A COMPREHENSIVE STUDY AND ANALYSIS OF POWER SECTOR VALUE CHAIN IN INDIA

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Abstract. *The power sector is one of the most critical growth drivers for any country. The power sector in India is highly regulated by the government and is dependent on the policies framed regarding bidding for power projects, regulations regarding transmission of power between states and pricing of power supply to consumer is also decided by the government. In India, the passage of the Electricity Act, 2003 brought about an impetus in the sector which paved way for new reforms in it. India certainly needs a huge jump in its electricity supply to sustain its rapid economic growth and meet the growing demand; it needs to make every effort to efficiently manage all components of value chain. In order to provide adequate support to country's growth aspirations, it is imperative that the sector scales its capacity up across the value chain and push reforms in requisite stages. This paper firstly presents the overview of Indian power sector followed by analysis of value chain of power sector in India -its current scenario as well as future prospects.*

Keywords: power sector, value chain, power generation, transmission and distribution, power trading, smart grid.

1. Introduction

Almost a decade ago, India's government under the National Electricity Policy set an ambitious target of “electric power for all by 2012”. It seems to miss its target by almost 60%. Though, India is the world's fifth-largest electricity producer after the U.S., China, Japan and Russia, but its per capita consumption is among the world's lowest, at 778.71 kilowatt hours a year as reported by the Wall Street Journal (Eric, 2012). Almost 300 million people don't have access to electricity. The power sector in India has evolved rapidly after the reforms introduced through the 2003 Electricity Act. It has grown tremendously in the last decade from an installed base of 100,000 MW in 2001 to 207,006 MW by August 2012 as per Central Electricity Authority (CEA). The 2003 Electricity Act introduced much needed reforms in the power sector such as unbundling of State Electricity Board’s into separate generation, transmission and distribution entities, and removal of license for setting up generation unit by any individual or corporation along with other reforms in distribution and transmission sector respectively.

National and international statistics usually demonstrate energy use in the end use sectors in final energy terms. Final energy consumption signifies the direct amount of energy consumed by end users whereas primary energy consumption includes final consumption plus the energy that was needed to produce and deliver electricity. In India, the factor that converts final electricity consumption to primary energy is relatively high and was equal to 4.2 in 2005 (de la Rue du Can and Price, 2008). Consequently, consuming one unit of energy from electricity is equal to consuming more than four units of energy at the source of generation. This large primary energy conversion factor can be explained by two reasons; firstly electricity distribution and transmission (T&D) technical and commercial losses are substantial and secondly electricity is generated for a large part with the use of fuel combustion with low efficiency. India’s transmission and distribution (T&D) network losses is approximately 25% (Ebinger and Avasarala, 2012) as compared to the world average of less than 15%. While by arresting the heavy T&D losses, almost 30GW of electrical power can be saved, the forthcoming need for India is definitely an efficient value chain of power sector.

The power sector is endeavoring to meet the challenge of providing adequate power needed to fuel the growing economy of the country. As the Indian economy continues to surge ahead, its power sector has been expanding concurrently to support the growth rate. The demand for power is growing exponentially and the scope for the growth of this sector is immense. The centre has targeted capacity addition of 100,000 megawatt (MW) each in the 12th Five Year Plan (2012-17) and 13th Five Year Plan (2017-22). However, this growth of the power sector has to be within the realms of the principles of sustainable development. While India certainly needs a huge jump in its electricity supply to sustain its rapid economic growth and meet the growing demand, it needs to make every effort to efficiently manage all stages of value chain. Therefore, focus should be on maximizing efficiency in the entire electricity chain, which has the duel advantage of conserving scarce resources and minimizing the effect on the environment.

2. Overview of India's power sector

India's energy-mix comprises both non-renewable (coal, lignite, petroleum and natural gas) and renewable energy sources (wind, solar, small hydro, biomass, cogeneration bagasse etc.). Nuclear fuel is also being used for power generation by government utilities and is limited only to government sector. The Indian power sector is largely coal based with the total installed capacity comprising of 99,503 MW (55%) coal based, 17,706 MW (10%) gas based, 1200 MW (1%) diesel generation, 38,206 MW (21%) hydro, 4,780 MW (2%) nuclear and 20,162 MW (11%) from renewable energy sources. The country is looking beyond fossil fuels; at nuclear energy and renewable energy in a big way. Renewable energy will play a key role for the sector indeed. However much needs to be done to realize the true potential of renewable energy sources. As per industry estimates, India's solar power generation potential is close to 5,000 TWh per annum, however the initial cost of set-up acts as a major detriment and therefore the generation and utilization of solar power is far below its potential. The same stands true for wind energy as well (Grant Thornton report, 2012).

Energy is available through various types of products; it is often transformed to more refined products, and it is finally consumed to operate a multitude of activities. Energy is a necessary input to any type of activity in the economy. Electricity production requires on average three times its final energy content (de la Rue du Can and Price, 2008). Final energy consumption represents the direct amount of energy consumed by end users while primary energy consumption includes final consumption plus the energy that was necessary to produce and deliver electricity. The demand for electricity in the country has been growing at a rapid rate and is expected to grow further in the years to come. In order to meet the increasing requirement of electricity, massive addition to the installed generating capacity in the country is required. According to CMIE approximations, coal-based power generation would increase by around 19200 mw. Since thermal power accounts for 80-85% of the power generated in the country, it is the biggest factor in any increase in power generation. Nuclear power generation is likely to grow by 17.1% in the current financial year due to improved availability of uranium and rise in installed capacity. Thermal power generation increased 7.2% on the back of a healthy growth in power generation capacity. Nuclear power generation also grew 5.9% to 2.8 billion units.

India has the third largest coal reserves and fourth in terms of production in world. As per planning commission estimates India would still have 50% plus power generation on coal by 2030. 77% of non-coking coal in India was consumed only by the power sector, for generation of electricity in the country and the remaining is used in other industries such as steel, cement, fertilizers, bricks manufacturing, textiles and chemicals. This substantiates the role of coal supply and prices in ensuring operations for power generation. India has a coal production to reserve ratio of 0.94 compared to 2.83 for China, which indicates that India's current production, is far less compared to its potential. Hence, it is imminent that India boosts its coal production. Currently power generation from gas stands at 10.2% according to information provided by the CEA. Gas although being a fossil fuel has considerable advantages over other fossil fuels. It has lower greenhouse emissions and less by products from combustion process. Other advantages include its ease of transportation through pipelines and lesser land and water requirements compared to coal fires stations. Given that country is going to face coal shortages gas can reduce energy dependence on coal. The gas supply to power sector has been lower than the requirement over the last 10 years, although the deficit for gas has reduced from 45% in FY01 to 20% in FY11 (PWC report, 2012).

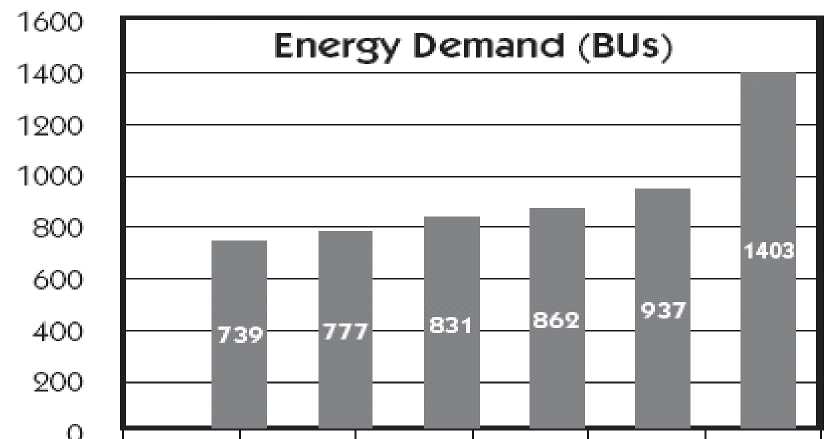
Hydro power generation is an environment friendly alternative to coal and operating cost of hydro power plants is also low although initial capital investment is huge and bottlenecks come in form of environment clearances. India is endowed with rich hydropower potential given a large network of rivers and ranks fifth in the world in terms of usable potential. Total hydro capacity has been assessed at 148700 MW by CEA and as per Asian Development Bank report only 25% of hydro power has been tapped for development. India aims to supply 25% of the electricity through nuclear power by 2050 but recent calamity in Japan has lowered the confidence on nuclear fuel as an alternative to conventional fuels and there seems to be present an apprehension regarding nuclear power. India comes up as a global leader in terms of hydro-electric power generation. It represents 17% of the total installed generating capacity. Along with solar and wind power, India has set ambitious targets to utilize nuclear energy sources as well. Earlier in 2009, the government announced its plans to generate 470 GW of nuclear energy by 2050, thus opening doors of huge opportunities in the sector. Power from renewable energy sources (RES) is important so as to control carbon emissions with rapid industrialization and increasing power consumption and to achieve the goal of rural electrification. RES has grown as percentage of total capacity from 3.2% in 2005 to 10.6 in 2011 having a CAGR of 22.2% in terms of percentage of total capacity.

According to the CEA, the demand for electricity in India has far exceeded its availability, both in terms of base load energy and peak availability. India needs to substantially bridge the gap between demand and supply of electricity for sustained economic growth and to kindle hope in the lives of its people. India's fast-paced economic growth and its rapid rate of industrialization and urbanization have fuelled energy demand. The CEA also states that an additional capacity of around 76,000 MW is needed to satisfy the projected demand by 2016-17. Based on the progress made during the 11th Plan (2007-2012), a total capacity of 54,964 MW was added, short of its revised target of 62,374 MW. The energy requirement during the year 2011-12 was 937.20 Bus (Figure 1). Energy deficit remained same on a year-on-year basis in

2011-12at 8.5%. Peak load demand increased by 6.31% thereby increasing peak load deficit to 10.6% in 2011-12 from 9.8% in the previous year.

During 2012-13, India's GDP is expected to grow at 6.5% to 7%. In order to sustain the growth in GDP and bring it around 9%, India needs to add power generation capacity commensurate with this pace since growth of power sector is strongly co-related with the growth in GDP and going forward it is expected that supply will create further demand.

India in order to sustain its plus 8% growth rate until 2030 requires its power supply to be ramped up by more than four times of the current levels (Grant Thornton report, 2012). While it is a challenge to improve power generation as the sector continues to suffer transmission and distribution (T&D) losses as high as 25-30%.



	FY08	Fy09	FY10	FY11	FY12	FY17
Real GDP growth	9.30%	6.70%	8.40%	8.40%	6.50%	
Y-O-Y Demand Growth	6.95%	5.14%	6.95%	3.73%	8.72%	
Energy Demand (BUs)	739	777	831	862	937	1403

Source: CEA, Report of Working Group on Power for XII plan).

Figure 1. **Energy Demand from FY 2008 to FY 2017**

3. Literature review

Many researchers have analysed the efficiency of electricity generating plants analytically (Kleit and Terrell, 2001; Arocena and Wadams Price, 2002; Knittel, 2002; Barros, 2008). Kleit and Terrell (2000) emphasized that deregulating electricity generation increases efficiency while Arocena and Waddams Price (2002) highlighted regulation and competition accompanied by privatisation promotes efficiency. While there is extensive literature on benchmarking applied to a diverse range of economic fields, the scarcity of studies regarding the Indian energy sector accepts the testimony to the fact that this is a comparatively under-researched topic. India certainly needs a huge jump in its electricity supply to sustain its rapid economic growth and meet the growing demand; it needs to make every effort to efficiently manage all components of value chain. Mapping the relevant value chain helps to identify where there are weak links. Thus, the value chain approach provides a framework for sector-specific action.

Value chains analysis conceptualizes enterprises as parts of chains of different but linked production and exchange activities operating in different geographical areas (Kaplinsky, 2000). Within value chain analysis there is a proliferation of related concepts, different researchers (Porter, 1985; Gereffi, 1994; Raikes et al., 2000) use different terminology to discuss very similar ideas. Value chains, value systems, value stream, and value networks are just some of the terms used by researchers whose common ground is much greater than their divisions. Value chain analysis overcomes a number of important weaknesses of traditional sectorial analysis which tends to be static and suffers from the weakness of its own bounded parameters. It struggles to deal with dynamic linkages between productive activities that go beyond that particular sector, whether they are of an inter-sectoral nature or between formal and informal sector activities. Martin (1995) used value stream, rather than process, to define the end-to-end stream of activities that deliver particular results for a given customer (external or internal).

The idea of a value chain becomes useful for analytical and policy purposes. Value chain analysis helps the policymaker to find out where the bottlenecks are and which bottlenecks deserve priority attention of government. The competitiveness of the individual firm depends upon the competitiveness of the value chain to which it belongs and it pressures firms to add more value by interacting more closely with their upstream and downstream partners (Altenburg, 2004). Capturing the value generated along the chain is the new approach taken by many management strategists. By exploiting the upstream and downstream information flowing along the value chain, the firms may try to bypass the intermediaries creating new business models.

4. Methodology

In this section, a systematic approach is considered to study and improve the value chain framework of power sector in India. It is imperative to analyze value chain as the sector scales its capacity up across the value chain and push reforms in requisite stages. Secondary data sources were used to gain a comprehensive and in-depth understanding of the power sector in India. The study will help to examine that how power sector operates presently and what is required to improve the existing value chain in Indian. The study seeks to achieve following objective:

- To study prominent activities of value chain of power sector in India and identify challenges, if any.
- To examine additional activities for operating and managing the value chain more efficiently.

5. Analysis of the value chain of India' power sector

Prior to 2003 the market was characterized by vertical integration with the state electricity boards (SEBs) forming a monopoly and excessive price regulation. Each state's electricity board was responsible for generation, transmission and distribution (T&D) within its own jurisdiction. But the SEBs turned loss making and inefficient. In the wake of the growing power needs and the continuous surplus-shortage situations faced in various parts of the country, the government introduced Electricity Act 2003 for restructuring of the power sector and to introduce competition and increase efficiency. It de-licensed generation, recognized trading as a separate licensed activity and introduced open access in T&D.

Traditional value chain components of the electric power infrastructure include power generation, transmission, distribution and trading (Figure 2). The efficiency of the electricity value chain is a function of energy efficiency and the timing of energy consumption away from peak loads.

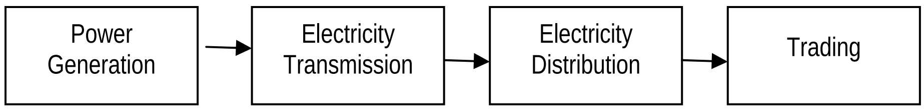


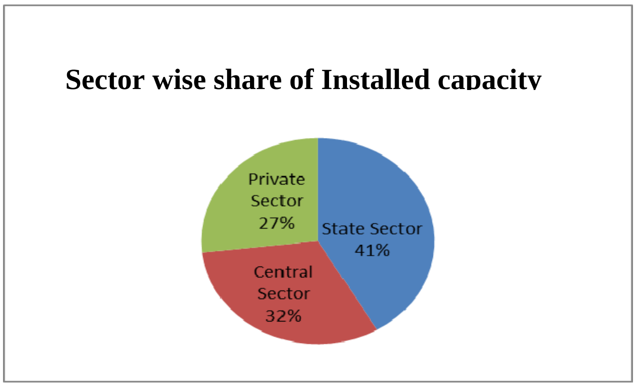
Figure 2. **Existing value chain of power sector in India**

5.1. The components of the value chain of the electric power Sector

In order to understand the nature of the issue and the opportunity, it is important to establish a perspective on the way in which the electricity value chain typically operates today. The flow along the electricity value chain starts with energy producers who mine and refine the fuels used in electricity productions including coal, gas, oil or nuclear based fuels. The fuels are then delivered to the generation facilities where they are converted to electricity through the generation process. The electricity generator uses the fuel to drive a generator to produce electricity and dispatch it to a transmission and distributions (T&D) system, which distributes the electricity to the consumer locations through a transmission and distribution grid. From producers it is transported via energy exchanges or other electronic trading platforms, over an extensive transmission network to regional suppliers and from there to private, public and industrial consumers.

5.1.1. Power generation

In India, coal accounts for more than 70 per cent of the country's electricity generation. Of the 54,000 megawatts of power capacity added between 2007 and 2012 in India, over 70 per cent was coal-based. The entire value chain of power sector is dominated by the central and state sector utilities, out of the total generation capacity of 2,07,006 MW (source: CEA as on 30 Aug'12), the share of central, state and private sector stands at 65,502 MW, 85983 MW and 55,519 MW respectively.



Source: Central Electricity Authority (CEA), as on 30 Aug'12.

Figure 2. **Sector wise share of intalled capacity**

From 2011 to 2016, the overall power generation capacity of India is projected to increase by an annual average rate of 6.76%, which indicates towards the level of 1,316 terawatt hours of power generation. The net power consumption, during this period, is expected to reach 1,021 TWh by 2016 from 729 TWh as registered in 2011 (Grant Thornton report, 2012). Indian companies have shown a huge interest in power generation and the recent change in power procurement landscape towards competitive bidding is expected to drive investments and efficiency in the sector.

Aided by a jump in output from thermal and nuclear power plants, power generation is expected to grow 13.2% in 2012-13. Power generation increased 8.1% in 2011-12. Thermal power generation, which moved up by 6.6%, is estimated to grow 14.4% in 2012-13, according to the Centre for Monitoring Indian Economy (Allirajan, 2012).

Major Central Utilities who are in to power generation in India are:

- Thermal: NTPC - National Thermal Power Corporation;
- Hydro: NHPC – National Hydro Power Corporation;
- Nuclear: NPCL – Nuclear Power Corporation of India Limited;
- NEEPCO – North Eastern Electric Power Corporation.

In addition, there are some generation companies who are running on private investment (referred as Independent Power Producers or IPP's) which sell their power through PPA's with State/Central Utilities or in open market through bilateral and spot trading. Power sector was let open to Private investment through economic reforms of 1991 but it was Post Electricity Act 2003 that private sector investment got impetus through removal of the clause that sought obtaining license for setting up generation unit. Some of the major independent power producers are-reliance power limited, Tata Power, Lanco, GMR, Adani, Jindal Power.

In addition, captive power plants (plant set up by any person to generate electricity primarily for his own use and includes a power plant set up by any co-operative society or association of persons for generating electricity primarily for use of members of such co-operative society or association) have been growing at a fairly aggressive pace in India. The growing captive capacity has been mostly catering to the captive demand of the parent industries and played very little role in catering to the overall system demand.

With the introduction of open access and sale of excess power by Electricity Act from 2003, government aims to bridge the demand-supply gap and it provides a revenue generation stream to captive producers through the sale of their excess power where they can use the distribution network which was earlier subjected to clearances.

5.1.2. Power transmission

Power transmission in India was restricted to central and state utilities until the year 2006. Though, the Electricity Act, 2003 opened doors for private sector participation in the power sector, private investment in transmission started only in 2006. Private sector investment was allowed in the form of 100 per cent private equity or as a 74 per cent JV with the Central Transmission Utility (CTU). The huge capital required for building efficient transmission infrastructure has attracted numerous domestic and international players. Total outlay for transmission sector in the XII Plan is estimated at Rs.2.4 trillion.

Transmission of electricity is bulk transfer of power over a long distance at a high voltage, generally of 132 KV and above. Transmission network supplies electricity from generating stations to substations located near the population and industrial centers. Central and state utilities own 40% and 60% of the total transmission capacity respectively.

Transmission system in the country has been divided in to five regions: Northern region, North Eastern region, Western region, Southern region and Eastern region. Inter-regional transmission of electricity within the regions is done through regional grid. Power transmission in each of these regions is monitored and controlled by National Load Dispatch Center. Further regional load dispatch centers control power operations in their respective regions. In India, at present, the north, west and eastern regions are integrally connected through strong transmission links to form what is called the NEW grid.

Power transmission is no longer a central or state monopoly. The sector remains one of the greatest concerns and the central government should extend a helping hand to states to help sourcing finances. Once states and the developers find a level playing field, the sector is set to witness phenomenal growth. The government has done a commendable job on the tariff-based competitive bidding route to bid for projects for private players. The step has brought enthusiastic support from private parties.

Proper transmission planning and execution are the areas that seek attention. The challenge before the sector is to build a strong integrated grid network that will allow large transfers from one part of the country to the other. For India to become an integrated power player, private sector will have to play a crucial role in establishing state-of-the-art power evacuation infrastructure in the country.

5.1.3. Power distribution

Unbundling of State Electricity Boards post Electricity Act 2003 has created separate entities for generation, transmission and distribution at state level. Distribution is different from transmission as distribution involves transmission of electricity from Substation to end consumer. After unbundling each state has DISCOMS i.e. distribution company who are responsible for metering, billing and collection. This sector also witnesses heavy government intervention with 95% of distribution network under State Distribution companies. Presently, there are 61 distribution utilities in India and government aims to promote private public partnership in power distribution sector so as to minimize aggregated technical and commercial losses (AT&C) and other problems plaguing the sector. Distribution is one of the weakest links in Electricity value chain as far India is concerned. The Sector is plagued by high AT&C losses, power thefts, inadequate metering, subsidized/free power, dilapidated networks & poor recovery of dues. So to achieve its development objectives government is trying to bring efficiency to sector. The country is progressing in terms of the distribution reforms taking place. There has been a thrust on involving private sector in it. Distribution franchisee, smart grid formation, etc. have been initiated in the country. However, the state electricity boards (SEBs) are still grappling with huge financial losses; there is an immediate need to realign these boards and distribution companies so as to fulfill the target of providing power to the whole country.

5.1.4. Power trading

Broadly power can either be a commodity to be sold in open market or it can be a utility which is an input for Power intensive products. Power as a commodity offers insight into the dramatic changes that have been undertaken in the Indian power sector since its reform in 2003. Power exchanges were set up in India in 2008. The two power exchanges in India are the Indian Energy Exchange (IEX) and the Power Exchange of India Ltd. (PXIL). Currently, sellers on the power exchanges are mainly independent power producers and merchant power producers, besides captive power plants. In addition, bilateral contracts are signed between licensed power traders and generation and distribution companies. Currently as per CERC there are 50 licensed traders but not all are undertaking trading activity. The Power Trading Corporation (PTC) is the largest trader in the country in terms of volumes of electricity traded by traders. Besides these, direct trading between distribution companies takes place in case of surplus power being sold outside state to deficit region subject to clauses agreed between distribution companies.

Power-starved India is yet to realize the full potential of power trading. Only 10% of the power generated in the country is traded (Infocus report, 2011). In India, the generators of electricity like Central Generating Stations (CGSs), Independent Power Producers (IPPs) and State Electricity Boards (SEBs) have all their capacities tied up. Each SEB has an allocated share in central sector/ jointly owned projects and is expected to draw its share without much say about the price. Lack of long term power contracts is a key factor that has impeded growth of the power trading market. Trading of power from surplus state utilities to deficit ones, through marginal investment in removing grid constraints, would help in deferring or reducing investment for additional generation capacity, in increasing PLF and reducing average cost of energy. Power trading aims to create a liberalized market structure. With the provision of non-discriminatory open access to transmission, the competition for bulk supply to distribution companies would become a reality in the near future.

5.2. Expansion of power value chain

To the above described power value chain two more components can be added as additional integral characteristics of modern electrical grids and networks. These components are electricity storage and ICT empowered smart grid (Figure 3) for operating and managing the value chain more efficiently.

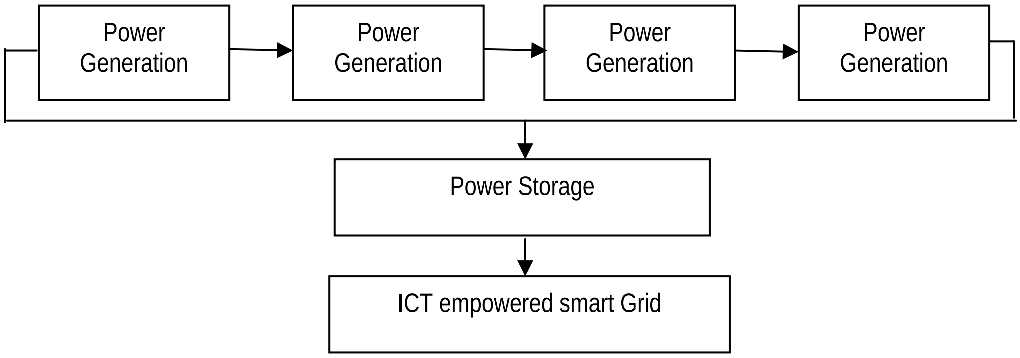


Figure 3. **Expansion of existing value chain of power sector**

5.2.1. Power storage

Although electricity cannot be directly stored (cheaply), it can be easily stored in other forms and converted back to electricity when necessary with the peak value of the electricity easily covering the cost of storing the power. An important role will be to provide relief for consumers in the power market during periods of extreme volatility. Once sufficient large scale storage assets are in place, one of the most visible impacts energy storage will have on the market will be to reduce both volatility and prices during the peak demand periods. According to Frost & Sullian report (2011), India is currently facing power deficit and peak power deficit to the tune of 8.1-9 percent (as at end of June 2012). In order to overcome this crisis, electric energy storage systems are slated play an important role in future of Indian power generation systems. Renewable energy has been regarded highly in this context of storage and usage of energy. Solar and wind energy can be stored and used during crisis, and/or when power demand is at its highest in the country, in order to maintain grid stabilization.

Energy storage technologies absorb energy during periods of excess capacity so that it can be released later. When released, the power can either be delivered as real power for consumer use, or it can be delivered as reactive power to support and stabilize the grid. Pumped-hydroelectric (hydro) storage (PHS) is the oldest and largest of all of the commercially available large scale energy storage technologies. Prospects for this technology are limited in most developed counties due to high development costs, long lead times, and the necessity to locate these facilities in very rural areas due to their size. The current focus for development of this technology is now up-rating existing facilities through use of advanced pumps, impellers, and variable speed drives to increase the unit’s capacity and operating efficiency by 10% to 15% (Baxter, 2002). India is looking at every possible option that is available for energy storage, from Li-ion storage device for short-term energy, to pumped hydro for long-duration storage. Keeping in mind the critical value of efficient energy storage, India is keen on cost-effective technologies for storing energy.

5.2.2. ICT empowered smart grid

Stable and reliable operation of power system is dependent upon control, communication and computation. The concept of smart grid has become hype and received substantial attention in modern times. Smart grid has emerged as a solution that empowers utilities and consumers to share the responsibilities of operating and managing the power grid more efficiently (Omar et al., 2012). Smart grid integrates the appropriate information and communication technologies (ICT) infrastructure, automated control, sensing and metering technologies, and energy management techniques. To ensure uninterrupted power services to end user, the key is to ensure complete visibility and monitoring of the grid accurately. Innovative technologies are emerging that enable cost effective solutions, which help in realization of the Smart grid. These are based on the optimization of energy demand and supply into traditional power grid in order to make it more efficient in many ways. The smart grid ICT industries, such as IBM, Intel, Cisco, Oracle and Google, are all contributing substantially in the makeover process from traditional grid to smart grid utilities (Garner, 2010, CISCO). Smart grid offers bett+-+er communications among all stakeholders in the system. The drivers to move towards smart grid are stronger in India due to high aggregate technical and commercial losses and poor efficiency across power sector value chain. India is trying to move in the area of smart grid due to high potential of renewable energy sources (RE) and large pool of information & communication technology.

6. Conclusions

The power sector plays a crucial role in industrialization and urbanization of India and faces challenges in absorbing high cost of inputs. It plays a socially responsible role in bridging rural-urban disparities by improving provision of affordable commercial energy access. In order to sustain high economic growth power will continue to play an integral role. Indian power sector has made considerable progress in the last decade and has evolved from a nascent market to a developing market led by policy reforms and increased private sector participation. The Indian power market is substantially dissimilar from power markets elsewhere in the world; its very nature poses unique challenges in the development of the market and the product as well. Challenges do exist in the sector, which India has to overcome, to evolve from a developing market to a matured market. In consideration of the issues highlighted above, a lot remains to be done on the part of regulators and other involved organizations to ensure smooth functioning of the power value chain. Energy storage is of critical importance, and investment in such technologies is essential in order to fully utilize potential of renewable energy generation. Further, the need for a smart grid is explored for better efficiency, reliability, with possible integration of renewable and alternate energy sources. Within the smart grid context, renewable non-variable resources such as pump storage, geothermal, biomass and hydro are used more than before. More generation from renewable variable sources, such as wind and solar energy can be added to improve the efficiency of power value chain in India. Looking from a long term perspective India would need 3870TWh of electricity by 2030 which implies CAGR of 7% from 2005-30.

According to McKinsey report (2008), to meet India's growing power demand an investments of US$600 billion will be necessitated across value chain. This provides several significant and rewarding opportunities across the value chain-setting up group captive plants, investment in over-sized captive plants by players in process industries, resource holders could consider integrating forward to realize higher prices for their resources, capacity expansion would lead to power trading on a more regular basis as volumes are increasing tremendously irrespective of prices and it can provide the opportunity of creating a permanent revenue stream. The private sector has emerged as a key player in both conventional and renewable power, and increasingly in other parts of the business. Positive future outlook of power sector also provides an opportunity in terms of expanding current capacity or fully fledged entry into power sector given that they have considerable expertise in power sector. In addition, there will also be demand for turnaround specialist; futures trading is also expected to take off hence that will open up another window of opportunity. Irrespective of many opportunities which may arise there will be several inherent risks in the power sector like uncertainty of key regulations and potential market failures. It is critical to recognize and proactively manage these risks. Bottlenecks across the value chain together with committed fixed tariffs will create project execution risks. Players will need to develop business models which can leverage on opportunities across value chain and overcome key risks associated with Indian power market in order to create sustainable value. If successful, power sector of India will be able to fulfill its ambitious target of "electric power for all".

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