ELECTRICITY ECONOMICS IN INDIA: LESSONS LEARNED FROM EUROPE

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Abstract:

Global energy sectors are in transition due to increasing concern over sustainability and climate change. Generation and use of energy is responsible for almost two-thirds of the world's Green House Gas (GHG) emissions. However, there are indicators that the global economy and the energy related emissions might be starting to decouple, due to an increased interest in the use of low carbon energy generation technologies (1). Nearly half of all the newly added power generation capacity in 2014 were accounted for by renewable energy technologies. In 2014, the European Union agreed on the 2030 climate and energy policy framework for the EU and set new targets for GHG emissions, renewable energy and energy efficiency for 2030 (2). Presently, the situation in Europe is mainly characterized by the need to increase the share of renewables, the de-carbonization of electricity generation and the stagnation of the electricity demand growth rates.

Developing countries like India are now predominantly concerned with rapidly increasing electricity demand growth rates, an ever increasing demand- supply gap and growing concern about environmental consequences. Furthermore, the population explosion situation in India resulting in a high electricity demand growth rate of 6.9% per year elevates the risk of energy scarcity in the coming future. The energy sector today in India is already unrecognizable from the one that existed two decades ago, before the beginning of the large economic reforms in 1991. With the projected exponential growth in the Indian economy, the change over the next decade is expected to be more dramatic. In this study, the main challenges for the transition of the Indian energy sector are identified, and an attempt has been made to compare the Indian and the European sectors to draw conclusions in aiding the transition process of the Indian energy sector.

Keywords: India, Europe, energy economy, energy transition, renewable energy, energy efficiency

1. Introduction:

Energy Transition or 'Energiewende', and climate change are the most discussed topics in today's world. Since the tragic Fukushima Daiichi nuclear accident in japan, the European electricity economy is in transition. Huge installations of wind and photovoltaic generation capacities, especially in Germany, has led to a high share of intermittent renewable electricity generation. This high amount of generation with very little marginal cost has led to a significant reduction of the prices at the European energy exchange. Therefore, majority of thermal power plants in

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Europe are not able to operate economically anymore and are already, or will be shut down. Some of these power plants are still needed in times of peak loads and as backup capacities. The EU is well on track to meet its emissions, renewable integration and efficiency targets by 2020. In 2013, 15% of the gross final energy consumption was covered by the Renewable energy sources, and the share is growing continuously at a steady growth rate. Most of half of the total generating capacity added last year were renewable capacities. The EU also has a sub- target for renewable energy, which is to reach 10% (2) of renewable share in the transportation sector. Progress here, though much slower than in the electricity and heat sector, is steadily developing. By 2022 Germany would have shut down all its nuclear power plants, and the share of the nuclear power plants is expected to be met by more capacity additions in the wind and PV energy sectors. All these measures have considerably decreased the GHG emissions, though however to meet up with the EUs long term 2050 targets, the EU will need to increase its efforts. The Energy transition process in general is observed to be a very complex and slow process.

On the other hand, developing countries whose economies are in transition, will have a much difficult task than the EU to improve its energy sector. As economic development and energy demand go hand in hand, many challenges like high electricity demand growth rates, security of supply and emissions make the energy transition process much more complex. For instance, a country like India, on the fast track for economic development and with a huge rise in population, huge increase in electricity demand and GHG emissions can be a major problem. Since around 70% of the electricity in India is generated using conventional fossil fuels (1), to reduce energy related emissions by shutting down conventional power plants could pose a major roadblock to the economic development. To discuss this problem, India has taken interest in the addition of renewable capacities to diversify the electricity generation sector. An ambitious target of 100 GW of solar PV has been set for year 2022, and over 90GW of wind energy has been planned in India by the year 2030. The Nuclear power capacity of India is projected to increase nine- fold in 2040 (8). For such a huge transformation, the electricity sector of India is naturally bound to face challenges. A brief comparison of the Indian sector with the European electricity sector could provide the answers to these challenges.

2. The Indian electricity sector:

India is a huge country both in terms of area and population. The country has an area of 3,3 million sq. km and a population of 1,295 billion in 2014 (a). The energy sector in India today is completely unrecognizable from the one that existed over two decades ago, because of the huge economic reforms in the early 1990s. The rapid economic development in these years resulted in a rapid urbanization of cities, which in turn led to the increase in the electricity demand forcing the country to opt for more power from fossil fuels. Thus, the energy sector now is dominated by the conventional thermal power (198,484 GW) (b). Electricity from coal occupies a large share of 65%-69% in the electricity mix (base and peak load), followed by hydro 21% (intermediate load). The Figure (1) shows you a brief classification of the installed generating capacity in India.

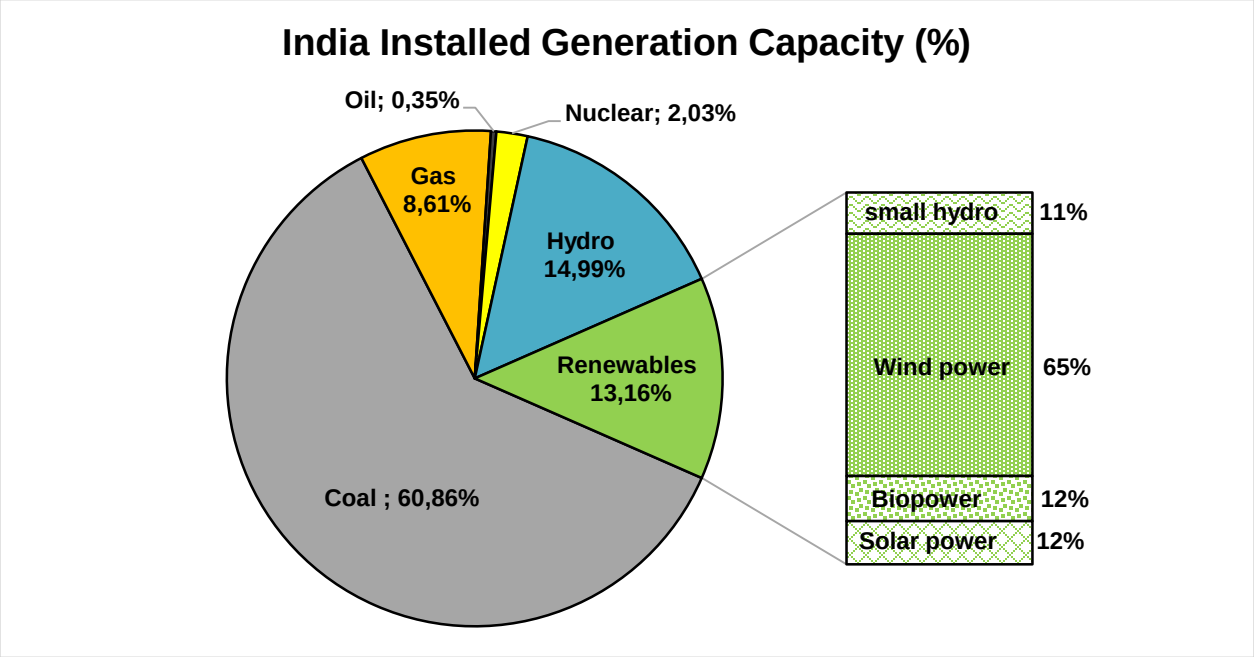

Figure (1) Classification of Installed capacity in India, as on 31.12.2015 (source: Central electricity Authority, Government of India)

Furthermore, the implications of the recently proposed industrial and economic policies, notably 'make in India' campaign, would mean a huge increase in the electricity demand of industries. As Industrial electricity represents almost 45% of the country's electricity consumption (3), this would mean a tremendous increase in generation capacity would be required within the coming decade. The Climate Change Conference (COP21) (c) summit held in Paris 2015, India has agreed to set up emission targets and to increase the renewable energy capacities in their electricity sector, but still continue the use of cleaner coal based power plant technology.

The Government of India (GoI) and the Ministry of power (MoP) have ambitious targets for renewable energy integration to the Indian electricity mix. Though faced by many challenges, the MoP is still confident that it can attain its target of 175GW of renewable energy by 2022 (4). The GoI has also recently initiated a radical transformation of the domestic coal mining, power generation, renewable energy and electricity distribution sectors. The GoI considers efficiency to be the key factor, to attain this radical transformation. Also, to promote renewable energy, the GoI introduced in April 2015, that all new thermal power plants should plan and accommodate an additional renewable energy plant for at least 10 percent of its generating capacity. The grid transmission and distribution system in India, including the inefficient and loss making distribution companies, and their associated lack of enforcing the Renewable Purchase Obligations (RPOs), is thus a key bottleneck constraining the electricity sector. The huge investment required and the already available debt of the power sector present a complex situation to the GoI. Overall, the GoI's target of 100GW of Solar PV and 75GW of wind energy by 2022 seems to be really ambitious, taking into consideration the roadblocks and challenges.

3. Challenges for Energy transition faced by the Indian electricity sector:

Based on several studies on electricity economics in India, several areas have been identified which could prove challenging for the GoI, in the process of the transformation of the country's electricity sector. A brief discussion on such areas of interest has been provided in this section of the study.

a. High growth rate of electricity demand:

A fast- developing country with a huge population like India is naturally bound to have a huge electricity demand. The World Bank database projects that by the year 2025, the population of India will overtake that of China's, making it the most populous country in the world. The *Figure (2)* shows a brief comparison of the population projections for India, China, the EU and the U.S.A.

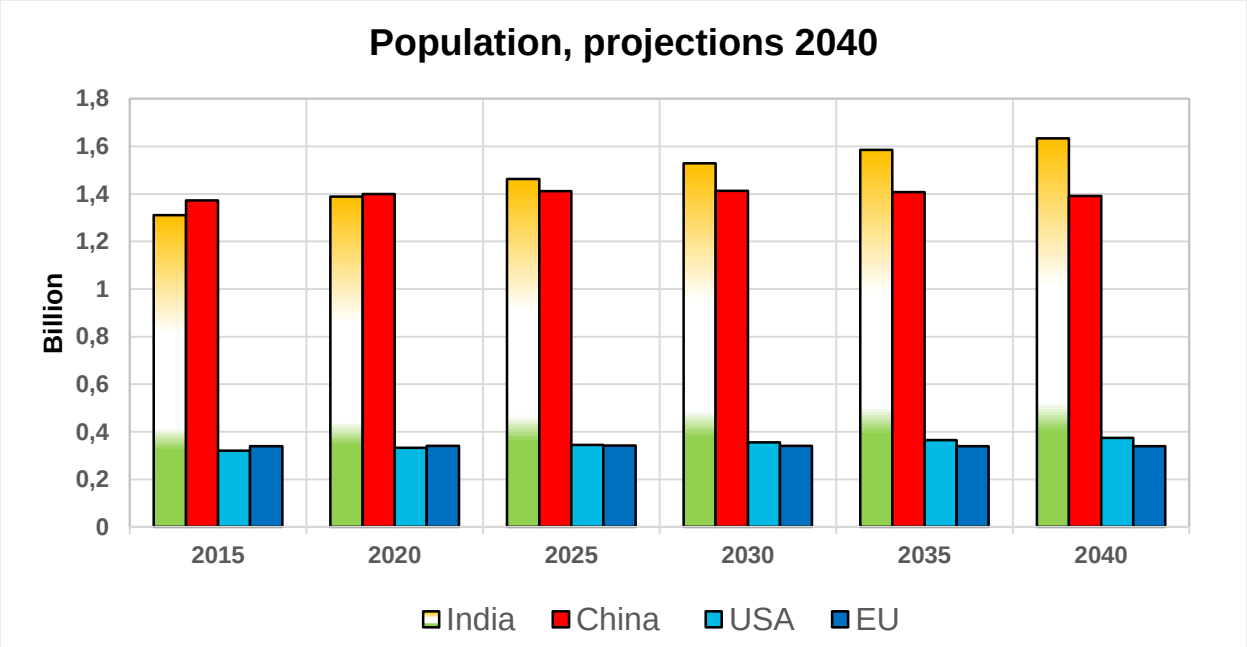

Figure (2) Population projections for India, China, USA and the EU till 2040, (source: The World Bank, population database)

As a result of the population and fast economic growth, the electricity demand is expected to grow at a rate of 6,9% annually (1). Demand for electricity is most likely increase more than five-fold, to over 3800 TWh in 2030 (5). India would need generating capacity additions up to 869 GW in the next 20 years, in a business as usual (coal dependent) scenario. As discussed, with economic policies like 'Make in India', focusing on industrial development and improvement of foreign investments, the industrial share of the electricity demand can be expected to grow at a high rate. As industrial electricity demand makes up for 41% of the country's total demand, more than the expected generation capacity addition is needed. With the continuously increasing rate of demand growth, the already occurring demand-supply gap in the electricity sector is also bound to increase. This will be one of the major challenges faced by the Indian sector. To tackle this problem, the MoP has a revised plan for distributed generation, like rooftop solar PV modules or regionalized gas fired thermal power plants, and energy efficiency standards directed towards energy conservation from the demand side.

b. Dependency on Coal:

Electricity generation in India is majorly dependent on conventional thermal power plant technology. Based on easy access to cheap coal from Indonesia, Australia and China, and the availability of domestic coal, large capacities of coal fired thermal power plants were added to meet the sudden increase in the electricity demand after the economic reforms of 1990. The Figure (3) shows the capacity addition over the years after 1990. As of December 2015, the share of coal fired thermal plants in the total installed capacity mix was at 60,6% (173,02 GW) . With the recent reforms in laws and improvements in the domestic coal mining, coal easily becomes the cheapest source of conventional power (6). Though India is committed to decrease its energy related emissions by 2030, coal still forms a considerable share in the electricity generation mix. Efforts are being made by the GoI to promote and increase the use of 'clean coal technology', as outlined by the National Action Plan for Climate Change (NAPCC) in 2008 (d). The NAPCC recommends that, in the immediate future, in view of the major coal –based power generation in the next decade, 'Supercritical' boilers are to be used and the introduction of ''ultra-supercritical' boiler technology, when the commercial viability is verified.

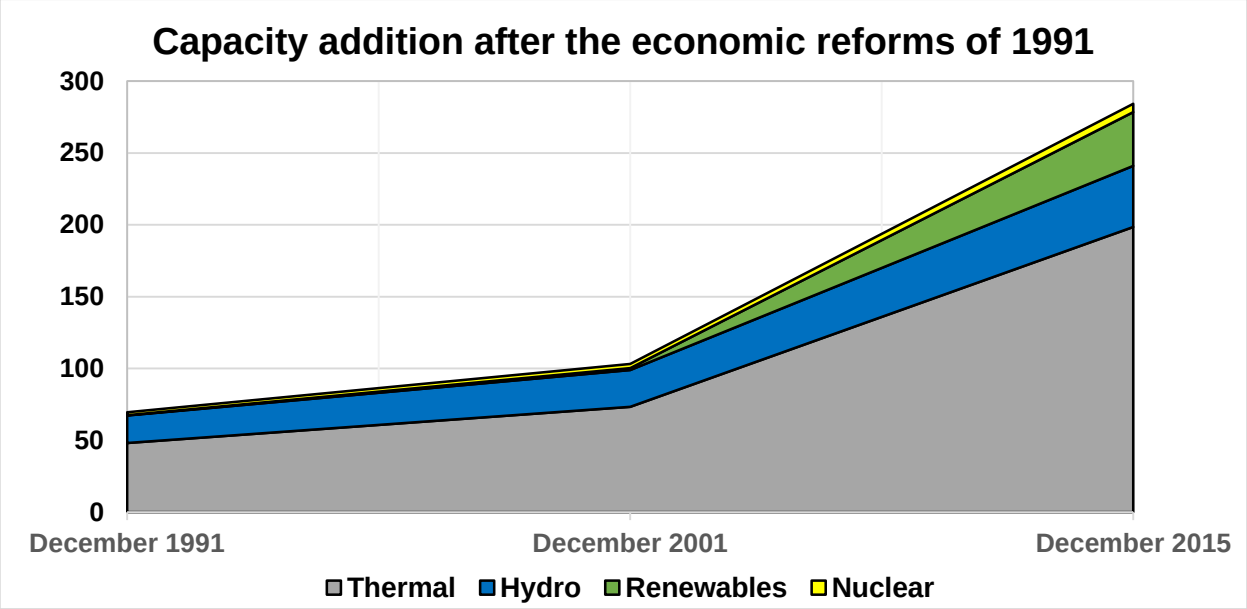

Figure (3) A Comparison over the years of the installed capacities in the Indian electricity sector (11)

c. Nuclear Power:

Since Independence, India has been committed to a large future goal for nuclear power in the electricity generation sector. These plans have not been materialized, the nuclear program being marred with several accidents and poor safety protocols. Like in the case of several developing economies with scarce capital, electricity from nuclear power has been expensive (7). Due to its nuclear weapons program, India was outside the Nuclear Non- Proliferation treaty (e), and for a major part of 34 years until 2009, the country was largely excluded from trade in nuclear plant technologies or fuel. This hampered India's development of the civil nuclear energy sector.

India has around 6 GW of installed nuclear capacity, as of December 2015 and a planned capacity of 20 GW by 2020. The GoI aims to supply 25% of electricity from nuclear power by 2050. The

planned capacity includes large prototype fast breeder reactors, as a part of its strategy to develop a fuel cycle using Thorium. This is in consideration of the country's large Thorium deposits in the southern and the eastern shores (e). Relating to shortage of domestic availability of easily mined Uranium, the nuclear plans of India are partly based on fast breeder reactor technology. The recent discovery of one of the largest Uranium deposits in the southern part of the country (f)thus, further boosts the nuclear plans of India. After the Fukushima nuclear disaster in Japan, there have been protests by the population around the proposed nuclear power plant sites. A Public Litigation Interest was also filed at the Supreme Court of India, against the government's civil nuclear program (g). Despite the protests and the opposition, the capacity factor of Indian reactors were at 79% in the year 2011-12, highlighting the usefulness of nuclear power in India.

India has nuclear cooperation agreements with several countries like Canada, Russia, France and the U.S.A, which could help in the area of reactor technology. With further interest from the government, nuclear power is expected to rise up to nine times its present share by 2040 (8). Substitution of coal based power with an aggressive expansion of nuclear power capacity is expected to be effective in the reduction of costs and energy related emissions in India.

d. Carbon / GHG emissions:

With the global climate change being one of the major priorities of most of all the countries in the world, the carbon footprint of India will play a major role as it houses almost 17% of the population of the world. India has some of the most air-polluted cities in the world, New Delhi topping the list followed by Mumbai and Bangalore. To curb the pollution issue on a city-level, the state government of Delhi had to shut down a coal fired power plant close to the city of New Delhi. Thus, the emissions have become a major source of concern to the country. The annual electricity consumption of India was ranked the fourth highest in the world. This means that the electricity sector of India can have major impacts on a global scenario. Also, with the large coal dependency, the electricity generation sector becomes one of the major sources of energy related emissions in the country, and can have major impacts on the global emissions scenario.

The GoI has argued, for several years, that developed countries have spent almost a century industrializing their economies without any emission restrictions, and therefore debated that developing countries should have the opportunity to do the same. However, after the Paris climate summit in December 2015, India is determined to reduce its carbon intensity by 33% - 35% from its 2005 levels by 2030 according to the Intended Nationally Determined Contribution (INDC) plan. The resolve to improve India's reputation on climate change has led the Government to seriously explore strategies and approaches to decouple its economic development from carbon emissions. The Figure (4) describes the projections of reduction of carbon intensity in India.

India's energy related emissions grew at a rate of 8.2% in the year 2014, driven by a double- digit demand growth in demand for coal, as power consumption increased in line with the rapid GDP growth of 7,4%. With new initiatives focusing on promoting the manufacture of goods in the country, the contribution of the industry sector to emissions is also expected to be dramatically huge.

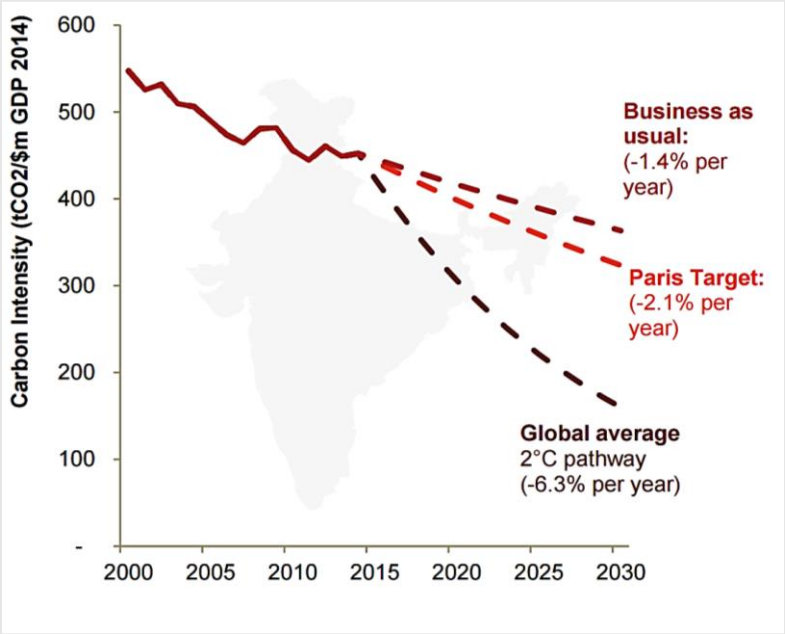

Figure (4) Business as usual and the projected carbon intensity reductions in India (source: PwC)

Overall, on a longer period, India has reduced its carbon intensity by 1,4% per year, between the year 2000 and 2014, which is slightly higher than the global average of 1,3% per year (9). Although the share of renewable share in the country's energy mix remained at a constant of 7%, there is a high growth in coal-fired power generation to keep up with the electricity demand. The reduction in the carbon intensity in the country falls short of its targeted 2.1% yearly reduction by 2030.

e. Capital Investment:

The GoI is faced with a challenge of limited budget and several development projects in different sector. The power sector in India can be described to be 'Drowning in debt' (10). Three of the leading private power companies in India needed refinancing due to the losses incurred. For example, The State Bank of India had to refinance the Adani power group and extend the loan repayment period to 19 years instead of 10 years under the 5/25 scheme of the Reserve Bank of India (h). The weak financial footing of the industry has left the Indian domestic banking sector an estimated loans of US$ 100 Billion to just 10 of the larger power and infrastructure groups. This situation could pose major setbacks to the ambitions of the GoI to increase the renewable share by 175 GW in the coming decade. With almost zero marginal cost of production, the renewable energy technology work immediately to undermine the viability of coal-fired power plants that usually have high marginal costs.

Furthermore, the MoP's plan to gain access to the global debt capital markets, the cost of renewables in India would lower significantly. As the technology of renewable energy develops rapidly, many coal- fired thermal power plants will definitely prove to be stranded assets, unable to generate any financial return. India may most likely encounter a similar electricity sector problem as Europe in the past decade with major utilities like E.ON and RWE seeing unprecedented shareholder wealth destruction (10).

f. Transmission and Distribution networks:

The transmission and distribution network connects various generating capacities across the country to various demand centers. India has a vast network of transmission lines covering almost 126965 circuit kms. 'One Nation-One Grid- One Frequency' (i), an initiative by the government ensured the coupling of different regions and that all the regional networks have a strong interconnection, and operate at a single frequency. HVDC technology was implemented for long distance transmission access, to effectively connect the heavy demand centers to big power plants. However, the efficiency of the distribution networks managed by the state owned Distribution companies (Discom) has been low, thus resulting in losses. In 2013, India's Transmission and Distribution (T&D) losses accounted to almost 23%, and the Aggregate Technical and Commercial losses (AT&C) almost 25,4%, though much lower than previous years, is a major problem (11). In simple terms, this loss rate would mean that the electricity generators would have to generate up to four units of electricity for every three units they sell to their retail and industrial customers. A loss of such magnitude could only mean a financial suicide, particularly when coupled with already subsidized electricity retail prices. The MoP has outlined a US$50 billion investment program to upgrade the capacity and efficiency of the Indian electricity transmission and distribution grid. Also incentives to upgrade the capacity of HVDC lines in the network for interregional interconnections are also provided, to improve the flexibility and security of supply. The Figure (5) explains the decrease in T&D and AT&C losses through the years, representing the improvement in the transmission grid.

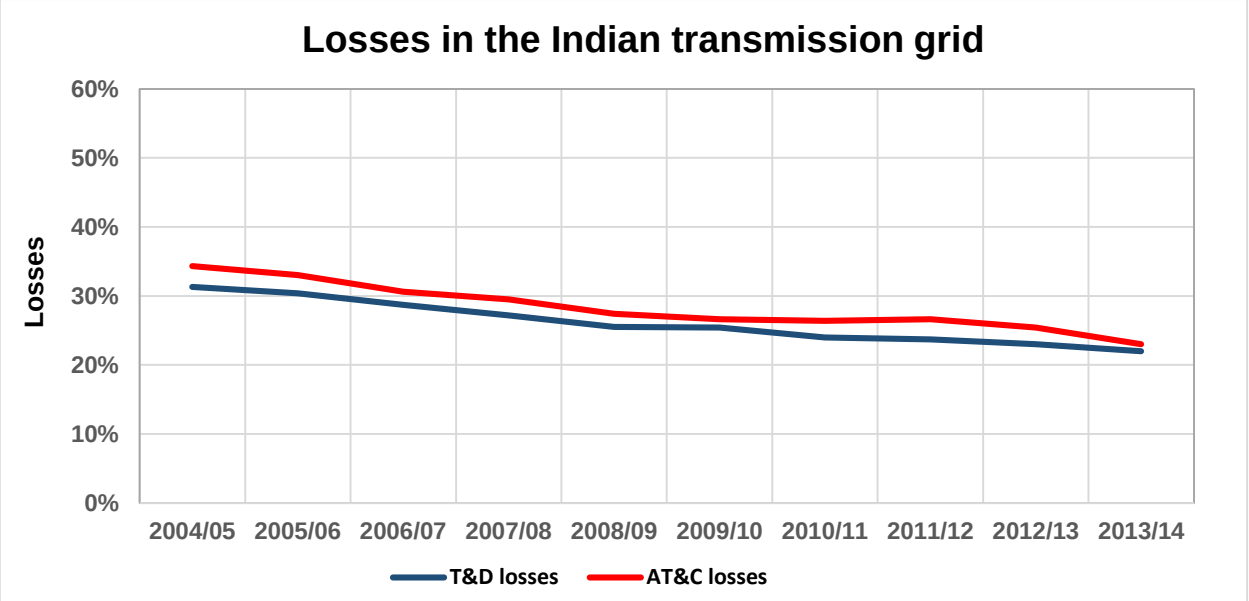

Figure (5) T&D losses and AT&C losses in the Indian grid (2005-2014), (5)

The consideration of whether to have complete reliance on central generation or not has become more important. When possible, a small portion of the massive investments in large scale generation plants planned by the administration might be better directed to increasing transmission capacity, especially using multi-link HVDC technology, placing a much higher reliance on distributed generation, and optimizing the network as it now exists (12). Many of the prosperous economic zones in India like Mumbai, are prosperous simply because they have their

own generation sources installed, shielding them from the poor reliability of the public network. Thus, distributed generation can add considerably to balancing load imbalances across the various grids and act as an effective supply (when aggregated) during peak periods.

Meeting each of India's energy challenges by large scale renewable integration, depends also on improving the efficiency of the transmission and distribution grids. In other words, a significant loss in transmission and distribution could only cause major problems in meeting the on-grid consumer demand, even with the availability of centrally generated power. The Figure (6) shows the existing and proposed transmission network in India.

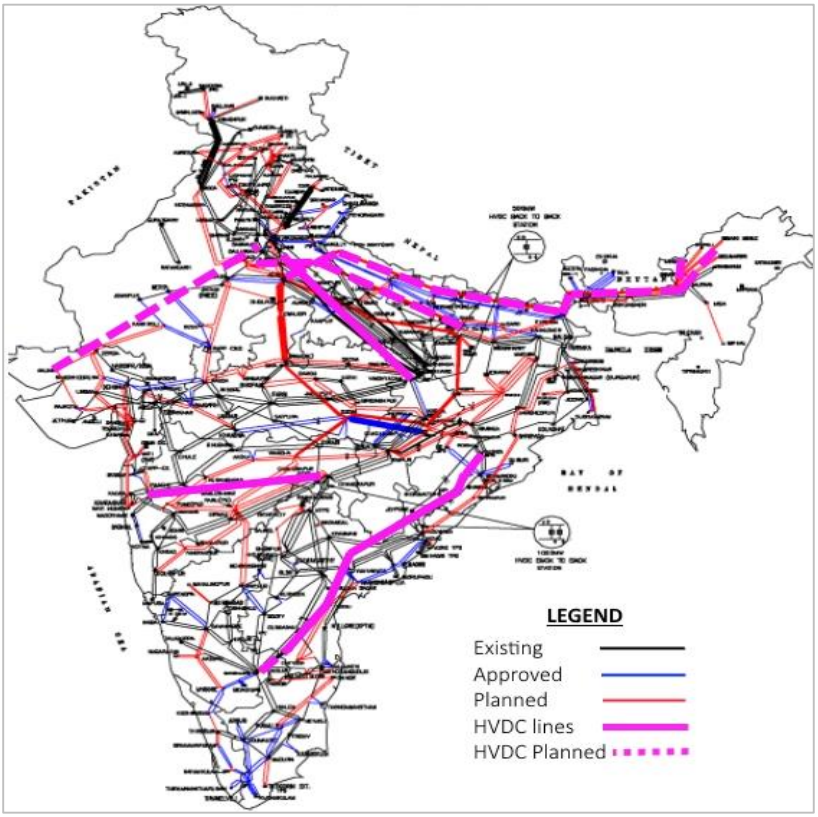

Figure (6) existing and planned Indian transmission grid (source: Powergrid, Ministry of Power)

g. Large scale Renewable Energy:

Renewable energy forms 13,16% of the total installed generation capacity in India (11), as of December 2015. India has the fifth largest installed wind capacity, which is a milestone for the Indian electricity sector. Further efforts are required by India, if energy related emissions have to be reduced. Though India's interest in large scale renewable energy integration developed in the last decade, the GoI has ambitious plans in this sector. After the Climate Change Conference in Paris 2015, the GoI revised its plans to increase its solar capacity fivefold from its initial target of 20 GW to an ambitious target of 100 GW by the year 2022. 75 GW of wind power has been planned to reach its renewable targets of 175 GW by 2022. Currently, power from non- fossil fuels including Hydroelectricity and nuclear power constitute of a 22% share in the generated electricity. Around 7% of the total electricity produced is from renewables (j)(k). Wind energy in India is already competitive as the Levelized Cost of Electricity (LCoE) from wind power was almost same

or less than that from the fossil fuel. However, The LCoE from solar power was 11,79% higher than imported coal in 2015 (4). The cost is expected to decrease over time due to technological learning effects that drive the solar prices down while fossil fuels become more expensive. Solar power is projected to be cheaper than imported coal based power in 2019. India's interest in solar energy is emphasized globally by initiating, along with France, the International Solar Alliance between 121 countries to boost solar energy in developing countries. The Figure (7) shows the forecasts for Levelized Cost of Electricity from imported coal, solar energy and wind energy.

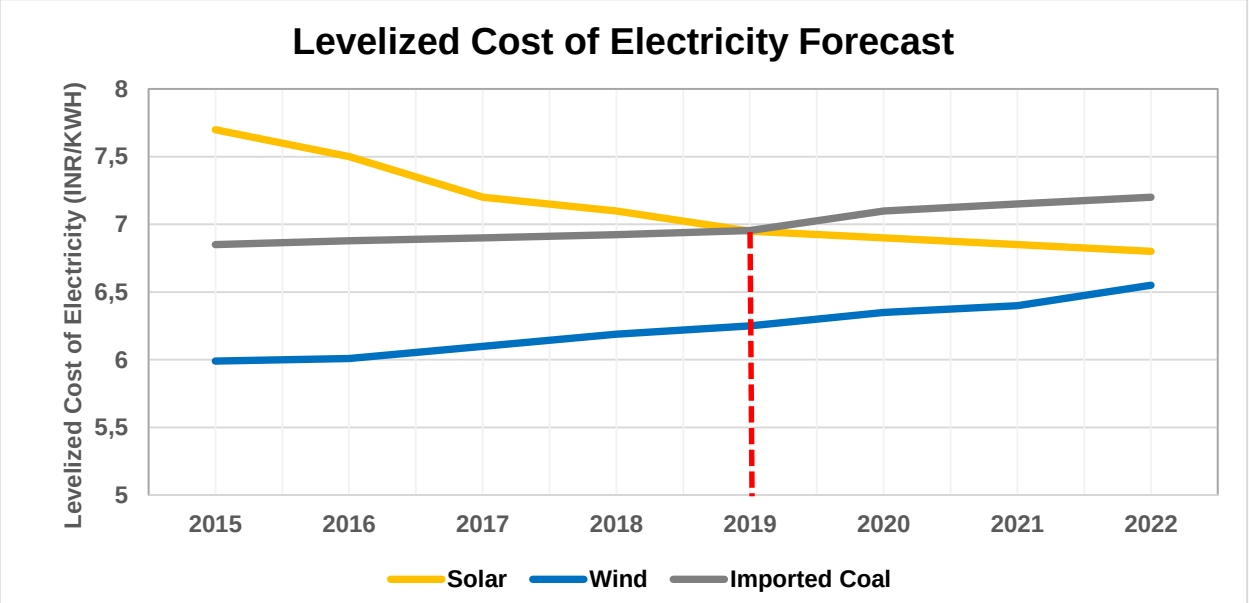

Figure (7) Levelized cost of Electricity forecast, Solar, Wind and Imported Coal (source: Climate policy initiative, (3))

Considering the vast potential of 784 GWp (with available area assumptions), solar energy can be a single solution to India's energy problems. The Figure (8) shows the solar potential in India, with the assumptions that only around 2%- 20% rooftop area and 3% of waste land area per state could be used. However, in reality, to meet India's energy and climate challenges, three very different sectors of solar energy deployment are needed: Utility-scale Solar, Distributed Solar and Off-grid solar. The GoI has recognized the importance of all the three sectors of solar energy and have set individual targets for each of the sectors (13). The GoI's target for Utility scale solar PV of 60 GW by 2022 claims its highest priority. The Distributed solar PV (rooftop PV) target of 40 GW and Off- Grid Solar of 3 GW by 2022 are more concentrated on securing access to electricity to curb the demand- supply gap. The utility scale sector and distributed solar sector address the major energy challenges like the energy related emissions and the energy import dependency, while the Off-grid solar sector is aimed at rural electrification and improving energy access in the remote parts of the country.

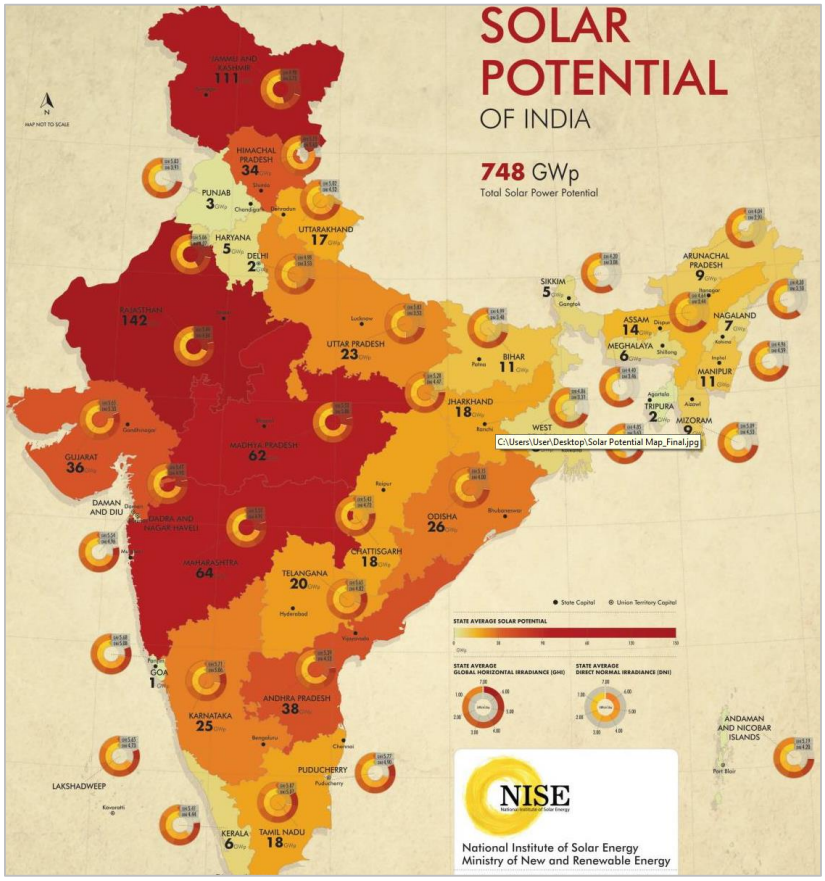

Figure (8) Solar potential of India (source: National Institute of Solar Energy and Ministry of New and Renewable Energy, India)

h. Energy Efficiency

Efficiency of electricity use can bring about considerable reductions in electricity demand, and in turn, energy related carbon emissions. In a country like India with a high rate of demand growth, energy efficiency should prove to be a major benefit. The GoI has undertaken a bi-directional approach to meet the electricity demand while ensuring minimum growth in CO_2 emissions: On the generation side, promotion of renewable energy in the electricity mix mainly through solar and wind power. On the demand side, efforts are being made to efficiently use the energy through various innovative policies under the Energy Conservation Act 2001.

A variety of measures have been introduced by the Bureau of Energy Efficiency (BEE) (l), some of them include the usage of efficiency standards and 'labeling', codes for building constructions, demand side management schemes, and energy efficiency standards at the industry level. The efficiency and savings directive had an encouraging response from citizens and the industries, as energy savings mean lesser price of electricity. The GoI has also introduced efficiency standards for street light, traffic lights, water pumping and also taken the initiative to distribute LED bulbs to replace the non-efficient incandescent bulbs, throughout the country. Figure (9) shows the progress of electrical energy savings in terms of avoided capacity each year by participating units. Several steps to educate children about efficient electricity usage through different educational schemes and competitions have been undertaken by the GoI (m).

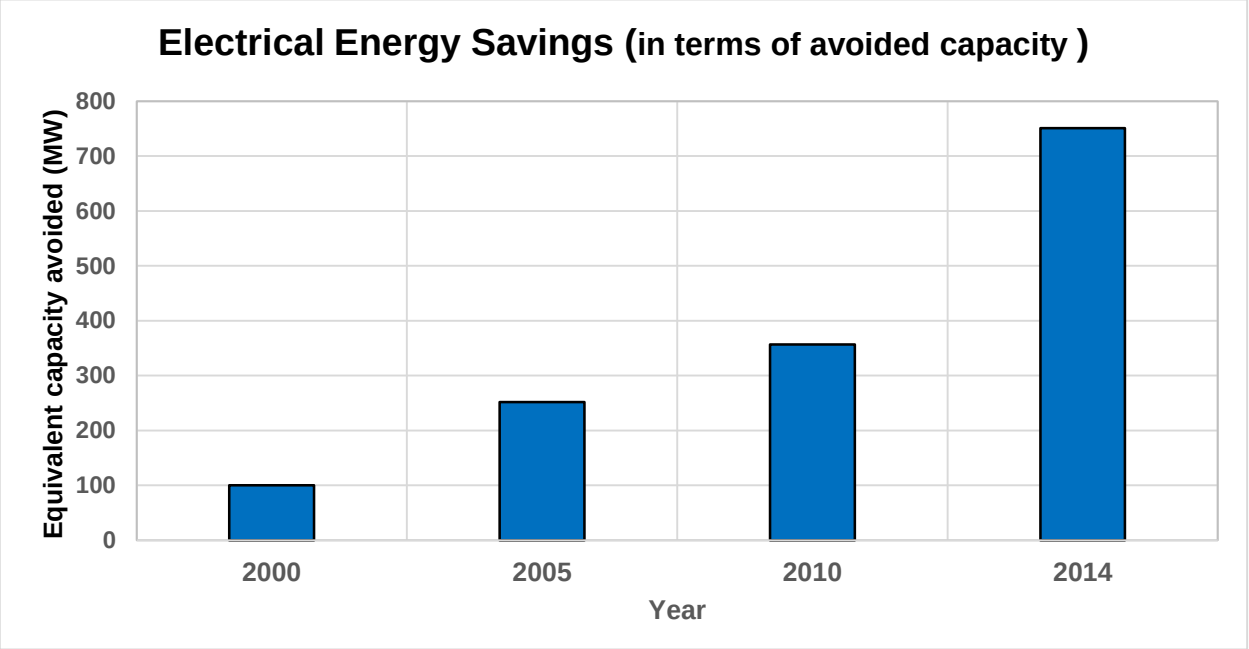

Figure (9) Electrical energy savings per year in terms of equivalent avoided capacity (MW) through the implementation of energy savings process in India (source: Ministry of Power, Government of India)

4. Solutions for energy transition derived by comparison with the European energy sector:

By comparison with the European energy sector as a model reference, a seven-point checklist for a smooth transition has been prepared for the Indian Electricity sector.

i. Promotion of energy efficiency programs in appliances, buildings, industry and agriculture for the reduction of electricity demand:

Energy efficiency outside the power generation sector could effectively decrease the power demand by almost 20%, which means one unit in five could be shut down. This could easily be the solution to the increasing demand-supply gap, and also reduce the growth rate of demand in the near future. Like the EU, India must introduce technical efficiency norms and standards for all buildings, appliances, and vehicles. Also, an incentive-based system for energy efficiency and conservation must be proposed, and trade able energy efficiency certificates for the industry. India could also adopt the European Energy Service Companies model (EESCO) (n) that support and accelerate energy efficiency policies. Demand side management, like in the EU could also be an effective solution for reduction in electricity demand, and to encourage the consumer to play his part in the system.

ii. Implementation of 'clean' coal based technologies and rapid expansion of nuclear capacity

India's dependency on coal based technologies could be greatly reduced with an aggressive expansion of nuclear generating capacity, which, as discussed before, could prove to be a cheap electricity source. The aggressive expansion could be made possible by opening up the nuclear generation sector to India's private sector, similar to Europe. Like in Europe, the nuclear reactor

designs have to be standardized, for an effective speeding up of the nuclear capacity addition in India. The nuclear capacity would also reduce India's carbon intensity on a large scale. These nuclear capacities could provide the base- load power, and with an ensured gas supply, decentralized gas-based power plant assets could provide the peak load power (16).

Considering the capital investment and the technical difficulties involved with the rapid expansion of nuclear capacity in India, the country might still continue to be dependent on coal in the next decade. Thus, implementation of new clean coal fired technologies like super-critical boilers and carbon capture and storage technologies could help in keeping up with India's emission goals. Also, upgrading the energy efficiency of the already available coal fired plants could also help in shutting down many older coal power plants.

iii. Approach for the reduction of energy related emissions

India has to follow in the footsteps of the EU in setting up of strict emissions target and also come up with similar strategies to meet these targets. Energy related emissions in Europe were drastically reduced by the integration of large scale renewable technologies in electricity generation, especially offshore wind. Considering the available potential of solar power and wind power in India, the country must aggressively and effectively focus on their renewable energy target and initiate policies to complement the same. Also, the strategy for rapid nuclear power expansion in the country should also aid in the reduction of energy related emissions. Further implementation of efficiency standards, similar to the EU, could greatly help in the reduction of electricity demand, facilitating a decrease in electricity generation from coal-fired power plants.

iv. Promotion of investments in the power sector

The in-debt Indian power sector could ease its financial situation by opening up the sector to foreign capital investments. The MoP's plan to access the global debt capital could also prove to be a blessing for the power sector. Huge investments are necessary to keep up with India's goals in the renewable energy, energy efficiency, and the carbon emissions field. As discussed, the levelized cost of solar electricity will be competitive with the cost of imported coal in 2019, and thus will need support from the government until 2019. Also, the GoI needs to consider opening up the civil nuclear energy sector to the private sector, if an aggressive approach to nuclear capacity addition is to be effective.

In place of the existing financial federal policy, a combination of extended tenor debt and reduced costs could work effectively in the reduction of government support for solar power. This also has the advantage to the government to recover the cost of support through over time loan repayments, and reuse this capital to support other projects.

v. A more responsive power sector to reduce T&D and AT&C losses

As discussed, the T&D and AT&C losses could severely hamper India's plan to improve its energy accessibility. Also, the Indian private sector could start profiting if these losses are somehow to be reduced. The current efficiency of the distribution grid should be drastically improved to reduce such losses. Problems arising due to inadequate transmission capacities between countries in the EU after the addition of large capacities of intermittent renewable energy must also be considered, and India must prioritize the expansion of its transmission and distribution grid. As the distribution

network of India is vast, improvements and building more infrastructure could prove a slow process. Thus, like the EU, partial or complete privatization of transmission and distribution networks could prove effective. The GoI could then set up targets for reduction of yearly losses to the distribution companies. A continuous improvement of the technology involved in transmission sector like High Voltage AC and DC technologies must be promoted.

vi. Scaling up of renewable capacity addition, especially solar energy

A greater generation capacity from renewable sources could actually mean reducing India's reliance on imported fossil fuel, reduction of energy-related emissions and also ensure power supply for peak load needs. Renewable power beyond wind power, especially solar power could prove to be much more effective. To ensure this, the RPO and the feed in tariffs have to be reconsidered, utility scale developments for Concentrated Solar Power (CSP), and demonstration projects for roof top PV must be done by the government, as in the EU. With the availability of cheap manpower and required resources, the GoI should promote the manufacture of solar energy technology components within the country for further cost reductions. Another solution is to scale up the wind power capacity, which is already competitive with power from fossil fuels in the country for the near term and gradually ramp up the solar deployment after 2019. As discussed, the expansion of Transmission and Distribution network, and the improvement of efficiency of the distribution grids are some of the priority tasks before deployment of renewable capacities.

The encouragement for government owned large scale energy storage is very important, for an effective utilization of India's targeted renewable capacity. Since the availability of solar power is majorly during the day, power for day time peak loads could be provided, and by ensuring electricity storage capacity, even evening time peak loads could be effectively met. India must promote the construction of pumped- storage power plants, similar to the EU. Encouragement of hydro power for ensuring peak load power could also be a solution, but there are already rehabilitation and resettlement related problems in India, concerning the hydro power capacity addition.

vii. Promotion of energy efficient urbanization

As discussed earlier, energy efficiency could prove an effective solution to increasing demand, emissions and energy prices. Like the EU, a special Energy Efficiency Directive (o) has to be set up in India, enforcing stricter efficiency standards on industry, appliances and buildings. All new buildings should be designed with respect to the efficiency and sustainability standards set up by the government, so that the carbon intensities of urban cities in India could be reduced. Also, improvement of energy efficiency in the agriculture field should be brought about by introduction of efficient farming technologies and ensuring the availability of off- grid renewable technology for agricultural use.

Efficiency targets have to be set up for industries, distribution companies and electricity generators for the effective utilization, distribution and generation of electricity. To encourage efficiency at a home- level, the government could may be implement similar exchange programs like the Spanish government to provide efficient appliances to households at reduced prices in exchange for their old appliances. LED street lighting and sustainable green buildings in cities are some of the initiatives which could be undertaken at the city administrative level. Overall, the government and the citizens should realize their responsibilities to improve the energy efficiency.

5. Possible benefits to the European electricity sector:

The European energy sector could profit from the opportunity to observe India as a country with a unique situation of progressive economic development with increasing electricity demand while managing emissions growth, ensuring energy and financial security. This way, the EU could also be prepared for an Extreme- case energy scenario, in the future. The EU could also profit from the development of the Indian electricity sector by promoting it as a market for clean energy technologies. The EU could mutually benefit along with India, with India being interested in foreign financial investments to aid the energy transition in the country.

6. Conclusion:

A comparison of the European and the Indian electricity sectors give a brief insight to the transition process and the solutions to the challenges it poses. In conclusion, this study suggests that the Indian electricity sector needs to diversify mainly its electricity generation sector, to meet most of the challenges. India should implement a plan for rapid expansion of nuclear power and renewable power to reduce their dependency on imported coal. With several renewable capacity addition projects already scheduled and in construction, the ambitious target of 175 GW of electricity generation from solar and wind seems achievable. India should focus on the expansion of the transmission network and inclusion of more HVDC technology, for an effective integration of this added renewable capacity. Also, the efficiency of the distribution grid must be improved to prevent T&D and AT&C losses. Energy efficiency standards are to be enforced to industries, appliances and agriculture, and demand side management should be implemented to reduce the electricity demand. Overall, India should follow the European energy framework for an easier energy transition, reduction of emissions, reduced electricity prices and improvement of energy efficiency.

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9. Abbreviations:

- *GHGs: Green House Gases*
- *GoI: Government of India*
- *MoP: Ministry of Power, Government of India*
- *RPO: Renewable Purchase Obligations*
- *NAPCC: National Action Plan for Climate Change*
- *INDC: Intended Nationally Determined Contribution plan*
- *T&D: Transmission and Distribution*
- *AT&C: Aggregated Technical and Commercial*
- *LCoE: Levelized Cost of Electricity*
- *BEE: Bureau of Energy Efficiency, India*
- *EESCO: European Energy Services Company*