



Large scale solar integration in India: Economic growth & need for assessment of barriers

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Abstract

India is one of the fastest emerging economies in the world. India's manufacturing sector is emerging at a very fast rate with increase in domestic demand. To maintain the pace of growth of economy with sustainable development, reduction of greenhouse gasses and a green initiative, India has to reduce its dependency on fossil fuels for electrification resulting an increase in solar installations in India. India has a high solar potential but due to intermittent nature, outdated grid infrastructure, delayed payment by DISCOM and various other barriers bought hurdle in development of solar, resulting delays from target. So, there is a need to revise solar policies by government. This study examines the need for assessment of consequent risk associated in development of large scale solar integration in India. Better understanding of these Barriers may help organizations & government bodies to manage their resource in effective and efficient way. That may increase number of solar projects in India.

Keywords: barriers, assessment, solar, India

Introduction

Energy is one of the essential needs of mankind. The economic development of a country remarkably depends on long-term availability of energy from sources that are affordable, accessible and environmental friendly [1, 3]. Every sector of national economy whether its agriculture, industry, domestic or commercial needs energy for its development [2]. So, consumption of energy is steadily rising in the country. High levels of Indian Economic Growth, coupled with the increasing population and extensive urbanization resulted in significant increase in demand of energy [3]. Energy plays an essential role for both demand and supply side in the economy. On supply side, Energy being a key factor from production with capital, labour & material plays a vital role in social and economic development of countries by increasing living standards and economic growth [4].

India is the third gigantic producer and fourth gigantic consumer of electricity in the world [14]. India has an installed power capacity reaching 334.39 GW as of January, 2018 [12]. Thermal (coal, gas and diesel) have the largest share in installed capacity with approximately 65.73% and RES with an installed 18.79% respectively followed by hydro and nuclear power [12]. Also, with the total production of 1,160.1 BU for FY 2017 in India, the country witnessed an overall growth of around 4.72% over previous FY 2016. It has been seen that from FY10-17, the electricity production in India grew at a CAGR of 7.03% [14]. The growing consumption of energy has increased its dependency on coal, oil and gas. Rising prices of oil and gas with future shortages has led to concerns in security of energy supply, which is needed to sustain economic growth. Increased consumption of fossil fuels has caused environmental problems on both local and global scales [7].

There has been a robust growth in Renewable Energy

satisfying the urgent need for country to develop a sustainable path of energy development [5]. Renewable Energy in India comes under the purview of ministry of new and Renewable Energy [6]. As per PM Modi, Paris Agreement reflected our duty towards earth and natural resource protection [8]. The target for renewable energy has been increased to 175 GW by 2022, an ambitious target that will require a four-fold growth in sector [9]. Power system will be balanced with 100GW of solar, 60GW of wind, 15 GW from biogas, achievable at 15 minute operational timescales with minimal RE curtailment [10]. This will result in reduction of our dependence on fossil fuels, reduction in greenhouse gases, better green initiative and improved waste management.

In India, Total solar Power generation capacity has significantly increased from 461 MW in 2011 to 12.288 GW in 2017 [12]. Over last few years the solar capacity of country has increased tremendously because of favorable government initiatives coupled with the overall development of technology resulting in reduced capital cost and amount of tariff.

The solar power tariff has drastically fallen in nominally from Rs.15/kWh in 2011 to Rs.2.44/kWh in 2017, due to a steep decline in module prices and foreign investments in power sector [13]. This fall came due to the introduction of competitive bidding and the price started declining when 750 MW for solar power park was set up at Bhadla, Jodhpur with viability gap funding (VGF) from SECI [11]. The above mentioned factors are not only responsible for declining of solar tariff whereas several other factors which are needed to be identify in this regard.

Present generation scenario

Indian Power sector is one of the most diversified sectors in the world having sources of power generation ranging from conventional sources (Coal, Natural gas, Oil, Hydro and

Nuclear) to viable non-conventional sources of energy [14]. Distributed energy, clean energy demand and various other technological progresses are reshaping the long established, centralized fossil fuel power system to accommodate variable Renewables and various network related loads [15]. Due to ever increasing population, urbanization and modernization, the

demand of energy in India is increasing rapidly [16]. Coal is primary fuel for the electricity generation in India [17]. 78.46% of the Electricity was generated from Thermal Power plants, when compared to all 2.9% from nuclear, 10.36% from hydro 7.82% from renewable. 46% from Bhutan [12].

Table 1: ALL India installed capacity (in MW) of power stations (CEA)

Resource	Share in installed capacity (MW)	Share in general (BU)
Thermal	219809.51	857.923
Hydro	44963.43	113.449
Nuclear	6780.00	31.673
Bhutan Import	-	0.4795
All India	334399.83	1003.525
Captive	40726	-
Renewables (Dec 2017)	62846.90	78256.54
1. Wind	32848.46	45474.88
2. Solar	17052.41	17312.31
3. Biomass	8413.80	2571.01
4. Bagasse	114.08	5871.45
5. Small Hydro	4418.15	6410.57
6. Others	-	614.32

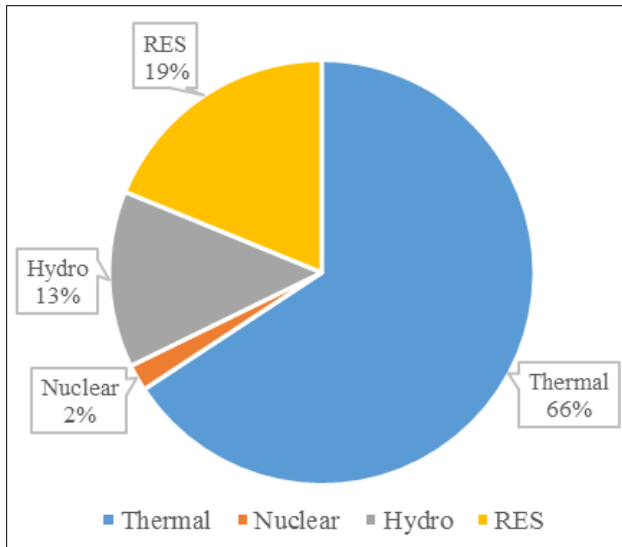


Fig 1: India's primary energy mix – fuel type (CEA)

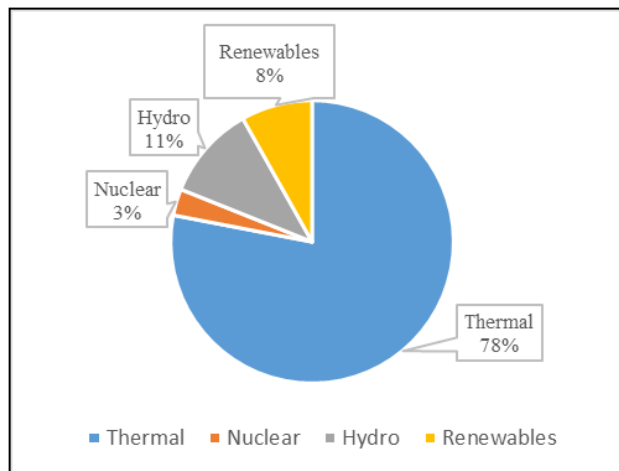


Fig 2: India's generation mix – fuel type (CEA)

The United Nations Framework Convention on climate Changes (UNFCCC) is considered as the foremost arena for the development of a global response to climate change [18]. The Paris conference of parties 2015, is considered as “One of the most successful conference ever” [19], though conceivably inadequate for keeping the temperature increase below 1.5° C and thus avoiding the strong impact of climate change [20, 21, 22, 23]. The Paris COP 21, has Projected India as a trailblazer in initiation of Solar based power generation [24]. The Government of India has set a target of 100GW of solar power till 2022, of which 60 GW is from utilities and the remaining 40 GW is from Roof top installations highly suppressing it's actual target of 18GW [25]. India has already achieved the target of 17.052 GW in a very short period of time [12].

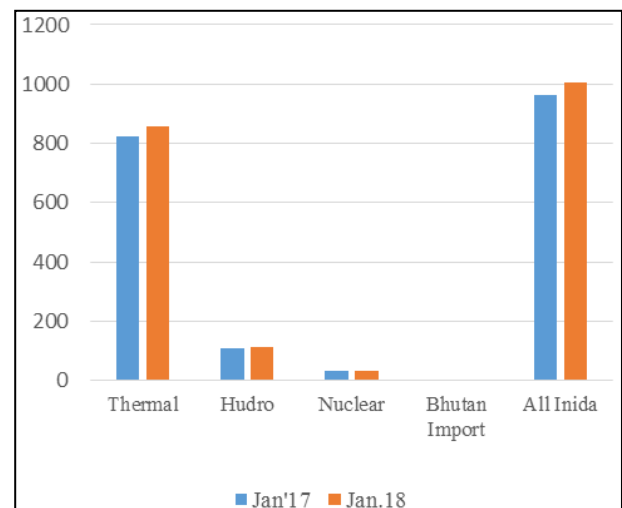


Fig 3: India's Electricity generation during April'17 to January'18 (CEA)

As per the Budget Report for FY 2015-16, there is a special call for development of marginal oil and gas field in India, leading to indigenous and cheaper gas resource for power

generation and the gas contract made with china is also in tunnel [26]. This stressed the necessity of National thermal Power plants in country. Gas is the cleanest form of energy and gas based power plants are suggested to take up uncertainties in Renewable power generation like solar and wind helping nation to build hybrid plants [28]. The gas based combined cycle plants are more efficient then thermal based power plants with the closest of 60-70% of its efficiency [44]. In addition to this Growth and development of nuclear is also stressed in the Budget [26]. While in FY 2016-2017, government wanted to bridge the gaps like electrification of villages, "Power for all" program was a major step taken [27]. India is making great Strides in Coal power plant production, setting up its capacity in indigenous coal production, thereby reducing its risk and dependence of imported coal [45]. Also, the coal and ash handling process have improved a lot in present era [45].

In 2017, *Saubhagya* or "*Pradhan mantra sahaj bijli har ghar yojna*" launched by PM Modi, is expected to provide "last mile electricity connectivity to all rural & urban households" [29], also government said that, "This scheme will be injecting approximately Rs. 16000 Crore in Indian Economy to create assets, which in turn will add more investment as well as create jobs in India." This scheme will result an increase in Demand, help India meet its global climate change commitments as electricity will substitute Kerosene for lighting purposes.

Present trend in Indian solar sector

Over the years, RE sector has emerged as a very significant player in grid connected power generation capacity, supporting government agenda of sustainable development [30]. As on November 11, 2017, a capacity addition of 27.07 GW of RE has been reported during last three and half years under grid connected renewable power, which includes 12.87 GW of solar [31]. Solar capacity addition for 2017 is expected to touch 8.8 GW, i.e. a rise of 76% over last year making India third biggest market worldwide [32]. India witnessed record capacity addition of around 4 GW in FY16, 9.5 GW in FY17, solar sector has strong growth path [33].

Tamil Nadu, Andhra Pradesh and Telangana emerged as the fastest growing states and in 2017, 60% of new capacity addition to come in three southern states, Telangana, Andhra Pradesh and Karnataka [32].

India's potential to generate solar power has expected to attract \$100 billion investments eventually, currently around 293 global & domestic companies have committed to invest approximately US\$ 310-350 billion for setting up a cumulative capacity of 266 GW in Solar, wind, mini-hydel and biomass with a time span of 5-10 years. From 2000-2016, India has attracted US\$ 10.48 billion in terms of foreign investment [34]. In September 2017, 15 Japanese company including Morocco, Toyoda Gosei, Topre & Murakami, intended to sign MOU's (Memorandums of understanding) with the intention to invest in Gujarat [35]. Large overseas investor or developer, such as AIDA, CLP, EDF, ENEL, Engie, Fortum, First solar, Goldman sachs, etc. have been taking participation in the sector. Also after FY17, Wind sector is facing headwinds, primarily due to diminishing additional benefits such as reduced Accelerated depreciation

and GBI (generation Based Incentive) and preferential feed-in-tariff covering the way for competitive bidding [33]. The ministry of power (MOP) declared National Renewable Purchase Obligations, overall RPO % is expected to be 11.5% in 2016-17, having 2.75% of solar and rising to 17% in three years (including 6.57% solar) [36]. GOI increased the solar RPO trajectory upwards from 3% to 8% till 2022. Furthermore, built up of evacuation infrastructure and time liners in land acquisition would have a crucial impact on capacity addition [33].

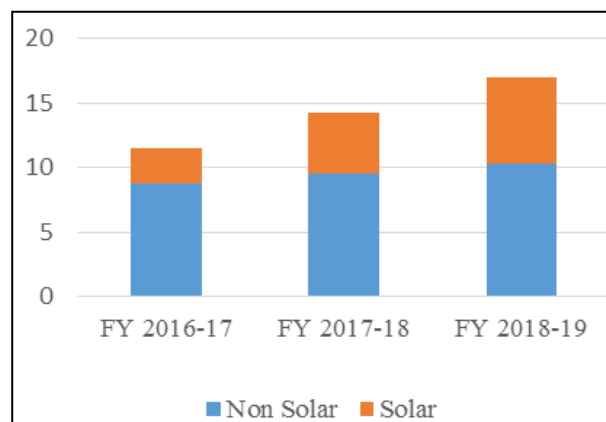


Fig 4: National RPO Trajectories (CEA)

The electricity generation cost of Renewable projects declined for projects commissioned in FY2017. There were primarily three reasons for declining trend line; Better technology, Competitive procurement and large base of experienced, internationally active project developers. Till 2019, the best onshore wind and solar PV projects will be delivering electricity for around US\$ 0.03/kWh or less [37]. In December 2017, It was reported that wind tariffs dropped to a record-value of Rs. 2.43/kWh (~\$0.038/kWh), quoted in Gujrat Urja Vikas Nigam Ltd. (GUVNL) For 500 MW auction. Central government actively worked with state government to issue bids of 8 GW of cumulative wind capacity, and Solar energy corporation of India issued a tender of 2 GW of Interstate transmission system (ISTS), connected with wind projects under Tranche-III [38]. In 500 Mw Bhadla phase-III solar park auction, ACME quoted a tariff of Rs. 2.44/kWh, which is 6.9% lower than tariff quoted at Bhadla phase-IV solar park auction @ Rs. 2.62/kWh [39]. In 2016, crystalline module prices have seen a decline of 9%, with slowdown in Chinese demand & oversupply situation in near term, Module prices have softened further. Resulting in reduced cost for developers who are trying up supply in near term [33].

Flexibility in power system is its ability to change in power demand & generation. Integrating large share of variable RE, especially solar and wind; can lead to strong increase of flexibility requirement for system, traditionally hydrothermal, which has responsibility to balance the grid [46]. Large-scale solar system are on rise all over the world, an expansion fueled by technological advances, policy changes & need to reduce CO₂ from earth. The major challenges in large scale solar installations remain in policies, research & technology [47]. Overcoming these challenges will require multidisciplinary approaches, perspective & collaboration. As

the requirement of solar in India has increased, we need a study to demonstrate the barriers to implement solar power knowing all contextual relationship among each other [1]. Although efforts are underway for large scale solar implementation in India in both rural and urban areas, but still RE technologies lack popularity due to various obstacles that hinders its integration at gross root level [48]. This implies there is a basic need for assessment of large scale integration of solar, knowing its barriers one can modify its business plan to achieve success with respect to organization & Nation also. "Most DISCOMs are still not willing to buy solar generated electricity mainly due to power demand-supply situation changing to surplus. DISCOMs already have excess power than they need, unfortunately RPOs are not being enforced," Vinay Rustagi, MD of market research firm bridge to India Money control. "Also, sharp reduction in tariffs from past 3 months has made DISCOMs to go slow on their procurement programmes as they wait for better option," he adds [49].

Energy Elasticity

Energy Elasticity is a term used for referencing energy intensity of Gross Domestic Production. Energy elasticity is the percentage in energy consumption to achieve one percent change in total national GDP [5]. It is mainly used to describe sustainable growth in a developing environment, while being aware of maintaining energy security & limiting the emission of greenhouse gases.

As per India's National Integrated Energy Policy of 2005, Energy Elasticity of India is 0.80, with 7-8% GDP Growth. It's expected to reduce to 0.67 till 2021-22 [5]. Electricity consumption leads Growth, conservation of electricity will inhibit economic growth of nation. The long run elasticity of consumption with respect to GDP is inelastic (0.86), concluding more electricity consumption required for higher growth rate. For ensuring sustainable economic growth, sufficient amount of supply must be ensured and solar is a vital component of India's sustainability drive. In long run, the growth & development in India, policies, investments are required to bring a shift in India's Economic structure leading towards a more-efficiency oriented and less- resource depleting one, relying more on Renewable sources of energy. RE technologies have enormous potential to solve all energy problem in India! [31]

Growth Outlook

Global installed base to reach 863 GW by the end of 2022, Asia pacific comprises of majority of market capturing 445.25 GW by 2022, Followed by Europe at 166.86 GW, Middle east-Africa 63.22 GW, and Latin America 49.12 GW [42]. As per "The Indian Solar PV Outlook, 2022", standard and advanced multi-crystalline module technology has largest share with its increasing scope and research on p-type and n-type mono-crystalline silicon modules, resulting increased efficiency of PV modules thus in turn increasing the solar plants capacity utilization factor.

India has faced twin challenges on environment and energy front, has more option other than to work towards increasing role of renewable in future energy system [40]. In next 5-6 years, Market size will be 9.5 times bigger than current market [41].

One of the biggest problem faced by the Indian solar Industry is rising price of Chinese module. The Indian solar market was growing accustomed seeing the price of Chinese panel price was falling quarter-over-quarter and year-over-year. But in Q32017, Chinese panel price increased by 14%, compared to Q2 2017 [43]. JNNISM bids in Gujrat stated a silent response with total bid received for 160 MW as against tendered capacity of 250 MW, due to relatively higher charanka solar park charges of Rs. 0.96 lakh/ MW, more than other states like Rajasthan and AP [33].

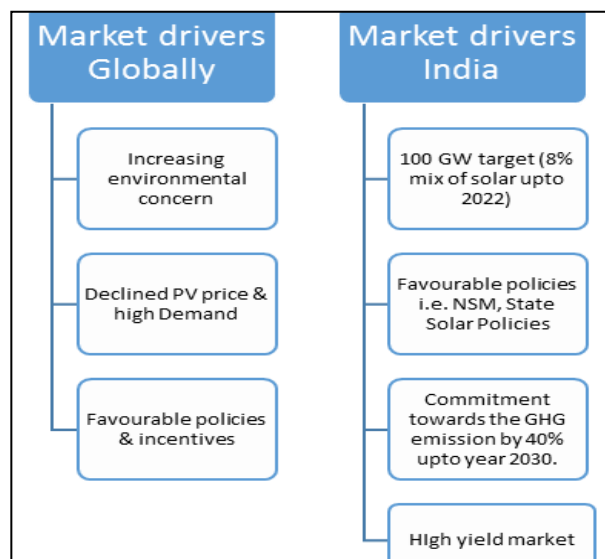


Fig 5: Global and Indian Market Drivers

Conclusion

The primary purpose of this paper is to investigate the enthusiastic suggestions for transitioning towards RE system running entirely on PV system in India. At technical level, we identified the current scenario of power in India & showed how variability & uncertainty of RES output require high system flexibility.

The first goal was to go beyond the technical aspects and exploring the current & future aspects of Indian Power Sector. Second goal was to know the need for identifying the barriers of solar integration in Indian Power grid. Recognizing these interdependencies we could advocate a proper research methodology and policy making in which various technical and institutional subsystems are considered in coherence. India's attempts to ramp up its RE capacity has got off to a slow start as target of installing 12GW of solar capacity in FY2016-17 & only 6GW by April 2017. Long term financing, inadequate budget allocation or insufficient T&D may be reason behind this underperformance. Thus, due to intermittency & high exemplified electricity of PV system, achieving all three policies objectives that is, self-reliance in electricity, climate mitigation and adequate electricity for all the people in the society by 2050 is going to be extremely challenging in most scenarios. So, this paper finds the importance of finding the barriers in solar development.

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