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India and Nigeria: An Overview of Power Sector Reforms and Performance

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Abstract
India and Nigeria have been experiencing rapid economic and population growth which eventually led to massive increase in demand of power. This has put so much stress on the two countries' power sectors making their governments to implement policies and reforms aimed at tackling the challenges. India was able to transform its power sector with the enactment of the Electricity Act 2003. The Electricity Act has succeeded in opening the generation and the distribution sectors for private sector participation. This eventually led to massive increase in the country's generation and transmission capacities which ultimately placed India as the third biggest producer of electricity in the world in 2014. Nigeria which started its reform in 2005 with the adoption of the Electric Power Sector Reform Act 2005 is still experiencing enormous challenges in its power sector. This paper examined the policies and reforms implemented in the two countries and compared their overall performance in terms of capacity and efficiency. This will serve as a guide to policy makers in Nigeria and other developing countries that have enormous energy sources but are still experiencing power shortages.
Keywords: India; Nigeria; Energy sources; Polices and reforms**.**

I. Introduction

India has a total land area of 3,287,590 km^2 and is the most populous democracy in the world with a population of 1.2 billion in 2014 (EIA, 2015). India is bounded to the west with Pakistan and the Arabian Sea and to the south with the Indian Ocean. It is also bounded with Bhutan, China and Nepal to the north and shares borders with Burma and Bangladesh to the east.

India was the ninth largest economy in the world with a GDP of $2.049 trillion in 2014 (IMF, 2014). Economic liberalization in the late 1990s transformed India into one of the fastest growing economies in the world second only to China. The country practices parliamentary system of government headed by the prime ministers and has maintained democratic rule since its independence in 1947.

India faced enormous power sector challenges as 25% of its population still had no access to electricity in 2012 (World Bank, 2013). Majority of the country's rural population relied on wood fuel for their energy needs due to lack of electricity during the same period. The challenges in the sector are compounded with massive demand due to economic and population growth. This propelled to government to embark on greater exploitation of coal for power generation to improve the generation capacity. Fossil fuels more especially coal are great polluters of the environment. The enormous use of the coal for power generation in India made the sector to be responsible for half of India's greenhouse gas emissions in 2013 (EIA, 2014).

Nigeria is located in West Africa shares land borders with the Republic of Benin in the west, Cameroun and Chad in the east, and Niger in the North. It also borders the Atlantic Ocean in the South. The country's terrain varies from the savannah and semi-arid desert in the north to the tropical rain forest and coastal swamps in the south (Shaaban and Petirin, 2014). Nigeria is the 21st biggest economy in the world with a GDP of $573.7 billion (IMF, 2014). It is also the 7th most populous country in the world with a population of 177 million in 2014 (Word Bank, 2014).

Nigeria has abundant resources like crude oil, natural gas, coal, iron ore, limestone and timber but the country's petroleum industry is the major factor in its growing influence and wealth (World Bank, 2013). As the oil revenues increase during 1970s oil boom, the government became so much dependent on the commodity and neglected other sectors that were contributing meaningfully to the economy. This eventually led to the demise of the agricultural and mineral resources sectors which were the bedrock of the country's economy during 1960s. The country's economy was ruined by various military administrations that toppled the democratically elected governments. The military first took over power in 1966 but handed over power to an elected government in 1979. The military over threw the government again in 1984 and ruled up to 1999 when they handed over power the current ruling party based in Abuja, the country's federal capital (CIA World factbook, 2014).

Nigeria faces even greater power sector challenges compared to India due to decay in its power sector as a result of long time neglect and corruption. About 62% of the country's population had no access to electricity in 2013 (WEC, 2014). The country's existing power plants were operating at about 40% of their installed capacities despite the massive increase in demand due to economic and population growth (Usman and Abbasoglu, 2014).

2. Literature review

In study of Thakur et al. (2004), one of the major reasons for system collapse in developing countries like India, is rampant corruption which is synonymous with government controlled energy sectors. Singh and Srivastava (2004) studied the role of India's State Electricity Boards (SEBs) and the Central Electricity Board in the country's struggle to reform the power sector. Electricity sector in most of the states in India are owned, operated and managed by the SEBs which have monopoly over the entire power sector within their domain. The central government ventured into generation and transmission in 1975 in order to supplement the efforts of the cash starved state electricity boards in order to avoid large scale power outages.

Yadav et al. (2010) takes a critical look at the SEBs performance and the government's efforts to improve the sector. According to the authors, the central government finances majority of the electricity development projects in India but the state governments are the ones responsible for delivering the electricity to the customers. However, the SEBs gradually became unviable and unprofitable accumulating enormous liabilities to the government. According to the author, the sector's poor service delivery was mainly due to the SEBs' inefficient planning and slow execution of capital projects, inadequate maintenance, low power generation capacity, high Transmission and Distribution (T&D) losses, electricity theft, frequent power outages and massive financial losses. Such inept and consistently low performance on all fronts by the SEBs convinced the planners and policy makers in the country (in 1991) to amend the legislation in formally restructuring the power sector. In order to ensure coordinated development of the regional and national grids, the entire power sector was unbundled into generation, transmission and distribution entities. In 1993, the transmission asset of the central government was completely transferred to the Power Grid Corporation of India Limited (PGCIL) which is a state-owned electric utility company.

Bajaj and Sharma (2006) overview the policies adopted by the central government to consolidate the reform initiated in 1991. According to Bajaj and Sharma (2006) the government formed the National Development Council (NDC) in 1993 and the Mega Power Policy (MPP) in 1995 in a bid to solidify the reforms. MPP is a policy in which plants with capacities above 1000MW for thermal and 500 MW for hydro would receive additional incentives in the form of exemption of customs duty for imports and a 10-year tax holiday. Indian ministry of power coordinated a meeting in 1996 between the central and the state boards which came up with the Common Minimum National Action Plan for Power (CMNAP). CMNAP recommended the reorganization of the SEBs and the establishment of independent state electricity regulatory commissions. It also recommended that tariffs should be set to provide return on investments in not more than 30 years (Bajaj and Sharma, 2006)

Singh and Srivastava (2004) indicate that the Electricity Regulatory Commission (ERC) established in 1998 and the Central Electricity Regulatory Commission (CERC) established in 1999 were all aimed at strengthening the regulatory framework of the reforms embarked by the government. Still not satisfied with the performance of the power sector, the Indian government enacted the Electricity Act in 2003 to further strengthen the sector in order to meet the massive demand of power in the country.

Unlike India, Nigeria was reluctant to embrace reforms in its power sector despite the chronic power shortages in the country during 1980s and 1990s. The epileptic power supply in the country according to Ladan (2009), forced about 62% of Nigerians to totally rely on wood fuel for their entire energy needs. Babanyara and Saleh (2010) indicate that, the country lost an average of 409,700 hectares of forest between 1990 and 2000 due to heavy reliance on wood for energy needs.

Onakoya et al. (2013) indicates that the commercialization and privatization decree No. 25 was promulgated in 1988 to address the acute power shortages. However this effort did not yield the desired result due to the inability of the government to implement the reforms. Ekeh (2008) notes that the enormity of the problems in the power sector propelled the government to form the Electric Power Implementation Committee (EPIC) in 2000 which drafted the National Energy Policy (NEP) in 2003. NEP has an overall theme of optimal utilization of the nation's energy resources; fossil fuels and renewable sources, for sustainable development with the active participation of the private sector. The policy advocates extensive development of the petroleum and the power sectors to make reliable electricity available to 75% of the population by 2020 and also to broaden the energy generation options.

EPIC 2000 established the National Independent Power Projects (NIPP) in 2004 as a fast-tract government funded initiative to construct new power plants and transmission lines to stabilize the power sector. The committee also drafted the Electric Power Sector Reform Act (EPSR Act) in 2005 and incorporated the Niger Delta Power Holding Company Limited (NDPHC) to serve as a limited liability company to hold the assets and liabilities of the NIPP. EPSR Act 2005 consists of 3 major components (Ekeh, 2008):

- Creation of the Power Holding Company of Nigeria (PHCN) to assume the assets, liabilities and employees of the National Electric Power Authority governing the power sector.
- Breaking up of PHCN into independent generation, transmission and distribution entities. The act ordered for partial transfer of assets, liabilities and staff of the PHCN to the new companies while

preparing them for eventual privatization

- Establishment of the Nigerian Electricity Regulatory Commission (NERC) which will be responsible for all forms of regulation and tariff determination in the sector.

The government also established the Nigeria Bulk Electricity Trading Plc (NBET) in 2010 to act as a broker between the IPPs and the distribution companies until the new actors understand the concept of power retail and stabilize. The NBET's role is to purchase power from the IPPs and resale it to the distribution companies with the government acting to cushion the effect of adapting to the new system.

EPSR Act 2005 plays a pivotal role in re-invigorating the Energy Commission of Nigeria (ECN) established by Act No. 62 of 1979 as it motivated the ECN to inaugurate five energy research centers located in various Universities in 2008 to carry out research on renewable energy.

The studies available in the literature generally concentrated on evaluating the performance of the countries separately without comparing the policies implemented by different governments with similar challenges and resources. This study however, is unique as it compares the outcomes of the various policies and strategies employed in India and Nigeria in a compact framework. This will essentially serve as a reference point to policy makers in Nigeria and other developing countries with similar challenges and resources.

3. Methodology

Availability of reliable power supply with considerable access to electricity is going to be the major the benchmark for evaluating the performance of the power sectors in the two countries. The performance of the reforms and policies in India and Nigeria are examined according to:

i) *The renewable and renewable energy sources.* This sources include fossil fuels (Coal, oil and natural gas), hydro, solar and wind.

ii) *Power generation capacities*. This refers to the total power generation capacity of the two countries

iii) *Power transmission capacities and losses.* Transmission and distribution (T&D) losses are estimated from the discrepancy between power produced and power sold to the customers assuming no theft of utility occurs.

iv) *Electric power consumption (kWh per capita).* This measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants (World Bank, 2011).

v) *Energy efficiency and renewable energy policies.* These are policies that promote energy management and effective use of renewable energy sources like solar, wind and biomass.

vi) *Energy sustainability index.* Energy sustainability index published by the World Energy Council compares energy sustainability policies and prospects in many countries. The Index ranks countries according to their capability to provide sustainable energy policies using 3 dimensions of energy trilemma:

- *Energy security*: refers to the effective management of primary energy supply, the ability of participating energy companies to meet current and future demand and the reliability of energy infrastructure
- *Energy equity:* deals with accessibility and affordability of energy supply in the country.
- *Environmental sustainability:* is concerned with the development of energy supply from renewable sources and the achievement of supply and demand-side energy efficiencies.

Countries are awarded a balance score which ranges from A – D for the three competing dimensions of energy trilemma. The balance score demonstrates how well a country manages the trade-offs between the three dimensions. Countries that perform high receive the score AAA while those that do not perform well receive a DDD score.

4. Performance analysis

4.1 Sources of power generation

India on the other hand has been reported to have 5.48 billion barrels of proven crude oil and 43.8 trillion cubic feet of natural gas reserves at the end of 2012. The country's western offshore holds majority of the reserves and the remaining are in the eastern regions of the country. It was the third largest producer of coal in the world in 2011 and holds the fifth largest coal reserves estimated to be 60.6 billion tons in the world (WEC, 2013). India's deposits of hard coal are located in the eastern part of the country. Eastern states of Chhattisgarh, Jharkhand and Orissa together account for about 64% of India's total coal reserves (EIA, 2014).

The north and north-eastern states of the country are rich in hydropower resources with significant river systems which benefit from energy surpluses in the monsoon period helping the country attain its targets in renewable energy generation (Raj and Ram, 2012). Himalayan rivers, Himachal Pradesh, Jammu and Kashmir and Uttarakhand hold 65 percent of India's small hydropower resources with lowest generation costs. Large hydro power potential in India is estimated as 148 GW but only about 40 GW out of the total potential capacity

has so far been utilized for power generation in the country (Purohit et al. 2013).

Similarly Nigeria, which has tropical climate is blessed with considerable reserves of fossil fuels more especially crude oil and natural gas. According to the US Energy Information Administration, Nigeria is the largest oil and natural gas producer in Africa. It is the ninth largest reserves holder of natural gas in the world and holds the largest natural gas reserves in Africa (WEC, 2013). The country also has abundant renewable energy sources like hydro, wind, solar and biomass mostly found in the northern part of the country. There are over 278 unexploited small hydro sites with total potentials of 3,500 MW but so far less than 30 MW has been utilized (Shaaban and Petirin, 2014).

Table 1 Fossil fuel reserves in India and Nigeria in 2011

Resource type	Total (Global)	India	Nigeria
Crude oil (Million tons)	**179,682**	0.4%	2.8%
Natural gas (Mtoe)	**209,741**	0.5%	2.4%
Coal (Mtoe)	**891,530**	6.8%	0.02%

Table 2 Hydro potentials in India and Nigeria

Resource type	India	Nigeria
Large hydro (GW)	148	11.2
Small hydro (GW)	15	0.7

India has good solar radiation within a range of 4 - 7 kWh/m^2/day with 250-300 sunny days in a year and an annual average wind speed of 3 – 6 m/s. Nigeria also has solar radiation with a range of 2 – 7 kWh/m^2/day and an annual average wind speed of 2 – 4 m/s (Agbetuyi et al. 2012).

4.2 Power generation capacities

Power generation using fossil fuels is growing rapidly in India, primarily due to the government's efforts to improve the power supply to meet the growing demand. India is witnessing a remarkable growth in its power generation sector due to effective government policies like the Mega Power Policy, Electricity Act 2003, National tariff policy 2006, National Rural Electrification Policies 2006 and the feed-in tariffs policy. The most successful policy that hugely transformed the Indian power sector is the Electricity Act 2003 (Sharma et al. 2013). The most conspicuous features of the Electricity Act 2003 are as follows (Singh and Srivastava, 2004):

- Assigned SERCs and CERC as being responsible for licensing, tariff setting, grid rules and access rules
- Techno-economic clearance and state licensing for generating stations were abolished,
- Provided open access to transmission networks by all distribution companies without any discrimination
- Contributed to transparent power trading and creation of a spot market
- Called for gradual reduction of subsidies by the government
- Stipulated mandatory metering for all consumers to enhance accountability
- Provided special provisions for economically weaker people and promoted access to electricity in rural communities
- Had provisions for transition from a government-owned monopoly to a privately-owned and competitive industry
- Created an efficient and dependable national transmission grid for optimum scheduling and dispatch of electricity among the regional transmission grids

The private sector is encouraged to participate meaningfully in the Indian power sector after the enactment of the Electricity Act 2003. Percentage contribution of the various sectors in hydro power generation in India is shown in Figure 1.

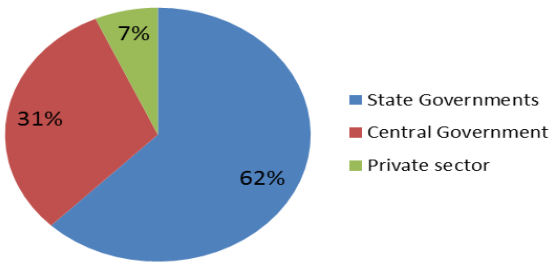

Figure 1 Sector wise installed hydro capacity in India (Sharma et al. 2013)

Figure 1 indicates that state governments in India have the largest share of installed hydro generation capacity compared to both the central government and the private sector.

The mega power policy is also having great impact in the Indian thermal generation sector as it encourages the private sector participation in the construction of mega power plants. In 2014 thermal power contributed 163.3 GW out of the 237 GW total generation capacity in India.

The total contribution of hydroelectric power in India was about 40 GW in 2014 out of which about 3.8 GW comes from small hydro plants. The country achieved total grid- connected renewable energy generation capacity of 25 GW excluding large hydro at the end of 2012. Growth of power generation capacities from various renewable energy sources in India are shown in Table 3.

Table 3 Grid- connected renewables generation potentials and capacities in India (MNRE, 2014)

Energy source	**Estimated Potential (MW)**	**Cumulative Achievements (MW)**		**Percentage increase**
		(as on 30-09-2012)	**(as on 30-09-2014)**	
Wind energy	49000	17967.15	21996.78	18.3%
Small hydro power	15000	3434.07	3856.68	10.9%
Solar power	30 – 50 MW/km^2	1044.16	2765.81	62.2%
Bagasse cogeneration	5000	2109.73	2689.35	21.6%
Biomass	17000	1209.60	1365.20	11.4%
Waste to power	3900	93.68	106.58	12.1%
Total	**89000**[1]	**25858.39**	**32780.40**	**21%**

Table 3 indicates that solar power generation witnessed the highest growth rate from 2012 to 2014 among the renewable energy sources in India. Wind power generation is the leading renewable energy source in India which added about 4 GW of power between 2012 and 2014. It is followed by solar power which added about 1.7 GW within the same period (MNRE, 2014). Although small hydro power has higher generation capacity compared to solar power, it only added about 0.42 GW of power to the grid between 2012 and 2014. Hydro power development in India has been coordinated in a planned phase since 1951 and has witnessed significant growth in the last four decades.

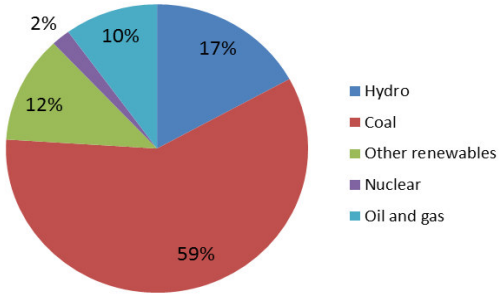

Figure 2 Power generation mix for India in 2014

Figure 2 indicates that thermal power plants contribute the highest share in the Indian generation mix. Thermal power contributes about 69% of the total power generated and is made up of 59% from coal and 9.9% from diesel and gas (CEA, 2014).

According to India's central electricity authority, the country generated about 69 GW of power in 1992. The available power generated in the country rose to 237.7 GW in 2014 as shown in Figure 3 below. The available power rose from 237 GW in February 2014 to 245 GW in April the same year (CEA, 2014). On the other hand Nigeria generated about 1.7 GW of power in 1992 which eventually rose to 3.7 GW in 2014 (Oyedepo, 2014) (MOP, 2014).

[1] Solar is excluded in the total potential of the renewable energy sources due to differences in units

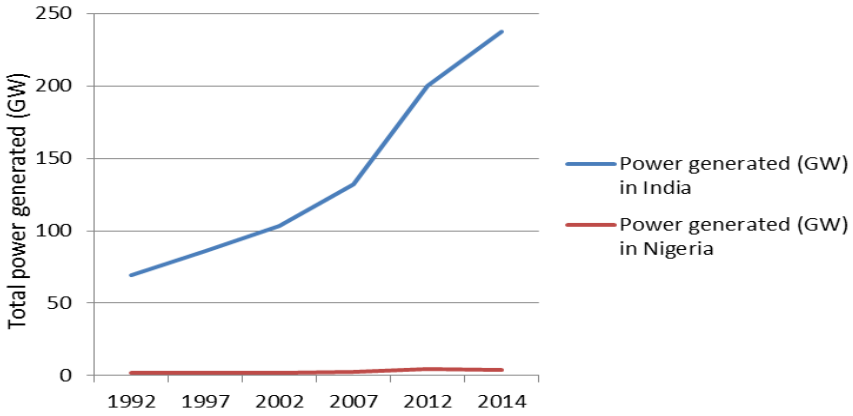

Figure 3 Growth of power generation sectors in India and Nigeria.

Figure 3 indicates that the Indian generation sector witnessed a surge in capacity from 2003 to 2014 with more pronounce growth recorded between 2007 and 2012. Nigeria on the hand witnessed very little additional capacity between 1992 and 2014. The highest peak power generated in the country was 4.5 GW in December 2012. Existing thermal power plants in Nigeria contributed about 72% of the total 3.7 GW of electricity generated in 2014 (MOP, 2014). Despite contributing the highest share in the generation mix, majority of thermal plants in Nigeria operate below 50% of their installed capacity (Aliyu et al. 2013).

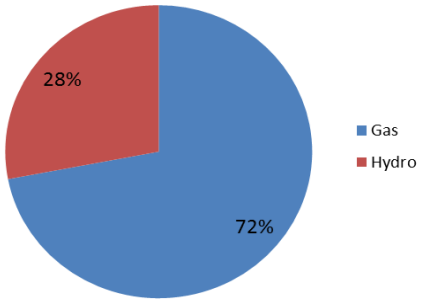

Figure 4 Power generation mix for Nigeria in 2014

Figure 4 indicates that thermal power plants contribute about 72% of the total power generated. The three existing hydroelectric dams in the country (Kainji, Shiroro and Jebba) contributed the remaining 28% of the power generated to the national grid during the same period.

Currently there is no grid connected renewable energy generating plant in Nigeria despite the abundant renewable energy sources in the country. The 10 MW Katsina wind farm which is the first renewable energy generating plant initiated by the government in 2009 (Oji et al. 2012). The 10 MW wind farm is still not completed due to inadequate funding by the government.

4.3 Power transmission capacities and losses.

Transmission lines in India are divided into 765 kV lines which have a total length of 32,250 km, 400 kV with 144,819 km and 220 kV transmission lines having a total lenght of 170, 980 km. The country's transmission and distribution (T & D) losses vary from state to state with some states having losses as high as 33% while others have losses around 25%. The average T & D losses in the country currently stand at 23.6% (CEA, 2013).

On the other hand high voltage transmission lines in Nigeria are made up of 132 kV and 330 kV transmission lines. The 330 kV lines have a total length of 5,650 km while the 132 kV lines have 6,687 km making a total of 12,337 km (NDPHC, 2014). Nigeria's T & D losses were rated as one of the highest in Africa with losses reaching up to 35% in 2013 due to the poor state of the power sector (Shaaban and Petirin, 2014).

4.4 Electric power consumption (kWh per capita)

This measures the average electricity use per capita in a country for a specified period which is usually one year. The electricity consumption per capita in India and Nigeria for 2011 is shown in Table 4.

Table 4 Electricity consumption per capita for India and Nigeria (World Bank, 2013)

Country	Electric power consumption per capita(kWh/year)
India	684
Nigeria	149

Nigeria's electricity consumption per capita in Table 4 implies that its population does not have access to reliable electricity supply. The country's electricity consumption per capita is one of the lowest in the world.

4.5 Energy efficiency and renewable energy policies

Energy efficiency policies and laws are adopted as a means to improve power sector performance. Table 5 below lists the energy efficiency policies in India and Nigeria. These laws and policies are necessary in order to minimize greenhouse gas emissions and improve the reliability of electricity supply.

Table 5 Energy efficiency policies and laws in India and Nigeria (WEC, 2014)

Energy efficiency policies and programs	India	Nigeria
National energy agency	●	✖
Ministry or department for energy efficiency	●	✖
Local/regional energy agencies	51	2
Dedicated energy efficiency fund	●	✖
Energy efficiency law	●	✖
Energy efficiency law with targets	✖	✖

● - Available ✖ - Not available

Table 5 indicates that India has more energy efficiency policies and laws compared to Nigeria. The Indian government also established the national mission on enhanced energy efficiency as an initiative aimed at addressing national problems of inefficient energy use. The mission introduced an innovative mechanism called "Perform, Achieve and Trade'' (PAT) mechanism which assigns energy efficiency improvement targets to India's most energy intensive industries (WEC, 2014). Despite having more challenges in its power sector, Nigeria still lags behind India in the promotion and implementation of energy efficiency policies to manage the little power produced.

4.6 Energy sustainability index

Table 6 Comparison of Energy trilemma scores of India and Nigeria (WEC, 2014)

Country	Energy Security	Energy equity	Environmental sustainability	Score
India	C	D	D	CDD
Nigeria	A	D	C	ADC

Table 6 indicates that Nigeria performs better in energy security and environmental sustainability due to higher natural gas reserves and lower carbon emission from its power generation sector compared India. Nigeria's weakest performance is in the energy equity which is largely due to its inability to provide reliable power supply to majority of its population. Nigeria ranked 81st in the 2014 global ranking for trilemma index and balanced scores.

While India's lowest performance comes from the energy equity and environmental sustainability dimensions which eventually placed it in 122nd position in the 2014 global ranking for trilemma index and balanced scores (WEC, 2014).

5. Conclusion

Nigerians have been experiencing chronic power shortages despite several reforms implemented by the government. The challenges experienced before the enactment of the ESPR Act 2005 still exist in the power sector despite the huge investments and reforms implemented to improve the performance of the sector. The average power generated by all the country's power plants was about 3.7 GW in 2014 which is grossly inadequate for Nigeria's population of about 177 million. Major factors that inhibit the development of Nigerian power sector are inconsistency in the implementation of government policies and corruption. On the other hand, India's power sector witnessed massive transformation after the enactment of the Electricity Act 2003. The Electricity Act opened up the generation and the distribution sectors for private sector participation. The mega power policy and the renewable energy policies like the feed-in tariffs have contributed immensely to the growth and development of the Indian power sector. The country's generation capacity was about 100 GW in 2002 which rapidly rose to about 237 GW in 2014. Although its transmission sector is also witnessing remarkable improvements with the adoption of higher transmission voltages up to 765 kV, still its transmission and distribution losses are among the highest in the world. The country has been taking drastic measures to curb the inefficiencies in the in its power sector by promoting renewable energy generation and energy efficiency policies and laws like the ''perform, achieve and trade'' mechanism.

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