India have currently announced their own solar policies, which provide preferential tariff and other benefits such as single window clearances, transmission facility, tax exemptions, and development of solar parks, among others (Appendix C).

BOX 4: KEY PROVISIONS IN STATE SOLAR AND WIND POLICIES

Land acquisition

Conducive state land allocation policies can help a state emerge as a favoured destination for renewable energy projects.

- The Rajasthan state government allots land to wind and solar power developers either on lease or at a concessional rate of 10 per cent of the market rate (GoR, 2011; GoR, 2012).
- Gujarat, in its Wind Power Policy 2013, has introduced provisions for allocating the state's vast tracts of wasteland for wind installations (GEDA, 2013b).

Unfavorable land acquisition policies can also detract investments in clean energy projects. For example, West Bengal's policy to allocate state-held land through competitive bidding has been a roadblock in attracting investments for wind farm projects in the state (Bose, 2013).

Solar parks: A package deal

Solar parks enable streamlining of project development timelines by allowing government agencies to undertake land acquisition and necessary permits, and provide dedicated common infrastructure (in the form of developed land, water, gas availability and access roads, power transmission system) for setting up solar power generation plants by private developers.

Advantages

- Solar parks can lead to reductions in cost of solar power by providing economies of scale in procurement, permit acquisition, and development of power.
- Well-planned solar parks can reduce project implementation risks for developers and expedite project execution.
- Grid connectivity has not emerged as a major issue in Gujarat and Rajasthan (where the majority of solar PV is being deployed) in part because of the states' approach to using solar parks (CEEW & NRDC, 2012).

Disadvantages

Dependency on a solar park developer or the government for correct project siting and assessment of solar resource potential can also mean increased project costs (CEEW & NRDC, 2012).

2.2.3 Research and Development in Green Technologies

In India, the ratio of public to private sector investment in R&D currently stands at 3:1 (GoI, 2013a). India's 12th FYP (2012–2017) has earmarked approximately US$24 billion for investment in R&D—a 2.5 fold increase when compared to R&D spend in the 11th FYP (Jayaraman, 2012). Gross Expenditure on R&D (GERD) in the year 2009–2010 was mainly driven by the public sector, with the central government contributing 54.4 per cent, state governments 7.3 per cent, higher education 4.1 per cent and public sector industries 5.3 per cent. The contribution of private sector industries has only been 28.9 per cent during that period (DST, 2013).

> **MNRE's key focus areas (R&D) for scaling manufacturing:**
>
> - MW scale SPV power generating systems.
> - MW scale wind turbine electric generators for low wind regimes.
> - Simulators for RE grid-interactive power stations (MNRE, n.d.g)

MNRE established a Research Development and Design (RD&D) division in 1994 to make renewable energy in India competitive and renewable energy generation supply self-sustainable/profitable. It also facilitates industry in technology mapping and benchmarking; implementation of research, design, development, demonstration and manufacturing; and improving international competitiveness (MNRE, 2010c). Other than a dip in 2009, R&D investments in renewable energy, as outlined by MNRE have shown an increasing trend (Table 2.1). The budgets cover R&D expenses (machinery, equipment, scholarships, etc.) and grants-in-aid, but exclude subsidies for various schemes to promote RE.

TABLE 2.1: MNRE BUDGETARY ALLOCATION FOR TOTAL R&D IN RENEWABLES (IN INR MILLION)

YEAR	BUDGET ESTIMATE	REVISED ESTIMATE	ACTUAL EXPENDITURE
2009-10	750	628.1	589
2010-11	1480	1230	891.8 (as on 31/01/2011)
2011-12	930	1132.5	1104.1
2012-13	1920	1250	690.3 (as of 31/01/2013)

Source: MNRE (2012b) ; MNRE (2013b).

R&D for solar and wind is largely focused on applied research and has been led by the government with little involvement of the private sector. The government has set up two institutes to specifically focus on R&D. The National Institute of Solar Energy (formerly Solar Energy Centre) was set up in 1982 by MNRE to focus on development on solar energy technologies, and the Centre for Wind Energy Technology (C-WET),set up in 1998 by MNRE in collaboration with Riso National Laboratory, Denmark to act as a technical focal point for wind energy (Joshua Earnest, 2011). Budgetary allocations for the two institutions are outlined in Table 2.2.and Table 2.3 goes on to highlight institutions and agencies which focus on R&D in solar or wind energy.

TABLE 2.2: MNRE BUDGETARY ALLOCATION FOR SEC AND C-WET (IN INR MILLION)

INSTITUTION	BUDGET ESTIMATE 2011-12	BUDGET ESTIMATE 2012-13
SEC	125	110
C-WET	50	200

Source: MNRE (2012b); MNRE (2013b).

TABLE 2.3: R&D INSTITUTIONS IN INDIA

TYPES OF INSTITUTIONS	SOLAR ENERGY	WIND ENERGY
Government/ Academic	• National Institute of Solar Energy(Solar Energy Center) • NCPRE, IIT Bombay • National Physics Laboratory, New Delhi • IIT Delhi	• C-WET
Private	• HHV Bangalore • Maharishi Solar • Moser Baer Solar	• Suzlon • Vestas • General Electric • Gamesa

Source: CEEW compilation

Demonstration Projects

Presently, MNRE's Special Area Demonstration Project Division implements demonstration projects to demonstrate application of renewable energy systems in a project mode at locations of national importance as well as in energy parks. Most of the active efforts (currently) in RE demonstration projects cater to solar energy (MNRE, 2010d).

The JNNSM places an emphasis on demonstration projects to promote technology development and cost reduction. In its first phase the mission had proposed to set up demonstration solar plants such as (MNRE, 2010b):

- A 100–150 MW solar hybrid plant with coal, gas or biomass to address variability and space constraints; and
- Grid-connected rooftops PV systems on selected government buildings and installations, with net metering.

Though the status of the above mentioned projects is not clear, the Solar Energy Centre (SEC) has successfully established a number of technology demonstration projects which includes a 46 KW solar PV power project within the premises of the SEC (MNRE, n.d.f).

In the case of wind, demonstration projects are developed in states where there is a sizable wind potential, but where commercial wind power projects have not yet been initiated. They are implemented through the state governments, state nodal agencies or state electricity boards. Under the Special Area Demonstration Project Division's program, a total wind power capacity of 71 MW was established in 33 different locations (MNRE n.d.h). The 11th Plan kept a provision of INR 750 million (US$13.6 million) for wind power demonstration projects. Support has been limited to 1 per cent of technical potential or 5 MW per state, whichever is lower at INR 25 million/MW (US$0.45 million) (Planning Commission, 2006b).

BOX 5:DEMONSTRATION PROJECTS – ONE OF THE KEY TRIGGERS OF WIND POWER REVOLUTION

- Department of Non-conventional Energy Sources (DNES), constituted under the Ministry of Non-conventional Energy Sources (now MNRE) initiated a wind farm demonstration program in 1986 that offered substantial grants to five projects of 550 kW each across four states: Gujarat, Maharashtra, Tamil Nadu and Odisha (GWEC-IRENA, 2013).
- Further commercial-scale deployment of wind was supported in 1988 when the Indian government and DANIDA developed two commercial projects of 10 MW each in the states of Gujarat and Tamil Nadu. These DANIDA-sponsored projects marked the first demonstrations of large-scale grid-connected wind farms in India. The success of these demonstration projects, in conjunction with favourable policy measures, led to private sector participation in wind energy (GWEC-IRENA, 2013).

R&D Support for Solar PV

MNRE's photovoltaic R&D efforts are aimed at improving overall system efficiency and cost reduction. The specific focus areas include:

- Improvement of efficiency in existing materials.
- Reducing the costs of balance of systems, establishing new applications by addressing issues related to integration and optimization.
- Developing cost-effective storage technologies that would address both variability and storage constraints.
- Targeting space intensity through the use of better concentrators, application of nano-technology and use of better and improved materials.

Along with the creation of the National Institute of Solar Energy, 11 existing institutions have been designated as "Centres of Excellence" in thematic areas of research and education. Five of them focus on solar PV technology (Table 2.4)

TABLE 2.4: CENTRES OF EXCELLENCE FOCUSING ON SOLAR PV

CENTER OF EXCELLENCE	TECHNOLOGY
NCPRE, IIT Mumbai	PV technology
Amrita Vishwa Vidyapeetham, Cochin	Integrated nanomaterial-based photovoltaic storage devices and development of an integrated panel consisting of PV cells and nano structured super capacitors cells
Indian Institute of Chemical Technology, Hyderabad	Dye-sensitized solar cells
National Chemical Laboratory, Pune	Dye-sensitized solar cells
National Physics Laboratory, Delhi	Thin film solar cells

Source: MNRE (2012a); MNRE (2013a).

MNRE has also set up targets and taken initiatives to spur R&D in cells and modules (Table 2.5).

TABLE 2.5: R&D INITIATIVES IN INDIA IN 2012

INITIATIVES /TARGETS	ORGANIZATION
Development of polysilicon material	Maharishi Solar
20–22% efficiency single crystal silicon cells	IIT Mumbai
10–12% efficiency nano-crystalline thin film modules	IACS Kolkata, HHV Bangalore, National Physics Laboratory, BES University-Howrah
12–15% efficiency CIGS cells	Moser Baer, National Physics Laboratory, KIIT University
10–12% efficiency Dye sensitized cells	Amrita Nano Centre, IIT-Kanpur
6% efficiency organic-inorganic hetero junction cells	Delhi University ,IIT Delhi

Source: Bhargava (2012).

BOX 6: OTHER KEY INITIATIVES

The Department of Science and Technology (DST), GoI, has a mandate to promote R&D activities. DST's initiative on solar energy is positioned upstream, focusing on the entire spectrum of solar technologies including balance of systems. This is expected to be achieved through nurturing of R&D groups, formation of consortia and setting up of state-of-the-art facilities. Solar energy use in electricity and non-electricity applications, with the aim of developing convergent technology solutions under real-life conditions, is being explored and assessed (DST).

In 2011, the India-U.S. Joint Clean Energy Research and Development Centre awarded three matched grants to facilitate collaborative R&D in Solar, Building Efficiency and 2nd Generation Biofuels. The solar grant was awarded to a consortium led by the National Renewable Energy Laboratory in the United States and Indian Institute for Science in India. SERIIUS (the Solar Energy Research Institute for India and the United States) seeks to decrease the cost per MW of solar PV. The initiative's objectives include focused fundamental and applied research efforts to create disruptive solar PV technologies.

R&D Support for Wind Power

The Centre for Wind Energy Technology (C-WET) carries out technical research for wind power development, realizes wind power assessments, provides information, training and commercial services, and tests facilities as per national standards. The R&D activities of C-WET are arranged into five areas (C-WET, n.d.b):

- Improvement in performance of existing wind turbine installations
- Research support for wind resource assessment
- Labour training and HRD
- Technology support to wind power industry
- Research and advanced technology development

Though C-WET acts as a focal point, R&D for wind energy in India has been led by private players, with companies like Vestas, Gamesa, Suzlon and General Electric setting up dedicated research and development facilities in different parts of the country. Indian organizations have formed joint ventures with foreign firms and highly rely on their technological capability and R&D facilities (Mizuno, 2011).

2.2.4 Demand Stimulation

General Policies

Renewable Purchase Obligations (RPOs) devised under the Electricity Act 2003 have been a major driving force in the progression of the renewable energy sector, under which distribution utilities and large captive consumers are required to buy a certain percentage of electricity from renewable energy sources (CERC, 2003). Though the CERC in 2010 had recommended a standardized RPO target of 5 per cent in every state, state RPO targets in reality range between 1 and 20 per cent, and most states have been unable to achieve them (Greenpeace India, 2013).

After the launch of JNNSM, almost every state announced its own solar-specific RPO (a solar specific percentage as a part of the overall RPO) which range from 0.25 per cent to 0.5 per cent and are expected to go up to 3 per cent by 2022 as envisaged in the Mission guidelines (MNRE, 2010b). Appendix D details the overall RPO targets and solar specific RPOs for the fiscal years 2012–2013 and 2013–2014. The overall cumulative targets set by various state regulators stand at 5.44 per cent, which is not in agreement with the national target of 7 per cent set out under the NAPCC (with 5 per cent as national RE target in 2010 and a 1 per cent increase annually till 2020). This results in a deficit of 1.56 per cent, translating into around 14,268 million kWh of electricity from RE projects. Studies have pointed out that states have formulated ineffective and unambitious RPO targets due to a lack of clear rationale or standardized guidelines (Greenpeace India, 2013).

RPOs are facilitated by the **Renewable Energy Certificate (REC)** mechanism, which is a market-based instrument to promote renewable energy and are tradable in the market through a power exchange platform. It helps the obligated entities[12] to meet their RPO targets by purchasing traded REC (Climate Policy Initiative, 2012). Figure 2.3 indicates that wind power projects contribute a large majority of the total generation registered under the REC mechanism. Almost 41,092 Solar RECs have been issued (as of September 2013) but only half of them have been redeemed. (RECRI, 2013).

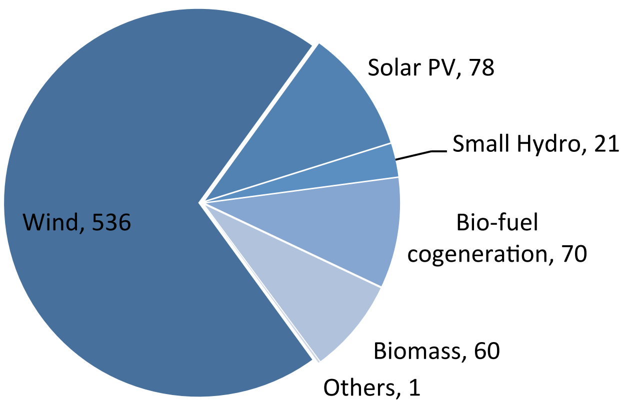


FIGURE 2.3: SOURCE-WISE UNITS REGISTERED UNDER REC (MWh) AS OF 31 AUGUST, 2013

Source: CEEW analysis

[12] Obligated entities include include distribution companies, captive consumers, and any open-access users.

BOX 7: HOW HAVE THE RPOs/RECs FARED?

The electricity utilities of nearly 22 states failed to meet their renewable energy target for 2012 (Greenpeace India, 2013). There had been a significant drop in demand for RECs in 2012 that showed the lack of interest by obligated entities to buy them. This was largely due to non-enforcement of RPO targets by state regulators across the country (Ramesh, 2012b), and had resulted in oversupply of RECs. As of October 2013, demand for non-solar RECs have increased more than three fold since September, and for solar RECs demand has marginally improved (by 38 per cent) since last month. This improvement in demand may be due to ongoing enforcements efforts by SERCs. Clearing prices for both non-solar RECs and solar RECs remained at floor prices and were INR 1,500/ REC and INR 9,300/ REC respectively (REConnect Energy Solutions, 2013).

2.2.5 Manufacturing-Linked Incentives

Special Investment Promotion Schemes

The JNNSM aims to create favourable conditions for manufacturing in solar energy sector in India. It aims to reduce the dependency on imports and develop India as a solar energy hub. A manufacturing capacity target of 4–5 GW of equivalent of installed capacity which includes 2 GW of polysilicon solar cells has been set for 2020. It may be achieved through proactive implementation of the SIPS (Special Incentive Package Scheme) and now through the M-SIS (Modified Special Incentive Scheme) (MNRE, 2010b).

To support the SMEs (Small and Medium Enterprises) in the manufacturing sector, IREDA may also provide low-interest refinance options for expansion of facilities, technology upgradation and working capital (MNRE, 2010b).

In order to encourage export-oriented manufacturing, RE industries are provided with the same incentives as other manufacturing industries when sited within a *special economic zone* (SEZ). Those investing in a SEZ can avail a range of fiscal and non-fiscal benefits such as income tax benefits; exemption from customs/excise duties, minimum alternate tax act, dividend distribution tax, central sales tax and service tax (Department of Commerce, MoC&I):

The *'Special Incentive Package'* scheme (SIPs) was launched by the Department of Electronics and Information Technology (under the Ministry of Communication and Information Technology) to encourage investment in semiconductor fabrication and ecosystem units. Fifteen applications of solar photovoltaic manufacturing domain were included in the SIPs scheme. Under this scheme, the minimum investment required for a fabrication unit and for the ecosystem unit was INR 25 billion (US$454 million) and INR 10 billion (US$182 million) respectively. The scheme required the central government to provide a capital subsidy of either 20 or 25 per cent depending on whether or not it was located in a special economic zone (SEZ) (GoI, 2009). The scheme was available until March 2010 (IESA, n.d.).

An SEZ for semiconductor and solar energy sector was set up in Hyderabad, Andhra Pradesh in 2006. The Andhra Pradesh Industrial Infrastructure Corporation (APIIC) had allotted 475 acres of land to 23 industries with an expected investment of US$9 billion (APIIC, n.d.). However, only three industries have been set up following six years of operation. (Mahesh,2013)

It was estimated that investment by various enterprises in SIPs may lead to an additional 8 to 10 GW of solar power by 2022, which would be sufficient to meet the targets of the JNNSM even after accounting for exports (MNRE, 2010b). The government had received 26 project proposals worth US$51.7 billion under this scheme (Sahoo & Shrimali, 2013). Of this, 12 were solar energy enterprises that submitted proposals involving investment worth INR 939 billion (US$17.1 billion) (PwC, 2012). However, owing to challenges such as high threshold investment requirements and lack of documentation, most of the proposals were rejected (Sahoo & Shrimali, 2013). It is noteworthy that the only four of the projects under consideration for financial support are related to solar industry. This clearly indicates that the MNRE's attempt to leverage the SIP scheme to support the manufacturing industry under the Mission has not been successful.

A similar scheme Modified – Special Incentive Scheme (M-SIS) with lower threshold investment requirements was launched in July 27, 2012 to attract investment to the Electronics System Design and Manufacturing (ESDM) Industries and would remain effective until July 26, 2015. The financial incentives offered include 20 per cent capital expenditure subsidy for units located in an SEZ and 25 per cent capital expenditure subsidy for those not located in an SEZ, and also a reimbursement of Excise/CVD on imported capital equipment. The threshold investment requirements for solar photovoltaic fabrication units are indicated below (Table 2.6).

TABLE 2.6: THRESHOLD INVESTMENT REQUIRED FOR SOLAR PHOTOVOLTAIC FABRICATION UNITS

TECHNOLOGY		THRESHOLD INVESTMENT (INR BILLION)	THRESHOLD INVESTMENT (US$ MILLION)
Polysilicon Technology	Polysilicon	6.5	118
	Ingots and/or wafers	4	73
	Cells or cells and modules	1	18
Thin Film Technology	Cells or cells and modules	3	55

Source: DeitY (2012).

National Manufacturing Policy: A National Manufacturing Policy was announced in 2011 that aims to increase the share of manufacturing in the GDP to 25 per cent and create 100 million jobs by 2021–2022. Under the policy, National Manufacturing and Investment Zones (NMIZ) would be set up across the country to provide the necessary infrastructure support to the industries. The policy proposes to provide multiple financial, fiscal and infrastructure support for all industries. It is designed to be technology-neutral, location-neutral and sector-neutral but has special focus on industries under the category "Priority Sector". Solar and Wind Energy sectors are categorized as a "Strategic Industry" under "Priority Sector classification." The government also aims to incentivize solar domestic manufacturing by considering a requirement of local content in public procurement (Department of Industrial Policy & Promotion [DIPP], 2011).

Domestic Content Requirements [13]

Through the announcement of the policy for a National Solar Mission, the government aims to "create the necessary environment to attract industry and project developers to invest in research, domestic manufacturing and development of solar power generation and thus create the critical mass for a domestic solar industry" (MNRE, 2010b, p. 3). In view of the above directive, the government expected developers to procure their project components from domestic manufacturers, as far as possible.

[13] In the Indian context domestic content requirement is the preferred term, as opposed to local content requirement. They may be used interchangeably.

In NSM Phase 1, Batch I, projects based on crystalline silicon technology had to use modules manufactured in India, whereas in Phase 1 Batch 2 it was mandatory for all the projects to use cells and modules manufactured in India. PV modules made using thin-film technologies were kept out of the scope of the DCR largely due to limited domestic manufacturing capacity for this technology in India. Thin-film panels could be sourced from any other country provided the technical qualification criterion was met (MNRE, 2011b).

The absence of restrictions on thin-film cells and modules led to project developers importing them at cheaper prices (often utilizing cheaper source of finance from foreign export credit agencies) leading to a bias towards thin-film technologies. It is estimated that over 70 per cent of the NSM projects (Phase I) were using imported cells and modules (Ramesh, 2013b). State schemes play an important role in the achievement of the national solar mission targets. It is important to note none of the states have domestic content requirement clause in their policies. This trend towards thin film is also counter to worldwide trends for thin film usage, which has seen a drastic decline owing to the reduction in prices of crystalline silicon.

In the case of wind, empanelled wind energy enterprises are required to have the nacelle assembly facility in India.[14] A nacelle assembly includes all the generating components of a wind turbine such as generator, gearbox, drive train and brake assembly. Because nacelle assembly requires a large number of generating components, it is not feasible to bring these under the stipulation of domestic content requirements as it would be virtually impossible to have the entire range of components manufactured in India. Wind towers and turbine blades, two major components of a wind turbine, are not imported in any case, as their large size imposes logistical constraints. Despite the absence of specific regulations, there is a strong manufacturing base for wind turbine towers and blades in India.

Joint Venture requirements/Foreign investment Policy/ Technology Transfer Requirements

The United Nations, in *Agenda 21* recognizes the need for the transfer of environmentally sound technologies and necessary knowledge to developing countries. Technology transfer delivers the best possible returns if both public and private institutions engage systematically and extend cooperation at all possible levels over a long period of time (United Nations Conference on Environment & Development, 1992).

There are no restrictions for Indian enterprises to form joint ventures but there are certain rules and regulations that govern investment by foreign companies. These enterprises can invest in an Indian enterprise through a joint venture agreement (or as a wholly owned subsidiary) with certain sector-specific restrictions. The Foreign Direct Investment (FDI) policy and the Foreign Exchange Management Act, 1999 (FEMA) govern foreign investment in India (GoI, n.d.). A foreign investment may go through one of two approval routes:

- Automatic Approval Route: Investments in those sectors covered by this process do not require any prior approval from government or the Reserve Bank of India. The investors must notify RBI within a stipulated time.
- Foreign Investment Promotion Board (FIPB) approval route: Those activities not covered under the automatic route would require prior approval from the Foreign Investment Promotion Board in the Ministry of Finance.

Technology transfer may imply transfer of technology design as well as transfer of property rights. Such transfer may typically take place through a patent license. MNRE plans to facilitate transfer of technology by incorporating this requirement in both public- and private-sector procurement from foreign sources (MNRE, 2010b).

Foreign direct investment up to 100 per cent has been allowed through the automatic route in the renewable energy sector subject to conditions under the Electricity Act, 2003 (PIB, 2013a).

[14] CEEW stakeholder interaction.

TABLE 2.7: FDI IN RENEWABLE ENERGY

YEAR	INVESTMENT (US$ MILLION)
2006–2007	2.11
2007–2008	43.15
2008–2009	85.27
2009–2010	622.52
2010–2011	214.40
2011–2012	452.17

Source: PIB (2013a); Business Standard (2010).

Foreign investors can set up a liaison office in India and are encouraged to set up renewable energy-based power generation projects on a build-own-operate model (MNRE, 2010a).

MNRE aims to develop strategic international collaborations and partnerships with various countries. The focus has been on exploring opportunities for the exchange of scientists, and joint research, design, development, demonstration and manufacture of new and renewable energy systems by R&D institutions/organizations of both countries. This would help establish institutional linkages between institutions of India and abroad (MNRE, n.d.b).

The National Council of Research (NCE) proposed to be established under the JNNSM is expected to serve as an interface between international research institutions and groups and high technology startup companies (in India) and multilateral programs. The Council aims to encourage technology transfer by facilitating joint projects with sharing of IPR and setting up R&D bases in India by companies abroad (MNRE, 2010b).

BOX 8 : EXEMPTION OF SOLAR/ON-SHORE WIND PROJECTS FROM ENVIRONMENTAL IMPACT ASSESSMENT (EIA) NORMS

Environment Impact Assessment (EIA) Notification was originally issued in 1994 by the Union Ministry of Environment and Forests (MoEF), GOI, under the Environmental (Protection) Act 1986, which made environmental clearance (EC) mandatory for expansion or modernization of any activity or for setting up new projects listed in Schedule 1 of the notification. Since then there have been 12 amendments to the EIA notification of 1994, culminating in new EIA legislation in September 2006, which exempts wind power projects from obtaining environmental clearances (MoEF, 2006; MoEF, 2001). In order to expedite the implementation of solar RE projects, MoEF, in 2011, decided to exempt solar PV projects from the ambit of EIA notification, 2006 (MoEF, 2011a).

Impact on environment?

Although MoEF's decision to exclude wind and solar PV from the EIA framework has aided developers, the environmental/ecological impacts of such projects, wind in particular, have recently been brought to the fore. One of the key findings indicate that around 3,454 hectares of forestland, including ecologically sensitive areas like wildlife sanctuaries, has been diverted for wind power between April 2006 and March 2013—representing a seven-fold increase since 1980–2006 when EIA was mandatory for wind projects (CSE, 2013b). However, one of the key industry associations for wind manufacturers—IWTMA, estimates that less than 2 per cent of land diverted for wind power projects since April 2006 to March 2012 has been forested land.[15] It has opposed the idea of introducing mandatory EIA norms for wind projects into an already uncertain policy environment and at a time when the power ministry is considering exempting even coal-based ultra-mega power projects from the compensatory afforestation norms (IWTMA, 2013).

[15] Assuming that there is a requirement of 10 hectares per MW of wind power; total wind power installations as of March 2012 were 1.7 GW, translating to 170,000 hectares of total diverted land, of which, 3,317 hectares is forested.

2.3 Survey of the Various Indirect Policies

This section highlights indirect policies/instruments utilized to stimulate the market for renewables. This includes science and innovation; carbon pricing; removing financial constraints through low cost financing; land acquisition policy and power transmission (Figure 2.4).

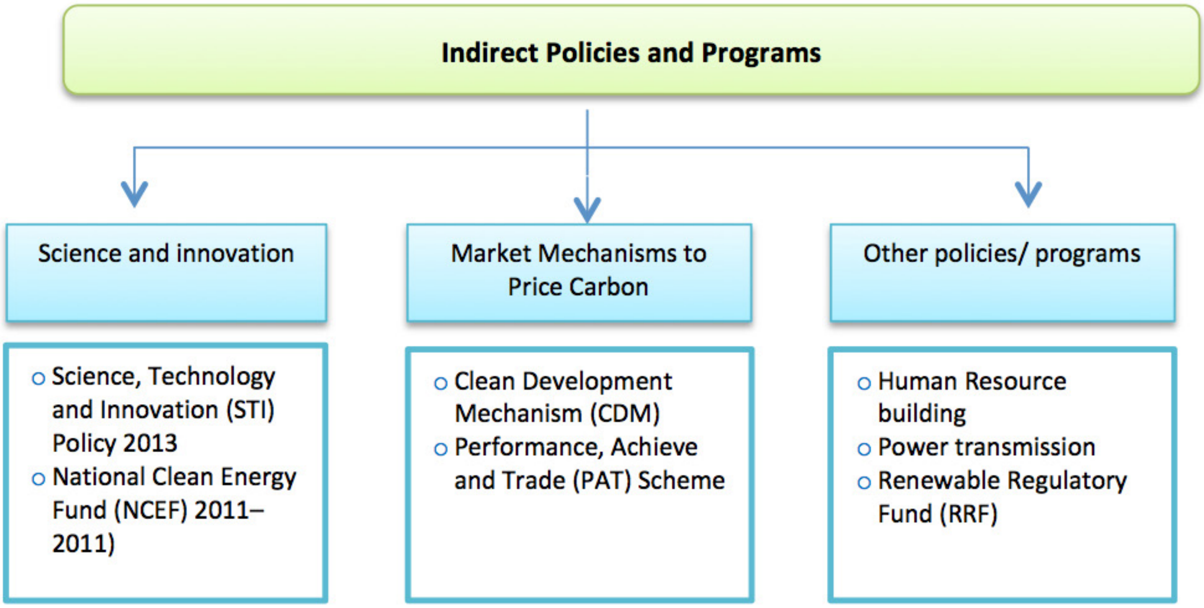


FIGURE 2.4: OVERVIEW OF INDIRECT POLICIES/PROGRAMS

Source: CEEW analysis

2.3.1 Science and Innovation Policies

Science, Technology and Innovation (STI) Policy 2013 strives to put India among the top five scientific leaders in the world by 2020 (GoI, 2013a). "India has declared 2010 to 2020 as a 'Decade of Innovation' and the STI 2013 could be viewed as an added manifestation of this strategy" (Lele, 2013). The STI Policy 2013 replaces the Science and Technology Policy (STP) 2003 and uses innovation as a policy instrument for the first time. The STP 2003 aimed to increase India's expenditure on science and technology from under 1 per cent of GDP to 2 per cent between 2003 and 2007 (GoI, 2013a). However, even 10 years after the launch of STP 2003, India's gross expenditure on research and development (GERD) continues to hover around 1 per cent of GDP (GoI, 2013a). "At a global level, India's GERD accounts for about only 2.5 per cent of world's total spend on R&D" (GoI, 2013a)

The goal of the new STI policy is to establish "a strong and viable Science, Research and Innovation System for High-Technology led path for India (SRISHTI)." The STI Policy 2013, like its earlier version, envisages raising GERD to 2 per cent from the present 1 per cent of the GDP in this decade (2013 to 2023) by enhancing the private sector contribution. In order to meet the country's long-standing GERD target, the ratio must be enhanced to 1:1 (GoI, 2013a).

The STI policy envisages doubling India's global share in publications from 3.5 per cent to 7 per cent, and quadrupling the number of publications appearing in the top 1 per cent of high-impact journals from the current level of 2.5 per cent (GoI, 2013a). In order to realize this, the policy emphasizes an increase in the number of Full-Time Equivalent (FTE) R&D personnel in India by at least 66 per cent of the present strength in five years (Department of Science and Technology, 2013). The policy identifies energy and environment as one of the areas where innovation needs to be stepped up. STI also aims to set up a National Science, Technology and Innovation Foundation, promoting the establishment of large R&D facilities via public-private partnerships (PPP) with provisions for benefits sharing. STI also suggests establishing a centrally implementable Performance-Related Incentive Scheme (PRIS) to promote basic research leading to scientific publications by offering grant-based investments. It should be noted that government has yet to launch these initiatives.

It is also expected that this policy would assist the corporate sector and would encourage private companies to undertake greater R&D efforts. The policy also marks a major shift by considering R&D in the private sector at par with public institutions for accessing public funds.

The **National Clean Energy Fund (NCEF)** was set up under the Government of India's Finance Ministry in the Union Budget in 2010 with an objective of funding research and innovative projects in clean energy technologies. It is an open-ended fund under the Public Accounts of India formed through the levy of a Clean Energy Cess on coal produced domestically or imported to India. The Inter-Ministerial Group (IMG) headed by the Ministry of Finance (MoF) is responsible for establishing eligibility requirements and approving projects to access funds from the NCEF. As of March 2013, it has been estimated that around INR 81.79 billion (~ US$1.5 billion) has been accumulated through the carbon cess (in NCEF) but the MoF has approved projects worth only 45 per cent of that sum (Figure 2.5). The MoF, citing the lack of quality proposals on R&D projects, has allocated funds to projects that mostly promote small-scale proven technologies (for example, solar water heaters, biomass cookstoves, solar PV systems, etc.) which should have been funded by the ministries through their regular schemes. This also indicates that there is a need to strengthen capacities of sponsored ministries for them to develop quality proposals consistent with NCEF guidelines, and to tap the full potential of the fund (Panda & Jena, 2012).

The NCEF reportedly suffers from several bottlenecks related to its operation and administration. It was originally established with the mandate of funding R&D and innovative projects in clean energy technologies, but the fund has reportedly been used by various government ministries to bridge the gap between budgetary allocations and programatic requirements that should have been funded by the ministries through their regular schemes. Some of the budgetary shortfalls being met include INR 2 billion (US$36 million) approved for the Ministry of Environment and Forests' (MoEF) Green India Mission, while another INR 18.75 billion (US$340 million) was approved for funding solar projects under Phase II of the JNNSM (Panda & Jena, 2012). The absence of a robust project monitoring mechanism can also raise questions about the long-term credibility of projects. IMG's approval for a MoEF project seeking funds for remediation of selected hazardous waste contaminated dump sites is in violation to NCEF's guidelines.t[16] Permitting projects of such varying scope compromises the ability of the NCEF to achieve its stated objective (Gyana Ranjan Panda, 2012). Hence, there is a need to revise the guidelines to foster those projects whose focus involves research, development or adoption of clean energy technologies. India needs to allocate sufficient resources to ramp up its energy-related R&D. The NCEF has yet to play the catalytic role for which it had been designed.

[16] In addition to funding core R&D projects, NCEF guidelines also permit projects having limited, if any, links to development of clean energy technologies.

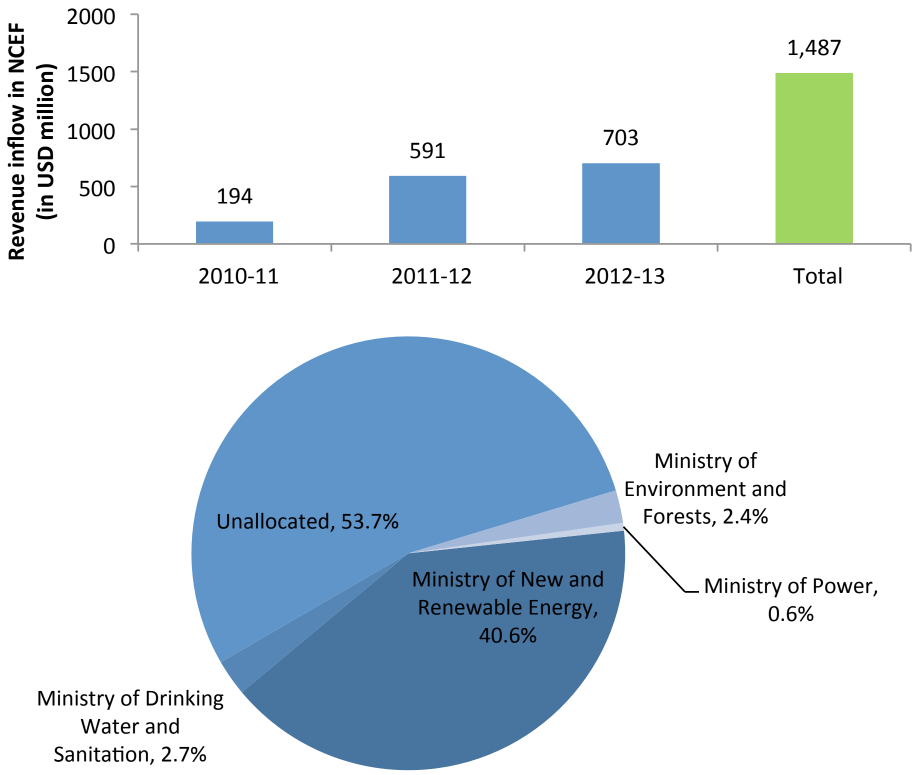


FIGURE 2.5: CESS INFLOW INTO NCEF AND ITS ALLOCATION TO DIFFERENT GOVERNMENT MINISTRIES

Source: Panda & Jena (2012); CSE (2013a).

2.3.2 Market Mechanisms to Price Carbon

Clean Energy Cess on coal/"Carbon Tax": Under the provisions of the Finance Bill 2010, government has imposed a clean energy cess of INR 50 (US$ 0.90) per tonne of coal, lignite and peat that has been imported or produced domestically. The bill came into force from July 2010 and has been used to channel money into the NCEF for funding R&D in clean energy technologies.

The Clean Development Mechanism (CDM) is one of the three flexibility mechanisms under the Kyoto Protocol. The CDM enables developed countries to meet their GHG emission reduction obligations through projects in developing countries. Funding through CDM for RE projects is based on the avoided GHGs by lowering demand for conventional (fossil-fuel based) energy. For RE projects, India is one of the largest sellers of carbon credits (KPMG, 2012). As of 2011, there have been 727 registered CDM projects in India, accounting for a fifth of such projects worldwide. Of these, 520 constitute RE projects, of which wind accounts for the maximum of 225 projects, while solar energy has only six to its credit. The government organized various workshops and seminars in collaboration with industry organizations in an effort to strengthen capacities for participation in the CDM (PIB, 2010). To date CDM's most significant achievement is the spurring of technology transfer in the wind energy sector through the introduction of higher capacity (MW) wind turbines in India by local subsidiaries of multinational companies (e.g., 2 MW Gamesa wind turbine and 1.65 MW Vestas wind turbine) (FICCI, 2012).

Energy Conservation Rules 2012 – Perform Achieve and Trade Scheme: In an effort to increase energy efficiency in Indian industries, the Bureau of Energy Efficiency notified the Perform Achieve and Trade Scheme (PAT) under the mandate of the Energy Conservation Act (2001). The PAT scheme is a direct result of the National Mission on Enhanced Energy Efficiency (NMEEE) under the NAPCC. It is an ambitious project given its scale, complexities, timelines and absence of precedence.

As per the notification, designated consumers (DCs) were identified in a total of eight industrial sectors including aluminium, cement and thermal power. The DCs account for nearly 25 per cent of national GDP and consume an equally large share of the primary energy in the country. For example, for a cement manufacturing unit to be included as a DC the annual consumption of energy, in all forms entering the "gate" of the unit, would have to be at least 30,000 tonnes of oil equivalent (TOE). The limit for the aluminium industry is far lower, at 7,500 TOE (BEE, 2012). As a second step a baseline was established for the energy intensity associated with each unit for the period from 2009 to 2012. Energy intensity is broadly defined as the amount of energy (in TOE) consumed by the facility in consideration, to manufacture one unit of its primary product.

Given that manufacturing facilities will be at various levels of technology and process uptake, a wide range of energy intensity values were observed. The facility with the lowest energy intensity in each industry category was required to bring down overall energy intensity by 5 per cent and the target for the rest was set at a higher level, reflecting their poorer baselines.

The PAT scheme stipulates specific energy consumption (SEC) targets for DCs. Those who have surpassed their SEC target are issued energy saving certificates (ESCerts). Given that ESCerts are issued ex-post (after verification of energy savings), there will be no traded price for ESCerts upfront and therefore no price indications for energy efficiency investments (Bhattacharya & Kapoor, 2011). Drawing lessons from implementation of REC mechanism in the country, it is important that the government intervene to maintain a competitive price for ESCerts by establishing a minimum or floor price (as in the case of RECs).

The PAT scheme allows large consumers to benefit from the use of renewable energy in meeting the energy-intensity reduction target. This is explicitly brought out in clause 4(b) (iii), which states that the scheme "not take into account energy consumed . . . through renewable energy sources not connected to the grid" (BEE, 2012). While this is an innocuous provision, it has the potential to incentivise large industrial units, which have significant land available within their premises, to consider solar or wind farms that would supply electricity to fulfill their needs and sell any surplus power generated to the grid at higher prices. Many industries like cement, aluminium and fertilizers are situated in areas with high wind potential and solar insolation. Although it is more likely that the provision in the PAT scheme will be interpreted as incentivizing off-grid installations, the economies of scale associated with larger RE power plants are likely to drive on-grid installations. This is already being considered by industrial units, most of which have significant cash reserves and profit margins. The benefits associated with tax breaks and accelerated depreciation for RE installations is still likely to be the key drivers for industrial players.

2.3.3 Other Policies/Programs

Skilled Human Resource Building for Wind and Solar

MNRE has estimated that India will require 100,000 solar professionals by 2020 (MNRE, 2010b). In light of these policies and initiatives, MNRE deemed it necessary to put in place a comprehensive **Human Resource Development (HRD) Programme** to bridge the requirement of skilled human resources in renewable energy. The broad objective of MNRE's HRD program is to institutionalize RE education and training in the country. The various strategies deployed to achieve this include (MNRE, 2012c):

- Training and organizing study tours for various stakeholders.
- Incorporating RE in the main course curriculum of various engineering branches and trades.
- Supporting selected educational institutions to act as centres for excellence and undertake degree/diploma programs in renewable energy. Currently 11 such institutions act as centres of excellence for renewable energy.
- Encouraging students and scientists to take undertake research on renewable energy.
- Institution of Renewable Energy Chairs at 15 selected premier academic institutions to act as focal point on sector specific education in that institute.

Also as a part of education and activity, NCPRE, in year 2011, conducted a **Teach 1000 Teachers Training Program** for which it developed a laboratory kit that would help to convey and demonstrate the concepts taught during the lecture hours. NCPRE's effort in providing complimentary laboratory kits to colleges running courses in SPV or RE were funded by MNRE (NCPRE, 2011). Semiconductor Equipment and Materials International (SEMI) in India also collaborated with NCPRE to offer technical courses in the field of solar PV at all levels, from research programs to technician training (India Infoline, 2011).

C-WET provides regular national (three days), international (two to four weeks) and short-term courses on wind energy. The international courses, which includes participants from foreign countries have provided training on wind turbine testing and applications and national training courses provide training on wind energy technology, wind farm development and fundamentals on wind energy. Two short term courses have also been delivered to the wind farm operators and technicians in collaboration with the Indian Wind Power Association, Chennai and at Tirunelveli in Tamil Nadu (C-WET, n.d.c).

Power Distribution

Several developers and financiers have identified power distribution and access to the grid as issues of concern, and in their absence, secure financing for projects has been challenging for developers (CEEW & NRDC, 2012). Many project developers have difficulties siting projects in areas with sufficient grid capacity, resulting in increased costs and project commissioning delays (CEEW & NRDC, 2012).

The Government of India plans to roll out the Green Energy Corridor project worth INR 430 billion (US$6.9 billion) to facilitate distribution of over 30,000 MW power generated from renewable energy sources into the national grid. The proposed project will receive financial assistance from Germany, which has offered EUR 1 billion (US$1.33 billion) as soft credit. The corridor will be constructed across seven states in the next five to six years and is expected to strengthen the power distribution network in India (PIB, 2013b).

Scheduling and Forecasting

The **Renewable Regulatory Fund (RRF) Mechanism** was established by the CERC, under provisions (Regulation 6.1 (d)) of the Indian Electricity Grid Code (IEGC), 2010, to achieve better generation prediction (using weather-forecasting tools), exempt wind power generators from paying unscheduled interchange (UI) charges up to a certain level of variation and develop a self-sustaining mechanism towards countering intermittent generation. It became effective from July 15, 2013 and is operated by the National Load Dispatch Centre (NLDC). The RRF mechanism requires new solar and wind farm developers to schedule and forecast their power generation on a day-ahead basis. Wind farm developers are liable to face penalties in the form of UI charges if the actual generation deviates beyond +/- 30 per cent from the scheduled generation. UI charges for schedules within +/- 30 per cent shall be borne by the host State. "However, the implication of these charges shall be shared among all the states of the country in the ratio of their peak demands in the previous month, in the form of a regulatory charge known as the Renewable Regulatory Charge operated through the RRF" (CERC, 2010b). All payments arising from renewable regulatory charges and interest received for late payment are credited to the RRF. In the case of solar generation no UI shall be payable/ receivable by the generator. The host state is required to bear the UI charges for any deviation in actual generation from the schedule. The RRF mechanism for wind and solar project is summarized in Table 2.8.

Although this mechanism is considered vital to promoting grid stability both by developers and policy-makers, it has generated concerns amongst new wind farm developers, who feel they lack the required technical competence and experience to implement scheduling and forecasting requirements stipulated in RRF; the failure to adhere to these norms can potentially reduce their profits. However, on a more positive note, there has been an emergence of a few companies are offering scheduling and forecasting services to help developers overcome the technical challenges of implementing the RRF.

TABLE 2.8: RRF MECHANISM FOR WIND & SOLAR

	WIND		SOLAR
Applicability	New wind farms: 10 MW & above		5 MW & above
Connection Point	33kV		33 kV
Forecasting Obligation	Up to an accuracy of 70%		Based on availability of generation requirements
Deviation (UI Charges)	Yes		Yes (but no charges to generators)
	Within +/- 30%	Outside +/- 30%	
Payable/Received by	Host state	Wind generator	
	Settled through RRF		

Source: CEEW compilation

2.4 Costing of Direct Policies

An exercise that looks into the costing of India's green industrial policy assumes mammoth proportions, given the diverse range of incentives (at the state level) and multiple combinations of the same that have been made available to the RE players. The full list of policies considered in the costing exercise for solar PV and wind industry are detailed in the summary table at the end of this section (Table 2.9). In order to paint a clearer picture, we break down the costing process into two components—manufacturing and project development—the two large pieces of the value chain associated with the green industry.

The following analysis uses a separate methodology to evaluate direct financial implications and the fiscal implications. Fiscal impacts refer to those tax implications for the exchequer from measures such as accelerated depreciation, tax holidays for initial years of the project post-commissioning and tax rebates through waiver of customs duties and excise duty reduction. They are, invariably, purely based on the size of the investment and some that are delinked from the actual activity and quantum of power generation. Financial incentives, on the other hand, are (mostly) directly linked to the actual amount of generation and in some cases on the amount of investment. Financial impacts are a result of direct payouts driven by policies such as feed-in-tariffs (FiTs), generation-based incentives (GBI) and direct capital subsidies (if any). It is also crucial to differentiate the two on the basis of the ministries that bear the load in each case. In case of direct financial outlays, the MNRE (directly or through affiliated entities) and its state nodal agencies are responsible for the payouts. In the case of fiscal incentives the implications are for the Ministry of Finance.

2.4.1 Manufacturing

Many of India's policies that are aimed at supporting green industry are for project developers and producers of energy. Manufacturing does not stand to gain as much, as it is treated on par with other industrial activity with customs and excise duty waivers granted only for specific components. In fact, in the solar manufacturing value chain only the import of silicon (in all forms—poly-crystalline, ingots, cells, modules, etc.) is exempted for duty. Many of the elements that constitute the balance of system are taxed at normal rates. The most easily monetized component of the costs imposed as a result of the government's policies is the revenue loss as a result of the basic customs duty exemptions granted. Only items under HS code 854140 (silicon-based) are exempted from this duty, with the rest of the imports being levied duties at the standard rates, which vary between 5 per cent and 15 per cent. The prevailing basic customs duty rate for products under HS 854140 was 7.5[17] per cent before the waiver came into effect in 2008. Wind-powered generating sets (HS code 850231) cannot access any such duty waivers. The only notable benefit for wind turbine manufacturers is the concessional duty rate of 7.5 per cent that is currently charged, as opposed to the earlier rate of 12.5 per cent (prior to 2007). In addition, India has seen minimal imports under the product header HS 850231, as most of the imports are for the components constitute the nacelle, and these are categorized under a gamut of HS code headers.

The value of imports of solar cells and modules for the period 2008 through 2013 was on the order of INR 256 billion (US$4.65 billion). The loss in revenue to the exchequer on account of the waived custom duty (at 7.5 per cent) amounts to INR 15.5 billion (US$273 million). The value of imports of wind powered generating sets for the period 2008 through 2013 was INR 1.3 billion (US$23 million). The loss in revenue to the exchequer on account of the reduced customs duty (of 5 per cent) amounts to INR 95 million (US$1.74 million).

2.4.2 Project Development

While India's industrial policies for the renewable energy sector have tried to address the need for a domestic manufacturing base, the primary focus has been on ramping up installed capacity for electricity generation.

Solar Power

Solar PV installations have taken off in India only in the last two years, with the rollout of the JNNSM. Until 2010, installed capacity was a mere 10 MW and had increased to 1,839 MW by July 2013 (MNRE, 2013d). Much of the installation is driven by solar policies in specific states like Gujarat and Rajasthan, which are better endowed with solar resources. It would seem that the JNNSM has resulted in the states bringing out specific policies, having seen the success of the reverse auction

[17] All information pertaining to current and past rates of customs and other duties has been sourced from Eximguru, 2013.

process to allocate projects under Phase-1 of the JNNSM. While some states have gone ahead with a negotiated FiT for solar PV projects (like Gujarat), some (Karnataka, Odisha and Rajasthan) have also adopted an auction based system for allocating projects. The prices encompass a continuous spectrum ranging from INR 7 per kWh to INR 12 per kWh (Prabhu, 2012).

Fiscal Impacts

Since the beginning of the JNNSM, the approach has been to streamline the '"subsidy" disbursal and for large grid-connected installations, the only benefit available is the differential between the auctioned tariffs and the average cost of power purchase/production for various utilities. The fiscal impacts will really arise from an evaluation of the foregone revenue (to the government) in providing tax holidays for projects commissioned in remote areas and for grid connected facilities (FICCI, 2011). An analysis of fiscal impacts would require data at a firm level (of those engaged in project development), their annual statements and the tax benefits accrued on account of the tax holidays. Given that this is fairly dispersed information, this exercise is not undertaken and needs to be initiated by the government specifically at some stage to understand the implications for the exchequer.

Financial Impacts

As noted earlier, the primary financial implication of solar PV projects is in the payout of the higher tariff. Given that electricity prices for retail consumers do not necessarily reflect the true cost of generation (Planning Commission, 2012); it is very likely that the incremental outlay to procure solar power will be borne by government-owned distribution companies. Public utilities are required to have a certain percentage of their procurement through RE sources and specifically from solar. For all practical purposes the incremental outlay can be assumed as financial outlay for the government in promoting the penetration of solar power.

In order to estimate the overall impact, it is first necessary to estimate the amount of solar power that was fed into the grid by projects that were commissioned in the first part of Phase-1 of the JNNSM. Projects were commissioned at different points in time and started generating at different plant load factors PLFs. As a result, it is not possible to account for the generation of each unit. Instead, the procurement data from NTPC Vidyut Vyapar Nigam Ltd. (NVVN), the trading arm of NTPC, which was given the responsibility of bundling solar power with unallocated coal power, was used to estimate the incremental outlay.

As per NVVN, for the period 2011 to 2013, the total procurement of solar power was 52 million kWh, procured at an average price of INR 14.13/kWh (NVVN, 2012). The average cost of electricity that remains unallocated from NTPC's generating stations is assumed to be INR 2.5/kWh (CEEW & NRDC, 2012). The incremental outlay to procure solar power then works out to INR 610 million (US$11.1 million).

In addition to the procurement of power by NVVN from large installations, GBI has been available for smaller grid connected installations in rural and urban areas under the scheme of **Rooftop PV & Small Solar Power Generation Programme (RPSSGP)**—typically rooftop and small community plants for projects less than 2 MW with an aggregated capacity of 100 MW.

Seventy eight projects were selected to set up 98 MW capacity projects from 12 States under RPSSGP (MNRE, 2012e). The price paid to small installations is based on the prevailing tariff for solar PV, as prescribed by the SERC of the state where the project is located. From this prescribed rate, a base price is deducted to reflect the average price of electricity, and only the premium is paid as a top-up to the project developers. On average, this figure is INR 4.5/kWh for the two years. The total outlay for the period from 2011 to 2013 works out to INR 560 million (US$10.8 million).

Wind Power

Fiscal Impacts

The first (modern) wind turbines were installed in India in the mid-1990s. The primary suppliers of the investments were industrial units in southern Tamil Nadu, who were provided an incentive through an accelerated depreciation (AD) on investments made in wind energy installations. They were allowed to depreciate their assets almost entirely within the first year of commissioning, thereby allowing a deferment of taxes. The AD rate was reduced to 80 per cent (over the first year) for a good part of the last decade, when much of the present capacity in the country started coming online. There are also arguments that suggest that AD incentives are tax neutral over a period of seven years (Ramesh, 2013d), at least under current conditions and prevailing discount rates. It does not, however, imply that there is no cost involved to the government in providing this incentive. Time value of money is an important concept, and accounting for the social (or in this case corporate) discount rate, one can get a good estimate of the true cost of this deferred tax payment. Over the last 16 years there has been a significant variation in the cost of wind turbines, and there is no documentation of the actual estimates on deferred taxes. Also, several state governments even offer varying FiT rates after accounting for the provision of AD by the central government. Given this complexity, in order to provide an estimate which is easily contextualized, we chose to highlight the cost of AD for the period 2010 to 2012. AD has since been discontinued, and this has, according to investors and manufacturers alike, contributed to the slow pace of capacity addition after March 2012.

The total capacity addition for this period that has claimed AD benefits is roughly 1,890 MW. There were many more projects that applied for AD but were disqualified under various conditions and also because some preferred to reap the benefits of GBI and hence became ineligible for AD. In addition, many of the project developers are captive consumers who may not be injecting (or at least do not envisage doing so) power into the grid on a regular basis and thus are not eligible for GBI. Such developers prefer the AD route, as it also complements the financial interests of their core businesses by deferring tax payments. The total investment cost for the installations was approximately INR 111.30 billion (~US$2 billion).[18] Our estimate for the annual fiscal implications of providing for AD is INR 7.65 billion (US$139 million).[19] In estimating the implications of AD, the analysis does not account for the benefits of the investment that is made (direct), in terms of service tax revenues that accrue on account of the setting up of the plant. Industry proponents state that without the AD regime these other revenues for the government would not have been realized in the first place.

Income tax holidays are also provided for a period of a block of 10 years in the first 15 years after commissioning, on the revenues generated from the sale of power. However, the overall fiscal impact on the government is difficult to estimate, as there is no central repository of information on earnings of specific firms/developers—and given that a large portion of the electricity generated could be sold to "captive" customers at undisclosed prices—it is not possible to estimate that figure.[20] An estimate of this has been made based on assumptions around the fraction of power used for captive consumption and projected revenues based on return rates specified in the various tariff notifications issued by states. For the period 2009–2012, if one were to assume two-thirds of the projects generating electricity did receive the

[18] Capital cost assumptions have been provided by the Indian Wind Energy Association (InWEA) to the TNERC for the calculation of tariffs in 2011.

[19] A standard lifespan of 20 years has been used in calculating this. A discount rate of 13 per cent has been applied arriving at this figure and chosen to reflect the weighted average cost of capital as reported by industries. As a result of the rapid changes in the US dollar–INR exchange rate, value of INR 55 has been assigned to 1 U.S. dollar.

[20] It must be noted that there is no blanket exemption from paying taxes as a Minimum Alternative Tax (MAT) is applicable for all companies that show no revenue, during periods when the income tax holiday is not invoked.

income tax holiday, an estimate for an annual outlay can be arrived at.[21] The margins (profits or return on equity) for the companies are assumed to be in line with the provisions of the various electricity regulators. The estimated annual loss to the exchequer on account of the income tax holidays provided amounts to INR 6.7 billion (US$122 million). For every MW of installed capacity, this amounts to INR 0.6 million per year (~US$1,000 per year) over the three-year period.

Financial Impacts

In some of the states financial incentives like FiTs have been around since the late 1990s. They form the core of the monetary incentive structure for developers of projects by guaranteeing a specific tariff over the course of the life of the project. The FiT mechanism is efficient only so long as the payments are made in a time-bound manner and the contract to off-take a specified amount is enforced. FiTs in India are a subject matter of the specific states. CERC merely plays a guiding role and sets normative values for FiTs. In states like Tamil Nadu, where the industry is more established, the FiTs have been on the lower side, reflecting the maturity of the industry. Tamil Nadu has nearly 45 per cent of the installed capacity for wind in the country. In states like Madhya Pradesh and Rajasthan, which want to leverage their resource potential and exploit it effectively, the tariffs are significantly higher as they look to expand their installed capacity base.

While data on FiTs is available since 2005, the data on wind generation is available (comprehensive, for all the major states) only from 2007. Hence, the period for this analysis is from 2007 to 2012. It must be also mentioned that the "incremental cost" that must be sought in this case is the differential between the average cost of power purchase (or production) from conventional sources and that from wind. The data on wind energy generation was obtained from the annual publication of the Central Statistics Office titled "Energy Statistics" (CSO, 2012) and the data on average cost of power purchase was obtained from the annual Planning Commission publication titled "Annual Report on the Working of State Power Utilities and Electricity Departments" (Planning Commission, 2012). In some years, the data revealed the average cost of power purchase from conventional sources (in some states) was actually higher than the FiT on offer for wind. In such cases the additional cost of wind energy was assumed to be zero.

The overall incremental expenditure to procure wind energy was calculated as a temporal aggregation for each state, and across the states, of the product the units generated and the incremental per unit tariff (prevailing). The overall layout for this works out to INR 39 billion (US$ 709 million) for the period from 2007 to 2012.

In addition to the FiT provided by the SERC concerned, the central government, in December 2009, announced the extension of a generation-based incentive (GBI) for wind power generation as well. This was fixed at a flat rate of INR 0.50/kWh. It could only be accessed by those units that did not claim benefits against AD. A formal registration process was put in place and limits placed on the subsidy for each project and timelines for the same. At the time of announcement, the overall outlay limit for the MNRE was set at INR 3.8 billion (~US$69 million) for the remaining period until March 2012 (MNRE, 2009). IREDA, set up by the MNRE to deal with issues of financing RE projects in India, maintains an excellent database of projects that have qualified for obtaining GBI: this analysis is driven by this list of projects only. GBI was also withdrawn along with AD, starting in April 2012. The budget for FY 2013 to 2014 spoke of reinstating the GBI, but there has been no official notification or provision for the same. The analysis on GBI outlay is carried out for the period from 2010 to 2012, encompassing a full two-year period when it was in effect. The overall outlay for the central government was calculated to be INR 3.8 billion (~US$69 million). It is almost coincidental that the outlay mentioned in the MNRE communication is exactly equal to the final estimated outlay.

[21] While there is no specific data available on the average age of wind turbines and the staggered nature of the income tax exemptions, this becomes a limiting assumption in the estimation.

For purposes of the estimation, an average PLF of 27 per cent was assumed, which is on the higher side—there is a large variation across the country.

The significant assumption in the calculation of FiT and GBI outlay is that every unit of electricity generated is fed into the grid and GBI/ FiT are claimed against this. However, a large portion of the generation is for captive consumption and is not eligible for any specific incentive. Given this assumption, it can be observed that these estimates represent an upper bound on the government outlay. From information available through the financial accounts of the MNRE, it is also seen that the outlay for the GBI scheme (for wind) was only a fourth of what was budgeted, clearly indicating that actual costs can be far from the estimates, given the delays in implementation and the lack of granular data that would help improve the estimates.

TABLE 2.9: SUMMARY OF COSTS OF GREEN INDUSTRIAL POLICIES IN INDIA

SECTOR	PERIOD OF ANALYSIS	VALUE CHAIN	OUTLAY MECHANISM	ANNUAL MONETARY OUTLAY (US$ MILLION)
Wind	2008–2013	Manufacturing	Customs Duty Exemption	1.75
Wind	–	Manufacturing	Excise Duty Exemption	Not Available
Wind	2010–2012	Project Development- Fiscal	Accelerated Depreciation	139.1
Wind	2009–2012	Project Development-Fiscal	Income Tax Holiday	122
Wind	2007–2012	Project Development- Financial	FiT	141.8
Wind	2010–2012	Project Development- Financial	GBI	34.5
Solar PV	2008–2013	Manufacturing	Customs Duty Exemption	54.7
Solar PV	–	Manufacturing	Excise Duty Exemption	Not Available
Solar PV	–	Project Development-Fiscal	Accelerated Depreciation	Not Applicable
Solar PV	–	Project Development-Fiscal	Income Tax Holiday	Not Available
Solar PV	2011–2013	Project Development- Financial	FiT	5.6
Solar PV	2011–2013	Project Development- Financial	GBI	5.4
Renewable Energy Industry		**All**	**All**	**505.2**

Source: CEEW compilation

Table 2.9 summarizes the net outlay for the government on an annual basis to support the capacity increase in solar PV and wind installations. In the year 2011–2012, the generation attributable to solar (including a very small amount of concentrated solar power) and wind facilities was to the tune of 46 billion kWh. If the cost of pursuing India's green industrial policy was indeed of the order indicated in the above calculation, and if this were equally divided among the entire generation from the solar PV and wind, we would see that each additional kWh of electricity has cost a mere US$0.011 to the exchequer and the other ministries supporting the rollout. Yet another comparative metric would be the total cost of electricity supplied (in 2011–2012) to the utilities across the countries. The total cost of supporting green industry works out to less than 1 per cent of the cost of electricity supplied in that year, indicating the relatively inexpensive nature of the support extended so far.

3. Impact of Policies

The multiplicity of motivations and objectives can make for a complex balancing act where different ministries and levels of government are required to act in concert to ensure robust policy outcomes. Section 2 sought to illustrate the types of direct and indirect policies being implemented to support India's renewable energy aspirations and the annualized costs of the policies over the period they have been active. This section highlights the impact of various policies on specific outcomes chosen for the study.

3.1 Energy Access and Security

Unlike developed countries, where energy demand has reached or is close to saturation, the latent demand for energy is significant in India, and a large portion of it remains unmet. Numerous programs have been rolled out in pursuit of the elusive goal of universal energy access. The Indian government has been cognizant of the role that energy access plays in alleviating poverty, and the importance accorded to addressing this has been greater than even the measures to ensure national-level "energy security" (Ahn & Graczyk, 2012). While grid-based electricity supply certainly increases the potential for increased availability, disaggregated data (at the household level) correlating increased RE generation with increased access is not available. More specifically, it is virtually impossible to specifically identify whether increased access or consumption of electricity resulted from solar PV- and wind-based sources. The contribution from RE sources towards electricity generated is evident from statistics presented earlier. RE (~ 70 per cent from wind), contributes nearly 4.5 per cent of the overall energy supply in the country. The overall energy deficit in the country is roughly 7 per cent (including the availability from RE) (CEA, 2013a), and to the extent that the RE supply satisfies unmet demand, it bridges the deficit and increases access.

Decentralized systems and their penetration more directly indicate the impact on energy access. Among decentralized systems, only solar PV has made inroads in India, and wind-based technologies like micro-wind turbines[22] have not yet established themselves in the marketplace.

Between 2001 and 2011, the number of households reporting solar-based electricity sources as the primary source of lighting increased from a little over 500,000 to more than 1 million. While they still constitute a miniscule fraction of the 250 million households in the country, the impact is significant (Census of India, 2011). MNRE also indicates that nearly 138 MW of off-grid solar PV capacity (of size > 1kW) exists currently—this is growing at an annual rate of more than 30 per cent. Some of these are improving the state of access through micro-grids and standalone rooftop systems. Given that nearly 32 per cent of the population relies on kerosene for lighting services, the potential for off-grid solar PV systems (which are already more economical than kerosene) to improve access is immense. In addition to improving access at a household level, solar PV applications in other areas have an impact on productivity as well. Nearly 8,600 solar pumps (MNRE, 2013a) find use in agricultural irrigation application across the country and displace diesel in many cases, allowing for extended irrigation given the higher likelihood of the sun shining than the electricity utility delivering the necessary electricity. Solar-based applications are also being experimented with for heating (solar water heaters, dryers, desalination systems) and mechanical energy (solar PV and wind water pumps), although firms have not yet achieved significant scale (CEEW & WWF, 2013).

In the Indian context, energy security found a new definition in the Integrated Energy Policy (2006) that was formally adopted in 2008. The IEP indicates that the country is "energy secure when we can supply lifeline energy to all our citizens irrespective of their ability to pay for it as well as meet their effective demand for safe and convenient energy

[22] Other distributed forms of wind energy have not yet caught on. A proposed National Wind Mission targets a capacity of 1,000 MW of off-grid wind by 2022.

to satisfy their various needs at competitive prices, at all times and with a prescribed confidence level considering shocks and disruptions that can be reasonably expected" (Planning Commission, 2006a, p. 54).

First, we discuss the energy supply implications for energy security, specifically for the electricity needs of the country, followed by a discussion of RE's impact on securing electricity supply through price effects. While energy access and delivery of energy are already a focus of policy-makers, import dependence and exposure to international price fluctuations associated with imports will be the key factor influencing the supply of fossil fuels—and ultimately India's energy security itself. By every measure, India's domestic energy sector has failed to deliver and, instead, increasingly looks to imports to fill the demand–supply gap. Lack of sufficient production capacity and the inability to make adequate investments give reasons to fear that an energy crisis is imminent (Ahn & Graczyk, 2012). India's highest share of imports is in the oil and gas sector. India has been a net importer of natural gas since 2004, and levels could be higher but for a lack of long term LNG contracts (CSO, 2012). Surprisingly, India is also the fourth-largest importer of coal in the world (EIA, Energy Information Authority, 2010). Between 2005 and 2010, coal imports saw an average growth rate of 14 per cent annually (CSO, 2012). That said, India's energy security is not solely about securing electricity supply through RE. It has a much broader definition (including transportation, industrial needs), that necessitates a focus on a much larger set of technologies that lies beyond the scope of this study.

Every additional unit of electricity generated feeds the ever-growing needs of the country. There is a critical correlation between displacement of conventional fossil fuel use and energy security. While the impact on energy security of having a large wind and solar industry (manufacturing and projects) is conceptually difficult to discern at the national level, it is possible to find evidences of substitution of thermal power at more disaggregated levels, i.e., states and electricity dispatch centres within states.

While wind power has been flourishing in India for over a decade, solar energy is relatively new and yet to make a significant impact on the supply side. The requisite analysis can be carried out for any of the states that are significant generators of wind or solar energy, provided the granularity in data exists. The burden of proof of establishing the causality (as indicated above) is taken up only for the case of wind. Tamil Nadu, a large state with a population of 72 million (Census 2011), was considered as the focus state, as it is home to more than 40 per cent of the wind power installations in the country today and there is a clear wind season (May through August), coinciding with the late summer peaks, that can help illustrate the implications on energy security. Data was obtained from the State Load Dispatch Centre (SLDC) on the split between the contributions of the three main sources of power in Tamil Nadu: thermal, hydro and wind. The SLDC is responsible for scheduling and bringing on board the various energy sources in a manner so as to match supply and load (demand), and operates planning on a day-ahead basis.

For the state of Tamil Nadu, there exist two peak power requirement periods, the morning peak (7:50 AM) and the lighting peak (7:05 PM). For each of these, an analysis was carried out statistically and graphically, using the plant load factors that each of these sources (at the aggregated level) was operating at, while catering to the peak power requirement. Thermal power for all practical purposes is baseload in India, but small changes can be discerned at peak power periods. As plants typically operate within a certain range and in the presence of alternative power sources, it does make sense to cut back on their use, both from a cost saving and environmental perspective.

A visual inspection of the load factor trends will provide us a good understanding of the contribution of each source at the two peak periods. The figures below (Figure 3.1 and Figure 3.2) indicate the same for each of the peaks.[23]

[23] The morning peak is shown for a one-year period to increase the scale of the plot and to clearly display the variations, which are not as clear while observing the same for all three years.

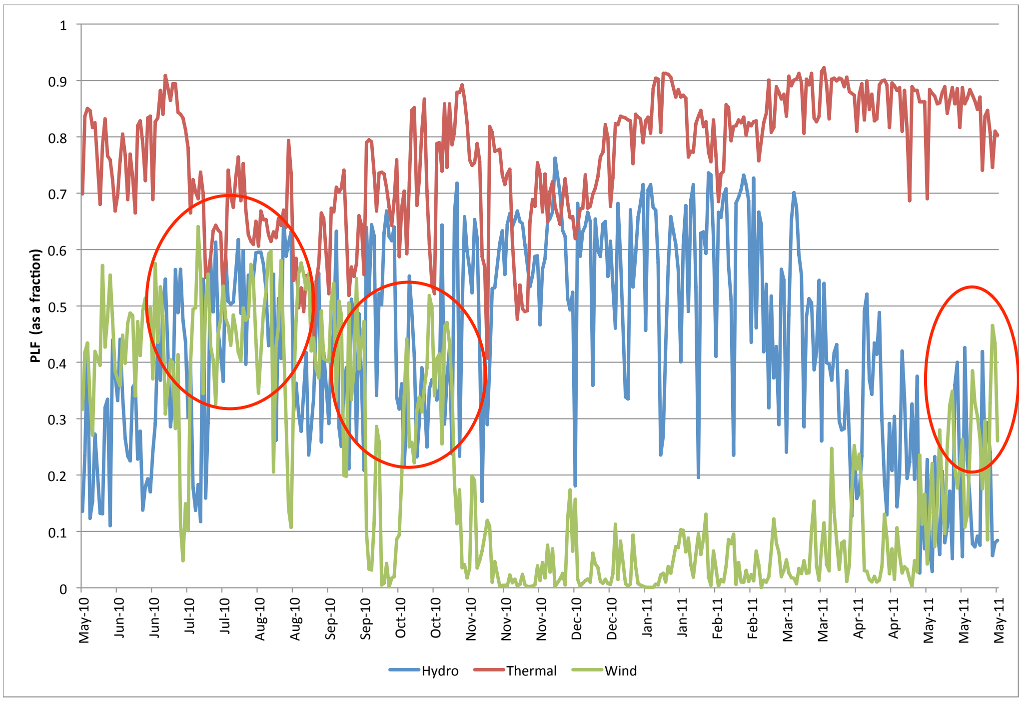


FIGURE 3.1: LOAD FACTORS AT EVENING PEAK

Source: CEEW analysis

It is clear that wind certainly contributes to the lowering of the PLFs of thermal power stations during the peak periods and this impact in the high-season is clear from Figure 3.1 and Figure 3.2. Evidence from reports on reduced power outages during the peak wind season indicates that wind energy is able to sustain domestic activity and uninterrupted industrial production across the state (Mahesh, 2013). At first glance, however, it is not easy to compare all three sources, as there is interplay between them. Wind alone or hydro alone cannot pick up the slack that thermal power offers and at times they have to work in tandem and the more easily varied resource contributes at varying levels. One must also remember that Tamil Nadu, more than the rest of the industrialized states of India, suffers from a chronic deficit of power distribution lines, particular for RE sources (Preetha, 2013). Thermal power stations are kept running on a priority basis as it is costly to turn down generation in frequent cycles to match the variability in RE sources. In principle, therefore, the contribution of RE sources could be more significant and pronounced, but for the lack of adequate transmission infrastructure.

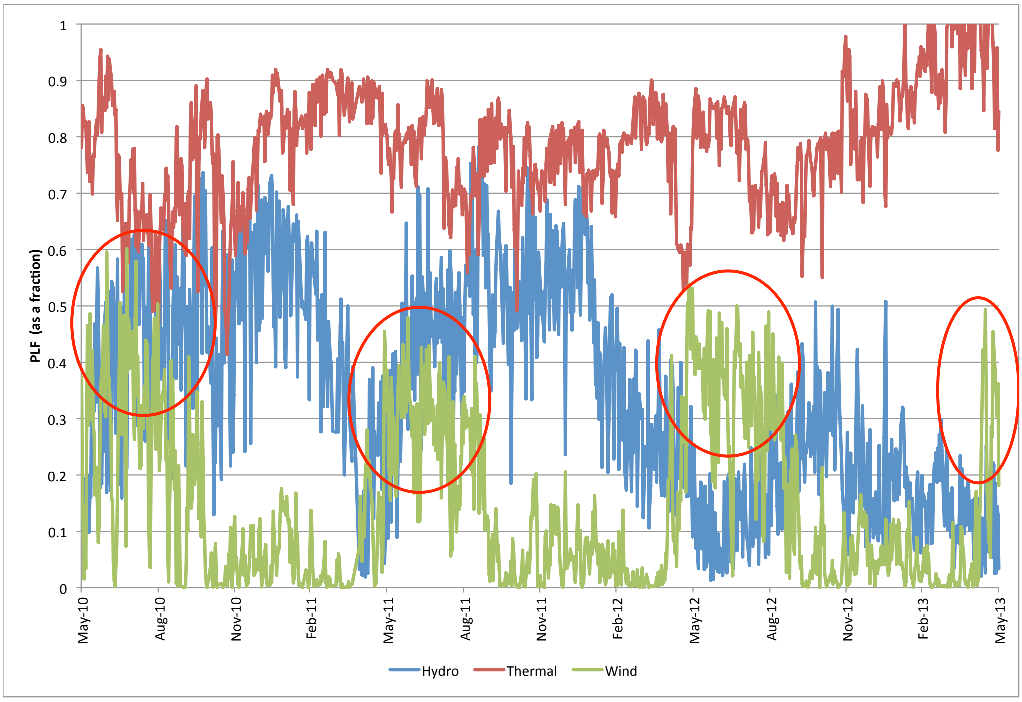


FIGURE 3.2: MORNING PEAK – PLANT LOAD FACTORS 2010–2013

Source: CEEW analysis

Over and above the conclusions that can be drawn from a simple visual inspection, a statistical analysis based on a simple correlation analysis and regression model was carried out, one each for the morning and lighting peaks. A correlation analysis for the lighting peak and morning peak is provided in Table 3.1

TABLE 3.1: CORRELATION BETWEEN THE PLFS OF THREE MAIN SOURCES OF POWER FOR TN

LIGHTING PEAK			
	Hydro	*Thermal*	*Wind*
Hydro	1		
Thermal	-0.23376	1	
Wind	-0.37992	-0.27112	1

MORNING PEAK			
	Hydro	*Thermal*	*Wind*
Hydro	1		
Thermal	-0.29556	1	
Wind	-0.20695	-0.23224	1

Source: CEEW Analysis

There is a fairly strong negative correlation between thermal PLFs and the remaining two options. This is intuitive and indicates that when PLFs for hydro and wind increase those of thermal generation tend to drop. This is a robust conclusion backed by nearly three years of daily generation data.

A regression analysis with the thermal PLF as the dependent variable and the hydro and wind PLFs as independent variables also provides a clear view of this. The coefficients of both the independent variables are significant at the 1 per cent level, as indicated by the P-value (close to zero) and the t-stat, as indicated (Table 3.2). The R2 value is close to 0.21 in each case and indicative of the degree to which the variation in the dependent variable is explained by the two independent variables in the analysis. Given the significant coefficients and the R2, we can conclude that wind has had a positive impact on energy security for the state of Tamil Nadu.

TABLE 3.2: REGRESSION ANALYSIS TO ESTABLISH IMPACT OF RE ON THERMAL PLF

LIGHTING PEAK				
	Coefficients	*Standard Error*	*t Stat*	*P-vaule*
Constant	0.92	0.01	104.51	0.000
Hydro	-0.23	0.02	-13.50	0.000
Wind	-0.24	0.02	-14.39	0.000

MORNING PEAK				
	Coefficients	*Standard Error*	*t Stat*	*P-vaule*
Constant	0.89	0.01	116.85	0.000
Hydro	-0.20	0.02	-12.45	0.000
Wind	-0.22	0.02	-10.63	0.000

Source: CEEW analysis

Energy security can also be explored from the other element mentioned in the guiding doctrine on India's energy policy (Planning Commission, 2006a)—that of price. Again, while the stark difference between supply and demand exists at all levels, the impact of an RE source contributing to the generation basket and its impact on energy prices for utilities is more easily discerned at a state level. Out of the 874.17 billion kWh (874.1 terawatt [or TWh] hours) generated in 2011 to 2012 (in India), 15.54 TWh of electricity was traded through electricity markets at an average price of INR 3.57/kWh with a total market size of INR 55.53 billion (CERC, 2012c). Most of the transactions took place through a double-sided auction also known as the day-ahead market (14.82 TWh or 95 per cent of the total power transacted in electricity markets) (CERC, 2012c). Over the last two years (for which data is available) Tamil Nadu has been one of the largest purchasers of power from the electricity markets in India—either through bilateral trading or procuring in the day-ahead markets. Between 2011 and 2013, the state purchased more than 1.8 billion kWh of electricity from the day-ahead markets at average prices ranging from INR 4.34 to INR 5.84/kWh. (CERC, 2012c). The feed-in tariff for wind power producers during the financial year was INR 3.51/kWh. The state certainly pays a premium for power purchased from the markets, as opposed to that generated from wind sources.

As noted earlier, for planning purposes the state of Tamil Nadu, records two peak power periods, the morning peak (7:50 AM) and the lighting peak (7:05 PM). A closer inspection the power prices in the two exchanges reveals that the average price of electricity for these time slots (in the relevant southern grid) was INR 4.9/kWh and INR 7.31/kWh for the period May to September 2011, coinciding roughly with the high wind season.[24] One can easily conclude that, but for wind energy the state utilities may have had to pay as much as 100 per cent more in order to procure power from the exchange. In some periods, the FiT is even less than the cost of power generated by the state utilities from conventional sources. The influx of wind power comes in handy to the cash-strapped state utility TANGEDCO.

While the approach considered here details one of the possible methods of distribution, extending the above analysis from wholesale prices to end consumer prices is difficult. With few market principles at work in the Indian electricity sector, large distortions through subsidies and cross-subsidies mask the true impact (on consumer prices) of any new policy instrument. Furthermore, determining the impact on energy access is complex, given the numerous bottlenecks in the delivery of electricity through the grid to the poor. However, the analysis of Tamil Nadu suggests that RE has the potential to lower electricity procurement prices for large utilities, and it would be useful to extend this analysis to other states with RE potential.

[24] CEEW analysis from IEX data.

3.2 Competitiveness of Domestic Firms

Both the wind and solar PV value chain consist of a plethora of components, many of which may be competitively manufactured in various countries for end uses that serve other industries as well. In order to get an objective understanding of the state of play, the analysis below focuses on the core elements of the technologies (cells/modules/panels for PV and wind turbine systems). Specific product categories that are catalogued in international trade databases have been used to define the scope (HS- 854140 for solar and HS- 850231 for wind). Broad narratives of the other elements that are indicative of competitiveness are woven in, highlighting the transition of the industry.

3.2.1 Solar PV

In the early years of the last decade (2000 to 2010) India had a strong manufacturing base for solar cells and modules and was catering to rising demand in Asian and European markets. Nine companies were manufacturing cells, and 22 companies were manufacturing modules with a capacity of 6.5 MW and 9.5 MW respectively (World Bank, 2000). During this period, there was no significant domestic demand, and the increase in production base was largely driven by re-export.[25] Until 2009, components were imported from countries like China, Germany, Taiwan and Japan and then exported (as modules and panels) to the likes of Germany, Spain, the United States and Italy, which had a thriving project development environment for solar projects.

Across the globe, the economic slowdown (post-2008) led to a decrease in demand from foreign markets, and, with their relatively small manufacturing base, Indian exporters were unable to compete with the scale of Chinese output. On the domestic front, India's solar manufacturing industry also faced significant challenges in being competitive with imported products. An exponential rise in imports was observed for the main components. There was a clamouring from numerous players for support measures, such as domestic content requirements (DCR), to provide a semblance of competition to the vastly cheaper imports. Only with the announcement of the JNNSM did Indian manufacturers increase their production capacity, incentivized by the 100% domestic content requirement for crystalline silicon cells and modules in Phase 1.[26]

Exports and imports were comparable until 2010 but subsequently imports have outstripped (many-fold) the demand for domestically manufactured components (Figure 3.3).

25 Exports from India driven by imported components.

26 For crystalline modules in Batch 1 and crystalline cells and modules in Batch 2, of Phase I.

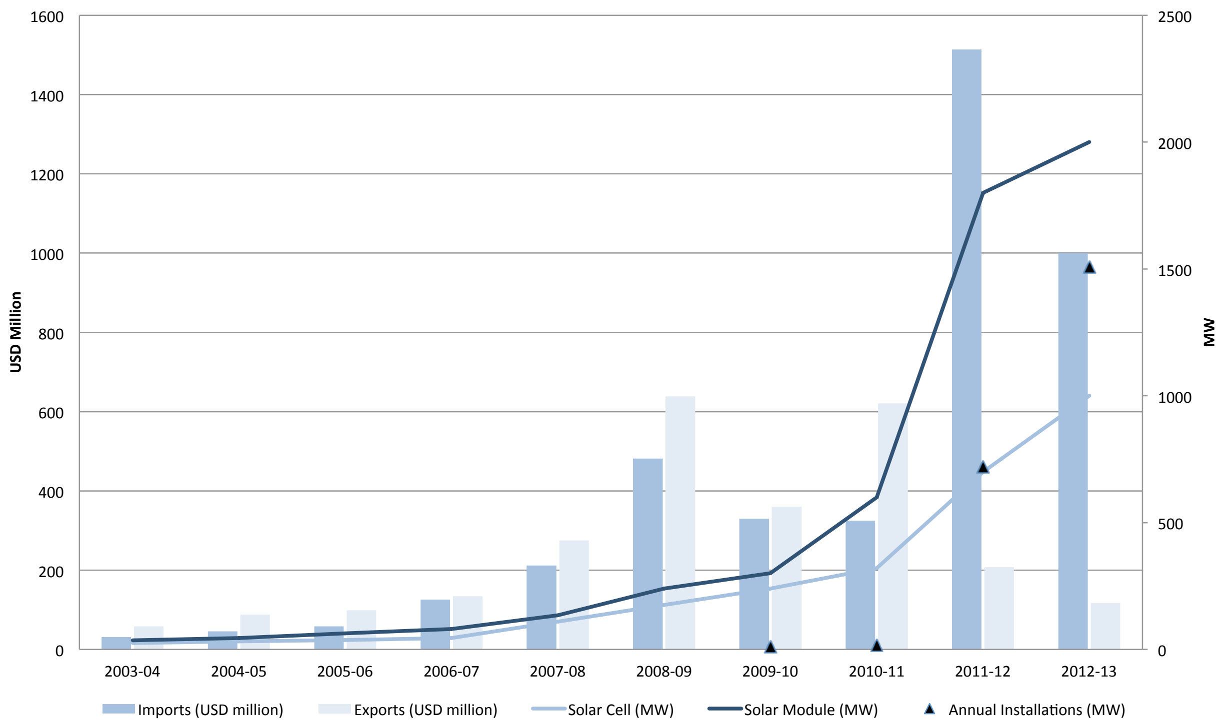


FIGURE 3.3: EXPORTS AND IMPORTS OF SOLAR COMPONENTS (HS 854140) IN INDIA

Source: CEEW analysis

As a result, market leaders such as Tata Power Solar (formerly Tata BP Solar), Moser Baer and Indosolar either operated at very low capacity or closed their manufacturing units. Companies defaulted on their bank loans and went through a debt restructuring. This led to a reduction in R&D investments and diminishing of joint ventures with foreign players (Johnson, 2013). Recently, higher costs have also been attributed to a lack of expertise and economies of scale (PVTECH, 2013). A combination of these factors points to the decreasing competitiveness of the Indian solar PV manufacturing sector. Domestic manufacturers have also approached the Directorate of Anti-Dumping (DGAD) seeking anti-dumping duties in the range of 35–40 per cent on 10 international companies (Table 3.3) ("Domestic solar cell makers slam," 2013).

TABLE 3.3: BREAKDOWN OF COMPANIES AGAINST WHICH ANTI-DUMPING DUTIES HAVE BEEN SOUGHT, BY COUNTRY

COUNTRY	NUMBER OF COMPANIES
China	5
Malaysia	2
Taiwan	2
USA	1

Source: "Domestic solar cell makers slam" (2013).

Indian manufacturers had failed to anticipate the price drop due to oversupply and continued to invest in increasing capacity without backward integration. Domestic firms came under increasing pressure as a result of plummeting international prices. The value added in the products was quite small as India does not have supportive industries that manufacture poly-silicon, ingots and wafers. Table 3.4 indicates that other Asian countries have a significantly lower cost of manufacturing (inherent or aided by subsidies) solar modules, cells and wafers and are competitive across all elements.

TABLE 3.4: COMPARISON OF INDIAN MANUFACTURING COSTS OF MODULE, CELL AND WAFERS IN 2013 TO THOSE OF OTHER COUNTRIES

PARAMETER	MODULE		CELL		WAFERS	
	India	China and Rest of Asia	India	China and Rest of Asia	India	China and Rest of Asia
	In cents/Watt					
Depreciation	1.25	1	3	2	5	4
Interest	1.75	0.75	5	1	8	3
Manpower	1.5	1.5	1	1	1	1
Utility & Spares	2	2	4	3	6	4
Balance of Material (Incl. Duties and Tax)	28	22	15	12	20	18
Total	**34.5**	**27.25**	**28**	**19**	**40**	**30**

Source: FICCI (2013).

The competitiveness of Indian firms as highlighted by the revealed comparative advantage (RCA)[27] metric shows a declining trend (Figure 3.4). With a miniscule export base (and share of the global pie), the trend indicates that the industry is declining.

[27] Revealed comparative advantage (RCA) is the ratio of the fraction of the export of a selected commodity to export of a selected class of commodities to the similar fraction for a selected set of countries. It aims to highlight those sectors in which the country in question has a comparative advantage in a given good relative to other goods, for that given set of countries.

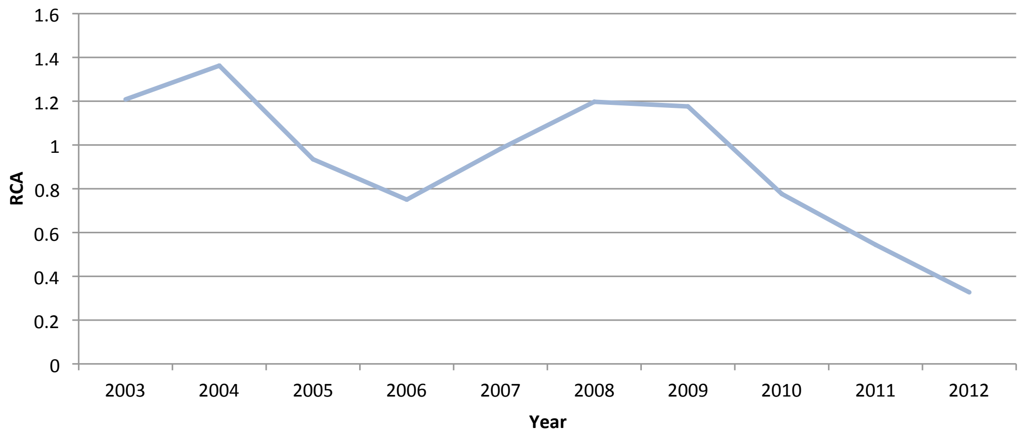


FIGURE 3.4: RCA OF INDIAN SOLAR PV (HS 854140)

Source: UN Comtrade Database

A combination of preference for cheaper imports (for thin-film panels) and higher interest rates faced by domestic manufacturers (of crystalline PV) exacerbated the stress on the latter, thereby leading to their inability to cope with the flood of low priced components from China and the United States; the attraction of lower-cost finance and the drastic drop in demand. The U.S. Exim Bank and Overseas Private Investment Corporation (OPIC) offered low-interest loans to Indian solar project developers (about 3 per cent) and a long repayment schedule (up to 18 years) for purchasing thin-film panels manufactured by U.S. companies. At the time this resulted in 80 per cent of India's domestic manufacturing capacity being closed forcibly and companies having to undergo debt restructuring (CSE, 2012).

The global share of the Indian solar PV sector has decreased over the last decade. It can be observed (Figure 3.5) that the Indian manufacturers have not been able to keep the pace with global developments and have barely expanded their production capacity.

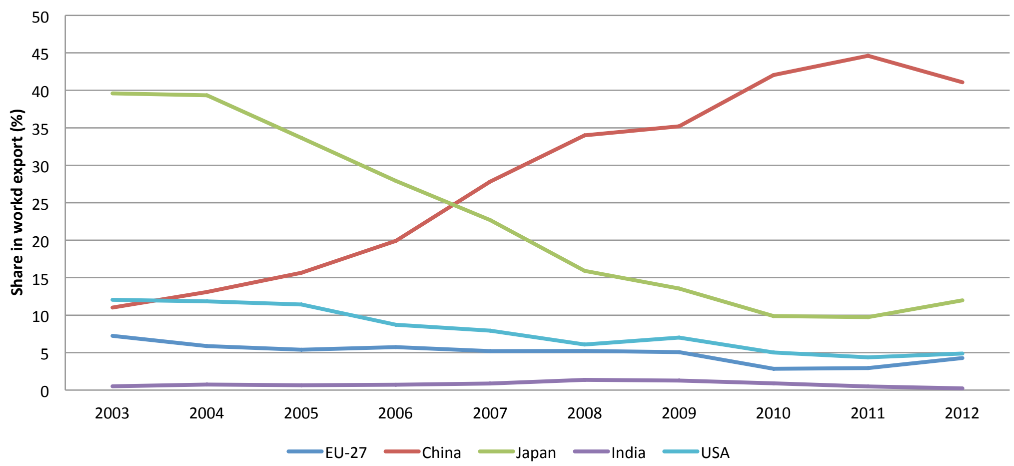


FIGURE 3.5: EXPORT SHARE OF SOLAR PV

Source : UN Comtrade Database

In addition to the lack of vertically integrated production lines (for core solar PV components), Indian firms have also faced challenges due to the less competitive nature of the industries that supply balance of systems, such as power inverters and transformers to solar power plants. It is observed that Indian firms are highly reliant on turnkey[28] manufacturing, signalling that the industry has lagged behind in innovation and process engineering (Sahoo & Shrimali, 2013). Despite being early movers, Indian manufacturers were unable to capitalize on their position. They failed to adapt to global changes and challenges in the sector, partly due to the inherent deficiencies of the manufacturing ecosystem in India and the failure of institutions and policies meant to cater to the solar PV industry. Various firms complained in the face of cheap imports but did not co-ordinate well with research institutions and invest in R&D.

However, enterprises have now started to adapt to the changing marketing dynamics and begun reworking their strategy to address the challenges. Recent stakeholder conversations have suggested that, for some companies, the capacity utilization factor has gone up significantly; ranging from 60 per cent to full capacity utilization. They are now diversifying both their domestic and international market and even working as contract manufacturers for Chinese firms. High demand has been witnessed from government-sponsored projects (i.e., public procurement). There has also been an increase in demand from European markets (where Chinese goods face high anti-dumping duties) and from countries such as Japan, where solar energy has taken centre stage after the Fukushima crisis. With the announcement of the second phase of the JNNSM, which mandates 375 MW of solar power plants from Indian firms, the manufacturing sector could get a new boost as long as it has the capacity to deliver.

3.2.2 Wind Power

Presently, with over 9.5 GW of manufacturing capacity, Indian wind manufacturers cater to both the domestic and global market (GWEC, 2012a). Nineteen firms manufacture turbines in the range of 225 kW to 2500 kW (C-WET, 2013b). Indian manufacturers supply systems to the United States and countries in South Asia, Middle East, Africa and South America.

However, while Indian firms manufacture turbines in the range of 225kW to 2500 kW, the global average installation size of wind turbines is estimated to be 1800 or 2300 kW according to different sources (GWEC, 2012b; IEA, 2013). The sector has seen a constant lag in terms of introduction of higher-capacity wind turbines when compared to European markets (Mizuno, 2011). For example, international companies like Vestas, Enercon and Gamesa have not introduced higher-power rating turbines in the Indian market, which requires a great deal of customization to account for the prevailing wind regimes in India (see Table 3.5).

TABLE 3.5: COMPARISON OF WIND TURBINE CAPACITY BY MANUFACTURER

Organization	Wind turbine manufacturing capacity range for on-shore installations (kW)	Wind turbine capacity range introduced in India for on-shore installations (kW)
Vestas	1,800 to 3,300	1,800 to 2,000
Enercon	800 to 7,580	800
Gamesa	850 to 5,000	850 to 2,000
Suzlon	1,800 to 6,150 (Manufactured by RRB, Germany)	600 to 2,100 (Manufactured by Suzlon, India)

Source: CEEW compilation from company websites.

[28] Turnkey in the manufacturing industry refers to the reliance on finished goods from other entities.

Figure 3.6 captures the export and import of wind-powered generating sets (HS 850231). However, this is indicative only of those transactions where the generation unit was imported or exported as one. There are many components of the nacelle and rotor head that are actually imported but not captured separately (50 per cent of the entire wind-generation unit). However, it is difficult to separate the fraction of such components from those that were imported or exported for use in other industries (they are generic and find multiple uses).

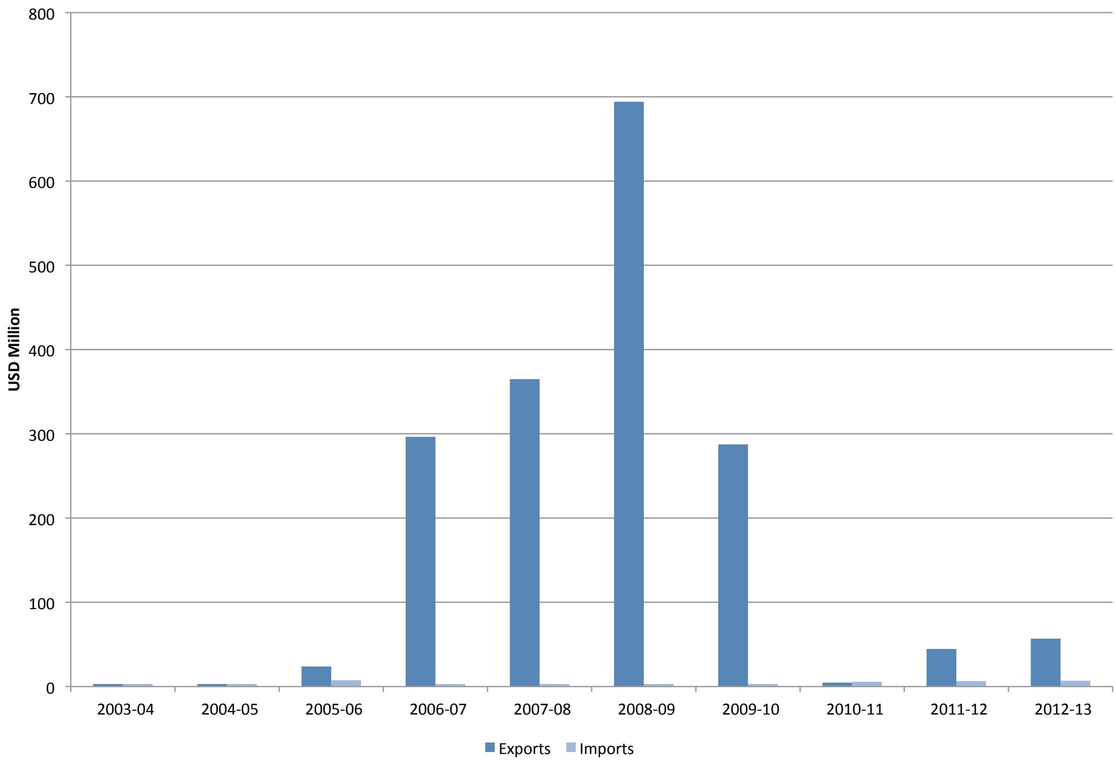


FIGURE 3.6: EXPORT AND IMPORT OF WIND-POWERED GENERATING SETS 2003–2013 (US$ MILLION)

Source: (Department of Commerce, 2013)

With the average wind turbine size increasing worldwide, Indian manufactures are losing their share in the global export market (Figure 3.7). The export share of the Indian wind industry was over 12 per cent in 2008, when the average size of wind turbines installed globally was 1.6 MW (IEA, 2013). Indian manufacturers like Suzlon were incentivized by lower labour and production costs, benefits from series production, increasing levels of local manufacture of all turbine components, which helped reduced the cost of Indian turbines compared to the global average. Stakeholder interviews reveal that exports from India have so far been only from Indian firms, not the subsidiaries of foreign manufacturers.

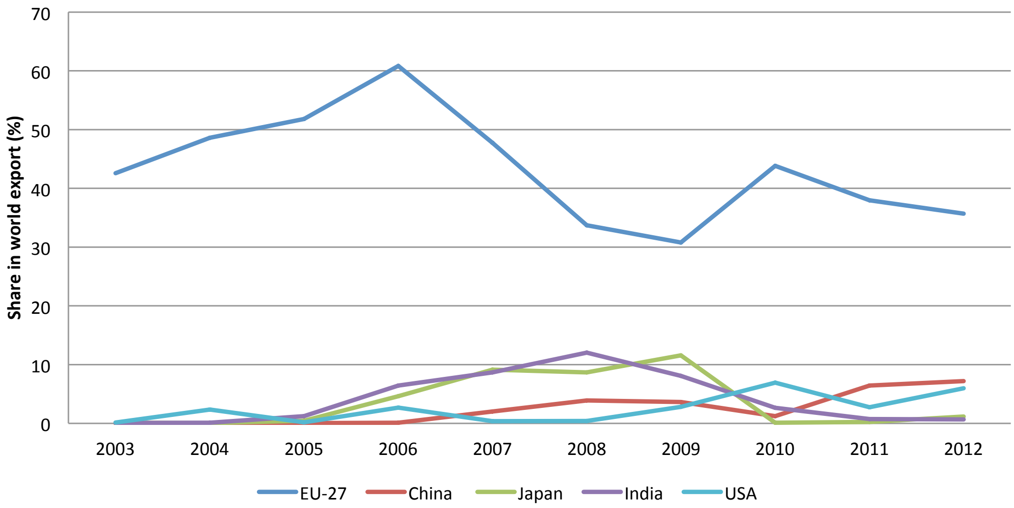


FIGURE 3.7: EXPORT SHARE OF WIND-POWERED GENERATING SETS (%)

Source : UN Comtrade Database

Exports over the last few years have dipped since the highs that were seen between 2007 and 2009. They have declined on the back of sluggish demand and increased domestic manufacturing in the United States, which was the largest market for Suzlon. This is mostly as a consequence of monopsony of sorts for turbines manufactured in India (Table 3.6).

TABLE 3.6: INDIAN EXPORTS OF HS CODE 850231(WIND-POWERED GENERATING SETS) IN US$ MILLION

COUNTRY	2012-13	2011-12	2010-11	2009-10	2008-09	2007-08	2006-07	2005-06
United States	1.08	9.21	1.13	208.48	267.25	175.4	273.86	21.81
Brazil	29.34	-	-	28.77	121.07	63.72	-	-
Australia	-	-	0.23	26.18	132.96	81.53	1.01	-
Portugal	-	-	-	0.59	64.42	29.21	15.22	-
Spain	0.7	-	-	0.3	58.81	9.26	1.75	-
Total Exported	**56.92**	**44.58**	**4.62**	**287.42**	**694.21**	**364.97**	**296.52**	**23.76**

Source: Department of Commerce (2013).

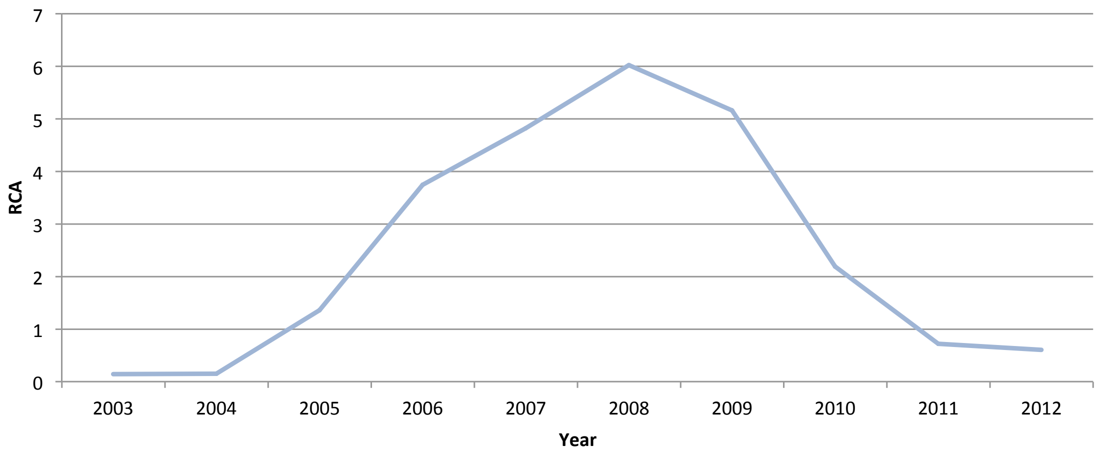


FIGURE 3.8: RCA OF INDIAN WIND TURBINE MANUFACTURING (HS 850231)

Source : UN Comtrade Database

When seen through the lens of the RCA, the competitiveness of the Indian wind turbine industry is consistent with the export share analysis. With an RCA in excess of one, from 2005 to 2010, and a peak value of six in 2008 (Figure 3.8), export of wind turbines certainly reflected the high competitiveness of domestic Indian manufacturers in the recent past.

Many small players like Shriram EPC and Elecon Engineering have re-entered the market with higher capacity turbines (GWEC, 2012a). However, there have been some doubts about the space available for the entry of new manufacturers. Decreasing installations (both globally and in India) in recent years have compelled manufacturing units to underutilize their existing capacity. These challenges may lead to consolidation or exit of many enterprises unless they are able to scale up their manufacturing facility to over 500 MW and achieve economies of scale (Shah, 2012).

Indian manufacturers have historically relied on import from foreign manufactures for complex and high-value components. Indian companies are importing critical parts from China, which have largely benefitted from their large scale manufacturing units. Both Suzlon and Enercon (the two largest manufacturers) have assembly units for nacelles and rotor heads, but with a large number of components within the nacelles being imported, there is a significant dependence on imports even for these "domestic" manufacturers. Also, international companies like Gamesa have opened up manufacturing units in China and Spain that supply the global market; manufacturing units in India cater only to the local market (Gamesa, 2012). It is estimated that subsidiaries of foreign manufacturers like Gamesa and Vestas etc. import nearly 50 per cent of their wind turbine components (in value terms) from their established vendors with bases in Europe. In considerations of logistics they have manufacturing units for towers and blades, but only assembly units for the nacelle and rotor, as that is a certification requirement under the C-WET rules.[29] Through our interactions with manufacturers we find that India has significant domestic capacity to manufacture towers and blades, which constitute up to 40 per cent of the value of all the components in a wind energy project (Table 3.7). However, even in this process, in many cases the materials (fibre composites and steel) required for towers and blades are imported. Only recently have some manufacturers started relying on domestic vendors such as SAIL to source high-performance steel.

[29] CEEW interaction with stakeholders.

TABLE 3.7: COST BREAKUP OF COMPONENTS OF A WIND ENERGY PROJECT

COMPONENT	COST BREAKUP (INR MILLION)
Nacelle	19.7
Hub	3.1
Blade	4.5
Power Panels	2.5
Hardware + Cables	2.6
Tower + Tower Logistics	7.9
Total	**40.3**

Source: TNERC (2012).

Domestic firms like Suzlon have been able to provide turnkey solutions at a lower cost as compared to the new entrants. In the past this has made them the preferred choice of investors and project developers who were relying on the benefits of accelerated depreciation to justify their investments. Turnkey solution providers in the Indian wind energy sector (the predominant model until recently) face stiff challenges as the market changes.

With the removal of accelerated depreciation benefits (from March 2012), a shift to higher performance and efficient wind turbines has been observed with a concomitant shift to products on offer from experienced foreign manufacturers from overseas. The increasing interest from independent power producers and long-term investors is also likely to expand the use of higher performance turbines that have higher output and are able to access FiT incentives better. This has also caused a shift in the business model to one where investors play a more participatory role in the designing of projects in an attempt to bring down the cost of generation and compete with conventional power generation.

From the discussion so far it can be observed that, despite the prevailing levels of indigenization, Indian manufacturers are largely dependent on their foreign counterparts for technology transfer and have also benefited immensely from the collaborations. Those without these connections have the capability to manufacture turbines only in the sub-MW range. The Indian manufacturing industry was highly competitive from 2005 to 2010, but in recent years it has been unable to compete in an international market largely dominated by European manufacturers. China and the United States are now slowly increasing their share of the export market. Indian manufacturers must be prepared for the imminent increase in competition for the domestic market, with the rapidly evolving business models being adopted by investors and developers, in pursuit of efficiency of conversion and stable performance life.

In the past decade both the wind and solar sectors have seen many ups and downs. At one point highly competitive, the sectors have lately been unable to meet global expectations in terms of price and quality, leading to a decrease in exports and an increasingly visible presence of foreign manufactured products even in domestic installations. While Indian wind manufacturers are able to meet domestic expectations, the solar sector witnessed an onslaught due to cheap imported products. Both industries did not invest aptly in research and development and hence had to largely rely on their overseas suppliers/collaborations. This skewed dependence on foreign players for technological transfer led to lag in the adoption of technology and a continued reliance on legacy systems. Manufacturers suggest that the high cost of finance, lack of working capital and an insufficient export credit line also put Indian manufacturers at a disadvantage. Also, it has been noticed that while the Indian wind sector has been the more competitive of the two as a result of the maturity over time, the solar sector has been

propped up by creating a demand through the DCR clause in the policy. Having witnessed the competition from imported products, Indian solar manufacturers have started to diversify their business models, and some sort of consolidation of the sector is expected. Also, it is still to be seen how the wind sector would react to the advent of Chinese wind turbine manufactures in India.

3.3 Increased Competition in the Global Market

The question of whether India's manufacturing industry in solar PV and wind has affected the structure of the international market for these products is a difficult one to answer. This is largely due to the small (and insignificant) market share of Indian entities in the global export pie. The annual installations in India, currently and historically, are also not of the order that they shake up the existing price regimes in the international market (for components that it imports).

Despite a healthy domestic market for solar PV products, there are no domestic manufacturers of any standing among the top 15 in the world. The list is dominated, unsurprisingly, by Chinese manufacturers and a few North American manufacturers (REN21, 2013). When compared to global production capacity (~100 GW), Indian manufacturers put together have meagre share of less than 1.5 per cent. While this represents the status in the manufacture of the core components of a solar PV system (panels/modules/cells), the status of the manufacture of balance of system is negligible. It can be safely concluded that manufacturers in India do not impact the global order.

TABLE 3.8: GLOBAL MARKET SHARE OF MAJOR MANUFACTURERS OF WIND TURBINES (PERCENTAGE)

COMPANY	2005 %	2009 %	2010 %	2011 %	2012 %
GE Energy (United States)	18	12	10	8	16
Siemens (Germany)	6	6	5	6	10
Vestas (Denmark)	28	13	12	13	14
Gamesa (Spain)	13	7	7	8	6
Enercon (Germany)	14	9	7	8	8
Suzlon (India)	6	10	6	8	7
Nordex (Denmark)	3	3	2	0	0
Goldwind (China)	0	7	10	9	6
Sinovel (China)	0	9	11	9	3
Dongfang (China)	0	7	7	0	0
Guodian United Power (China)	0	0	0	7	5
Mingyang Wind Power (China)	0	0	0	4	3
Others	11	18	23	21	23
Hirschman Herfindahl Index	0.168	0.109	0.121	0.112	0.127

Source: CEEW Compilation.

A summary of the market share of large manufacturers for wind energy systems at the global level is provided in Table 3.8. Nearly 80 per cent of the market is in the hands of 10 manufacturers. However, Suzlon's share has decreased marginally over the last few years which can be attributed to the advent of Chinese manufacturers and a host of other factors explored earlier. The policies that spurred the growth of companies like Suzlon were not specifically intended to promote export of wind turbine components. It was more to cater to the captive demand or supply to the domestic market. The data for the period and the associated competitiveness index as calculated using the Hirschman-Herfindahl Index indicate that competition in the international market has increased over the last seven years. However, this has been due to the increased number of manufacturers from China. While consolidation in this industry is a regular affair, this has not had any adverse effects on the competition. The recent split between Enercon and its Indian subsidiary and the acquiring of REPower Systems by Suzlon in Germany could increase the Indian footprint and may lead to a shift in the industry rankings over time.

Indian manufacturers have not had a significant impact on the international market. While wind companies were competitive in the global market for a few years, their presence is declining. Other than Suzlon, no company (wind or solar) has any major international presence—at least no export from their Indian manufacturing base. The Indian solar industry has just not reached a scale of production where it can contribute significantly to the global manufacturing pool, and no real analysis can be made of its impact on international competition.

3.4 Impact on Employment Generation

3.4.1 Solar

While there is no doubt that manufacturing and installation related to solar energy generate additional jobs, no concrete study has been performed to estimate the number of additional jobs in the sector. A detailed study needs to be performed on the number of indirect and direct jobs that are created across the value chain in the sector. Some studies have tried to estimate the number of jobs, but significant variations are seen in the estimates. MNRE estimates that at least 50,000 jobs have been created in the past three years in the new and renewable energy sector (MNRE, 2013c). Another study suggests that the solar sector has a potential to employ over 200,000 people if the whole value chain were manufactured in India (FICCI, 2013). Table 3.9 and Table 3.10 list various (not necessarily exhaustive) studies that were reviewed for this study.

TABLE 3.9: JOBS IN MANUFACTURING[30]

JOBS PER MW	SOURCE
32	MNRE, 2008
30	Confederation of Indian Industry [CII], 2010
20	Kumar, 2012

TABLE 3.10: JOBS IN INSTALLATION& MAINTENANCE[31]

JOBS PER MW	SOURCE
Six people per MW	CII, 2010
65 people per MW for installation 15 people per MW for operation and maintenance	Kumar, 2012
16 Jobs per MW for installation One to two jobs per MW for operation and maintenance	MNRE, 2013c

[30] MNRE estimates that on an average 25 to 40 direct jobs are created for each MW of solar manufacturing capacity addition. Hence we take an average of 25 and 40.

[31] MNRE has estimated that 400 indirect jobs may be created for a 50 MW solar power plant. CII estimates that three direct and three indirect jobs are created per MW. MNRE estimates that 40 jobs are created for 1–2 MW for erection and commissioning and 15 each additional capacity. Hence a 10 MW plant may employ 160 people.

In our study we attempt to estimate the number of jobs by tempering the potential ascribed to the sector in the various studies that were surveyed. First, we list all the sources which have tried to estimate the employment intensity (jobs per MW) and then average the figures, while ensuring no outliers exist. Using these employment-intensity figures and the installed capacity at the country level, we arrived at the final (albeit imperfect) employment figures.

A further assumption is that there has been little variation in the intensity estimates over the past few years during which the solar industry has grown in the country (Table 3.11, Table 3.12 and Table 3.13).

TABLE 3.11: CEEW ESTIMATES OF JOBS PER MW*

PARAMETER (PER MW)		JOBS/MW [32]
Manufacturing for both cells and modules (Direct+ Indirect)	(32+30+20)/3	27
Plant installation and maintenance of a grid-connected solar plant For installation For maintenance	 (65+16+6)/3 (15+2)/2	 29 7

Note: These numbers have been estimated based on the sources mentioned in the above tables. However since no wide stakeholder estimation has been done till now, the actual number may differ.

TABLE 3.12: JOBS IN MANUFACTURING SECTOR

YEAR	ESTIMATED MANUFACTURING CAPACITY (CELLS + MODULES) IN MW	ESTIMATED CUF[33]	JOBS (27 JOBS PER MW)
2010-2011	920	60%	14,904
2011-2012	2,500	20%	13,500
2012-2013	3,000	15%	12,150

Source: CEEW calculation

TABLE 3.13: JOBS IN INSTALLATION AND MAINTENANCE

YEAR	APPROXIMATE NEWLY INSTALLED CAPACITY	TOTAL JOBS PER YEAR (29 JOBS PER MW)
2010-2011	10 MW	290
2011-2012	1,000 MW	29,000
2012-2013	1,000 MW	29,000

Source: CEEW calculation

[32] This data captures only the number of jobs that have been created, but a better estimation may be the number of man-hours of work that has been created every year, because installations are on a project basis and do not offer permanent employment.

[33] CUF has been estimated based on stakeholder conversations and on the export data of solar PV.

TABLE 3.14: TOTAL JOBS CREATED IN THE PAST THREE YEARS*

YEAR	JOBS IN MANUFACTURING	JOBS IN INSTALLATION AND MAINTENANCE	TOTAL JOBS CREATED IN THAT YEAR
2010-2011	14,904	290	15,194
2011-2012	13,500	29,000	42,500
2012-2013	12,150	29,000	41,150

**Note: The above numbers should only be used as a reference figure*
Source: CEEW calculation

From Table 3.14, we observe that despite the increase in manufacturing capacity, the jobs generated from the solar PV industry may have decreased over the years. This has been primarily due to a decrease in the capacity-utilization factor of the manufacturing units. Jobs in installation and maintenance have increased tremendously due to new capacity additions.

We should also be aware that these numbers do not capture the jobs created in the off-grid sector, which may employ the maximum number of people per MW. MNRE estimates that 20 jobs are created per MW whereas CII estimates that 60 jobs are created per MW in the off-grid sector (MNRE, 2012d; CII, 2010). Consultations with off-grid enterprises have suggested that the number of jobs may vary according by organization and business model. Also, the number of people permanently employed may be equal to the number of people employed on a temporary basis. A medium-sized organization with presence in four or five states may employ approximately 250 permanent and 200 contract employees. The number may vary from less than 50 to larger than 1,000 across the enterprises. Clearly, a bottom-up estimation of jobs in the off-grid sector would require much more data than available currently.

3.4.2 Wind

Existing literature and publications do not present a comprehensive and consistent analysis of the employment generated across the value chain of the wind energy sector in India. Significant variations have been found in the numbers reported in studies/reports and manufacturers. While industry proponents project a tripling of the employment figures over the next two decades, the baseline employment figures are questionable[34] (GWEC, 2012a). It is estimated that around 15 jobs are created per MW of wind capacity installed (GWEC, 2009; WISE, 2011; Suzlon, 2011). In addition, one extra job is generated for O&M on a cumulative basis, for every 3 MW installed (Suzlon, 2011). The major functional areas of employment in the wind energy sector include project development, O&M and marketing (CII, 2010).[35] For the industry as a whole, Suzlon estimates that 38,000 to 40,000 job-years are generated on an annual basis (Suzlon, 2011).

Table 3.15 outlines employment data of Indian wind companies. While this is not an exhaustive listing of employment figures across all manufacturers in the country, it captures the figures as listed in public sources—documents, newspapers and company websites—for some of the largest manufacturers in India representing a bulk of the capacity (> 80 per cent) in the country. Clearly, the figures here represent only a third of the annual jobs generated by the sector in other reports.

[34] Includes both direct (through manufacture, component supply, wind farm development, installation) and indirect employment; underlying methodology is unknown.

[35] The typical job profiles in wind constitute qualified mechanical, electrical, & material science engineers, technical staff for operation and maintenance, project managers, environmental engineers and other specialists to analyze the environmental impacts of wind farms, meteorologists for wind energy forecasts and prediction models, etc.

TABLE 3.15: EMPLOYMENT DATA FOR INDIAN WIND COMPANIES

COMPANY	HEADCOUNT
Suzlon Energy Ltd	7,500
Wind World India Limited (WWIL; formerly Enercon India Ltd)	5,600
Gamesa Wind Turbines Pvt Ltd	850
Regen Powertech	2,300
Global Wind Power Ltd.	100
Inox Wind	1000
Leitwind Shriram Manufacturing Ltd	300-500

Note: These numbers do not reflect all direct jobs and indirect jobs; employment data for all existing wind companies could not be accessed.
Sources: Wind companies' websites.

In fiscal year 2012-2013, key wind power players like Gamesa, Suzlon and Vestas reduced their workforces in India. One of the important reasons attributed was the withdrawal of the GBI and AD incentives by the government and the resultant decrease in interest from project developers. Gamesa reduced its workforce in India by 135 employees in FY 2011–2012 (Ramesh, 2012a). Suzlon Energy Limited, which is one of the biggest wind turbine manufacturers in India, had 9,000 employees in India and 13,000 globally as of FY 2011–2012 (NDTV, 2012). However, in an effort to contain its liabilities, it reportedly reduced its workforce by around 1,500 in the last fiscal year (2012 to 2013) (Bakewell, 2013).

Our analysis reinforces the need to undertake comprehensive studies that could provide clarity on the extent of impact that myriad RE policies such as JNNSM, domestic content requirement, GBI, AD and so forth have had on employment generation. The impact on jobs is indirect, through the commissioning of projects and the associated activities. The influence of policies such as the GBI and AD on employment in the wind sector can only be deduced by evidence that indicates companies having downsized their operations and curtailed workforce following the roll-back of these incentives. Employment in the wind sector has received a boost with government's customs and excise duties' norms, which make imports of wind turbine components (such as nacelles) and their domestic assembly more attractive than imports of assembled turbines. A large portion of the employment in the solar energy value chain (PV) is in the project development and maintenance phases, and India certainly stands to gain in the years to come, even if the solar manufacturing industry is slow to take off.

3.5 Impact on GHG Emissions

Renewable energy installations have contributed positively to climate mitigation efforts within the country, and this clearly needs to be accounted for as a direct impact of the pursuit of "green growth" by Indian policy-makers. Though India has no mandatory targets for reduction of emissions, the renewable energy contributes to the lowering of the average greenhouse gas (GHG) footprint of the electricity generation process in the country.

It would be a useful exercise to evaluate the avoided GHG emissions, assuming all the generation from wind and solar displaced fossil fuel based generation. The starting point for such an exercise, as with many others, is the evaluation of the counterfactual. In the absence of green energy, the required electricity would have been generated from the mix that represents the non-renewable portion of the existing capacity. More than 70 per cent of electricity generation in the country from 2010 to 2011 came from thermal sources. About 17 per cent came from a mix of hydro and nuclear (CEA, 2012a). This mix has not varied much over the last few years since the addition in capacity of hydro and nuclear has been at a very slow pace.

The weighted average emission factor for the country as a whole for recent years ranges from 0.78 to 0.79 kgCO_2eq/kWh, for the years 2007 to 2012 (CEA, 2013b). The total electricity generated from wind for the years 2007 to 2012 was 85 billion kWh. The overall emissions avoided as a result of this level of generation would then be 66.3 MTCO_2eq. This translates to an annual emissions reduction of roughly 13.3 MTCO_2eq. This is nearly 3.5 times the emission reductions as represented by those wind projects that gained CDM accreditation.

The same estimation can be carried out for solar generation. For the period 2011–2013 (for which solar generation data is available), overall generation from solar is around 276 million kWh. Thus overall emissions avoided from solar generation would be 215,000 TCO_{2eq}. The emissions reduction achieved per year are only 107,500 TCO_{2eq}. However, given that solar projects have developed largely in the last couple of years, the emissions reductions achieved from wind projects are far more significant and render the solar equivalent irrelevant from an analysis perspective.

It is interesting to note that the emissions reductions of registered solar CDM projects (from the PDDs), are significantly higher than the calculated emissions reduction from the reported generation. Clearly there is a mismatch arising from either the under-reporting of solar generation, captive consumption or under-performance of projects that actually registered for CDM credits.

The last official estimation of India's overall GHG emissions inventory was carried out in 2010[36] (with data from 2007). The estimate is around 1,722 $MTCO_{2eq}$ (INCCA, 2010), from all sources in the Indian economy. The abatement achieved from the two RE sources as a percentage of overall national emissions works out to a miniscule 0.72 per cent. This would be even lower if one were to use the overall emissions for the country in more recent times, say 2010 or 2013. While every additional ton of carbon dioxide reduced is beneficial, the RE sector has not reduced the national carbon footprint significantly. That said, the power sector (in 2007) represented nearly 38 per cent (719 $MTCO_{2eq}$) of the overall emissions. As a percentage of the power sector emissions, the reductions offered by wind are definitely more significant and amount to 1.7 per cent of the total emissions of the power sector.

The impact of RE on the country's overall GHG emissions is not very significant today. This illustrates the immense size of the effort necessary to scale up RE to seriously dent the emissions profile of the country—for both energy and non-energy uses. Though much of the emissions reduction has happened without the support of a price on carbon, a functioning carbon market could provide the right incentive: the small number of projects that accessed the CDM in earlier years certainly benefited from the additional revenue stream associated with it. With a voluntary target (for India) of reducing emissions intensity by 20 per cent to 25 per cent by 2020, RE can certainly play a role.

3.6 Local Environmental Impacts

In addition to serving the broader goal of mitigating climate change, "green industries" have a positive impact on the local environment as they help avoid emissions-derived air pollution,[37] the costs of which can be significant. In justifying the higher costs of RE (specifically solar), both avoided climate change costs (global) as well as avoided local air pollution costs could be incorporated in a cost–benefit analysis. We apply available research findings to use a suitable per kWh figure value for local air pollution costs of thermal power generation in India. While the most significant and pronounced impacts of air pollution arising from power plants are on human health and mortality, there are a wide range of impacts on the immediate surroundings—i.e., vegetation, forests, agricultural productivity, historical monuments, contemporary constructions, etc.

[36] The Second National Communication issued in 2012 still reports emissions figures for the years 2000 and 2007 (MoEF, 2012).

[37] Only the health impacts of air pollution are considered while evaluating local environmental impacts, though there could be a broader impact on forest and agricultural productivity, recreational areas, etc.

An externality (cost or benefit), is defined as an unpriced and uncompensated side effect of one's actions that directly affects the welfare of another agent (Baumol & Oates, 1988). Since these effects are not reflected in market prices, there exists a need to assist market processes by assigning them monetary values to integrate them into private and public decision making. The type of fuel and the technology used can greatly influence the impact of emissions, and so emissions data needs to be ascertained through site-specific investigation. In the context of thermal power plant emissions, the coal-fired ones are widespread and constitute a bulk of the electricity generation capacity across the world (OECD, 2012). India's Integrated Energy Policy (2006) also envisions coal contributing close to 42 per cent of the electricity generation needs of the country up until 2032, even in the best-case scenario with a large expansion in the capacity of renewable energy sources (Planning Commission, 2006a). It is then reasonable to assume that the counterfactual to renewable energy growth and promotion would be a continued reliance on the current mix of coal, natural gas, hydropower and nuclear based generation. Coal-based power currently contributes nearly 63 per cent of electricity generation. The evaluation in the exercise below provides a lower bound on the impact of coal-based power, to the extent that it contributes to the energy mix.

Green industries also have their share of pollutant load. Solar PV cells have a cadmium and mercury footprint, as these form part of the manufacturing process. However, life-cycle assessments indicate that this is still a small fraction (0.33 per cent to 1 per cent) of the emissions of these elements from a conventional coal-fired power plant. Given that these are an order of magnitude lower than the pollutant load from conventional power plants, these can be neglected.

The first order of tasks then is to establish a reasonable estimate for the externalities caused by burning coal in thermal power stations: this will form the basis for the avoided costs and the local environmental benefits arising from the pursuit of solar and wind power. Until the beginning of the last decade, most studies pertaining to the externalities of electricity were carried out in the developed world (Sundqvist & Soderholm, 2002). Even in the studies performed in Asia around the time, the common practice was to draw on the results of such studies and to 'transfer' values with suitable adjustments to reflect the economic conditions in the developing country. There are large variations in the estimated external damage costs, which makes a direct assimilation of values for policy formulation quite a challenge. There is a lack of precise data and absence of standard index for calculation of externalities. As per one estimate for India, the externality of coal is only around US$0.014 US cents/kWh, which is tiny in comparison to the valuations carried out in the European Union, namely US$0.36 US cents/kWh in Belgium and US$0.19./kWh in the United Kingdom (Sundqvist & Soderholm, 2002).[38] The reasons for this broad range of values could be explained by a variety of factors. The foremost important factor is the large variation in the estimates of externalities considered in the various studies, including loss in forest and agricultural productivity and in some cases, the entire cycle of fuel use starting from mining to use. The other significant factor explaining the variation is essentially a manifestation of purchasing power and living standards, which reflect differences in the cost of medical treatment and value of statistical life (VOSL), two important valuation components, between developed and developing economies.

Epidemiological evidence from the North America and Western Europe indicates that current ambient levels of airborne pollutants do result in premature mortality and a wide range of morbidity outcomes (USEPA, 2004; WHO, 2000). The valuation of the impacts typically relies on estimating the mortality and morbidity related impacts of air pollution. While it is possible to estimate the impact for the entire life cycle of the fossil fuel in question (mining, transportation, burning and ash disposal) and for the entire range of impacts on the local environment, we limit our analysis to externalities on human health associated with the combustion of coal in thermal power plants.

[38] All values for externality in this paragraph expressed in constant 1998 U.S. dollars.

Two recent studies provide a relatively consistent measure of the impacts associated with coal fired power plants. The first (Gunatilake & Ganesan, in press), captures the underlying economic impact of PM10, SO_2 and NOX[39] emissions on mortality and morbidity in the local area (up to 100 km^2) of a single modern coal-fired power plant. They estimate the cost to be around US$0.94/kWh. The second study (CAT, Urban Emissions & Greenpeace, 2013) focuses only on the impact of particulate matter (both PM10 and PM2.5) on morbidity and mortality associated with human population. The study is extensive and evaluates, through a robust dispersion model, the cost of air pollution of nearly 121 GW of installed capacity based on coal across India. The average cost of pollution is estimated to range from US$0.84/kWh to US$0.01/kWh. While the range of economic estimates is inferred from the figures provided in the study, the scale of impacts is seemingly much larger in the number of people impacted and the increased incidence of various health endpoints.[40] The valuations in both exercises are contingent on assumptions around the value of statistical life and the cost of hospital admissions, economic value associated with restricted days of activity and the range of illnesses considered for assessing morbidity. Given the sensitivity (as indicated earlier in the section) to the context of the valuation, an average cost of US$0.01/ kWh is assumed to arise from pollution impacts associated with coal-fired power plants.

The total generation from wind and solar for the year 2011 to 2012[41] in India was roughly 46 billion kWh (more than 99 per cent of which was from wind). Assuming that the average impact of thermal generation on local environment is as calculated in the exercise above, we can conclude that the avoided costs or the perceived benefits of using 'green power' amounts to at least[42] **US$460 million**. This is a component that has not been monetized in practice, in any ex-ante analysis—either by the private sector or by the state, though it has a significant bearing for the public at large.

In valuing the positive impacts of green industry one must be cognizant of the larger implications for the local environment, not all of which might be beneficial. In India, from 1980 until 2006, when EIAs were mandated for wind projects, only 478 hectares of forest land was cleared for setting up wind projects. Diversion of forest land for setting up wind power projects has increased considerably during the last seven years (since exclusion of wind projects from EIA Notification, 2006) with a total of 3454 hectares of forest area being cleared (CSE, 2013b). Accounting for the adverse impacts of wind power projects on local ecology (particularly of forest land and hilly areas), and having found that forest clearances for wind power projects have been granted by misrepresentation of facts, the Western Ghats Ecology Expert Panel Report (WGEEP), 2011, recommended mandatory EIAs for wind power (MoEF , 2011b). Similar issues arising from an altered land-use pattern for solar parks could also negatively affect the local environment, albeit in more arid and dry areas. While an economic assessment of these impacts is a complicated exercise, it is also likely to be specific to a project area and dependent on the enforcement of best practices of the local agencies.

Based on the analysis above, we can clearly state that solar PV and wind-based power generation has a positive impact on human health and the avoided costs associated with premature mortality and morbidity-related health end-points are significant. Conventional analyses that evaluate the costs and benefits of RE do not monetize these and their inclusion can give further boost to the case of RE financing. In addition to the impact on human health, there are a whole range of impacts on local agriculture, forest productivity, urban buildings which have not been valued in this study. Studies suggest that RE power too has ecological impacts that can—and must—be mitigated through proper planning and execution.

---

39 Particulate matter (10 micron), sulphur dioxide and nitrogen oxides.

40 Details are available in the executive summary of the study.

41 The overlap between the various data sources for wind and solar generation exists only for the year 2011–2012.

42 Only 63 per cent of the impact is apportioned in line with the contribution of coal to the energy mix. The study was limited to coal alone and no other fuels in the electricity mix.

3.7 Technological Advancement by Domestic Entities

3.7.1 Contribution of Institutions and Private Companies

Mirroring the economy-wide trend of public sector dominance in R&D spending, most R&D initiatives in solar and wind technologies in India have been undertaken by state-sponsored academic institutions and centres, with the exception of a few private players. The contribution of some of the institutions and companies towards technology advancement in solar and wind technologies are detailed below.

Solar-Specific R&D Efforts by Government/Academic Institutions

i. SERIIUS: Successful research projects:

- SERIIUS has developed a unique solar PV-module soiling test station which is being deployed to collect and analyze dust samples, test commercially developed PV-module coatings, and develop and evaluate new coatings based on nanotechnology.
- In a PV module, an encapsulating material helps cells to operate under desirable conditions and protect the cells from environmental damage. SERIIUS is developing a new material using polymer and nano-crystals to overcome certain limitations of conventional encapsulating materials while also improving their properties (SERIIUS, n.d.).

ii. National Centre for Photovoltaic Research and Education (NCPRE):

- Fabrication of a novel solar cell with 3-D junctions, silicon concentrator cells, novel technologies for contact formation using temperature-sensitive paste, plasmonics for photovoltaic applications, slicing of silicon wafers for pv applications using wire electric discharge machining (WEDM).
- They have filed four patents in the area of photovoltaic research, two each in 2010 and 2011 (NCPRE, n.d.).

iii. Indian Association for the Cultivation of Science(IACS): Fabrication of amorphous silicon solar cells

- Fabrication technology for single junction amorphous silicon (a-Si) solar cells has been developed with efficiency greater than 11.0 per cent with light induced degradation of 22 per cent.
- Double junction small area cells with initial efficiency ~11 per cent have been fabricated using light induced degradation (approximately 15 per cent). Triple junction cell with initial efficiency 10.5 per cent has also been fabricated.
- 77 cm2double junction cells with initial efficiency of 7.4 per cent have been fabricated. Connecting nine such cells in series double junction module with an active area of 700 cm2 has been fabricated with an efficiency of 6.2 per cent (IACS, 2012).

iv. National Institute of Solar Energy (NISE): Some efforts have been taken to rejuvenate existing entities to become world class, such as the Solar Energy Centre, which has recently received cabinet approval to become a National Institute of Solar Energy (Mohan, 2013; (MNRE, n.d.e). NISE is expected to serve as an "apex national centre for research and technology development and related activities in the area of solar energy technologies in the country." NISE aims to accelerate the process to support induction of the latest technologies ensuring maximum cost benefit and early commercialization. It should encourage the developers to use more efficient and optimized solar components (PIB, 2013d).

v. C-WET:

- **Solar Radiation Resource Assessment (SRRA):** Under the National Solar Mission (NSM), the availability of accurate and reliable solar radiation data was considered a key element. MNRE has decided to augment its network of solar radiation- monitoring stations in the country with a view to cover more areas, especially high-potential areas. The India Meteorological Department (IMD) is a statutory body for measuring weather parameters in the country, including solar radiation. In order to promote investor-grade solar radiation data, MNRE sanctioned a project for setting up 51 monitoring stations at sites having high potential for solar power in the country. The project is implemented by CWET, and the SRRA project is being supported by the Solmap Project funded by GIZ (C-WET, 2013a).

Solar-Specific R&D Efforts by Private Companies

Indian companies have adopted three approaches to acquire technologies, such as licensing of patents, collaborations and acquisitions (such as strategic alliances, joint ventures and other equity relations), and in-house R&D. Also, Indian manufacturers have worked closely with Indian research institutions and have used expired patents. For instance, licensing and expired patents have been used in the manufacturing of mono and multi-crystalline silicon cells and are being used by Indian manufacturers. It is also reasoned that Indian manufacturers actively drive the technology-transfer process and play a leadership role by picking up, refining, producing at low cost and engaging in their own patenting of the technology (Rasmus Lema, 2012). For instance, Indian companies like Moser Baer, HHV Solar and Tata Power Solar have adopted different approaches for R&D. Moser Baer entered into agreements with international companies and licensed thin-film photovoltaic technology. It has developed an in-house R&D facility in Netherlands and has strong linkages with academic institutions in India. It is in the process of upgrading its PV cell efficiency to 21 per cent and, in order to do so, it has adopted MIST (Metal and Intrinsic layer Semiconductor Technology) (EQ International, 2012). HHV Solar has mostly focused on in-house R&D of crystalline and thin-film solar cell and module technology.

Wind-Specific R&D Efforts by Government/Academic Institutions

i. C-WET:

- **Wind Resource Assessment Unit:** Developed in order to locate wind-rich areas using field measurements and consolidate all the data generated from various parts of the country to prepare a national wind resource atlas. Its achievements include successful monitoring of wind speed and direction at 725 sites in India. Also, it has conducted micro-siting/due diligence for more than 1,000 MW of wind farms. It also published the Indian Wind Atlas (CWET, n.d.e).
- **Development and validation of design methodologies and design tools for low and moderate wind regimes:** In collaboration with National Aerospace Laboratories (NAL), C-WET has initiated a project that would create an indigenous design data bank in order to develop indigenous, low-cost, robust, technologically advanced wind turbine blades/rotors optimized for low- or moderate-wind regimes prevalent in the country (C-WET, n.d.b).
- **Modelling of interconnection of the wind turbines with the grid:** The study aims to develop a tool that would study the grid interaction of wind turbines, determine how the wind turbine contributes in governing the grid behaviour and also study the planning and control strategies involved in implementing a wind farm (C-WET, n.d.b).
- **National Offshore Wind Energy Authority (NOWA):** NOWA, which is expected to be launched under MNRE, would carry out resource assessment and surveys in the Exclusive Economic Zones (EEZ) of India. It is expected to enter into contract with the project developers in order to promote the deployment of offshore wind energy projects in India's territorial waters (PIB, 2013c).

Wind-Specific R&D Efforts by Private Companies

Suzlon started as a joint venture with the German company Sudwind and purchased technical information from them. As India's flagship wind company, it started to manufacture turbines and blades through licensing agreements from Aerpac and Enron Wind. With little domestic know-how, the company subsequently transferred technology through its foreign acquisitions, such as AE-Rotor, Hansen Transmissions and REPower for blades, gearboxes and offshore turbines along with their R&D capabilities respectively. It entered into an agreement with Austrian firm Elin to co-design wind turbine generators. In addition, Suzlon also invested heavily in R&D both in India and Europe (Lewis, 2011; Rasmus Lema, 2012).

Researchers in General Electric's research facility in Bangalore developed low-windspeed turbines specifically for India's conditions. These turbines, the 1.5-77 and 1.6-82.5 Class IIIb wind turbines, are now being installed in India and around the globe (General Electric, n.d.). Another firm, Gamesa, recruited 100 engineers for its R&D facility in Chennai, which aims to work closely with the local supply chain and collaborate with various energy experts and institutions for developing manufacturing materials and processes (Gamesa, 2011).

Despite the R&D efforts initiated by C-WET and the private sector, based on Table 3.16 we observe that India has consistently lagged in the average size of wind turbine generators installed globally. Though the average size of wind turbines installed in India has increased, the difference between them and the largest installations in the world has remained constant. Though more recent data is not available, the difference is likely to persist, as no large re-powering exercise has been taken up in the country.

TABLE 3.16: AVERAGE SIZE (IN KW) OF WIND TURBINE GENERATORS INSTALLED

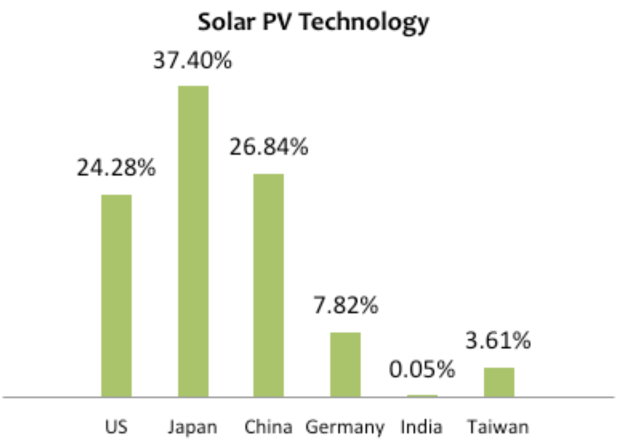
COUNTRY	2004	2005	2006	2007	2008	2009
China	771	897	931	1,079	1,220	1,360
Denmark	2,225	1,381	1,875	850	2,277	2,368
Germany	1,715	1,634	1,848	1,879	1,916	1,977
India	767	780	926	986	999	1,117
Spain	1,123	1,105	1,469	1,648	1,837	1,897
Sweden	1,336	1,126	1,138	1,670	1,738	1,974
United Kingdom	1,695	2,172	1,953	2,049	2,256	2,251
United States	1,309	1,466	1,667	1,669	1,677	1,731
Lag between India and first-in-class	-1,458	-1,392	-1,027	-1,063	-1,278	-1,251

Source: GWEC - IWTMA (2011).

3.7.2 Solar and Wind Patents

In order to understand trends in technology advancements, patents are useful in measuring the rate at which new innovations are being produced. Patents therefore provide a "quantitative metric" for the amount of technological innovation in a country, since each patent represents a new invention (Cosman, 2012). Despite the usefulness of patents as an indicator of trends in various areas of research, they have a few intrinsic downsides. Aggregated patent statistics do not indicate the quality of research as they do not differentiate between patents that have resulted in major innovations and those that have led to minor improvements. Also, many inventions are not being patented because trade secrecy may be preferred over patenting (United States General Accounting Office, 1997).

Patent data is publicly available through various agencies—some are country-specific, such as the Indian Patent Office (IPO), and others are global, like the European Patent Office (EPO) and the World Intellectual Property Organization (WIPO). For our analysis, we used the Total Patent database by Lexis-Nexis. Using the International Patent Classification codes (IPC) retrieved from WIPO's Green Inventory (Appendix E) our results show that India has **157** patents for solar PV technologies and **356** patents for wind technologies in a span of 10 years (2003 to 2013). The Espacenet global database by the European Patent Office (EPO) was also used to evaluate patent applications by India in solar PV and wind technologies compared to other major economies of the world for the period 2003–2013. The results indicate that, for these specific technologies, India has a low percentage of applications filed among all major economies considered for this analysis (Figure 3.9).



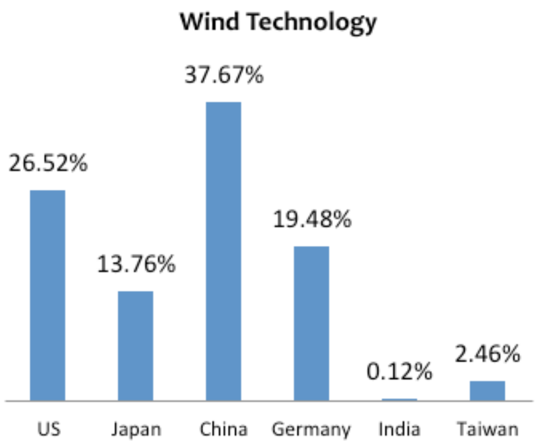


FIGURE 3.9: SHARES OF TOTAL PATENT APPLICATIONS IN SOLAR PV AND WIND TECHNOLOGIES FILED BY MAJOR ECONOMIES (2003-2013)

Source: Espacenet Global Database (n.d.).

Despite the growing importance of solar PV and wind technologies, Indian institutions hold a fraction of patents in these technology domains. India had shown an increasing trend in solar PV research output in terms of percentage of total publications (from 2000 to 2009) and was one of the five leading countries: the United States (19.71 per cent), China (11.59 per cent), Germany (10.56 per cent), Japan (9.8 per cent), and India (6.15 per cent), together contributed about 58 per cent of the total publications (note, India hardly had any patents registered until 2009) (Malti Goel, 2013). This indicates that there is a lack of effort towards translating research into commercially viable technology or products in solar PV and wind sector.

Registration of intellectual property is among the crucial steps between research and commercialization, and India's weak IP-registration and filing system has a direct bearing on the visibility of Indian-origin patents, compared to its significant competitors. The challenges in establishing a stronger IP regime in India are several:

- There is a lack of administrative and legal support to researchers in Indian institutions for patent filings.
- The Indian Patent Office (IPO) has a chronic and ever-increasing backlog of unexamined patent applications (123,255 pending applications as of April 2012) ("Over 1 lakh requests," 2013) mainly due to lack of manpower for patent examination.
- IPO staff experience the highest per-capita workload (20 applications a month, compared to seven in Europe and China, and eight in the United States) at the lowest pay, when compared to global standards (Unnikrishnan, 2010) which results in the granting of low-quality patents, which leads to certain other challenges and litigation related to such grants.
- International patent filing is a very costly affair, and research grants provided to universities/individuals usually do not include this expenditure as part of their budgets.

Current policies don't mandate or incentivize a constant technology advancement in the solar and wind sector in India, but institutes like the C-WET have played an important role in ensuring standardization and quality monitoring for wind turbines, and institutes like NISE and NCPRE are working on making solar technologies more affordable, while customizing the technology to local conditions. Demonstration projects have been pivotal in early-stage deployment of RE technologies, especially in the wind sector: the importance of these cannot be overstated. Low patent numbers indicate there is a lack of effort towards translating research into commercially viable technology/products in both the solar PV and wind sectors, is mainly due to a low level of private sector investment and a weak intellectual property regime that does not promote patent filing.

4. Lessons for Policy-Makers

Exploring the key contributions, successes and failures of the policies instituted to promote India's green industry is necessary to identify which end goals they have best supported. This would give an insight into the prospects for the RE sector in India, assuming the continuation of the current policies. Will the sector take off and trigger a renewable revolution, or has the heyday of the industry already passed without notice? These questions are of interest to potential investors (domestic and international), manufacturers looking to enter the Indian market and those looking for India to take a lead in mitigating climate change through RE deployment.

The section below answers the above questions and briefly identifies and evaluates the performance of some specific policies discussed in earlier sections. In an ideal scenario, a quantitative valuation of the costs and the benefits of various policy measures should answer these in a straightforward manner. However, the nascent stage of the industry in India, the multiple objectives it is intended to serve and the need for an RE industry from a development perspective (or in response to market failures) preclude arguments and evaluations supported solely on economic grounds. For the sake of completeness the table below captures the impact lines—direct and indirect—of a more comprehensive list of policies.

What Have the Policies Addressed?

As highlighted in the opening section, the notion of a green industrial policy is not widely discussed in India, nor is it a significant stream of thought in policy-making circles. In attempting to bring together the two elements of "green" technologies (in response to market failures) and industrial policy (to promote the more traditional goals of manufacturing or job creation), the emphatic victory has been for the green story.

The green argument supports three pillars—energy access and security, local environmental benefits, and climate change mitigation—all of which are public goods in their own right. Over the course of the last five years, a quarter of all power-generation capacity addition in the country has been based on RE sources (CEA, 2012c). Detractors will cite that the proportion of the generation attributed to RE sources is only 6 per cent (in 2013). This is, in part, a consequence of a large fossil fuel-based power capacity mix in the country. With a relatively brief history of large scale, grid-connected RE infrastructure, it is not surprising that electricity generation (as opposed to capacity addition) is still largely the domain of coal and gas. Another reason is technological, namely the intermittency associated with RE-based sources of electricity. For RE to play a more central role, technological innovation and better choices (say, for energy storage or smarter grids) would be necessary steps for tapping and using RE's full potential.

The incremental growth of RE in India notwithstanding, it is important to recognize that business as usual for fossil fuel-based sources is going to be increasingly difficult. Coal and natural gas-based generation in India faces intense supply-side pressures. In 2011–2012, it was estimated that natural gas shortage led to a shortfall in generation of roughly 10 billion kWh (CEA, 2012b). Even with an operational availability of coal-based power plants of 83 per cent, the plant load factors stood at a mere 73 per cent (CEA, 2012d). Given the coal- (and lignite-) based generation capacity in the country, this difference could have led to a shortfall of nearly 85 billion kWh of electricity. Generation from RE made up for more than 50 per cent of this deficit, with a cumulative generation across all sources of nearly 51 billion kWh (CEA, 2012c). This does not even factor in the impact of decentralized systems that touch the lives of many more millions, in a small but significant manner. Even if the constraints of low-carbon energy infrastructure were not there, fuel-security risks are already providing a strong argument to support green industries.

But the environmental costs do matter as well, further strengthening the green industry argument. Environmental impact has taken centre stage (at least in rhetoric) when the question of planning and siting of new industries is discussed. Proponents of unfettered economic growth, at whatever cost, would claim that these have had an adverse impact on industrial development and infrastructure and, thereby, the economy. The RE sector, however, largely enjoys support from both sections of society as it delivers much-needed electricity while also helping cut back on the massive emissions associated with fossil fuel-based generation. While notions such as the value of life and disability affected life years are yet to enter the Indian policy-makers' lexicon, the impact of the RE industry on air pollution cannot be understated. With poor enforcement of environmental standards and safeguards (despite civil society activism), inefficient coal-fired power plants are estimated to result in as many as 125,000 deaths annually (CAT, Urban Emissions & Greenpeace, 2013), across various age groups. These avoided costs on society underscore the need for a renewable energy revolution. And if the analysis and conservative valuations presented in earlier sections hold, this is already the most significant impact of the policies and will continue to be for the foreseeable future.

TABLE 4.1: IMPACTS OF DIRECT AND INDIRECT POLICIES.

POLICIES/ IMPACT CATEGORIES	DIRECT POLICIES								INDIRECT POLICIES		
	Financial Incentives (FiT/ GBI/ VGF)	Preferential Tax Treatment	Demand Stimulation	R&D	DCR	Investment Promotion Schemes	JV/FDI/ Technology Transfer	NCEF	Pricing Carbon	Human Resource Development	Power Evacuation
Technology Advancement				√		•	√	x			
Solar-Domestic competitiveness	•	•	x	x	x						
Wind-Domestic competitiveness	•	√	x	x		√	√			•	
Wind-Competition in the International Market	•					√					
Local Environment & GHG emissions	•		x						√		x
Energy Access and Security	•	√	x					x			x
Employment	•	√	x		•					•	

• Extent of Impact Unclear √ Positive Impact (intended or otherwise) x Impact not as desired (blank) no impact/change

Further, with increasing pressure on India to shoulder the responsibility for emissions reduction, and the reluctance in recent times to drive changes in GHG intensive sectors like agriculture and power generation, investments in RE hold the best promise (along with energy efficiency) for India. Actions to mitigate climate change do not find much support among the political class or the general public, as there is insufficient buy-in regarding the impacts of climate change and, when there is, these actions are perceived to increase the cost of goods and services. As a result, the success of policies that address climate change is likely to depend on the positive implications for energy security and the associated co-benefits that manifest through access to electricity, a cleaner environment and better developmental prospects. This could lead to a rapid uptake of RE which in turn, would start a virtuous cycle that reinforces the commitment to RE. Even with a meagre contribution of 5 per cent of total generation, RE currently accounts for more than 13 million tonnes of carbon dioxide reduction from India. Many of these projects have happened outside of the CDM regime and clearly are not driven by the monetary expectations around a carbon price. With a bulk of the investments happening in developed countries driven with an eye on future carbon markets, the scaling of India's RE program (at least in wind) has certainly had a significant impact on GHG emissions, without relying on a domestic carbon market. This bodes well for climate change action from India's perspective and with an ever-increasing appetite for power consumption the favourable impact on climate change is likely to increase.

Less successful have been the more classic industrial policy goals aimed at creating a thriving domestic industry that is competitive on its own, generating critical employment and establishing significant domestic R&D. Despite the targeted industrial policies over the decades, which focused on specific industrial activities with a view to attaining self-sufficiency in the manufacture of goods deemed critical for the economy, the manufacturing sector in India has not flourished. It also has a share of only 11 per cent of the employment in the organized sector (MoL, 2011). India has seemingly made a transition from an agricultural economy to a services-driven economy by bypassing the growth that is needed in large-scale manufacturing. At no point in the last 20 years did manufacturing contribute more than 16 per cent of GDP (RBI, 2013). What ails the manufacturing sector at large, also affects the ability of RE-related manufacturing to take off in a big way.

The Chinese and other growing markets were supported by increased local deployment of RE and policies that promoted R&D and expansion of domestic manufacturing. The enabling environment for manufacturers was a result of coordination with state and local governments, low-cost finance, significant economies of scale and the availability of the necessary supporting infrastructure (e.g., reliable and cheap electricity, domestic sourcing of components, etc.) (Ghosh, 2012b). Indian manufacturers faced many challenges in terms of poor coordination with R&D institutions, which did not focus on commercialization of technologies, high interest rates, imported machinery, high electricity costs, slow upgrading of technology, high inventory and lead times with lower volumes of production (Sahoo & Shrimali, 2013; FICCI, 2013).

We should note here that any evaluation of industrial policy goals and outcomes depends on reliable and updated information. Such information in the RE sectors in India is either not available, or covers a time period too short to undertake any trend analysis, or is not shared by firms (many of which are not listed companies). As a result, access to timely information and data remains a challenge, and will be a barrier to building the case to support industries in India or to tweak policies to make them more effective. Industry associations could play a key role in industry-specific information collection and dissemination. In this process, it is important that, i) trust is not only built between the public and private sector, but also with civil society organizations, which can play a role in supporting RE development through objective research; and ii) there be a concerted effort to build a database of key metrics at a granular level to help showcase the contribution of various renewable energy technologies. This should include jobs, R&D and domestic manufacturing.

Have the Policies Worked?

While the previous section makes some broad sweeping analysis based on the overall state of the RE industry in India, it is worthwhile examining the successes and failures of specific instruments which have broader acceptance overseas and are widely used in pursuit of RE.

Financial Incentives

Measures like FiTs and GBI have been the driving force in pushing RE in many a country, but the data from an Indian perspective is inconclusive on this subject. A large portion of the increased RE capacity analyzed in the costing exercise did not benefit from either FiT or GBI as it is being used as captive power (this is at least the case with wind, so far). Low IPP presence, which typically looks to maximize revenue stream by ensuring steady generation, also alludes to some failings of the FiT regime.

While the FiT for wind guarantees a return on equity upwards of 18 per cent in many states, developers and industry associations alike criticize the levels at which it has been set, as they claim that the process fails to account for actual costs incurred in commissioning a project. Furthermore, the disparity between CERC-determined tariffs and those notified by the various SERCs is controversial and illustrates the subjective nature of FiT determination. However, with public sector utilities across the country not guaranteeing the "must-run status"[43] of wind energy installations, a higher level of FiT would not be the solution to the problem because there is little room for the guaranteed rates materializing as revenue for the developers. In some cases, the reasons for backing down of RE generation is the lack of sufficient transmission infrastructure and in some cases it is the inability to pay for the higher price of RE (as compared to conventional power), given the sunk costs associated with thermal power stations owned by state utilities and hence the lower marginal cost of procurement. It must also be stressed that in many states FiTs are lower if the project has benefited from AD. This means that projects that choose to go the AD route must contend with lower FiT and cannot avail the GBI as well. While one would assume that this "double whammy" would incentivize a move away from AD, the inability of the utilities to pay the FiTs (in a timely manner) implies that entities that choose to stay away from AD potentially risk losing out AD and not being paid for the units the project generates. The FiT regime has been successful only to the extent that the utilities that procure power have paid for it. If the current trend (in states like Rajasthan and Tamil Nadu) is anything to go by, it certainly does not bode well for future project developers relying on FiTs for their revenue stream.

The amount of electricity procured by NVVN under the PPAs signed is too small to make for a comprehensive evaluation of the FiT regime in solar PV projects. The reverse auctioning mechanism (in essence an FiT arising from a price discovery) has driven down the price of electricity from solar PV, but they have been in place for less than two years and many of the projects are yet to commence generation (VGF is proposed only for the second phase of the NSM). The ability of the developers to deliver power at the prices quoted in the auction and of the utilities to pay these prices (though significantly lower than what was anticipated before the bid), is yet to be tested.

Demand Stimulation

One of other big factors that has dictated RE installation growth (or lack thereof) is the poor financial health of the state electricity utilities. The establishment of the necessary infrastructure to transmit power from the locations where RE exhibits potential will require significant investment, and the network nature of the good lends itself to public sector investment, with little that the private sector can do. The success of policies and instruments such as RPOs and RECs, which were designed to stimulate demand for RE installations and the power generated from them, is inextricably linked to the financial solvency of the utilities. The commitment to adhere to the RPO targets will materialize only through stronger financial performance—i.e., increased revenues and reduction of the subsidy burden of the utilities. It is no surprise then that most utilities paid mere lip service to the RPO targets, and as a result, a large supply of RECs floods the market today with little demand. Even after a second round of financial restructuring

[43] Procuring from RE as a priority when they are available and declining conventional generation should that be needed to balance the system.

(2012) that some of the large utilities went through, their ability to support and pay for power from RE sources is increasingly under question, with many deeming that this round is unlikely to make an impact and calling for more fundamental reform in the electricity sector.

Preferential Tax Treatment

Much of the installation in the wind sector has been driven by the short-term financial gains associated with tax breaks (such as AD) and deferred tax payments. This highlights the reasons behind the constant clamour for the reinstatement of AD benefits, wherein the returns are contingent on the initial investment materializing, rather than sustained generation. While there is a higher likelihood of inefficient installations under an AD-centric regime, an internal MNRE analysis suggests that has not been the case in India. The drop in installations upon withdrawal of the AD regime over the last two years is indicative of how significant a driver it has been in propping up the RE sector (specifically wind). This clearly illustrates that there is a fundamental mismatch between the end goals of policy-makers and developers. The incentive structure must be framed in a manner that the end goals of increased generation and efficiency are achieved. Project developers and owners have been hesitant in accepting that part of the risks associated with RE must be shouldered by them. Expecting a risk-free payoff from an inherently variable energy source is certainly part of the problem. While the private costs of such decisions may not be large, the impact on the wider public goods space is significant. Poorly conceptualized projects cast RE in a bad light and create significant barriers for players with the right intent and potential.

In reinstating the AD benefit, the ministry must consider those units that illustrate a clear intent to run an efficient generating installation. One of the suggestions put forward by the IWPA is to provide AD for entities that invest in hybrid generation facilities (i.e., solar + wind, biomass +solar/wind), signalling their intent to provide firm power despite the variability in the resource.

Manufacturing-Linked Incentives

In order to have a thriving manufacturing sector two prior existing conditions must be satisfied—i) a great degree of backward integration for sourcing the necessary components domestically (or integration with global value chains) and the necessary infrastructure to promote manufacturing, roads, power, etc. and ii) an overall ease of starting and running businesses in the country. India is not ideally placed when viewed through the lens of these above prerequisites. In addition, quality control and specialized material manufacturing in the country are in their infancy, which results in growing import dependency for advanced technologies. The absence of reliable power infrastructure certainly has deterred the manufacture of energy-intensive wafer fabrication and specialized steel and materials. While incentives such as tax breaks, export-duty waivers, SEZs, etc. help companies overcome the financial hurdles, the backbone of the manufacturing sector is not conducive in India. One could argue that the complementary policies to make manufacturing attractive in India are missing and go well beyond the realm of "green industrial policy."

With regard to RE sector, one of the most controversial and debated policy measures has been the use of domestic content requirements (DCR) for promoting manufacturing in the solar sector. However, the policy failed to be effective for several reasons. First, it was designed to favour local manufacturing for only crystalline silicon-based cells and modules while thin-film based installations were exempted. This resulted in distortions in the choice of technology, with India installing a far higher share of thin-film based capacity than the rest of the world. Secondly, the policy was focussed on manufacturing rather than value addition. This meant that the focus was only on the making of cells and modules, while inadvertently ignoring the large value-creation opportunities further upstream or in the balance of systems of the projects. Thirdly, the policy ran the risk of attracting trade disputes from countries, which consider such a policy to be in violation of WTO rules. The resulting surge of trade disputes globally has created further uncertainty in an already fragile market. Finally, the policy was bypassed by other countries using their donor and export credit agencies to finance installations using thin-film technology. Not only did this create distortions (as mentioned above), but it also created a false sense of financial comfort among developers while not preparing the domestic financial sector to take on a greater burden of financing solar projects in subsequent phases.

In the RE domain, India does not have specific requirements of technology transfer that must be achieved as part of any joint venture or agreement in a technological tie-up between Indian and overseas firms. This is evident in the wind sector, where there is a lag between the West and India in the introduction of higher output wind turbines, by manufacturers who operate in both geographies. Both in wind and solar PV technologies, significant modifications would be needed before they can be implemented on the field, due to lower windspeed regimes and higher mean temperatures in India. Given the lack of domestic spend on R&D and efforts undertaken toward re-engineering Western design, more active promotion of collaborative efforts in technology development among joint ventures would certainly benefit the industry. This in turn depends on the industry achieving the kind of scale of installations that has been witnessed in China over the latter half of the 2000s.

Research and Development

Many studies investigating the overall R&D ecosystem in India have found it wanting in many dimensions. The prime criticisms have been: (i) the lack of spending from the private sector as there is no clear path to commercialization and (ii) funding gaps at crucial stages of the technology development chain. While these shortfalls are applicable in equal measure to the R&D in the RE sector, the focus on making RE technologies more affordable and tailored to the needs of the country is certainly a step in the right direction. For better adoption of the latest technologies and the pursuit of indigenous research in the necessary areas, it is important that the financial incentives are centred on the output (of power) associated with the various technologies and performance requirements of new installations. While the wind sector has achieved this to a large extent through the active role of C-WET, the persistent demands for the reinstatement of AD threaten to derail the progress. The solar PV industry, while in its infancy, provides ample scope for R&D—specifically in ensuring the lifetime performance of modules and cells that are currently designed for temperate conditions. The jury is still undecided as to whether the pursuit of thin-films in the first phase of the NSM is beneficial in the long run or if crystalline-PV is the more suitable technology. The SEC and C-WET need to play a more active role in ensuring that the lessons from the many pilot/demonstration plants that they commission filter down to large-scale installations and enable a move up the learning curve.

Whither Green Industrial Policy?

A continuation of the extant policies is likely to reinforce the impact on the green (addressing market failures) front. It is aided by the fact that India's development aspirations will depend significantly on catering to the energy poverty needs of the poor, while maintaining the fragile balance between economic growth and environmental degradation. The country cannot afford to be a non-actor in the climate change negotiations and is certainly capable of delivering the kind of impact that is required of it in mitigating the effects of climate change. Policies that have been effective (intentionally or otherwise) so far need to be refined in order to ensure their relevance going forward. Scheduling of RE power, imperatives for integrating variable RE with the grid and the development of a more vibrant electricity market will aid the cause and drive higher efficiencies and ultimately a much larger RE base. A higher level of FiTs and RPOs without reform in the electricity sector would yield little benefit.

In order to boost the Indian manufacturing sector, a long-term focus on getting the prerequisites right is important. While this is an oft-repeated issue across many studies, it is clear that promoting investment in a setting where fundamental issues are not addressed is a deadweight loss for society at large. The impact of a good R&D ecosystem on future manufacturing capabilities cannot be understated, and it is important that the outcomes of planned R&D efforts are measured and reported to ensure continued efficacy of the policies.

In conclusion, policies cannot persistently be seen as supporting either the evolving notion of "green" or just the classic industrial policy goals. In a world of geopolitical uncertainty and major barriers in the areas of trade and technology transfer, it is difficult to envision a scenario where India would pursue capacity augmentation in RE, while solely relying on external providers of the technologies and manufacturing capabilities, while focusing its own manufacturing in other favourable domains. RE has implications for long-term energy security and, concomitantly, national security. Both must be given their due in order to ensure that there are no adverse long-term impacts on the economy. Industrial policies and environmental policies can reinforce each other in a positive manner—an efficient domestic manufacturing base will push the envelope of possibilities when it comes to achieving green goals through affordable technologies, while enjoying popular support on account of the benefits, both economic and environmental.

APPENDIX A: WIND TURBINE MANUFACTURERS AND THEIR COLLABORATIONS

SI NO	INDIAN MANUFACTURERS	COLLABORATION/JOINT VENTURE
1	Chiranjjeevi Wind Energy Ltd	None
2	Gamesa Wind Turbines Pvt Ltd.	Gamesa Innovation and Technology, S.L. Spain
3	GE India Industrial Pvt Ltd.	GE Infrastructure Technology International, LLC, USA
4	Global Wind Power Ltd	NORWIN A/S Denmark; Fuhrlander AG, Germany
5	Inox Wind Limited	License Agreement with AMSC-WINDTEC GmbH, Austria
6	Kenersys India	Kenersys GmbH, Germany
7	Leitner Sriram	WindFin B.V., the Netherlands (formerly known as Leitwind BV)
8	NuPower Technologies Ltd	W2E Wind to Energy GmbH, Germany
9	Pioneer Wincon Pvt Ltd	None
10	Regen Powertech Pvt Ltd	Sub-license agreement for VENSYS Energy AG's Technology, Germany
11	RRB Energy Ltd	Technology cooperation with Vestas Wind Systems A/S Denmark
12	Shriram EPC Ltd	License agreement with TTG Industries Ltd
13	Sinovel India DB Ltd	Sinovel Wind Group Co. Ltd., China
14	Siva Windturbine India Pvt Ltd	License agreement with Wind Technik Nord, Germnay
15	Southern Wind Farms Ltd	None
16	Suzlon Energy Ltd	Suzlon Energy GmbH, Germany
17	Vestas Wind Technology India Pvt Ltd	Vestas Wind Systems A/S, Denmark
18	Wind World (India) Ltd	Enercon GmbH, Germany
19	Winwind Power Energy Pvt Ltd	License agreement with Winwind Oy, Finland

Source: C-WET list of model and manufacturers of wind turbines, available at http://www.cwet.tn.nic.in/Docu/RLMM_Main_List_dated_29.10.2013.pdf.

APPENDIX B: SOLAR AND WIND ENERGY FITS

SOLAR ENERGY FITS

STATE	CONTROL PERIOD	TARIFF (RS/KWH)
CERC (FY12-13)	FY 2012-2016 (three years)	Lev - 10.39 AD - 1.04 After AD - 9.35
CERC (FY13-14)	FY 2012-2016 (three years)	Lev - 8.75 AD - 0.88 After AD - 7.87
Andhra Pradesh	2010-2011 and 2011-2012	17.91 (without AD) 14.95 (with AD)
Bihar	Up to March 31, 2015 commissioning	10.9 (without AD) 09.85 (with AD)
Gujarat	Jan 29, 2012 to March 31, 2015	For MW Scale Plants: **Jan 2012-March 2013:** 10.37 (without AD), 09.28 (with AD), **FY 2013-2014:** 9.64 (without AD), 8.63 (with AD), **FY 2014-2015:** 8.97 (without AD), 8.03 (with AD) For kW-scale Plants **Jan 2012-March 2013:** 12.44 (without AD), 11.14 (with AD), FY 2013-14: 11.57 (without AD), 10.36 (with AD), **FY 2014-2015:** 10.76 (without AD), 9.63 (with AD)
Haryana	Three years(until FY 2013-FY 2015)	9.18 (SPV Crystalline) 8.90 (SPV Thin film)
Karnataka	Up to March 31, 2013 commissioning	14.5 (including rooftop and small solar PV plants)
Kerala	For projects commissioned before Dec 31, 2009	15.18 (including incentives)
Madhya Pradesh	Aug 2012 to March 2014	10.44 (capacity >2 MW), 10.70 (capacity up to 2 MW)
Maharashtra	FY 2010 2014 (five years from the date of commencement)	Lev - 11.16 (11.66 - RT & SSPGP) AD - 1.65 (1.65) after AD - 9.51 (10.01)
Orissa	Plant commissioned in FY (2012-2013) onwards	Lev - 17.80 AD - 3.03 After AD - 14.77
Punjab	FY 2012-2016 (five years from the notification of order)	Lev - 10.39 AD - 1.04 After AD - 9.35
Rajasthan		9.63 (Plant commissioned by March 31, 2014) with AD - 10.45 9.63 (Roof top and SSPG commissioned by March 31, 2014)
Tamil Nadu	FY 2010-2011 (till 05/31/12)	Lev - 18.45 AD - 4.11 After AD - 14.34
Uttarakhand	FY 2009-2012 (three years from the commencement of these regulations)	Lev - 17.70 AD - 1.65 after AD - 16.05
Uttar Pradesh	FY 2010-2014 (five years)	15 (commissioned by Dec 2011, not covered under GOI incentive scheme)
West Bengal	FY 2013-2017 (five years)	10 (Capacity ranging 100 KW to 2 MW availing GBI) 10 (Grid connected plant not eligible for any incentive and commissioned upto 2012-13) 10 (Projects commissioned after FY 2012 till FY 2015

WIND ENERGY FITS

STATE	OLD TARIFF (INR/KWH)	NEW TARIFF (INR/KWH)	PER CENT INCREASE	TARIFF REVISED ON	PPA PERIOD (YEARS)
Madhya Pradesh	4.35	5.92 (from **FY 2013–2014** to **FY 2015–2016**)	36	March 26 2013	25
Rajasthan	5.18-5.44	**For FY 2013–2014** Jaisalmer, Barmer & Jodhpur districts: • 5.46 (AD benefit not availed) • 5.12 (AD benefit availed) Other districts: • 5.73 (AD benefit not availed) • 5.38 (AD benefit availed)		May 17, 2013	25
Maharashtra	3.78-5.67	**For FY 2013-14** Wind zone-1(<=250): • 5.81 (AD benefit not availed) • 5.46 (AD benefit availed) Wind zone-2 (< 250 & <=300): • 5.05 (AD benefit not availed) • 4.74 (AD benefit availed) Wind zone-3 (< 300 & <= 400): • 4.31 (AD benefit not availed) • Rs.4.05 (AD benefit availed) Wind zone-4(< 400): • Rs.3.88 (AD benefit not availed) • Rs.3.65 (AD benefit availed)	2	March 22, 2013	13
Tamil Nadu	3.39	3.51 (for two years from August 1, 2012)	4	July 31, 2012	20
Karnataka	3.70	3.70 (applicable for five years)	0	December 11, 2009	10
Andhra Pradesh	3.5	4.70 (until March 31, 2015)	34	November 15, 2012	25
Gujarat	3.56	4.15 (with depreciation benefit, irrespective of whether AD is availed or not) (From August 11, 2012–March 31, 2016)	17	January 7, 2013	25

Source: Wind World (2013); HSBC Global Research (2013).

APPENDIX C: BRIEF OVERVIEW OF SOLAR STATE POLICIES

STATE POLICIES	PROJECTIONS	MAIN INCENTIVE	OTHER BENEFITS	NODAL AGENCIES
Tamil Nadu Solar Policy 2012	3 GW till 2015	Preferential tariff	Exemption from electricity tax, development of solar parks, single window clearance, incentives to manufacturers	Tamil Nadu Energy Development Agency (TEDA)
Uttar Pradesh Solar Policy 2012	500 MW till 2017	Preferential tariff	Single window clearance, assistance in infrastructure	Uttar Pradesh Electricity Regulatory Commission(UPERC)
Andhra Pradesh Solar Policy 2012	Applicable until 2017 with no specific targets	None	Banking of 100% of energy shall be permitted for one year from the date of banking with the developer paying 2% of the banked energy	New and Renewable Energy Development Corporation of A.P. Ltd (NREDCAP)
Karnataka Solar Policy 2011-16	200 MW till 2016	Preferential tariff	None	Karnataka Renewable Energy Development Limited (KREDL)
Rajasthan Solar Policy 2011	700 MW till 2017	Preferential tariff	Development of solar parks, Rajasthan Renewable Energy Infrastructure Development Fund, govt. land available at concessional prices, exemption from electricity, cost of transmission borne by the govt., single-window clearance	Rajasthan Renewable Energy Corporation Limited (RRECL)
Punjab Solar Policy 2013	1 GW till 20122	Preferential tariff	Evacuation facilities, exemption of electricity duty, banking of power, exemption from stamp duty	Punjab Energy Development Agency (PEDA)
Madhya Pradesh Solar Policy 2012	Not known	Preferential tariff	Promotion of solar technology parks, 10-year (from COD) exemption in electricity duty	Madhya Pradesh Electricity Regulatory Commission (MPERC)
Chhattisgarh Solar Policy 2012-13	500 MW to 1 GW by March 2017	Not known	Exemption from electricity duty, exemption of VAT on solar materials/equipment, single window clearance	Chhattisgarh Renewable Energy Development Agency (CREDA)
Gujarat State Policy 2009	500 MW until 2014 (target exceeded)	Preferential tariff	Exemption from payment of electricity duty, exemption from demand cut, infrastructure support, promote R&D	Gujarat Energy Development Agency (GEDA) Gujarat Power Corporation Limited (GPCL)
Jharkhand Solar Policy, 2013	500 MW by 2017 and 1GW by 2022	Preferential tariff	Stamp duty exemption on purchase of private land, Electricity duty & cess exemption	Jharkhand Renewable Energy Development Agency (JREDA)

Source: CEEW compilation from various state policy documents

APPENDIX D: RPO TARGETS (BY STATE)

STATE	RPO TARGETS FOR SOLAR		OVERALL RPO TARGETS	
	For 2012-2013	For 2013-2014	2012-2013	2013-2014
Andhra Pradesh	0.25%	0.25%	5% for all RE	5% for all RE
Arunachal Pradesh	0.10%	0.15%	4.2% for all RE	5.6% for all RE
Assam	0.15%	0.20%	4.2% for all RE	5.6% for all RE
Bihar	0.75%	0.50%	4% for all RE	4.5% for all RE
Chhattisgarh	0.50%	0.75%	5.75% for all RE	
Delhi	0.15%	0.20%	3.4% for all RE	4.8% for all RE
JERC (Goa & UT)	0.40%	0.50%	3% for all RE	
Gujarat	1.00%	1.50%	5.5% for wind	
Haryana	0.75%	0.75%	2% for all RE	3% for all RE
Himachal Pradesh	0.25%	0.25%	10.25% for all RE	10.25% for all RE
Jammu and Kashmir	0.25%	0.25%		
Jharkhand	1.00%	1.00%	4% for all RE	
Karnataka	0.25%	0.25%	7-10% for all non-solar	
Kerala	0.25%	0.25%	3.63% for all RE	3.99% for all RE
Madhya Pradesh	0.60%	0.80%	4% for all RE	5.5% for all RE
Maharashtra	0.25%	0.50%	8% for all RE	9% for all RE
Manipur	0.25%	0.25%	5% for all RE	
Mizoram	0.25%	0.25%	7% for all RE	
Meghalaya	0.40%	0.50%	0.20% for wind	
Nagaland	0.25%	0.25%	8% for all RE	
Orissa	0.15%	0.20%	5.5% for all RE	6.00%
Punjab	0.07%	0.13%	2.9% for all RE	3.50%
Rajasthan	0.75%	1.00%	5.1% for wind	5.7% for wind
Sikkim	0.00%	0.00%		
Tamil Nadu	0.05%	0.05%		
Tripura	0.10%	0.10%	2% for all RE	
Uttarakhand	0.05%	0.05%	5% for all RE	
Uttar Pradesh	1.00%	1.00%	6% for all RE	
West Bengal	0.00%	0.25%	4% for all RE	

Source: CEEW compilation.

APPENDIX E: INTERNATIONAL PATENT CLASSIFICATION CODES IDENTIFIED IN THE WIPO GREEN INVENTORY

TECHNOLOGY DESCRIPTION	IPC CODE
Solar	
*Devices adapted for the conversion of radiation energy into electrical energy	H01L 27/142, 31/00-31/078 H01G 9/20 H02N 6/00
**Using organic materials as the active part	H01L 27/30, 51/42-51/48
*Assemblies of a plurality of solar cells	H01L 25/00, 25/03, 25/16, 25/18, 31/042
*Silicon; single-crystal growth	C01B 33/02, C23C 14/14, 16/24, C30B 29/06
*Regulating to the maximum power available from solar cells	G05F 1/67
*Electric lighting devices with, or rechargeable with, solar cells	F21L 4/00, F21S 9/03
*Charging batteries	H02J 7/35
*Dye-sensitized solar cells (DSSC)	H01G 9/20, H01M 14/00
Wind energy	F03D
*Structural association of electric generator with mechanical driving motor	H02K 7/18
Structural aspects of wind turbines	B63B 35/00, E04H 12/00, F03D 11/04
*Propulsion of vehicles using wind power	B60K 16/00
**Electric propulsion of vehicles using wind power	B60L 8/00
*Propulsion of marine vessels by wind-powered motors	B63H 13/00

Source: WIPO (n.d.).

References

100% FDI in renewables: Farooq Abdullah. (2009, December 15). *Times of India*. Retrieved from http://articles.timesofindia.indiatimes.com/2009-12-15/india/28101607_1_solar-energy-renewable-energy-solar-water

Ahn, S.-J., & Graczyk, D. (2012). *Understanding energy challenges in India: Policy, players and issues.* Paris: International Energy Agency.

American Superconductor (AMSC). (2012, May 23). AMSC: Press Release. Retrieved from http://ir.amsc.com/releasedetail.cfm?releaseid=676073

Andhra Pradesh Industrial Infrastructure Corporation (APIIC). (n.d.). *Land allottees*. Retrieved from http://www.fabcity.in/about/allottees/

Bakewell, S. (2013, August 2). Suzlon reports wider loss on costs at German wind unit. *Bloomberg News*. Retrieved from http://www.bloomberg.com/news/2013-08-02/suzlon-reports-wider-loss-on-costs-at-german-wind-turbine-unit.html

Baumol, W. J., & Oates, W. E. (1988). *The theory of environmental policy*. London: Cambridge University Press.

Bhargava, B. (2012, November 5). *ASEAN-India Workshop on Co-operation in Renewable Energy*. Retrieved from http://mnre.gov.in/file-manager/UserFiles/asean2012/Session%202%20-%20Solar/Bhargava05112012.ppt

Bhattacharya, T., & Kapoor, R. (2011, November 11). Energy saving instrument – ESCerts in India. *Renewable and Sustainable Energy Reviews*, 16, 1311–1316. Retrieved from http://www.teriin.org/projects/nfa/pdf/Energy_saving_instruments.pdf

Bose, P.R. (2013, April 7). Wind energy project hit by Bengal's land allocation policy. *Hindu Business Line*. Retrieved from http://www.thehindubusinessline.com/industry-and-economy/wind-energy-project-hit-by-bengals-land-allocation-policy/article4591546.ece

Bridge to India. (2013, September 12). *India Solar Map*. Retrieved from http://bridgetoindia.com/our-reports/indian-solar-map

Budget 2013: Government announces scheme for making renewable energy cheaper. (2013, February 28). *Economic Times*. Retrieved from http://economictimes.indiatimes.com/news/news-by-industry/energy/oil-gas/budget-2013-government-announces-scheme-for-making-renewable-energy-cheaper/articleshow/18732667.cms

Bureau of Energy Efficiency (BEE). (2012, March 30). Retrieved from http://beenet.gov.in:90/downloadbooks.aspx?fname=BEE_PAT_Booklet_Final.pdf

Business Standard. (2010, November 29). FDI in renewable energy growing rapidly. Retrieved from http://www.business-standard.com/article/economy-policy/fdi-in-renewable-energy-growing-rapidly-govt-110112900162_1.html

CAT, Urban Emissions & Greenpeace. (2013). *Coal kills: An assessment of death and disease caused by India's dirtiest energy source*. New Delhi. Retrieved from http://www.greenpeace.org/india/Global/india/report/Coal_Kills.pdf

Census 2011. (2011). *Tamil Nadu Population census data 2011*. Retrieved from http://www.census2011.co.in/census/state/tamil+nadu.html

Census of India. (2011). *Source of lighting*. Retrieved from http://censusindia.gov.in/2011census/hlo/Data_sheet/India/Source_Lighting.pdf

Central Electricity Authority (CEA). (2012a, April). *Central Electricity Authority*. Retrieved from http://cea.nic.in/reports/yearly/energy_generation_11_12.pdf

CEA. (2012b). *Annual report of fuel supply to gas based power stations*. Retrieved from http://www.cea.nic.in/reports/yearly/fuel_supp_consm_rep/gas_2011-12.pdf

CEA. (2012c, August). *Monthly generation report*. Retrieved from http://www.cea.nic.in/reports/articles/god/renewable_energy.pdf

CEA. (2012d, October). *Thermal performance review*. Retrieved from http://www.cea.nic.in/reports/yearly/thermal_perfm_review_rep/1112/complete_1112.pdf

CEA. (2013a, May). *Load generation balance report 2013-14*. Retrieved from http://www.cea.nic.in/reports/yearly/lgbr_report.pdf

CEA. (2013b, January). *CO_2 baseline database for the Indian power sector*. Retrieved from http://www.cea.nic.in/reports/planning/cdm_co2/user_guide_ver8.pdf

Central Electricity Regulatory Commission (CERC). (2003). *The Electricity Act, 2003*. Retrieved from http://www.cercind.gov.in/08022007/Act-with-amendment.pdf

CERC. (2009, September 17). *RE Tariff Regulations*. Retrieved from http://www.cercind.gov.in/Regulations/CERC_RE-Tariff-Regualtions_17_sept_09.pdf

CERC. (2010a, April 28). *Indian Electricity Grid Code*. Retrieved from http://www.powermin.nic.in/transmission/pdf/Indian_Electricity_Grid_Code.pdf

CERC. (2010b). *Procedure for implementation of the mechanism of Renewable Regulatory Fund*. Retrieved from http://www.cercind.gov.in/2013/orders/RRF_pro.pdf

CERC. (2012a). *Tariff determination from RE sources*. Retrieved from http://cercind.gov.in/2012/regulation/CERC_RE-Tariff-Regualtions_6_2_2012.pdf

CERC. (2012b, March 3). *CERC: Orders*. Retrieved from http://cercind.gov.in/2012/orders/Signed209_2011.pdf

CERC. (2012c, July). *Report on short-term power market in India: 2011-12*. New Delhi: Economics Division, CERC. Retrieved from http://www.cercind.gov.in/2012/market_monitoring/Annual%20Report%202011-12.pdf

Central Statistics Office (CSO). (2012). *Energy Statistics 2012*. Government of India, Ministry of Statistics and Programme Implementation. New Delhi: Central Statistics Office.

Centre for Science and the Environment (CSE). (2012, August 17). The US is using climate finance to kill the Indian solar panel industry: CSE. Retrieved from http://www.cseindia.org/content/us-using-climate-finance-kill-indian-solar-panel-industry-cse

CSE. (2013a, June 30). *CSE: Special Report*. Retrieved from http://www.downtoearth.org.in/content/crores-gamble

CSE. (2013b, July 3). *CSE: Renewable Energy*. Retrieved from http://www.cseindia.org/node/5041

Centre for Wind Energy Technology (C-WET). (n.d.a). *C-WET: Departments*. Retrieved from http://www.cwet.tn.nic.in/html/departments_ewpp.html

C-WET. (n.d.b.). *Research & development*. Retrieved from http://www.cwet.tn.nic.in/html/departments_rd.html

C-WET. (n.d.c). *Training courses*. Retrieved from http://www.cwet.tn.nic.in/html/departments_trainings.html

CWET. (n.d.e). *Wind Resource Assessment Unit*. Retrieved from http://cwet.res.in/web/html/departments_wra.html

C-WET. (2013a). *Solar Data Sharing and Accessibility Policy (SDSAP-2013)*. Retrieved from http://cwet.res.in/web/html/srra.html

C-WET. (2013b, October 29). *Revised list of models and manufacturers of wind turbines*. Retrieved from http://www.cwet.tn.nic.in/Docu/RLMM_Main_List_dated_29.10.2013.pdf

Climate Policy Initiative. (2012, December). *Climate Policy Initiative*. Retrieved from http://www.isb.edu/download/16739/Falling-Short-An-Evaluation-of-the-Indian-Renewable-Certificate-Market.pdf

Confederation of Indian Industry (CII). (2010). *Human resource development strategies for Indian renewable energy sector*. Retrieved from http://mnre.gov.in/file-manager/UserFiles/MNRE_HRD_Report.pdf

Cosman, J. (2012, April 18). *Trends in renewable energy R&D: evidence from patent databases*. Retrieved from http://www.globalpolicyjournal.com/blog/18/04/2012/trends-renewable-energy-rd-evidence-patent-databases

Council on Energy, Environment and Water (CEEW) & Natural Resources Defense Council (NRDC). (2012). *Laying the foundation for a bright future: Assessing Progress Under Phase 1 of India's National Solar Mission*. Retrieved from http://ceew.in/pdf/CEEW-NRDC-National_Solar_Mission_Interim_Report_30Apr12.pdf

CEEW & WWF. (2013). *RE+ Renewables beyond electricity.* New Delhi. Retrieved from http://www.wwfindia.org/news_facts/?10241

DeitY. (2012, October 7). *Guidelines for the Operation of the Modified Special Incentive Package Scheme for Electronics System Design and Manufacturing Sector*. Retrieved from http://deity.gov.in/sites/upload_files/dit/files/MSIPS_Guidelines.pdf

Department of Commerce. (2013). *Export Import Data Bank*. Retrieved from http://commerce.nic.in/eidb/default.asp

Department of Commerce, MoC&I. (n.d.). *Facilities and incentives*. Retrieved from http://sezindia.nic.in/about-fi.asp

Department of Industrial Policy & Promotion (DIPP). (2011). *National Manufacturing Policy*. Retrieved from http://commerce.nic.in/whatsnew/National_Manfacruring_Policy2011.pdf

Department of Science and Technology (DST). (n.d.). *Solar Energy Research Initiative*. Retrieved from http://www.dst.gov.in/scientific-programme/t-d-solar-energy.htm

Department of Science and Technology. (2013). *Science, Technology and Innovation Policy*. Retrieved from http://www.dst.gov.in/sti-policy-eng.pdf

DST. (2013, September). Research and Development Statistics at a Glance 2011-12. Retrieved from http://www.nstmis-dst.org/PDF/FINALRnDStatisticsataGlance2011121.pdf

Desai, V. (2011, August 29). India is a favoured destination for investments in renewable energy. *The Economic Times*. Retrieved from http://articles.economictimes.indiatimes.com/2011-08-29/news/29941384_1_scheme-for-wind-power-renewable-energy-certificate-maximum-fdi-inflows

Domestic solar cell makers slam govt for failing them (2013, April 17). Domestic solar cell makers slam govt for failing them. *Economic Times*. Retrieved from http://articles.economictimes.indiatimes.com/2013-04-17/news/38616159_1_indian-solar-manufacturer-dgad-anti-dumping-duty

Down to Earth. (2012, August 15). *Sunshine sector loses sheen*. Retrieved from http://www.downtoearth.org.in/content/sunshine-sector-loses-sheen?page=0,0

Dubash, N. (2012, November). Centre for Policy Research. Retrieved from http://www.cprindia.org/workingpapers/4279-working-paper-20121-november-politics-climate-change-india-narratives-equity-and-

Earnest, J., & Wizelius, T. (2011). *Wind power plants and project development*. PHI Learning Pvt. Ltd.

Energetica India. (2013, February). *India's renewable industry's budget wish list*. Retrieved from http://www.energetica-india.net/download. php?seccion=articles&archivo=BnJrEJT2aCCPXRdNI3d0mo3KxphKm7MOF4OJChAdkDt9ULK7Dn6pRw.pdf

Energy Alternatives India (EAI). (2012). *IREDA*. Retrieved from http://www.eai.in/ref/ae/sol/cs/fa/ireda/ireda___renewable_energy_financing_agencies.html

Energy Information Administration (EIA). (2010). *International Energy Statistics*. Retrieved from http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=1&aid=4

EIA. (2011). *India overview*. Retrieved from http://www.eia.gov/countries/cab.cfm?fips=IN

Energy Next. (2013a, August 16). *Cabinet approves GBI for wind projects*. Retrieved from http://www.energynext.in/cabinet-approves-gbi-for-wind-projects/

Energy Next. (2013b, July 9). *Energy Next: Devansh Jain*. Retrieved from http://www.energynext.in/devansh-jain/

EQ International. (2012). *Moser Baer's PV business adopts MIST technology to upgrade its PV cell efficiency to 21% to meet current industry challenges*. Retrieved from http://eqmaglive.com/EQ-ARTICLE-5843-Moser-Baer-s-PV-business-adopts-MIST-technology-to-upgrade-its-PV-cell-efficiency-to-21--to-meet-current-industry-challenges.html#.UkqobdLI298

Espacenet Global Database. (n.d.). Retrieved from http://www.epo.org/searching/free/espacenet.html

EximGuru. (2013). Photocells. Retrieved from http://www.eximguru.com/indian-customs-duty/85414011-solar-cells-whether-or-not.aspx

Federation of Indian Chamber of Commerce and Industry (FICCI). (2011, June 11). Federation of Indian Chamber of Commerce and Industry. Retrieved from http://www.ficci.com/events/20683/ISP/JNNSM.pdf

FICCI. (2012). *Impacts, governance, and future of CDM: Indian industry perspective*. Retrieved from http://www.ficci.com/spdocument/20158/CDM-FICCI%20-Report.pdf

FICCI. (2013). *Securing the supply chain for solar in India*. New Delhi: FICCI.

Gamesa. (2011, March). *Gamesa strengthens its presence in India to keep up with growth in the country´s wind energy market*. Retrieved from http://www.gamesacorp.com/en/cargarAplicacionNoticia.do?idCategoria=8&identificador=691&urlAmigable=gamesa-strengthens-its-presence-in-india-to-keep-up-with-growth-in-the-countrys-wind-energy-market.html

Gamesa. (2012). *Gamesa 850 kW*. Retrieved from http://www.gamesacorp.com/recursos/doc/productos-servicios/aerogeneradores/catalogo-g5x-850-kw-eng.pdf

General Electric. (n.d.). *Research and manufacturing*. Retrieved from http://www.ge.com/in/products_services/wind-energy/research-manfucturing.html

Ghosh, A. (2012a). Industrial demand and energy supply management: A delicate balance. *Empowering growth: Perspectives on India's energy future* (pp. 26-32). New Delhi: Economist Intelligence Unit.

Ghosh, A. (2012b). *Governing clean energy subsidies: What, why, and how legal?* Geneva: ICTSD. Retrieved from http://ictsd.org/downloads/2012/09/governing-clean-energy-subsidies-what-why-and-how-legal.pdf

Ghosh, A., Ghose, A., Bery, S., Bhaskar, C. U., Das, T., Desai, N., et al. (2011). *Understanding complexity, anticipating change: From interests to strategy on global governance.* New Delhi: Council on Energy, Environment and Water.

Ghosh, A., & Steven, D. (2013). India's energy, food, and water security: International cooperation for domestic capacity. In W. P. Sidhu, P. B. Mehta, & B. Jones (Eds.), *Shaping the Emerging World: India and the Multilateral Order* (pp. 281-301). Washington, D.C.: Brookings Press.

Giri, D. V. (2010, February 17). *Non-conventional energy*. Retrieved from http://www.iipe.co.in/journal/jun10/ase.pdf

Global Wind Energy Council (GWEC). (2009, September). *India Wind Energy Outlook 2009*. Retrieved from http://www.gwec.net/wp-content/uploads/2012/10/Ind_Wind-ENergy-Outlook_2009_GWEC.pdf

GWEC. (2012a, November). *India Wind Energy Outlook 2012*. Retrieved from http://www.gwec.net/publications/country-reports/india-wind-energy-outlook-2012/

GWEC. (2012b). *Global wind report annual market update 2012*. GWEC. Retrieved from http://www.gwec.net/wp-content/uploads/2012/06/Annual_report_2012_LowRes.pdf

GWEC & the International Renewable Energy Association (IRENA). (2013). *30 years of policies for wind energy, lessons from 12 wind energy markets*. IRENA. Retrieved from https://www.irena.org/DocumentDownloads/Publications/IRENA_GWEC_WindReport_Full.pdf

GWEC & the Indian Wind Turbine Manufacturers Association (IWTMA). (2011). *India wind energy outlook*. Retrieved from http://www.indianwindpower.com/pdf/GWEO_2011.pdf

Goel, M., Maurya, V., & Desai, P. (2013). R & D indicators and mapping of solar energy research output in India. *Journal of Scientometric Research* 2(1). Retrieved from http://www.jscires.org/article.asp?issn=2320-0057;year=2013;volume=2;issue=1;spage=52;epage=58;aulast=Goel

Government of India (GoI). (n.d.). *Joint ventures*. Retrieved from http://business.gov.in/growing_business/joint_ventures.php

GoI. (2009, May). *Catalyzing the growth of the semiconductor ecosystem in India*. Retrieved from http://psa.gov.in/sites/default/files/12583893781_CatalyzingtheGrowthoftheSemiconductorEcosysteminIndia.pdf

GoI. (2011). *National Manufacturing Policy*. New Delhi: Ministry of Commerce and Industry, Government of India.

GoI. (2013a). *Science, Technology and Innovation Policy 2013*. Retrieved from http://www.dst.gov.in/sti-policy-eng.pdf

Government of Rajasthan (GoR). (2011, April 19). *Rajasthan Solar Energy Policy, 2011*. Retrieved from http://www.rrecl.com/PDF/Solar%20Policy.pdf

GoR. (2012, July 18). *Policy for promoting generation of electricity from wind, 2012*. Retrieved from http://www.rrecl.com/PDF/Notification-Wind%20Policy,%202012.pdf

Government of Tamil Nadu. (2012, March). *Strategic plan for infrastructure development in Tamil Nadu*. Retrieved from http://www.spc.tn.gov.in//pdfs/TN_Vision_2023.pdf

Greenpeace India. (2013). Powering ahead with renewables: Leaders & laggards. Retrieved from http://www.greenpeace.org/india/Global/india/report/2013/powering-ahead-with-renewables.pdf

Gujarat Energy Development Agency (GEDA). (2013a, March 31). *Solar power projects installed*. Retrieved from http://geda.gujarat.gov.in/project_single.php?project=26

GEDA. (2013b, July 25). *GEDA: Home*. Retrieved from http://geda.gujarat.gov.in/policy_files/Wind_Power_Policy-2013.pdf

Gunatilake, H., & Ganesan, K. (In press). *Valuation of health impacts of air pollution from power plants*. Manila: Asian Development Bank.

Gupta, V., Ganesan, K., Raje, S., Ahmed, F., & Ghosh, A. (2013). *Strategic industries and emerging technologies for a future-ready India: Report to the National Security Advisory Board*. New Delhi: Council on Energy, Environment and Water.

Gyana Ranjan Panda, N. J. (2012, September 15). *Evaluating the performance of the National Clean Energy Fund*. Centre for Budget and Governance Accountability: Publications. Retrieved from http://www.cbgaindia.org/files/featured_articles/Evaluating%20the%20Performance%20of%20the%20National%20Clean%20Energy%20Fund.pdf

HSBC Global Research. (2013, April 30). *India Renewables–Good bye winter, hello spring*. Retrieved from http://natgrp.files.wordpress.com/2013/07/india-renewables-good-bye-winter-hello-spring-hsbc-report.pdf

ICRA. (2013, July). *Wind energy sector: Strong demand potential in the long run, although challenges remain on regulatory front*. Retrieved from http://www.icra.in/Files/ticker/SH-2013-H2-1-ICRA-Wind%20Energy.pdf

India Electronics & Semiconductor Association (IESA). (n.d.). Semiconductor Policy 2007. Retrieved from http://www.iesaonline.org/semiconductor_policy_notification_2007.html

India Infoline. (2011, August 24). SEMI India launches Solar PV technical training programmes. Retrieved from http://www.indiainfoline.com/Markets/News/SEMI-India-launches-Solar-PV-technical-training-programmes/5228850396

Indian Association for the Cultivation of Science (IACS). (2012). *Energy Research Unit.* Retrieved from http://www.iacs.res.in/eru/

Indian Network for Climate Change Assessment (INCCA). (2010). *India: Greenhouse gas emissions 2007*. New Delhi: Ministry of Environment and Forests.

InWEA. (n.d.). *InWEA: Services*. Retrieved from http://www.inwea.org/advisory.htm

InWEA. (2012). *Wind Energy Programme in India*. Retrieved from http://www.inwea.org/aboutwindenergy.htm

Infrastructure Development Finance Company (IDFC). (2011, November). *India solar policy: Elements casting shadow on harnessing the potential.* Retrieved from http://www.idfc.com/pdf/publications/India-Solar-Policy-Element-Casting-Shadow-on-Harnessing-the-Potential.pdf

Institute for Building Efficiency. (2010, August). *Feed-in tariffs: A brief history*. Retrieved from http://www.institutebe.com/energy-policy/feed-in-tariffs-history.aspx

International Energy Agency (IEA). (2012). *World energy outlook 2012*. Paris: International Energy Agency. Retrieved from http://www.worldenergyoutlook.org/publications/weo-2012/

IEA. (2013). *Technology roadmap wind energy*. IEA. Retrieved from http://www.iea.org/publications/freepublications/publication/name,43771,en.html

IWTMA. (2013). *Advocacy of EIA for wind power: Untimely and unjust*. New Delhi, New Delhi, India.

Jai, S. (2013, July 16). Breakthrough solar & wind power projects in India. *The Economic Times*. Retrieved from http://economictimes.indiatimes.com/slideshows/infrastructure/breakthrough-solar-wind-power-projects-in-india/slideshow/21098577.cms

Jayaraman, K.S. (2012, December 30). India prepares to boost science. *Nature Journal*. Retrieved from http://www.nature.com/news/india-prepares-to-boost-science-1.12135

Johnson, O. (2013). *Exploring the effectiveness of local content requirements in promoting solar pv manufacturing in India*. German Development Institute. Retrieved from http://www.die-gdi.de/uploads/media/DP_11.2013.pdf

Jowit, J. (2010, October 20). India set to be first country to publish 'natural wealth' accounts. *The Guardian*. Retrieved from http://www.theguardian.com/environment/2010/oct/20/india-natural-wealth-accounts

KPMG (2012). *Taxes and incentives for renewable energy*. Retrieved from http://www.kpmg.com/Global/en/IssuesAndInsights/ArticlesPublications/Documents/taxes-incentives-renewable-energy-2012.pdf

Kumar, D. S. (2012, November 5). *ASEAN-India Workshop on Co-operation in Renewable Energy Vigyan Bhavan, New Delhi*. Retrieved from http://mnre.gov.in/file-manager/UserFiles/asean2012/Session%202%20-%20Solar/SKumar_ASEAN_Delhi_20121105_Final.pptx

Kuntze, J-C., & Moerenhout, T. (2013). *Local content requirements and the renewable energy industry – A good match?* Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2188607

Lele, A. (2013, January 9). India's new science policy is about innovation. Retrieved from http://www.idsa.in/idsacomments/IndiasNewSciencePolicyisaboutInnovation_alele_090113

Lewis, J. I. (2011). Building a national wind turbine industry: experiences from China, India and South Korea. *International Journal of Technology and Globalisation*. Retrieved from https://www.china.tu-berlin.de/fileadmin/fg57/SS_2012/Umwelt/Lewis_windenery.pdf

Mahesh, K. (2013, February 7). Fab City remains a pipedream. *Times of India*. Retrieved from http://articles.timesofindia.indiatimes.com/2013-02-07/hyderabad/36971148_1_land-allotment-fab-city-acres-land

Ministry of Finance. (2013, February 28). Ministry of Finance. Retrieved from http://indiabudget.nic.in/ub2013-14/bh/bh1.pdf

Ministry of New and Renewable Energy (MNRE). (n.d.a). *Frequently asked questions on Wind Power Programme (FAQ).* Retrieved from http://mnre.gov.in/file-manager/UserFiles/faq_wind.pdf

MNRE. (n.d.b). *International Cooperation*. Retrieved from http://mnre.gov.in/schemes/support-programmes/international-cooperation-3/

MNRE. (n.d.c). MNRE - Analysis of State RPO regulations. Retrieved from http://mnre.gov.in/file-manager/UserFiles/Solar%20RPO/analysis-of-state-RPO-regulations.pdf

MNRE. (n.d.e). *Solar Energy Centre.* Retrieved from http://www.mnre.gov.in/centers/about-sec-2/

MNRE. (n.d. f). *Solar Energy Centre - Achievements*. Retrieved from http://mnre.gov.in/centers/about-sec-2/achievements-2/

MNRE. (n.d.g). *System focus.* Retrieved from http://www.mnre.gov.in/schemes/r-d/solar-pv-3/system-focus/

MNRE. (n.d.h). *WIND Power Programme*. Retrieved from http://www.mnre.gov.in/schemes/grid-connected/solar-thermal-2/

Ministry of New and Renewable Energy (MNRE). (2008, January 2). *MNRE declares generation based incentive for the first time*. Retrieved from http://www.pib.nic.in/newsite/erelease.aspx?relid=34348

MNRE. (2009, December). *C-WET. Scheme for implementation of generation based incentives (gbi) for grid interactive wind power projects.* Retrieved from http://www.mnre.gov.in/file-manager/grid-wind/gbi-scheme.pdf

MNRE. (2010a). *India's renewable energy sector: Potential and investment opportunities.* Retrieved from http://www.direc2010.gov.in/pdf/India's-RE-Sector-Potential-and-Investment-opportunites-SSM.pdf

MNRE. (2010b, January 11). *Jawaharlal Nehru National Solar Mission, Mission Document*. Retrieved from http://www.mnre.gov.in/file-manager/UserFiles/mission_document_JNNSM.pdf

MNRE. (2010c, October 18). *Policy guidelines of research, design, development, demonstration (rdd&d) and manufacture of new and renewable energy*. Retrieved from http://www.mnre.gov.in/file-manager/rd-scheme/om-rnd18102010.pdf

MNRE. (2010d, December 27). *SADP 10-12*. Retrieved from http://mnre.gov.in/file-manager/support-programme-scheme/sadp10-12.pdf

MNRE. (2011a, October). *RePowering wind farms in India*. Retrieved from http://mnre.gov.in/file-manager/akshay-urja/september-october-2011/EN/RePowering%20Wind%20Farms.pdf

MNRE. (2011b). *Guidelines for Selection of New Grid Connected Solar Power Projects - Batch 2*. Retrieved from http://www.mnre.gov.in/file-manager/UserFiles/jnnsm_gridconnected_25072010.pdf

MNRE. (2012a). *Annual Report 2011–2012*. Retrieved from http://mnre.gov.in/file-manager/annual-report/2011-2012/EN/index.htm

MNRE. (2012b). *Outcome Budget 2011-2012, MNRE*. Retrieved from http://mnre.gov.in/file-manager/UserFiles/outcome_budget_2011_12.pdf

MNRE. (2012c, July 16). *MNRE Support Programme Scheme - HRD Programme.* Retrieved from http://mnre.gov.in/file-manager/support-programme-scheme/hrd-programme-2012-13.pdf

MNRE. (2012d, December 17). *Grid-connected renewable energy projects generate employment of about 15 persons Per MW*. Retrieved from http://pib.nic.in/newsite/erelease.aspx?relid=90836

MNRE. (2012e, December). *Jawaharlal Nehru National Solar Mission: Phase II Policy Document.* Retrieved from http://mnre.gov.in/file-manager/UserFiles/draft-jnnsmpd-2.pdf

MNRE. (2013a). *Annual Report 2012–2013. New Delhi: MNRE*. Retrieved from http://mnre.gov.in/file-manager/annual-report/2012-2013/EN/index.html

MNRE. (2013b). *Outcome budget 2013–2014, MNRE*. Retrieved from http://mnre.gov.in/file-manager/UserFiles/outcome-budget-mnre-2013-14.pdf

MNRE. (2013c, March 6). *Over 50,000 direct jobs created in new & renewable sector.* Retrieved from http://pib.nic.in/newsite/PrintRelease.aspx?relid=93071

MNRE. (2013d, July 31). *Physical progress (achievements)*. Retrieved from http://mnre.gov.in/mission-and-vision-2/achievements/

MNRE. (2013e, August 14). *Draft national offshore wind energy policy* . Retrieved from http://mnre.gov.in/file-manager/UserFiles/presentations-offshore-wind-14082013/JS-MNRE.pdf

MNRE. (2013f, October 4). *Revised Draft Guidelines for setting up of 750 MW Grid Solar PV power projects with Viability Gap Funding (VGF) under Jawaharlal Nehru National Solar Mission (JNNSM), Phase-II, Batch-I.* Retrieved from http://mnre.gov.in/file-manager/UserFiles/revised-VGF_750MW_Guidelines_for-grid-solar-power-projects.pdf

Ministry of Power. (2003, June 2). *The Electricity Act.* Retrieved from http://www.powermin.nic.in/acts_notification/electricity_act2003/pdf/The%20Electricity%20Act_2003.pdf

Ministry of Power. (2006, January 6). *Tariff policy.* Retrieved from http://www.aegcl.co.in/Tariff_Policy%20.pdf

Ministry of Power. (2013, June 30). *Power Sector at a Glance "ALL INDIA"*. Retrieved from http://powermin.nic.in/JSP_SERVLETS/internal.jsp

Mizuno, E. (2011). *Diffusion of renewable energy technologies: Case studies of enabling frameworks in developing countries. UNEP.* Retrieved from http://www.tech-action.org/Perspectives/DiffusionRenewableEnergyTechnologies.pdf

MoEF. (2001, January). *Environment impact assessment*. Retrieved from http://envfor.nic.in/divisions/iass/eia/Cover.htm

MoEF. (2006, September 14). *MoEF: Notifications.* Retrieved from http://envfor.nic.in/legis/eia/so1533.pdf

MoEF. (2011a, May 13). *MoEF - Public Information*. Retrieved from http://moef.nic.in/downloads/public-information/OM-SolarPV.pdf

MoEF.(2011b, August 31). *Report of the Western Ghats Ecology Expert Panel*. Retrieved from http://moef.nic.in/downloads/public-information/wg-23052012.pdf

MoEF. (2012). *Second National Communication to the UNFCCC.* Retrieved from http://www.moef.nic.in/downloads/public-information/India%20Second%20National%20Communication%20to%20UNFCCC.pdf

Ministry of Labour (2011). *Second Annual Report to the People on Employment.* Retrieved from http://dget.nic.in/publications/annualreportemployment2011.pdf

Mohan, V. (2013, September 3). *Government clears proposal to set up premier institution to develop solar energy technologies. Times of India.* Retrieved from http://timesofindia.indiatimes.com/home/environment/the-good-earth/Government-clears-proposal-to-set-up-premier-institution-to-develop-solar-energy-technologies/articleshow/22263318.cms

Mukherjee, P. (2008). *India and global challenges: Climate change and energy security.* New York: The Asia Society. Retrieved from http://www.un.int/india/asia.pdf

National Centre for Photovoltaic Research and Education (NCPRE). (2011). *Education & Training - Year 2011*. Retrieved from http://www.ncpre.iitb.ac.in/pages/education_training_2011.html#tttp

NCPRE. (n.d.). *Silicon solar cell -year 2011.* Retrieved from http://www.ncpre.iitb.ac.in/pages/goals_silicon_solar_cells.html

NDTV. (2012, August 23). *Suzlon to slash 2,000–2,500 jobs in a bid to revive: Sources.* Retrieved from http://profit.ndtv.com/news/corporates/article-suzlon-to-slash-2-000-2-500-jobs-in-a-bid-to-revive-sources-309775

NVVN. (2012, June). *Annual Report.* Retrieved from http://www.nvvn.co.in/FinReports/NVVNAnnualReport2011-12.pdf

Organisation for Economic Co-operation and Development (OECD). (2012). *OECD Factbook 2011–2012: Economic, environmental and social statistics.* Retrieved from http://www.oecd-ilibrary.org/sites/factbook-2011-en/06/01/04/index.html?itemId=/content/chapter/factbook-2011-49-en

Over 1 lakh requests pending with patent office. (2013). *The Economic Times.* Retrieved from http://articles.economictimes.indiatimes.com/2012-05-14/news/31701420_1_patent-examiners-patent-applications-patent-offices

Panda, G. R., & Jena, N. (2012). *Evaluating the performance of the National Clean Energy Fund.* Retrieved from http://www.cbgaindia.org/files/featured_articles/Evaluating%20the%20Performance%20of%20the%20National%20Clean%20Energy%20Fund.pdf

Pearson, N.O. (2013, May 29). Inox Wind May Expand India Manufacturing Plants Next Year. *Bloomberg News.* Retrieved from http://www.bloomberg.com/news/2013-05-29/inox-wind-may-expand-india-manufacturing-plants-next-year.html

Power Grid Corporation of India Limited (PGCIL). (2012, July). *Report on green energy corridors: Transmission plan for envisaged renewable capacity.* Retrieved from http://www.indiaenvironmentportal.org.in/files/file/Report-Green%20Energy%20corridor.pdf

Planning Commission. (2006a). *Integrated Energy Policy: Report of the Expert Committee. Government of India. New Delhi: Planning Commission.* Retrieved from http://planningcommission.nic.in/reports/genrep/rep_intengy.pdf

Planning Commission. (2006b). *Report of the working group on new and renewable energy for 11th five year plan (2007-2012). New Delhi: Planning Commission.* Retrieved from http://planningcommission.gov.in/aboutus/committee/wrkgrp11/wg11_renewable.pdf

Planning Commission. (2012). *Annual Report (2011-12) on the working of State Power Utilities and Electricity Departments. New Delhi: Planning Commission.* Retrieved from http://planningcommission.gov.in/reports/genrep/arep_seb11_12.pdf

Planning Commission . (2013a). *12th Five Year Plan (2012-2017)*. Retrieved from http://planningcommission.gov.in/plans/planrel/12thplan/pdf/12fyp_vol1.pdf

Planning Commission . (2013b). *12th Five Year Plan (2012-2017)*. Retrieved from http://planningcommission.nic.in/plans/planrel/12thplan/pdf/12fyp_vol2.pdf

Prabhu, R. (2012, May). *Will India join the 'Gigawatt Club' this year?* Retrieved from http://www.mercomcapital.com/will-india-join-the-gigawatt-club-this-year

Preetha, M.S. (2013, July 18). Dip in evacuation of wind energy in TN. *The Hindu*. Retrieved from http://www.thehindu.com/news/cities/Coimbatore/dip-in-evacuation-of-wind-energy-in-tn/article4927021.ece

Press Information Bureau (PIB). (2005, February 3). *National Electricity Policy* (Press release). Retrieved from http://pib.nic.in/archieve/others/2005/nep20050209.pdf

PIB. (2008, January 2). *MNRE declares generation based incentive for the first time* (Press release). Retrieved from http://www.pib.nic.in/newsite/erelease.aspx?relid=34348

PIB. (2010, August 11). *Carbon credits* (Press release). Retrieved from http://pib.nic.in/newsite/erelease.aspx?relid=64589

PIB. (2011a, December 16). *Year end review* (Press release). Retrieved from http://www.pib.nic.in/newsite/erelease.aspx?relid=78807

PIB. (2011b, January 6). *Amendment in tariff policy* (Press release). Retrieved from http://pib.nic.in/newsite/erelease.aspx?relid=68902

PIB. (2011c, December 16). *Generation based incentive scheme* (Press release). Retrieved from http://www.pib.nic.in/newsite/erelease.aspx?relid=78829

PIB. (2011d, December 30). *Year end review – 2011* (Press release). Retrieved from http://pib.nic.in/newsite/erelease.aspx?relid=79281

PIB. (2012, June 16). *India is committed to increasing share of renewable energy, says Dr. Farooq Abdullah at IIEA, Dublin* (Press release). Retrieved from http://pib.nic.in/newsite/erelease.aspx?relid=84919

PIB. (2013a, March 8). *FDI worth 8569 crores in Renewable Energy Sector* (Press release). Retrieved from http://www.pib.nic.in/newsite/erelease.aspx?relid=93317

PIB. (2013b, May 15). *Power Minister leads high-level delegation to Germany* (Press release). Retrieved from http://pib.nic.in/newsite/erelease.aspx?relid=95990

PIB. (2013c, August 14). *National Offshore Wind Energy Authority (NOWA) to be constituted shortly* (Press release). Retrieved from http://pib.nic.in/newsite/erelease.aspx?relid=98283

PIB. (2013d, September 3). *Setting up of an autonomous institution named "National Institute of Solar Energy" (NISE) for Research and Technology* (Press release). Retrieved from http://pib.nic.in/newsite/erelease.aspx?relid=99083

PricewaterhouseCoopers (PwC). (2012). *Emerging opportunities and challenges. India Energy Congress–2012.* PwC. Retrieved from http://www.pwc.in/assets/pdfs/publications-2011/wec-pwc-report.pdf

Prime Minister's Council on Climate Change. (2008). *National Action Plan on Climate Change.* Retrieved from http://pmindia.gov.in/climate_change_english.pdf

PVTECH. (2013, September 05). *NPD Solarbuzz: Idled solar cell capacity in India belies bigger issues.* Retrieved from http://www.pv-tech.org/news/npd_solarbuzz_idled_solar_cell_capacity_in_india_belies_bigger_issues

Rajasthan Renewable Energy Corporation Limited (RRECL). (2013, June 30). *Details of grid connected solar power projects in Rajasthan.* Retrieved from http://www.rrecl.com/PDF/Details%20of%20Grid%20Connected%20Solar%20Power%20Projects%20in%20Rajasthan.pdf

Rajsekhar, B., Van Hulle, F., Jansen, J. C. (1999). Indian wind energy programme: Performance and future directions. *Energy Policy*, 669-678.

Ramesh, M. (2012a, November 12). Gamesa to lay off 135 in India. *Business Line*. Retrieved from http://www.thehindubusinessline.com/companies/gamesa-to-lay-off-135-in-india/article4090510.ece

Ramesh, M. (2012b, November 30). Oversupply, depressed demand dampens REC trading. *Business Line.* Retrieved from http://www.thehindubusinessline.com/markets/commodities/oversupply-depressed-demand-dampens-rec-trading/article4150743.ece

Ramesh, M. (2013a, February 18). Renewable purchase obligations enforcement is not our remit: Power regulator. Retrieved from http://www.thehindubusinessline.com/industry-and-economy/renewable-purchase-obligations-enforcement-is-not-our-remit-power-regulator/article4428240.ece

Ramesh, M. (2013b, March 24). National Solar Mission: 70% of projects using imported modules. *Business Line*. Retrieved from http://www.thehindubusinessline.com/industry-and-economy/national-solar-mission-70-of-projects-using-imported-modules/article4544528.ece

Ramesh, M. (2013c, May 13). Wind power producers oppose competitive bidding for projects. *Business Line.* Retrieved from http://www.thehindubusinessline.com/news/states/wind-power-producers-oppose-competitive-bidding-for-projects/article4712057.ece

Ramesh, M. (2013d, July 22). Wind power generators take CERC to court over "scheduling and forecasting." *Business Line.* Retrieved from http://www.thehindubusinessline.com/industry-and-economy/wind-power-generators-take-cerc-to-court-over-scheduling-and-forecasting/article4941030.ece

Rasmus Lema, A. L. (2012). Technology transfer? The rise of China and India in green technology sectors. *Innovation and Development*, 2(1), 23–44.

REConnect Energy Solutions. (2013, October 31). *REC Trading Report – October 2013.* Retrieved from http://reconnectenergy.com/blog/tag/rec-mechanism-in-india/

Renewable Energy Certificate Registry of India (RECRI). (2013). *RE Source & Unit wise break up.* Retrieved from https://www.recregistryindia.nic.in/index.php/general/publics/Rec_Source_Wise_Breakup

REN21. (2013). *Global status report*. Retrieved from http://www.ren21.net/Portals/0/documents/Resources/GSR/2013/GSR2013_lowres.pdf

Reserve Bank of India (RBI). (2013). *Handbook of statistics on Indian economy*. Retrieved from http://www.rbi.org.in/scripts/AnnualPublications.aspx?head=Handbook%20of%20Statistics%20on%20Indian%20Economy

Sahoo, A., & Shrimali, G. (2013). An analysis of industrial policy support for the Indian solar photovoltaic manufacturing sector. *Energy Policy,* 1470-1480.

SERIIUS. (n.d.). SERIIUS R&D Highlights. Retrieved from http://www.seriius.org/highlights.html

Sethi, N. (2013, April 16). *Solar manufacturers urge govt to levy anti-dumping duty.* Retrieved from http://www.livemint.com/Industry/vW409WhiXVQPQ1LvOXRyQI/Solar-manufacturers-urge-govt-to-levy-antidumping-duty.html

Shah, H. (2012). *Myths of wind power in India. Pipeline Clean Energy*. Retrieved from http://www.gwpl.co.in/news&events/MythsofWindPowerinIndia.pdf

Subbaraj, A. (2013, May 13). Wind power helps city beat the summer heat. *Times of India*. Retrieved August 10, 2013, from http://articles.timesofindia.indiatimes.com/2013-05-17/coimbatore/39335815_1_wind-mills-power-cuts-wind-energy

Sundqvist, T., & Soderholm, P. (2002, December). Valuing the environmental impacts of electricity generation: A critical survey. *Journal of Energy Literature*, VIII(2), 3–41.

Suzlon. (n.d.). *Suzlon: Key differentiators.* Retrieved from http://www.suzlon.com/key_differentiators/l2.aspx?l1=4&l2=14

Suzlon loses top spot in India wind market installations. (2013, May 10). Livemint. Retrieved from http://www.livemint.com/Companies/3wn6VrKIIZuJqcd6h4ZNDO/Suzlon-loses-top-spot-in-India-wind-market-installations.html

Tamil Nadu Electricity Regulatory Commission (TNERC). (2012). *Comprehensive Tariff Order on Wind Energy.* Order, Chennai.

Tanti, T. (2011, June). *Wind matters: Making the case for wind in India.* Retrieved from http://www.suzlon.com/pdf/case-for-wind.pdf

Thakur, B, Gupta, R., & Singh, R. (2012, December). Changing face of India's industrial policy: A look. *International Journal of Scientific and Research Publications,* 2(12), 1–7. Retrieved from http://www.ijsrp.org/research-paper-1212/ijsrp-p12104.pdf

Unnikrishnan, C.H. (2010). Indian IP examiners have world's highest workload, lowest pay. Retrieved from http://www.livemint.com/Politics/BV5jXcxAd1fU1ZuYNqVF2M/Indian-IP-examiners-have-world8217s-highest-workload-low.html

United Nations Conference on Environment & Development. (1992). *Agenda 21*. Rio de Janerio, Brazil.

United States Environmental Protection Agency (USEPA). (2004). *Review of the National Ambient Air Quality Standards for Particulate Matter.* EPA-452/R-96-013, North Carolina: U.S. Environmental Protection Agency.

United States General Accounting Office. (1997, March). *Measuring performance – Strengths and limitations of research indicators.* Retrieved from http://www.gao.gov/assets/160/155826.pdf

West Bengal Green Energy Development Corporation (WBGEDC). (n.d.). *Projects.* Retrieved from http://www.wbgedcl.in/projects/

Wind World. (2013). *Indian renewable energy regulatory scenario.* Retrieved from http://www.windworldindia.com/Regulatory-Governance.pdf

World Bank. (2000, April). India Renewable Resources Development Project. Retrieved from http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2009/11/02/000334955_20091102032839/Rendered/PDF/513830WP0P01041000Box342026B01PUBLIC1.pdf

World Bank. (2013, April 18). *Call to action on recognizing the true value of nature* (Press release). Retrieved from http://www.worldbank.org/en/news/press-release/2013/04/18/call-to-action-on-recognizing-the-true-value-of-nature

World Health Organization (WHO). (2000). *Air Quality Guidelines for Europe*. European Series, Copenhagen: World Health Organization.'

World Institute of Sustainable Energy (WISE). (2011, June). WISE. Retrieved from http://www.wisein.org/achieving-12-percent-green-electricity-by-2017-workshop.html

World Intellectual Property Organization (WIPO). (n.d.). *IPC Green Inventory.* Retrieved from http://www.wipo.int/classifications/ipc/en/est/

Further details and contact information

For further information contact Lucy Kitson at +41 22 917-8869 or Damon Vis-Dunbar at +41 22 917-8848

International Institute for Sustainable Development
Global Subsidies Initiative
International Environment House 2, 9 chemin de Balexert, 1219 Châtelaine, Geneva, Switzerland
Tel: +41 22 917-8373 | Fax: +41 22 917-8054