Renewable Energy in India: Policies, Trends and Foreign Direct Investments in Research and Development

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Abstract

Adopting Renewable Energy (RE) has become a necessity for achieving different development goals, for a fast growing economy and a demographically young country like India. At the same time intense Research and Development (R&D) and business activity in the domestic RE sector has become necessary to ensure the spread, affordability and efficacy of RE according to local needs. In a rapidly connecting and increasingly inter-dependent world, collaborative activities on an international level are important to finance growth, gain technical knowledge and promote cost effective manufacturing in a relatively new sector such as RE. Studying different types of collaborations e.g. manufacturing and R&D etc. while keeping focus on the future of RE in India is therefore important to understand business opportunities. At the same time capturing a larger picture of the situation in RE sector while focusing on the influence of different aspects on foreign collaboration e.g. policy influence on investment or on collaborative R&D is certainly needed to understand the challenges.

Keywords: frugal innovation, India, renewable energy, collaborative R&D, local needs

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1. Introduction

India has the second largest population in the world with a median age of around 27.3 years (Ministry of Health & Family Welfare, 2006). It is the second largest among emerging markets and developing economies, globally ranks third in terms of Gross Domestic Product (GDP) based on Purchasing-Power-Parity (PPP) valuation (International Monetary Fund, 2015). These demographic and economic development indicators point towards a rapidly developing economy powered by the working age youth.

Energy is a critical enabler of growth and in the case of advanced economies secure access to modern sources of energy has contributed in their development and prosperous growth (OECD/IEA, 2015a). India is still unable to provide secure energy access to all of its population. According to a statistic from 2012, only 78.7% of the population had access to electricity (The World Bank, 2015). Furthermore, those with access to electricity face problems such as electricity shortage and peak power deficit (CEA, 2015a). Besides providing energy access and energy security to meet the commercial demand and sustain economic growth, affordability of energy to all of its population is important in case of India. India, in the year 2010, had the largest share (32.9%) in the global total of 1.2 billion extremely poor people, who were living on less than $1.25 a day (United Nations, 2014). The energy challenge therefore, is not only limited to generation of additional and / or cheaper power by the power producers but also involves ensuring the supply of that power at very less per unit costs to the current as well as prospective consumers spread across a large range of income. These amounts must also include the costs that are necessary to build the additional infrastructure capable of delivering the power to the remote and / or rural regions which are mostly inhabited by people with lower income. RE technology which is able to provide off grid power and decentralized system solutions such as solar street lighting systems can therefore be one of the appropriate solutions especially in case grid connectivity is not physically viable or is not cost effective.

India is the fourth largest energy consumer, the third largest electricity producer in terms of gross output and also the third largest Carbon Dioxide (CO_2) gas emitter in the world (BP, 2015a). The world is heading towards dangerous climate change owing to rapid increase in the Green House Gas (GHG), particularly CO_2, emissions (WMO, 2015). This makes India's stand on climate change crucial to mitigate the risk. India's economical, demographical and environmental position on today's global stage compels one, therefore, to consider the extent

of international collaboration between India and the World, if one has to look at the future of energy in the world.

It has become imperative to look at India's domestic RE endeavors and international RE collaborations, if one has to understand the future of RE innovation and RE related business in the world. For instance, in an interview published by the US based National Bureau of Asian Research (NBR), Manish Bapna of the World Resources Institute (WRI) states "India is a key country in the efforts of the international community to shift to a sustainable, low-carbon path that will confront climate change, improve human health, and foster prosperity for all" (Luthra, 2014: 1). As stated earlier, RE can provide off grid and decentralized solutions for increasing the accessibility and affordability. RE power projects can also be connected with the grid thereby reducing the overall deficit and achieving energy security. Pursuing the goals of energy security, energy access and mitigation of climate change while taking care of the affordability points logically towards RE solutions with localization approach in R&D and manufacturing for catering to the Indian market. A report by the 'International Science Panel on Renewable Energies (ISPRE)' states, "Coherent R&D programs for renewable energies are key elements in designing political strategies, not only for renewable energies but also for carbon mitigation" (ISPRE, 2009: ii). The report argues that strong efforts nationally and internationally are necessary to establish RE R&D in almost every part of the world (ibid). This favors the theme of globalization of RE R&D. The report also mentions that "R&D has a particular role to play in helping to adapt technology to local needs and build capacity through the fostering of skills and local enterprise" (ISPRE, 2009: vii).

2. Energy Situation in India

It has already been mentioned that India is the fourth largest energy consumer in the world. The current situation of energy in India particularly the Power generation and the contribution of RE has to be understood in the beginning. In 2014, India's total primary energy consumption was 4.9% of the world total (BP, 2015a). The share of renewables consumed in India is just 2.18%. The energy production increased 4%, the highest growth rate in five years, while consumption increased 7.1% (all time high) over the previous year (BP, 2015b). It is important to note here that India is still highly dependent on the fossil fuels for its energy demands. In 2014, India's increase in both production and consumption of coal was highest in the world (ibid). India was the fifth largest coal producer in 2014 and the third largest coal market in the world (ibid). The dependency on coal and gas for energy is emphasized by figure 1 which shows the mode wise breakup of installed electricity generation capacity (Utilities) released by Central Electricity Authority (CEA) in India. The total installed capacity for utilities stands at 280.328 Giga-Watt (GW) as on 31.10.2015 (CEA, 2015b).

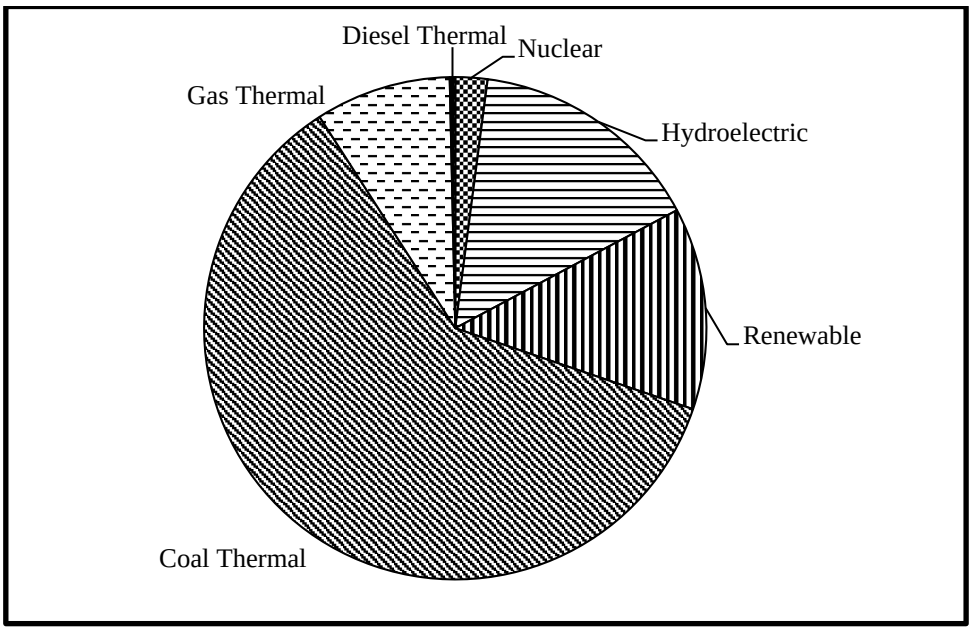

Figure 1. All India Installed Capacity of Power Stations in GW

Source: Own illustration based on (CEA, 2015b)

The share of RE based electricity in electricity mix is also an important indicator of the present situation. This stands at around 6% of the total electricity generated in India and the government intends to increase it to 15% in the next 10 to 12 years (PIB, 2015a). Total gross

electricity generation (Utilities) in India in 2014-15 was 1105.446 billion units[3] out of which 5.59 % i.e. 61.780 billion units electricity was generated from RE (CEA, 2015a). These figures give a static picture of the share of RE in consumption, installed capacity and energy mix. It is essential to look at the growth rates and other dynamic indicators. According to the country specific insights published in the 'BP statistical review of World Energy 2015', RE consumption grew 11.5%, the fastest among all fuel types over the previous year, in 2014 in India. Renewables in power in India, according to BP, have grown more than six times over the last 10 years (BP, 2015b). These growth rates show that although there is a huge dependency on coal, cleaner sources of energy are being increasingly adopted in India. Currently there is an installed renewable power generation capacity (grid interactive) of 38.8216 GW[4] in India according to Ministry of New and Renewable Energy (MNRE), Government of India (GoI) (MNRE, 2015a). At this stage it becomes necessary, to look into certain relevant aspects of this capacity. Figure 2 shows the mode-wise breakup of the total capacity as on 31.10.2015 in GW.

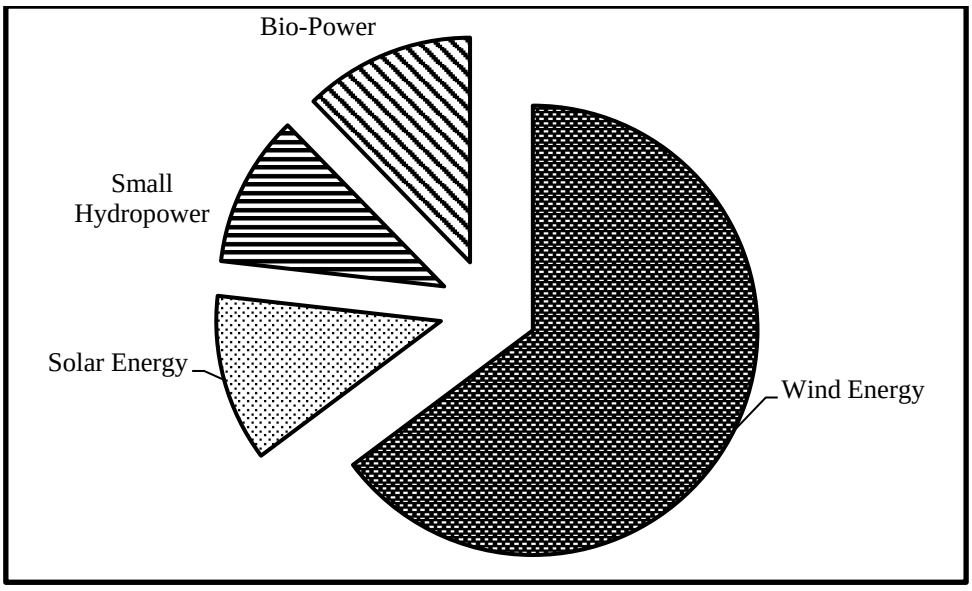

Figure 2. Mode wise breakup of installed RE Capacity in GW[10]

Source: Own illustration based on (CEA, 2015b)

It is interesting to note than out of the total RE capacity, almost 95% of the capacity belongs to private sector and around 5% to the state governments, with no generation capacity directly under central government (CEA, 2015b). Large involvement of private sector is

[3] 1 unit = 1 kilowatt-hour , 1 billion unit = 1 terawatt-hour

[4] Hydropower plant with capacity under or equal to 25MW is considered in RE Power and is termed as Small Hydro Power. Hydropower plants with more than 25MW are considered in conventional power and not included in RE Power in India.

indicative of the business opportunities present. Wind Energy dominates the Indian RE market. To get an idea of the size of the Wind sector in India, it is essential to note that India is the 5th largest Wind Energy producer in the world after China, the US, Germany and Spain in terms of installed capacity (MNRE, 2015b). India is also an important Wind Turbine and Equipment manufacturing hub with annual production capacity reaching 9500 MW in 2014 (MNRE, 2015b). Solar energy, although much behind Wind energy in terms of installed capacity, is receiving increased attention both domestically and internationally due to the ambitious targets set by the government, largely untapped estimated potential, a national level solar mission and other development initiatives taken by the government. The potential power generation capacity has been estimated and the targets for the installed capacities till 2022 have been determined by the government (PIB, 2015b). These targets are placed alongside the installed capacities in figure 3 in GW. The sector-wise estimated potential capacities are mentioned above the corresponding graphs of the sector in boxes.

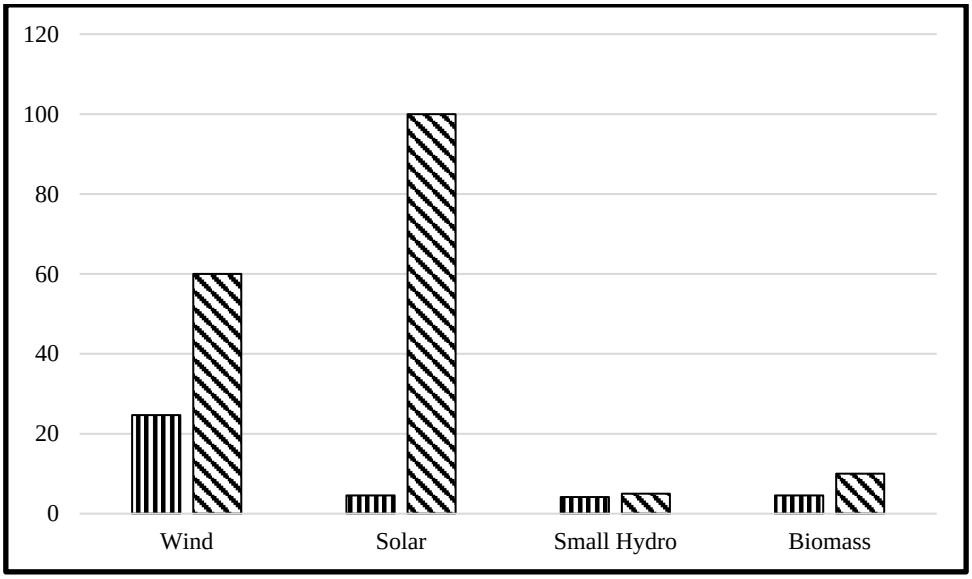

Figure 3. Current (Oct 2015) Installed RE Capacity vs Target till 2022 estimated potential in GW

Source: Own illustration based on official data (PIB, 2015b).

The significant thing here is the particularly ambitious target for solar energy considering the current standing of solar based capacity. Also, the estimated potential of solar energy based capacity is quite large in comparison to that in other subsectors. Looking at this figure, it is obvious that Wind and Solar energy sectors have importance in the Indian RE market. These targets are important indicators for understanding the focus of the government as well as the future of RE business in India. From an outsider's perspective these can be viewed as internal targets. One may argue that there exists a need to consider the targets, which are committed

by India on an international platform, with a certain obligation to achieve them in set time. These can also serve as another indicator for future of RE business in India as well as of India's efforts in mitigation of climate change.

India has formally committed in its 'Intended Nationally Determined Contribution' (INDC) to 'United Nations Framework – Convention on Climate Change' (UNFCCC) that emission intensity of its GDP is to be reduced by 33% to 35% by 2030 from 2005 level and around 40% of the cumulative installed power capacity is to be achieved from non-fossil fuel based energy resources (GoI, 2015). In the same submission, it is stated that India intends to "build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies" (ibid). This commitment is highly relevant as it is indicative of the attention given to encourage diffusion of climate technologies and collaborative R&D by the highest level of government.

Paris based International Energy Agency (IEA), in its World Energy Outlook special report titled 'Energy and Climate Change' has projected (OECD/IEA, 2015b) that in India –

1. Wind energy based installed capacity is projected to be 80 GW by 2025 and to 109 GW by 2030 at Compound Average Annual Growth Rate (CAAGR) of 10.4% whereas solar energy based capacity is expected to increase to 101 GW by 2025 and to 139 GW by 2030 at CAAGR of around 28%, the fastest among other energy sources.
2. Wind energy based gross electricity power generation is expected to increase to 149 billion units by 2025 and to 210 billion units by 2030 at a CAAGR of 11.6% whereas for solar energy, it is projected to increase to 161 billion units by 2025 and 224 billion units by 2030 at a CAAGR of more than 30%, the fastest among other energy resources.

These projections paint an optimistic picture for the growth of RE based power in India, particularly in case of solar energy. This fortifies the argument that RE sector as a whole and in particular solar energy sector, has a lot of untapped growth potential in India.

3. Relevant Renewable Energy Policies, Initiatives and Statistics

Ability of a sector to attract foreign investment depends upon several factors such as financial policies of the government and banking institutions, economic situation, legal framework, market barriers and business opportunities etc. Thus, it becomes necessary to look at the policy measures and initiatives etc. which create an environment for collaboration. Market attractiveness is complex to analyze and difficult to quantify. However, there are indicators published by different agencies that help point in the right direction for investment and opportunities.

Professional services organization Ernst & Young (EY) which publishes Renewable Energy Country Attractiveness Index (RECAI) quarterly, has ranked India third on its index after the US and China (EY, 2015a). According to RECAI, the countries have been ranked 'on the attractiveness of their renewable energy investment and deployment opportunities, based on a number of macro, energy market and technology-specific indicators' (EY, 2015a). The report recognizes that, in India, there are a significant number of challenges in the way of achieving set targets but also states that there is a "relentless" rollout of policy measures, continuous flow of big projects, deals and funding commitments made by major domestic and international investors (EY, 2015a: 21). In March 2015 RECAI, it is stated that there is a "significant policy, project and investment activity both at national and state level" (EY, 2015b: 15).

Up to 100% FDI in the RE sector is allowed under the automatic route in India (PIB, 2015b). According to the Department of Industrial Policy& Promotion (DIPP) of the Ministry of Commerce & Industry, GoI, the cumulative FDI equity inflow in the Non-Conventional Energy sector from April 2000 to September 2015 has been US$ 3926.89 million which is 1.48% of the total cumulative FDI equity inflows over this period (DIPP, 2015b). This is definitely a small fraction. For the sake of a more appropriate comparison, the cumulative FDI equity inflow in the power sector[5] is US$ 9967.22 million in the same period, which is 3.76% of the total FDI which is just 2.5 times that in the Non-Conventional Energy sector. Figure 4 shows the comparison of these FDI inflows over the years.

[5] The amounts for both of the sectors i.e. Non-Conventional Energy sector and Power sector are mutually exclusive.

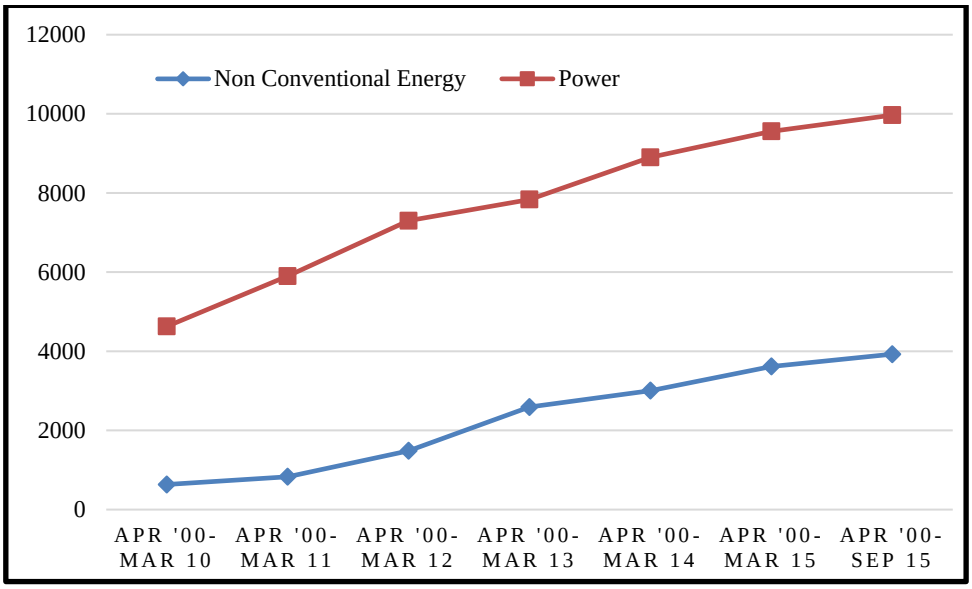

Figure 4. Cumulative FDI equity inflow in Million US$

Source: Own illustration based on (DIPP, 2015b)

The above figure shows that by September 2015, the cumulative FDI equity inflow in non-conventional energy sector has increased to almost six times its level in March 2010, whereas in power sector it has increased to a bit more than twice its level in March 2010. This shows the increasing FDI in favor of clean energy compared to conventional power. According to the same statistics, the FDI received in the last 12 months i.e. Sep'14 to Sep'15 was US$ 544.97 million which is 13.87% of the cumulative FDI in this sector till date. This seems to be indicative of the increasing interest shown by foreign investors in this sector as well as the effectiveness of the FDI policy. However, from a neutral perspective it is also worth noting that the difference between cumulative FDIs of both the sectors (from Apr'00- Mar'10 to Apr'00-Sep'15) has increased from approx. US $ 4 billion in the first year to approx. US $ 6 billion over the shown period. This highlights a widened gap over this period between the cumulative FDIs in both the sectors.

Figure 5 builds up on the same data set for cumulative FDI in both Power and Non-Conventional Energy sector and illustrates the yearly FDI equity inflow over the same period.

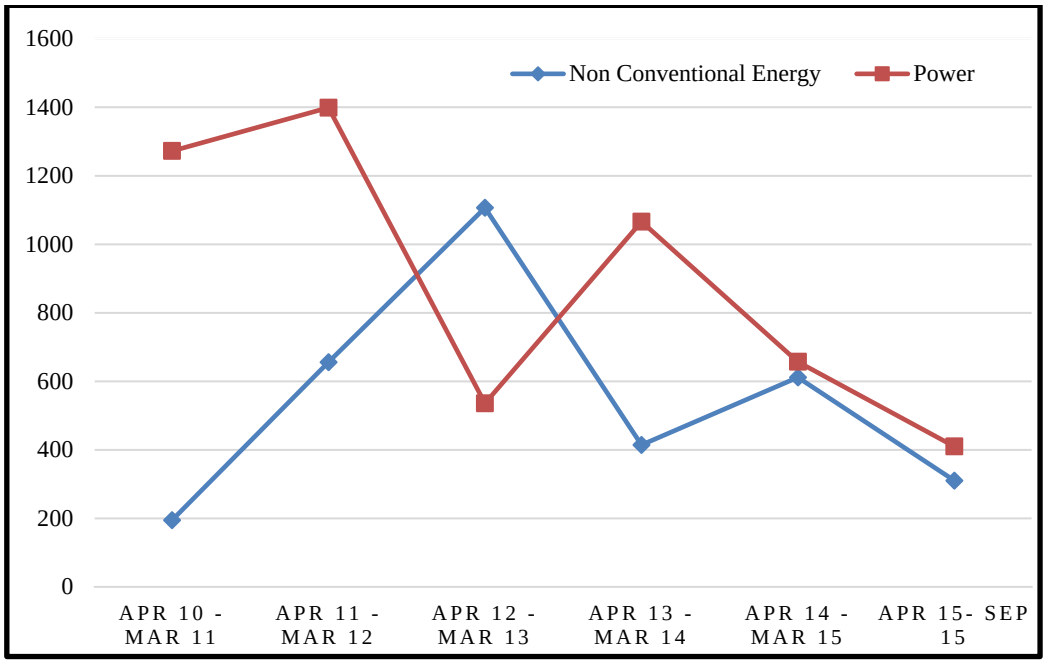

Figure 5. Yearly FDI Equity Inflow in Million US $

Source: Own illustration based on (DIPP, 2015b).

When the yearly inflow of FDI equity in both the sectors is seen over these years the picture becomes clearer and one can see that there have been ups and downs but the average annual FDI inflow over this period in the Non-conventional energy has remained at around US $ 600 million and during the first five months of financial year 2015-16 it had already achieved more than US $ 300 million figure. Although compared with the Power sector this average is less and observing this trend over the coming years will provide with more definitive conclusions for researchers and enthusiasts.

Reserve Bank of India (RBI) has recently included the RE sector in the 'priority sector lending' category (RBI, 2015). This is done in order to provide finance to small and medium enterprises in a manner that facilitates their investment in different areas of this sector. It would help these enterprises raise the necessary capital for investing in solar power, biomass power etc. (Upadhyay, 2015a).

The central government offers fiscal, financial and promotional benefits in the RE sector to boost investment, entrepreneurship and growth. This helps the spread of different types of REs even if the grid parity is not reached for that particular method or source. Easy and flexible method of repayment of borrowed funds is important for involving more investors in India. Ensuring this, increases the activity in the sector and make RE cost competitive,

thereby fostering business. Some important benefits and schemes are mentioned here which have had positive impact.

Accelerated Depreciation (AD) is a type of fiscal incentive provided for Wind, Solar (PIB, 2015c) and Biomass Power sector in India (MNRE, 2015c). AD provides tax benefits to renewable energy projects by depreciating the capital assets by 80% in the first year and thereby reducing taxable income in the initial years of the project. Large companies e.g. Public Sector Undertakings, small investors and captive power producers have increasingly participated in the wind sector due to this incentive (PIB, 2014a). AD has been recognized as the main driving force behind the development of Wind sector in India so much so that when the incentive was withdrawn from April 2012 to July 2014, a sharp drop in the annual capacity addition (ibid) and a sharp decline in investments in the wind sector was observed (Singh, 2014).

Generation Based Incentive (GBI) is an another important incentive offered for Wind and Solar sectors which is intended to incentivize actual generation of power instead of incentivizing just capacity building projects like that in the case of AD (The Economic Times, 2012). This was also intended to broaden investor base by attracting large Independent Power Producers (IPP) and FDI who were not able to avail the AD benefits (PIB, 2009). The positive effects of these two schemes in boosting wind sector growth and investment in India have been widely reported in several articles and it is also estimated that these schemes in their current form will continue to benefit and bring investment in this sector in the near future (Prithiani, 2014).

Apart from these two schemes, a number of support schemes and benefits such as tax holidays, capital subsidies, concessional duties for critical components, excise duty exemptions, viability gap funding and preferential tariff etc. are offered by Central and state governments which directly or indirectly encourage investment for RE in India (DIPP, 2015a). For instance, a recent decision to exempt parts and components of Wind Operated Electric Generators from excise duty (The Economic Times, 2015a) is expected to benefit Wind turbine and equipment manufacturers in India, many of which are subsidiaries of foreign companies (Mittal, 2015b). This is an example of the policies influencing the international collaboration in a positive manner. Indian Renewable Energy Development Agency (IREDA) is a financial institution set up by the government exclusively for financing the RE sector. It promotes, develops and extends financial assistance for renewable energy

and energy efficiency or conservation projects. Foreign loans and line of credit have been a major component of financial resources of IREDA.

The ambitious RE capacity targets by 2022 sectors according to an estimate would entail an investment of total US $160 billion with US $120 billion in the capital investment and US $40 billion as equity in the next seven years till 2022 (Energy Next , 2015). The solar energy target (100GW) alone calls for around US $100 billion (Upadhyay, 2015b). RE sector in India saw an investment of around US $7.4 billion in 2014, a 14% increase over the previous year (Ren21, 2015). Foreign investment could play a major role in terms of achieving the required increase in investments. Thus, it makes sense that the GoI has been making efforts to arrange these finances by attracting investment.

'RE- Invest', which aims to bring together global investors exclusively for the RE sector, is a joint initiative taken by the GoI, MNRE, IREDA and several other agencies since 2015. This event is the first of its kind organized by the government where the domestic market potential is showcased, government policy and strategies are highlighted and business to business interactions are arranged etc. in order to make a case for investing in RE in India. This event is also associated with a larger initiative of 'Make in India' for attracting foreign investment and collaboration to boost domestic manufacturing.

According to a report published by 'Institute for Energy Economics and Financial Analysis' (IEEFA), eight months after the first RE Invest in 2015, well over US $100 billion firm commitments have been signed including those with many of the leading global RE firms and utilities (IEEFA, 2015). The report also argues that this influx of investment announcements in the sector shows that the initial skepticism expressed by global financial markets regarding big targets and promises of Indian RE sector growth can be done away with. "India is executing one of the most radical energy sector transformations ever undertaken, and this year has shown that the flow of finance is matching the ambition", said Tim Buckley, the author of this report (IEEFA, 2015: 1).

Owing to the primary focus of the companies, domestic or international, on power generation, capacity addition, FDI and manufacturing, in this rapidly expanding sector, it is difficult to pin-point the impact of the above mentioned policies and initiatives on the 'collaborative R&D' in RE in India. However, it is logically arguable that such large commitments to building power projects, manufacturing and investments would certainly boost RE R&D collaboration as well.

Figure 6 is based on the data from the 'Global Trends in Renewable Energy Investment' reports published annually (from 2009 to 2015). This figure shows the trend of RE R&D investment in India from the last six years. It is clearly visible that these have increased over the last few years with a notable increase in 2014, particularly in the Corporate R&D. It is however, noteworthy that the share of RE R&D (US $0.3 billion) in total RE investments (US $7.4 billion mentioned in section 3.5) for the year 2014 is just 4.05%.

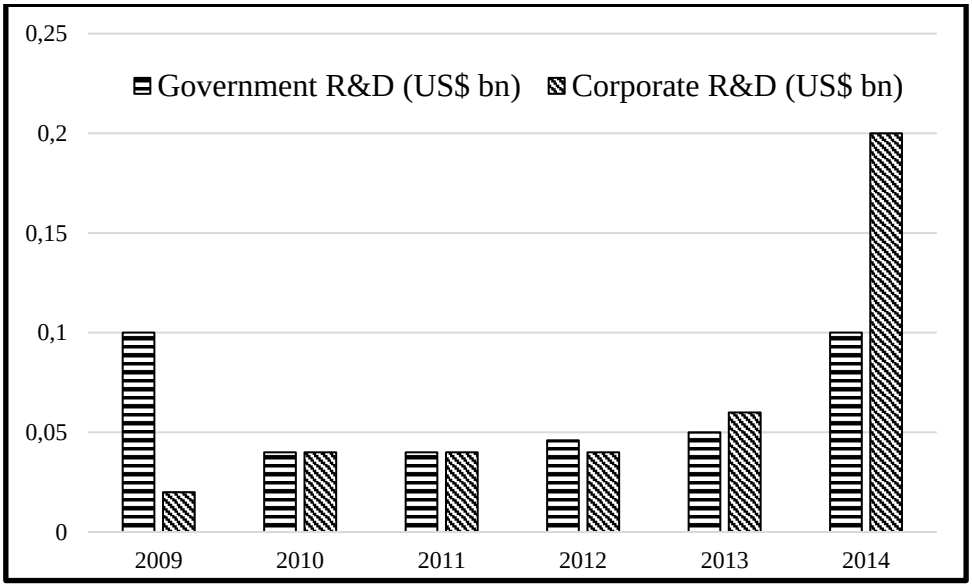

Figure 6. Trend in RE R&D in India in billion US $

Source: Own illustration based on (Frankfurt School-UNEP Centre/BNEF, 2015)

Figure 7 shows the trend in total new RE investment in India based on the 2015 annual report. This is adjusted for re-invested equity. The investment figures also include estimates for undisclosed deals. This helps in understanding the past and future financial situation in the Indian RE sector to some extent. As earlier mentioned, the fall of investments in 2012 and 2013 was attributed to the withdrawal of incentives.

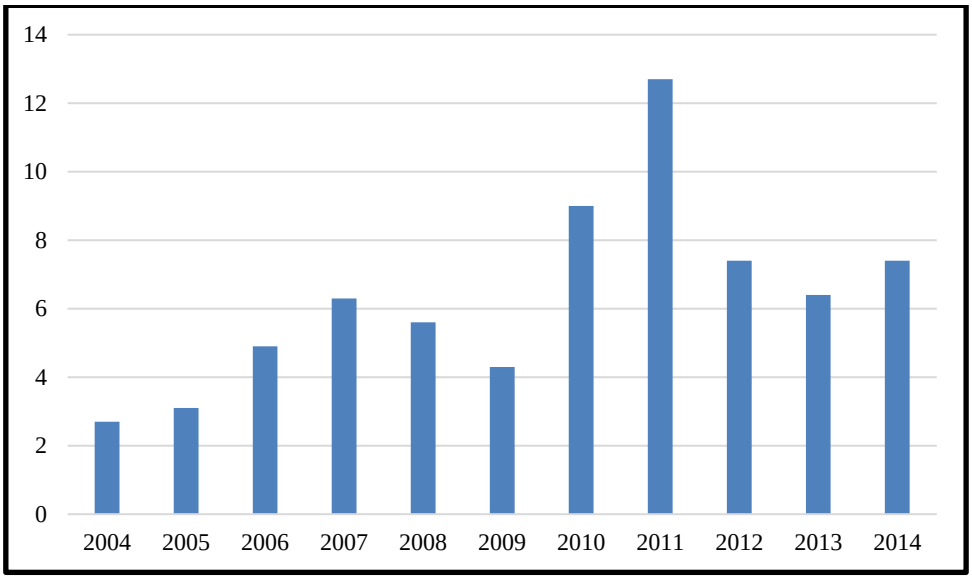

Figure 7. Total RE Investment Trend in India in billion USD

Source: Based on (Frankfurt School-UNEP Centre/BNEF, 2015, p. 15).

4. Wind and Solar Energy Sector

It is important to mention that there are autonomous R&D institutions exclusively set up for the RE sub sectors by the government e.g. National Institute of Wind Energy (NIWE) and National Institute of Solar Energy (NISE) etc. These institutes carry out their activities in different areas and in different capacities in addition to the R&D carried out by private or public companies. It is essential to begin the discussion on RE collaboration by further looking at the estimated potential for installed capacities in some detail. This is because the promise of untapped potential in terms of generation capacity is one of the important reasons behind the international attention that the Indian RE sector has received.

Wind Atlas for India was prepared in 2010 for 50-meter hub height with actual measurements and indicative values for 80-meter hub height were used for estimation of the potential that yields the sum of 49130 GW at 50 meter and102788 GW at 80 meter (NIWE, 2015a). Recently potential has also been estimated at 100-meter hub height with more advanced modelling and data collection techniques that yields a sum of 302 GW (NIWE, 2015b). Riso National Laboratory, Denmark has been majorly involved in the Wind Resource assessment and preparation of Wind Atlas in collaboration with NIWE (ibid).

According to MNRE, India receives 4-7 kilowatt-hours of solar radiation per square meter per day (MNRE, 2015e), with clear sunny weather in most parts of India for 250 to 300 days, which translates to equivalent energy potential of around 6 billion Gigawatt-hour per year

(MNRE, 2015f). The previously mentioned figure of 749 GW solar potential has been determined by NISE (NISE, 2014). NIWE has been involved in carrying out Solar Radiation Resource Assessment and has launched 'Indian Solar Radiation Atlas' in June 2015 in collaboration with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) Gesellschaft mit beschränkter Haftung (GmbH) and a German consulting company 'Suntrace GmbH'providing technical assistance in the preparation (NIWE, 2015c). The Atlas is prepared under the 'SolMap' Project which is a part of Indo-German Energy Programme with financial support from German Federal Ministry for the Environment (ibid).

The history of international collaboration in the Wind sector dates back to the 80's in India. The first grid connected wind turbine that was demonstrated in India in 1984 was an imported Dutch turbine according to a joint report published by International Renewable Energy Agency (IRENA) and Global Wind Energy Council (GWEC) (IRENA and GWEC, 2013).

One of the significant collaboration in the initial stage of development of Wind sector, according to the above mentioned report, was between the GoI and the Danish Agency DANIDA. In 1987-88, DANIDA granted funds worth 180 million Danish Krone (US $58.99 million) for the supply of wind turbines, erection, commissioning and monitoring of wind farm projects (ibid). These were the first demonstrations of large scale grid connected wind farms in India. Owing to this, real data on the techno-economic feasibility of wind energy generation in India could be obtained.

In 1999, the R&D Unit in NIWE (C-WET) was established with the support from DANIDA which provided generic information and knowledge to innovate wind turbine components and sub-systems suited for India's specific conditions (ibid). The Wind Turbine Testing Station at NIWE was established in the same year for standardization, testing and certification of Wind Turbines, with the financial support from DANIDA and technical assistance from Riso National Laboratory, Denmark (MNRE, 2015b).

A number of licensing agreements with German and Danish companies among many others gave early momentum to domestic wind energy manufacturing sector (IRENA and GWEC, 2013). According to the report, over 24 companies had formed collaborations with foreign companies from Austria, the USA, Denmark, Germany, The Netherlands, Sweden and Belgium. Notable case among these is the one of Suzlon, an Indian company which began by entering into an agreement with Sudwind Energiesysteme GmbH to share technical know-how, later on set up wholly owned subsidiaries in Germany and The Netherlands and is one

of the top Wind Energy companies in the world. Some of the other collaborations were RRB-Vestas and NEPC-Micon (ibid).

Wind Energy program benefited from the World Bank's Renewable Resources Development Project (US $ 195 million) during 1993-1999, which supported commercial RE development. The project also provided technical assistance from Global Environment Facility (GEF) (ibid).

According to the list of manufacturers published by NIWE, there are a total of 19 wind turbine and equipment manufacturers, who manufacture 53 models of turbines ranging from 250 kW to 3MW (NIWE, 2015d). 12 out of 19 have either foreign collaboration (licensed production/Joint Ventures) or are wholly owned subsidiaries of foreign companies. Only 13 out of total 53 models are made without any foreign collaboration. India is a well-established manufacturing hub for wind turbines with global manufacturers like Gamesa, GE, Vestas and Suzlon etc. having production facilities and at the same time are engaged in exports as well. "A number of global firms with subsidiaries here source over 80 per cent turbine content from local sources" according to an article published (Renewables International, 2015). In the 'Small wind turbine' sector a total of 9 manufacturers of small wind turbines are empaneled by MNRE/NIWE out of which 4 have collaboration with foreign companies (NIWE, 2015e).

Apart from manufacturing collaborations, R&D collaboration is also an active element in the current times. For instance, MNRE/NIWE has collaborated recently with Spain's renewable energy modelling specialist, 'Vortex Factoria de Calculs, S.L., Spain' for developing first-of-its kind project to improve Wind power forecasting and scheduling in Tamil Nadu, India. This helps predict power generation and to better manage fluctuations and downtime (Vortex, 2015). This shows that future focus will be not just on adding capacity but also on employing techniques and developing better models for prediction of wind regimes.

As mentioned earlier in this section, there are 19 Manufacturers of Wind Turbine/Equipment in India and some of these are subsidiaries of global major companies like Gamesa, GE etc. In addition to manufacturing in India, these companies have been involved in wind farm development and R&D as well. Following are some representative example cases which help understand the different ways in which collaborative R&D and manufacturing activities in the Indian Wind Energy sector are functioning.

Example Case 1: 'Gamesa', the leading wind turbine manufacturer in India (Business Standard, 2015) has one of its eight R&D center in India since 2011 which participate in the leading international, national and regional wind energy projects (Gamesa, 2015). Gamesa, India is a subsidiary of Gamesa, Spain (NIWE, 2015d). According to the company's annual report the company invested €109 million in R&D in 2014 globally, made 26% (the highest of all countries) of its sale (in %MW) in India and developed a custom made variant of one of its turbine models in order to suit local market characteristics and maximize performance at low-wind sites (Gamesa, 2014). This showcases the attention paid by large companies in the RE sector in terms of R&D towards localization in order to maximize business.

Example Case 2: 'Global Wind Power Limited' is a Joint Venture between Reliance Anil Dhirubhai Ambani Group and China's Ming Yang Wind Power Group (Global Wind Power, 2015a). The foreign collaboration partner to the company is registered with NIWE as 'Guangdong Ming Yang Wind Power Industry Group Co. Ltd, China'. The company has four technology partners namely Norwin, Lagerway, Führlander and Ming Yang as per their website with different technical license agreements (Global Wind Power, 2015b).

Example Case 3: 'Suzlon' brings in to light another side of international collaboration. Unlike other large leading wind energy companies in India which are either subsidiaries or Joint ventures of foreign companies or produce under license or depend for technology from foreign companies, Suzlon is an Indian company which has a global presence in terms of number of R&D centers, production facilities and markets all across the globe (Suzlon, 2015a). As mentioned earlier, Suzlon started in India with a technical knowledge transfer from a German company but today the picture is different and it has its R&D Headquarters in Hamburg, Germany with cross border development teams in Germany, The Netherlands, Denmark and India working together (Suzlon, 2015b). Figure 8 shows the trend of R&D expenditure in INR (millions) by Suzlon over last couple of years.

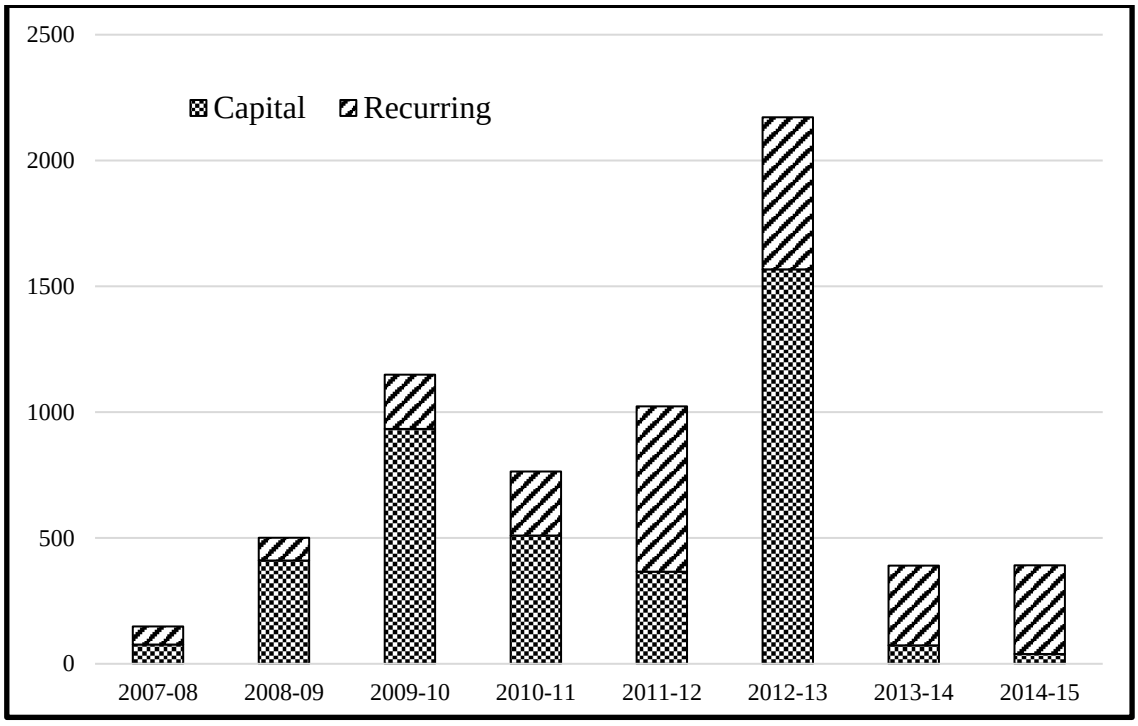

Figure 8. Suzlon R&D Expenditure trend INR (millions)

Source: Own illustration based on resp. Annual Reports (Suzlon, 2015c)

Example Case 4: Another interesting example of an Indian Wind company that has ownership of foreign R&D and production facilities is **'**Kenersys'. In 2007, 'Kalyani Group' from India bought a German design and engineering firm that used to offer expertise in Wind energy sector and renamed it to 'Kenersys' (The Economic Times, 2007). Today it has headquarters as well as global technology center in Germany in addition to a production facility (Kenersys Kalyani, 2015) .

A number of other foreign Wind energy companies such as Vestas and GE also have R&D centers in India. This proves a robust wind energy R&D capability in the Indian wind energy private sector. There are also 7 manufacturers that manufacture without any collaboration and have indigenously developed their own R&D capabilities for manufacturing Wind turbine for e.g. M/s Siva Wind turbine India Private Limited (Siva Wind, 2015).

With a strong background of collaboration in the past and present and much of the estimated Wind resource potential still untapped, the future seems promising. In addition, GoI has recently approved (Sep 2015) the 'National Offshore Wind Energy Policy' (PIB, 2015d). This policy opens up the possibility of allocation of offshore wind energy blocks, setting up projects and R&D activities up to a seaward distance of 200 Nautical Miles which is termed as the 'Exclusive Economic Zone' from the base line according to the press release by

MNRE. The press release also mentions that this policy is aimed at providing a 'level playing field for investors/beneficiaries, domestic and international'. This statement itself is profound and indicative of willingness of the policymakers to invite collaboration and investment. The wind seems to blow favorably since before the policy for offshore wind was even approved. For instance, GWEC is spearheading a project named 'Facilitating Offshore Wind in India' or 'Fowind' along with other Indian consortium partners and DNV-GL, Norway (Fowind, 2015). This project has received € 4 million from the European Union and has multiple and diverse R&D goals according to the website of the project (ibid). Another example is that of China's Sany group which has announced US $ 3 billion investments in RE in India. It has also expressed interest in the offshore wind energy sector and plans to establish efficient technologies for the same (The Economic Times , 2015b). Based on the report by a ratings and research firm, Indian Wind sector can attract an investment worth a potential INR 1000 billion (Sengupta, 2015). This shows a promise for the future.

The most recent and high impact effort towards seeking international collaboration in Solar Energy was made by the GoI in the Paris Climate Conference in November end 2015. India along with France has launched an 'International Solar Alliance' of 120 countries for large scale expansion of solar energy use in the tropical regions and other parts of the world (UNFCCC, 2015). The declaration of the launch mentions many things among which the intention to work together for 'development of appropriate benchmarks, facilitating resource assessments, supporting research and development and demonstration facilities, with a view to encouraging innovative and affordable applications of solar technologies' is one that of relevance to this topic. It is the statement that shows the emphasis on Solar R&D collaboration by topmost level of government.

In 2010, India launched a National Solar Mission titled 'Jawaharlal Nehru National Solar Mission' (JNNSM). This mission is the umbrella under which all other efforts of the government in the solar sector are planned. The initial Solar capacity target of 20 GW by 2022 has now been increased to 100 GW by 2022 (PIB, 2015e) with 40 GW for Rooftop and 60 GW for grid connected Solar Power. The government has integrated all endeavors such as policy innovation, getting the finance, acquiring the technological acumen, achieving grid parity for solar, rural electrification and developing the manufacturing capabilities etc. under this mission. Thus, this mission is the biggest driver for solar sector in India and hence important from the point of view of collaboration.

There primarily two types of technologies to harness solar power, Solar Photo Voltaic (Solar PV) and Concentrating Solar Technology (CST). According to MNRE annual report of 2014-15, there are two internationally funded projects that India is running for CST under JNNSM (MNRE, 2015b): The objectives of this projects are multiple and include promoting commercialization of CSTs, developing knowledge documents, test standards and test protocols, and removing barriers in promoting these technologies, develop business models for solar based heating/ cooling and tri-generation projects through different CST technologies for industries and for commercial purposes. Thus innovation that is centered around local needs is in focus.

Manufacturing companies have also partnered with international companies and institutions for technology. Indian company 'Tata Power Solar' which has collaborated with different companies such as US based 'Transphorm Inc.' in order to use their patented technology for manufacturing efficient solar inverters (Transphorm, Inc., 2014), and with 'DuPont' which provides material for the Solar Home Lighting Systems manufactured by 'Tata Power Solar' (DuPont, 2014). 'Moser Baer Solar', another Indian manufacturer, has several collaborations with international players for R&D. According to its website, SINTEF and UMOE Solar from Norway and OM&T from The Netherlands are its collaborative research partners (Moser Baer Solar Limited, 2015).

4.1. Solar Energy for Rural/Remote areas: Low Cost Solutions and Localization

As mentioned in the introduction Energy access and affordability are one of the major goals for India's development. The task of taking electricity to rural areas or remote areas is thus very important. If one thinks of RE, the challenges such as infrastructure, cost and adaptability to local environment appear. Several companies in the solar energy sector are collaborating to target these issues and offer solutions. For instance, 'Moser Baer' and 'DuPont' have joined hands and developed PV units that can supply reliable solar power to 'Ladakh' region of Indian Himalayas (DuPont, 2013). This region experiences harsh weather and is remote due to high altitudes and limited connectivity by road. These units as per the website are low cost due to higher efficiency (reduced number of panels for the same amount of power generated) and durable against the harsh climate (DuPont, 2015).

Another example is that of 'SELCO (Solar Electric Light Company) Solar Private Limited', an Indian manufacturer that has a number of international partnerships for technology (e.g.

D-Lab, Massachusetts Institute of Technology) and in the form of funding or investments (SELCO Solar, 2015) . As a recent example, last year its partner 'SELCO Foundation' was awarded a grant worth US$ 200,000 by the United States Agency for International Aid (USAID) to help establish 'innovation labs' aimed at developing and testing sustainable energy solutions (The Economic Times, 2014). SELCO sees customers in the rural sector as its target and engages in providing customized products, services and affordable finance to customers such as small businesses and households in order to increase the diffusion of solar energy. SELCO offers products such as Solar Lighting, Solar Thermal Heaters, Solar Inverters, customized products such as DC Sewing machine and Solar micro grid etc. and financial services such as helping underserved households obtain necessary credit for purchasing solar equipment. SELCO has gone beyond the role of manufacturer in order to become a social enterprise working towards rural electrification and development of rural communities. Thus, this is a classic example of international collaboration which has reached grassroots in India through innovative business processes and localized products.

4.2. Near Future of Solar Energy Sector - Collaboration

Looking at the future, recently there have been a number of announcements of collaboration and foreign investment. For example, India and Germany have signed an MoU on Indo-German Solar Energy Partnership based on concessional loans in the range of 1 billion Euros over the next 5 years and stating that collaboration will be intensified on 'next generation solar technology' (The Federal Government of Germany, 2015). According to the press release, the implementation of the Green Energy Corridors Partnership with an overall German commitment of 1.15 billion Euros in the last two years is progressing well.

In the private sector also there are a number of recent announcements. A three-way Joint Venture 'SBG Cleantech' worth US$ 20 billion of 'SoftBank', Japan, Taiwan-based 'Foxconn', and Indian 'Bharti Enterprises' is announced to set up solar power projects (SoftBank, 2015). 'SunEdison', USA intends to invest US$ 15 billion by 2022 (Marketwatch, 2015). It will put US $ 2 billion into a Joint Venture with 'Adani Group' to manufacture PV modules. China's Trina Solar has plans to invest US$ 500 million in a plant to make panels with 'Welspun Energy' (See News Renewables, 2015).

4.3. Academic Research Collaboration

In addition to R&D and manufacturing collaborations in both the sectors, number of examples of academic collaboration between universities and research institutions can also be seen.

The 'Solar Energy Research Institute for India and the United States' is co-led by the Indian Institute of Science Bangalore, India, and the National Renewable Energy Laboratory, Golden, Colorado, USA. It also has number of university, research and industry partners from both countries. The consortium comes under a larger Indo-US joint R&D center namely 'Joint Clean Energy Research and Development Centre'. The center is designed to promote clean energy innovation by teams of scientists and engineers from India and the United States. It supports multi-institutional network projects using a public-private partnership model of funding (Seriius, 2015).

To summarize, a lot of activity with regards to international collaboration can be observed in the field of R&D, manufacturing and academics in the two sectors discussed. This gives a broader picture of knowledge exchange as well as business that has crossed borders.

4.4. Export and Import

The export and import of equipment, devices and other products is a lower level of business engagement with the world as compared to other collaborations such as setting up subsidiaries and research labs etc. Nevertheless, it is an interesting aspect to look into in terms of gaining information about the trends in international trade in a particular sector. Analysis of exports and imports in any sector requires larger data sets and analysis of several influencing parameters such as actual mechanism of export-imports, regulations and policies etc. which may or may not be sector specific. Thus it requires a separate study.

5. Analysis of the Study and its Findings

A case study research technique of qualitative and exploratory nature is employed here to understand the topic as no quantitative data collection methods or analysis is done. The emphasis of this study remains on the exploration of different aspects concerning the main topic rather than formulating a complete theory or arriving at concrete conclusions from the findings. Thus, further research into the individual details of the topic, into similar areas in other contemporary sectors, in other developing countries and with the use of other research strategies has to be conducted. This apparent limitation is also an advantage of this work as this approach provides flexibility in exploration of the topic.

5.1. Limitations of the Study

Owing to above mentioned exploratory nature and positioning of this study, the criteria for interpreting the findings of this study are subjective. For instance, the significance of the large power capacity building commitments given by companies in 'RE-Invest' in predicting the increase in the future investments is open to questions, as there can be multiple and consistently changing policy influences. Since this sector is young and developing, many of the activities are in their early stages of plan. Policies are being continuously being structured or restructured according to changing realities. Thus any analysis criteria can only be applied in the limited context of the phenomenon being observed without generalizing.

There are many questions such as 'How much has the collaborative RE R&D helped for the purpose of rural electrification and which R&D methods are required to make the technology more affordable?' which require additional data collection, surveys, expert opinions from industry and policy makers etc. to answer. Only after doing this any recommendations can be made to improve the situation further. This illustrates that although many areas have been explored around the central theme of the study, further research is necessary for understanding the totality of the situation.

5.2. Analysis of the findings

The study has shown that India has been a market for RE products especially those related to Wind energy since over a decade. An interesting concept of 'lead markets' and 'lag markets' can be of use here to analyze the findings. There has been quite a lot of research about what a lead market is and what characteristics it has which drive the innovation, with one of the most appreciated one conducted by Beise (2004). Lead market is the country where an

innovation is first widely accepted and adopted followed by diffusion into other countries (ibid). Similarly lag market is where the innovation design is adopted after its acceptance in the lead market. The typical attributes that researchers have associated with lead markets are 'largest, most sophisticated and most competitive' (Bartlett and Ghoshal, 1990) with examples of lead market commonly cited as USA for the internet, Japan for Robotics and LCD monitors (European Commission, 2006) etc. It has also been argued that despite the prevalent thought that lead markets are typically sophisticated, have technological prowess and are located in developed countries, evidence is emerging due to changing ground realities that some emerging countries such as India can be considered as lead markets (Tiwari and Herstatt, 2011). Thus, it is justifiable to examine the findings of this study considering India as a lead market for RE.

R. Tiwari and C. Herstatt in their working paper referred above, propose that lead markets will increasingly emerge in "countries that offer volume driven growth, favorable policy framework and entrepreneurial spirit" (Tiwari and Herstatt, 2011: 13). They also argue that with changing ground realities for global innovation, a sizable and growing market, a demand that drives low cost and frugal innovations to be produced by companies, openness to foreign collaboration and supporting institutional infrastructure together confer a potential lead market status to India in different sectors.

Coming to the RE sector, this study has shown in previous chapters that –

1. India has a need for low cost renewable energy and products, especially for rural and remote areas
2. India has taken up ambitious RE targets for 2022, the RE sector has promising future projections and the country has made international commitments to reduce emission intensity and adopt non-fossil based energy
3. India has a well-developed Wind energy sector both in terms of R&D and Manufacturing with a lot of activity in terms of research collaborations and also there are examples of custom made Wind turbine model being developed for India
4. Large investments have been promised by foreign companies for solar manufacturing.
5. New sectors policies are being rolled out such as 'National Offshore Wind Energy Policy' that has signaled the opening up of a new sub-sector and
6. Support mechanisms such as inclusion of RE in 'priority sector lending' category that are aimed at increasing entrepreneurial spirit etc.

It was mentioned that many global leading RE companies already have R&D centers that are operational and at the same time new R&D centers along with manufacturing enterprises are being proposed by foreign companies. This can also be an emerging evidence of India qualifying as a Lead market for RE innovations owing to its local needs and market size. There are many other initiatives being taken to engage investors, forge academic collaborations and provide fiscal and monetary benefits to power producers. Hence, it can be seen that low cost-innovative products and localized business models that deliver power projects according to local needs in India can be taken to other 'lag' markets such as other developing countries, thereby conferring a tag of 'lead market' for RE to India. As stated earlier there can be numerous more theories which can be applied to this work to look at different aspects of international collaboration, RE R&D or other such sectors in India. However, this lies outside the limited scope in which this exploratory study is conducted.

5.3. Future Research Scope

As has been mentioned in the previous sections, this study has started by exploring different aspects of RE sector in India while always maintaining central theme of collaborative R&D and manufacturing. Thus, it has brought to light different possible research questions such as the study of policy influence, study of administrative framework, study of roles played by private sector and study of academic collaboration etc. in relation to the topic of foreign collaboration. It has also highlighted the importance of market needs such as need for attention to per unit costs, to localization and customization as well as need for innovations aiding in rural diffusion of RE technologies and remote area electrification. Thus, this work can be treated as a base for augmenting the understanding of foreign collaboration in RE in India.

To better use this study in practice, future research has to be in the direction of recognizing the patterns of favorable policies and functional business model examples like that of SELCO which can be used to make decisions and design products and services by companies, governments and other such stakeholders involved in diffusion of RE technology and products in India. These patterns can be recognized on the basis of specifically designed surveys, further case studies of similar nature looking into different developing countries, expert opinions and most importantly quantitative research based on data collected for such purpose. Grounded theory as first proposed by Glaser and Strauss in 1967 (Glaser & Strauss, 1967) is an excellent tool which deals with qualitative research data and works in a reverse

manner developing labels for different categories of data and studying the interaction between different variables. The detail sequence of steps illustrated in this technique, when applied, lead to emergence of a theory based on these data and qualitative facts. Thus, the theory is 'Grounded' into the dataset. In the context of studying foreign collaboration in RE R&D, this strategy could work really well as mostly qualitative data is available and the number of influencing variables cannot be determined from the beginning. Hence, there is an immense scope for future research into this area on which practical business applications can be conceived.

6. Conclusion

Rapid and large scale adoption of RE has become an urgent necessity for India to power its fast growing economy, mitigate the burden of consistent energy shortage, provide basic access to electricity in underserved regions, curb increasing GHG emissions and reduce its current dependency on fossil fuel based sources of energy of which imports constitute a major share. The targets set by India to achieve all of this hold a certain promise. The target commitments on international forums made regarding RE inclusion are also in line with the domestic targets. There is a continuous activity in terms of new policy rollout such as Offshore Wind policy in order to achieve the targets. However, the policy actions have to be dynamic, bold and have to address concerns on multiple fronts such as finance, regulation etc. This is illustrated by past examples of poor policy decisions which have harmed the RE sector growth directly e.g. the AD and GBI policy withdrawals in the Wind sector.

The current energy supply situation gives a picture of an economy which is dependent on coal, facing energy shortages and power deficits with large population lacking basic access to electricity leave alone the electricity for commercial activities. The RE sector in its present form is relatively small compared to conventional power but has been assessed to have an immense potential for meeting capacity and generation demands in the near future. The growth projections for Solar and Wind sectors are particularly remarkable.

The initiatives and policy measures taken have been designed to back the ambitious targets. The manufacturing industry, particularly Wind, has responded positively and there are signs of increasing manufacturing activity that can be seen from the announcements and Green Energy commitments given by companies. The research institutions, government or private

have jumped in to maximize the efficiency of technologies and adopt better means of assessing the resources via collaborating internationally for technology transfer and funding.

India has received international support in the RE sector since quite a long time and many positive developments particularly in the Wind sector in the past few decades would have been impossible without it. This study shows that such collaborations have been increasing in the recent past with the attractiveness of RE sector increasing continuously which is corroborated by agencies such as EY. The level of R&D activity is certainly increasing and also good extent of localization is being done before formulating product development and market strategies as can be seen in the example of custom made turbines by 'Gamesa'. Financial influx also holds promise with investors using different means of investing in India e.g. Joint ventures and FDI etc.

In the solar sector, as shown by the remarkable case of SELCO, manufacturing enterprise has grown beyond the traditional lines of R&D, Design, Production and Sales into the territory of social enterprise where custom made products are being offered along with the facilities of financial packages in partnership with banks that enable rural customers and many a times customers who don't have access to grid to purchase equipment and access electricity at affordable rates. Coupled with such offering are the services that cater to the needs from installation till after-sales. This case is most inspiring and also relevant to this research topic as SELCO has a number of international partnerships.

Overall it can be said that due to the concerted effort of government agencies and banking and R&D institutions, the RE sector in India is poised to embark on the path of exponential growth majorly aided in many ways (technology and finance etc.) by foreign companies. In Chapter 5 it is also concluded that India can be considered a lead market by companies that can take the successful innovation to other markets. However, concrete results and more research is the only sure way to confidently determine the success of collaboration and that has to be seen objectively in the near future. RE in India shows a natural propensity towards absorbing the techno-commercial knowledge coming its way.

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Bibliography

Bartlett, C. A., & Ghoshal, S. (1990): Managing innovation in the transnational corporation, In C. A. Bartlett, Y. L. Doz, & G. Hedlund, eds, *Managing the Global Firm* , London, Routledge: 215-255.

Beise, M. (2004): Lead markets: country-specific drivers of the global diffusion of innovations, *Research Policy*, *33*(6-7): 997-1018.

BP (2015a): *Statistical Review of World Energy 2015:Workbook*, Retrieved 17.11.2015 from http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

BP (2015b): "India | Country and Regional insights | Statistical Review | Energy Economics | BP Global," Retireved 17.11.2015, from http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/country-and-regional-insights/india.html.

Business Standard (2015): "Gamesa tops wind energy installations in India", Retrieved 20.12.2015, from http://www.business-standard.com/article/companies/gamesa-tops-wind-energy-installations-in-india-115031001160_1.html.

CEA (2015a): "Growth of Electricity Sector in India from 1947-2015", Retrieved 18.11.2015, from http://www.cea.nic.in/reports/others/planning/pdm/growth_2015.pdf.

CEA (2015b): "All India Installed Capacity October 2015", Retrieved 2.12.2015, from http://www.cea.nic.in/monthlyinstalledcapacity.html.

DIPP (2015a): "Renewable Energy - Make In India.", Retrieved 9.12.2015, from http://www.makeinindia.com/sector/renewable-energy.

DIPP (2015b): "FDI Statistics - The Department of Industrial Policy & Promotion", Retrieved 9.12.2015, from http://dipp.nic.in/English/Publications/FDI_Statistics/FDI_Statistics.aspx.

DuPont (2013): "Providing Reliable Solar Power in India", Retrieved 20.12.2015, from http://www.dupont.com/corporate-functions/our-approach/global-challenges/energy/articles/solar-power-in-india.html.

DuPont (2014): "DuPont Photovoltaic Solutions Addresses India's Energy Challenges", Retrieved 20.12.2015, from http://www.dupont.co.in/corporate-functions/media/press-releases/dupont-photovoltaic-solutions-addresses-energy-challenges.html.

DuPont (2015): "Advanced Photovoltaic Materials to Enable Electrification of Remote Corners of Ladakh, India", Retrieved 20.12.2015, from http://www.dupont.com/products-and-services/solar-photovoltaic-materials/case-studies/cs-ladakh-india.html.

Energy Next (2015): "RE-INVEST: A road to India's RE glory!" Retrieved 18.12.2015, from http://www.energynext.in/re-invest-a-road-to-indias-re-glory/.

European Commission (2006): *Economic reforms and competitiveness: Key messages from the European Competitiveness Report 2006*, Brussels: Commission for European Communities.

EY (2015a): "Renewable energy country attractiveness index", Retrieved 20.12.2015, from http://www.ey.com/GL/en/Industries/Power---Utilities/Renewable-Energy-Country-Attractiveness-Index.

EY (2015b): "Renewable energy country attractiveness index", Retrieved 20.12.2015, from http://www.ey.com/GL/en/Industries/Power---Utilities/Renewable-Energy-Country-Attractiveness-Index---Archive.

Fowind. (2015): "Fowind | Home| About the Project", Retrieved 20.12.2015, from http://fowind.in/,

Frankfurt School-UNEP Centre/BNEF (2015): "Global Trends in Renewable Energy Investment Reports". Retrieved 18.12.2015, from http://fs-unep-centre.org/publications/global-trends-reports.

Gamesa (2014): Annual Report, Retrieved 10.09.2015 from http://www.gamesacorp.com/en/investors-and-shareholders/financial-information/annual-report/.

Gamesa (2015): Gamesa | Products-and-Services | Wind Turbines | R&D. Retrieved 20.12.2015, from http://www.gamesacorp.com/en/products-and-services/wind-turbines/rd/.

Glaser, B. G., & Strauss, A. L. (1967): *The Discovery of Grounded Theory: strategies for qualitative research* (8th edition), Piscataway, New Jersey: Aldine Transaction.

Global Wind Power (2015a): About us | Profile. Retrieved 20.12.2015 from http://www.gwpl.co.in/about-us/profile.php

Global Wind Power. (2015b): About US | Technology Partners, Retrieved 20.12.2015 from http://www.gwpl.co.in/about-us/technology_partner.php

GoI (2015): INDC Submissions, Retrieved 31.12.2015 from http://www4.unfccc.int/submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf

IEEFA (2015): India's Electricity- Sector Transformation: Global Capacity building, Retrieved 18.12.2015 from http://ieefa.org/us100-billion-in-new-renewable-investments-in-2015-power-indias-energy-transition-2/

International Monetary Fund (2015): World Economic Outlook: Adjusting to Lower Commodity Prices, Retrieved 17.12.2015 fromm http://www.imf.org/external/pubs/ft/weo/2015/02/

IRENA and GWEC (2013): 30 Years of Policies for Wind Energy: Lessons from 12 Wind Energy Markets: India, Retrieved 18.12.2015 from http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=281

ISPRE (2009): Research and Development on Renewable Energies: A Global Report on Photovoltaic and Wind Energy, Retrieved 26.1.2016 from http://www.icsu.org/publications/reports-and-reviews/ispre-photovoltaic-wind

Kenersys Kalyani (2015): KENERSYS – An Ideal Partner for Growth. Retrieved 20.12.2015 from http://www.kenersys.com/KENERSYS-Profile.23.0.html?&L=1%27%22%22

Luthra, S. (2014): "India's Shift to a Sustainable Energy Future", Retrieved 2.12.2015 from http://www.nbr.org/research/activity.aspx?id=409

Marketwatch (2015): "SunEdison to invest $15 billion in India*" by 2022*, Retrieved 21.12.2015 from http://www.marketwatch.com/story/sunedison-to-invest-15-billion-in-india-by-2022-2015-06-07

Ministry of Health & Family Welfare (2006): *Population Projections for India and States 2001 - 2026.* Retrieved 21.12.2016 from https://nrhm-mis.nic.in/Pages/HMIS-PeriodicReport.aspx

Mittal, S. (2015b): "India Announces Tax Incentives For Wind Turbine Equipment", Retrieved 17.12.2015 from http://cleantechnica.com/2015/10/26/india-announces-tax-incentives-wind-turbine-equipment/

MNRE (2015a): Physical Progress (Achievements), Retrieved 4.12.2015 from http://mnre.gov.in/mission-and-vision-2/achievements/

MNRE (2015b): Annual Report 2014-15. Retrieved 20.10.2015 from http://mnre.gov.in/file-manager/annual-report/2014-2015/EN/Chapter%201/chapter_1.htm

MNRE (2015c): Biomass Power/Cogen - MNRE. Retrieved 17.12.2015 from http://mnre.gov.in/schemes/grid-connected/biomass-powercogen/

MNRE (2015e). Programmes and Technology | Grid Connected Power| Solar. Retrieved 20.12.2015 from http://mnre.gov.in/schemes/grid-connected/solar/

MNRE (2015f). Public Information | Solar RPO. Retrieved 20.12.2015 from http://mnre.gov.in/information/solar-rpo/

Moser Baer Solar Limited (2015): About Us | R&D. Retrieved 20.12.2015 from http://www.moserbaersolar.com/about-rnd.asp?links=ab6

NISE (2014): State wise estimated solar power potential. Retrieved 20.12.2015 from http://mnre.gov.in/file-manager/UserFiles/Statewise-Solar-Potential-NISE.pdf

NIWE (2015a): Estimation of Installable Wind Power Potential at 80 m level in India. Retrieved 19.12.2015 from http://niwe.res.in/department_wra_est.php

NIWE (2015b): Wind Power Potential at 100m agl. Retrieved 19.12.2015 from http://niwe.res.in/department_wra_100m%20agl.php

NIWE (2015c): Solar Radiation Resource Assessment. Retrieved 20.12.2015 from http://niwe.res.in/assets/Docu/srra_solar_radiation_brochure.pdf

NIWE (2015d): Revised List of Models and Manufacturers of Wind Turbines. Retrieved 19.12.2015 from http://niwe.res.in/rlmm.php

NIWE (2015e): NIWE| Downloads | Small Wind Turbine. Retrieved 20.12.2015 from http://niwe.res.in/downloads.php

OECD/IEA (2015a): Modern Energy for all: why it matters - World Energy Outlook. Retrieved 17.11.2015 from http://www.worldenergyoutlook.org/resources/energydevelopment/modernenergyforallwhyitmatters/

OECD/IEA (2015b): Energy and Climate Change - World Energy Outlook Special Report. Retrieved 5.11.2015 from https://www.iea.org/publications/freepublications/publication/weo-2015-special-report-energy-climate-change.html

PIB (2009): "Winds of Change: MNRE incentives for independent power producers | PIB english features", Retrieved 17.12.2015 from http://pib.nic.in/newsite/efeatures.aspx

PIB (2014a): "Shri Piyush Goyal Holds Discussion with Stakeholders in Wind Sector", Retrieved 16.12.2015 from http://pib.nic.in/newsite/PrintRelease.aspx?relid=106001

PIB (2015a): "PM Inaugurates Re-Invest 2015 ; Says India is Graduating from Megawatts to Gigawatts and Renewable Energy Production" Retrieved 4.12.2015 from http://pib.nic.in/newsite/PrintRelease.aspx?relid=115472

PIB (2015b): Renewable Energy Manufacturing Sector, Retrieved 2.09.2015 from http://pib.nic.in/newsite/PrintRelease.aspx?relid=117383

PIB (2015c): Year End Review –MNRE. Retrieved 16.12.2015 from http://pib.nic.in/newsite/pmreleases.aspx?mincode=28

PIB (2015d): Approval of National Offshore Wind Energy Policy. Retrieved 20.12.2015 from http://pib.nic.in/newsite/PrintRelease.aspx?relid=126754

PIB (2015e): Revision of cumulative targets under National Solar Mission from 20,000 MW by 2021-22 to 1,00,000 MW. Retrieved 20.12.2015 from http://pib.nic.in/newsite/PrintRelease.aspx?relid=122566

Prithiani, R. (2014): "Fresh surge of wind power" *The Hindu.* Retrieved 17.12.2015 from http://www.thehindu.com/business/Industry/fresh-surge-of-wind-power/article6533470.ece

RBI (2015): Priority Sector Lending-Targets and Classification - RBI Notification,. Retrieved 10. 12. 2015 from https://rbi.org.in/Scripts/NotificationUser.aspx?Id=9688&Mode=0

Ren21 (2015): Renewables 2015 Global Status Report- Key Findings. Retrieved 2.11.2015 from http://www.ren21.net/status-of-renewables/global-status-report/

Renewables International (2015): Wind projects and economy in India. Retrieved 19.12.2015 from http://www.renewablesinternational.net/wind-projects-and-economy-in-india/150/435/84942/

See News Renewables (2015): "Trina Solar to make in India PV panels for US, EU - report", Retrieved 21.12.2015 from http://renewables.seenews.com/news/trina-solar-to-make-in-india-pv-panels-for-us-eu-report-480943#

SELCO Solar (2015): Partners. Abgerufen am 20. December 2015 von http://www.selco-india.com/

Sengupta, D. (2015): "Wind power can attract Rs 1 lakh crore investments by 2020: CRISIL", Retrieved 20.12.2015 from http://articles.economictimes.indiatimes.com/2015-07-09/news/64243968_1_crisil-wind-power-project-lakh-crore

Seriius (2015): Home Page, Retrieved 21.12.2015 from http://www.seriius.org/

Singh, S. P. (2014): "Wind power industry body asks govt to re-introduce fiscal incentives | Business Standard News", Retrieved 16.12.2015 from http://www.business-

standard.com/article/companies/wind-power-industry-body-asks-govt-to-re-introduce-fiscal-incentives-113072000530_1.html

Siva Wind (2015): Research and Development, Retrieved 20.12.2015 from http://www.sivawind.com/researchanddevelopment.html

SoftBank (2015): "SoftBank, Bharti and Foxconn to Form Joint Venture", Retrieved 21.12.2015 from http://www.softbank.jp/en/corp/news/press/sb/2015/20150622_01/

Suzlon (2015a): Suzlon At a Glance, Retrieved 20.12.2015 from http://www.suzlon.com/about_suzlon/l3.aspx?l1=1&l2=1&l3=8

Suzlon (2015b): Suzlon Research and Development, Retrieved 20.12.2015 from http://www.suzlon.com/about_suzlon/l4.aspx?l1=1&l2=2&l3=15&l4=12

Suzlon (2015c): Financial, Annual Reports | Suzlon, Retrieved 20.12.2015 from http://www.suzlon.com/investors/annual_result.aspx?l1=6&l2=23&l3=42

The Economic Times (2015b): "Make in India: China's Sany Group to invest $3 billion in India on renewable energy projects", Retrieved 20.12.2015 from http://economictimes.indiatimes.com/industry/energy/power/make-in-india-chinas-sany-group-to-invest-3-billion-in-india-on-renewable-energy-projects/articleshow/49388244.cms

The Economic Times (2007): "Kalyani group buys German energy co.", Retrieved 20.12.2015 from http://articles.economictimes.indiatimes.com/2007-09-04/news/27687102_1_kalyani-group-wind-energy-amit-kalyani

The Economic Times (2012): "Wind power needs a tax incentive on the power produced", Retrieved 17.12.2015 from http://articles.economictimes.indiatimes.com/2012-05-09/news/31641790_1_wind-power-generation-capacity-renewables

The Economic Times (2014): "USAID to provide $2.7 million for clean energy to India", Retrieved 20.12.2015 from http://articles.economictimes.indiatimes.com/2014-03-04/news/47894600_1_clean-energy-usaid-sustainable-energy-solutions

The Economic Times (2015): "Parts, components of wind turbines exempted from excise duty", Retrieved 17.12.2015 from http://economictimes.indiatimes.com/news/economy/policy/parts-components-of-wind-turbines-exempted-from-excise-duty/articleshow/49467590.cms

The Federal Government of Germany (2015): Indo-German Joint Statement on Climate Change and Energy Technology Cooperation. Retrieved 21.12.2015 from

http://www.bundesregierung.de/Content/EN/Pressemitteilungen/BPA/2015/2015-10-05-erklaerung-klima-und-energie-indien_en.html

The World Bank (2015): World Development Indicators: Electricity Production, Sources and access. Retrieved 18.11.2015 from http://wdi.worldbank.org/table/3.7

Tiwari, R., & Herstatt, C. (2011): Lead Market Factors for Global Innovation: Emerging Evidence from India. *Institute for Technology and Innovation Management, Hamburg University of Technology (TUHH), Working Paper No. 61*, 1-18.

Transphorm Inc. (2014): "Transphorm Partners With Tata Power Solar To Introduce India's Most Efficient Solar Inverter". Retrieved 20.12.2015 from http://www.transphormusa.com/news/transphorm-partners-tata-power-solar-introduce-india%E2%80%99s-most-efficient-solar-inverter

UNFCCC (2015): "India and France Launch International Solar Energy Alliance at COP21", Retrieved 20.12.2015 from http://newsroom.unfccc.int/clean-energy/international-solar-energy-alliance-launched-at-cop21/

United Nations (2014): The Millennium Development Goals Report. Retrieved 1.12.2015 from http://www.un.org/millenniumgoals/reports.shtml

Upadhyay, A. (2015a): "Reserve Bank Of India Notifies Renewable Energy Under Priority Sector Lending | Clean Technica", Retrieved 10.12.2015 from http://cleantechnica.com/2015/04/28/reserve-bank-india-notifies-renewable-energy-priority-sector-lending/

Upadhyay, A. (2015b): "India Officially Ramps Up Solar Power Target To 100 GW By 2022 | Clean Technica", Retrieved 18.12.2015 from http://cleantechnica.com/2015/06/22/india-officially-ramps-solar-power-target-100-gw-2022/

Vortex (2015): "Vortex FORECAST helps India's wind industry to forecast wind farms", Retrieved 18.10.2015 from http://www.vortexfdc.com/vortex-forecast-india/

WMO (2015): "Greenhouse Gas Concentrations Hit Yet Another Record", Retrieved 17.11.2015 from http://www.wmo.int/media/content/greenhouse-gas-concentrations-hit-yet-another-record