The Indian Power Sector: Need of Sustainable Energy Access

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While moving towards renewable energy sources, India needs to ensure efficient coal-based generation with high end technologies. Since coal will continue to dominate, cleaning the sector is the only way out.

Power is crucial for the development of a country. Being a developing one, access to power is a big challenge which India has for its people, agriculture and industry. Here, the trilemma comes; the need of low cost power, adequate supply and environment conservation. And the zeroed-in option for India is coal as a source of electricity which is a taboo. Above 60 per cent of the power generation capacity is from coal-based plants, which estimates to around 167GW as of now (CEA, June, 2015). And the taboo brings in pollution with it - emission of particulate matters (PM), sulphur dioxides (SO2) and oxides of nitrogen (NOx), neurotoxins like mercury and carbon dioxide, the most discussed one.

The contribution of hydro-power and other renewable sources in India is lower, 15 per cent and 13 per cent of the capacity respectively (CEA, June, 2015). No doubt, coal-based power will continue to dominate for quite some time, but what is inevitable is the disaster if we don't choose sustainable ways moving ahead. And the sustainable way needs a multi-point approach to be implemented - technological, economic and administrative coupled with political will to make the fleet efficient and protect the environment and public health. This can certainly be done, but requires determination and a right approach to do. Business as usual is not the way out. The major coal-based power producing countries like China and USA have faced these issues and dealt with them. We need to learn and make an epochal shift in the idea and approach.

Efficient fleet is a must

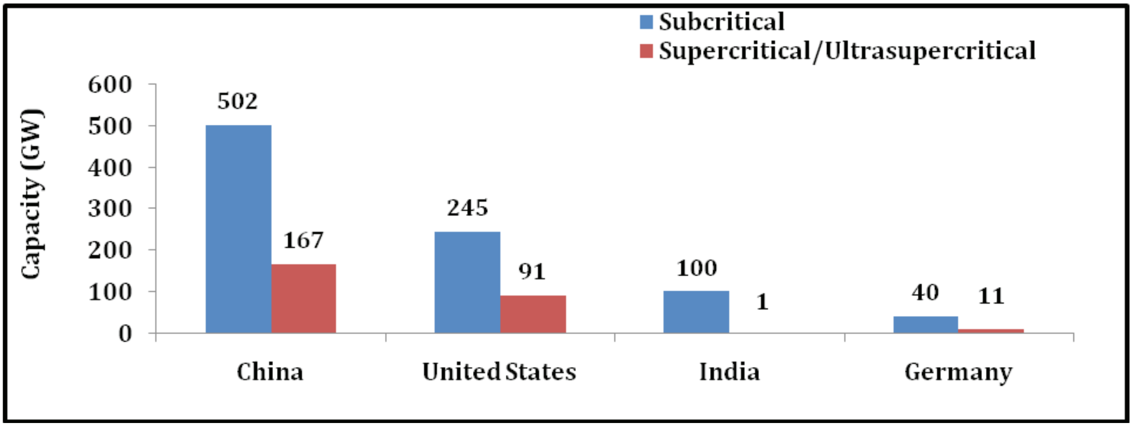
Welcome high end technologies let the dated ones out

The sector is growing fast, and all in the name of assured and adequate power access.

But more and more capacity addition is not the answer. What must be ensured is that new additions are efficient and equipped with high-end technologies. Simultaneously, out-dated ones, which are performing poorly, should be disposed off. Where techno-economic feasibility allows, life extension with renovation and modernizations can be carried out. Currently, India has no ultra-supercritical (USC) technology and only 15 per cent of the coal-based power is supercritical (SC) based whereas in China, nearly 25 per cent capacity is USC and SC.

Technology used in coal plants in major countries, 2012

India had the one of the lowest contributions from SC/USC plants among countries with coal capacity.



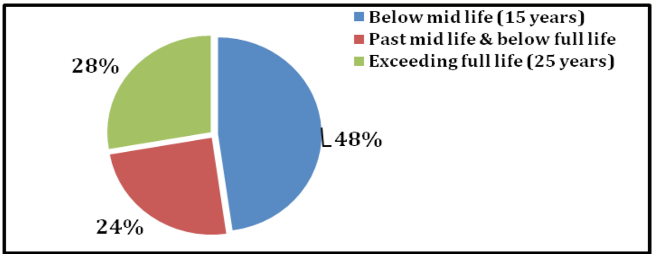
Source: Matthias Finkenrath, Julian Smith, Dennis Volk, 2012, CCS retrofit: Analysis of the Globally Installed Coal-Fired Power Plant Fleet, International Energy Agency, p34

With age, plant-efficiency deteriorates, especially with inadequate operation and maintenance (O&M) and poor operating conditions. This is quite common among dated state-owned plants. China, which has made significant additions to coal capacity over the past decade, has a relatively young fleet of plants. In contrast, only 18 per cent of India's plants are younger than 10 years and have capacity exceeding 300 MW.

Capacity distribution by age, 2013

A large portion of India's plants are aged

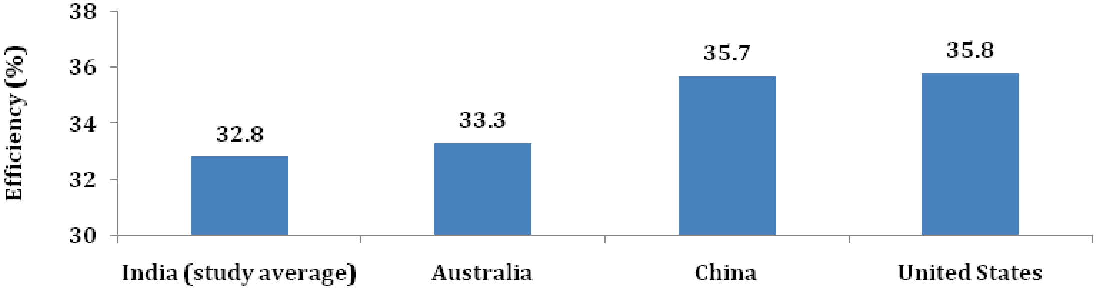
Recently, China has replaced significant capacity of dated and in-efficient Sub-C technology-based plants of around 80 GW with efficient SC and USC technology-based ones. This has led China go high in energy efficiency, 3 percentage points above India's (33 per cent). It matters a lot because, apart from more power output from same quantity of fuel consumption, it also reduces GHG emission. Every percent of efficiency improvement reduces GHG emission by 3 per cent.



Source: 2013, Developing Markets for Implementation of R&M Schemes in Thermal Power Stations in India, Mercados Energy Markets India Pvt. Ltd. Page 30

Efficiency of the plants in various countries (LHV basis), 2011

The Indian fleet is one of the most inefficient (3 percentage points) below China's

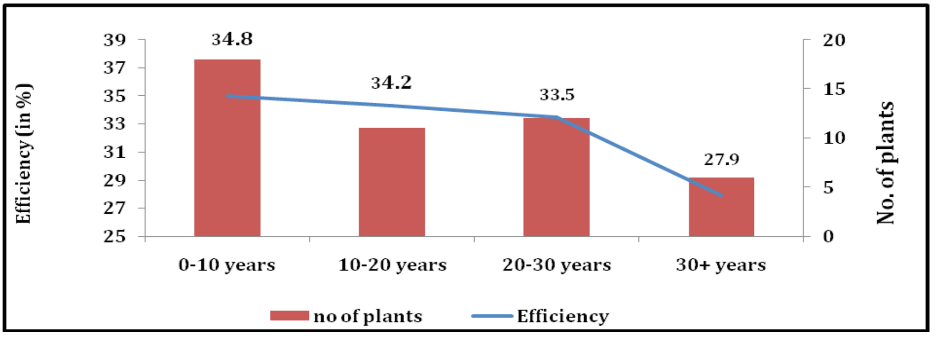


Source: Charlotte Hussy, Erik Klaassen, Joris Koornneef and Fabian Wigand , 2014 September, International comparison of fossil power efficiency and CO2 intensity – Update 2014, ECOFYS Netherlands B.V, Page 66

Nearly 50 per cent of the plants in the sector have more than 10 per cent efficiency deviation from design. These units are called poor performers by Central Electricity Authority (CEA), India. Almost all of these plants have sub-critical technologies, which initially have lower efficiency compared to super-critical and ultra-supercritical, and which, with time, deteriorate further. The key reasons include age as well as inadequate and irregular O&M. Even newer plants have high deviation of above 20 per cent. Stated-owned units are best fit examples of this.

Age versus efficiency of plants

Older plants in the sample are less efficient



Source: Centre for Science and Environment, 2014, "Heat on Power", p54

Efficient fleet without maximum capacity utilisation makes no sense

Most of the SC plants in the country are under utilised. Merit Order Dispatch (MOD) doesn't encourage them.

Only a few SC plants have been set up in India, which are comparatively efficient and possess advanced technology for pollution control, but they are under-utilised. Plants like Coastal Gujarat Power Limited (Mundra) and Adani Power (Mundra) have adopted SC technology but run at only around 70 per cent plant load factor (PLF) despite having higher availability for generation. The costs of power generation for these plants are naturally higher. Ultimately, MOD allows them to sell electricity only after the inefficient and polluting ones that can produce electricity cheaply.

Since the past few years, PLF has been seeing a decline in the sector. Presently (as of July 2015), average PLF of the sector has been noted to be merely 59 per cent. This raises a bigger question- do we need to install more and more plants when we are unable to utilize the existing capacity in the country? In-fact, if the existing capacity is fully utilized, we can meet of all of the electricity demand in the country. Many reasons don't allow it to happen: adequate coal unavailability, coal transport bottleneck, demand deficit and un-favorable merit order dispatch (MOD). States where enough electricity is produced power deficit rules, on the other hand there are poor states like Bihar and Jharkhand where electricity generation is not enough to meet the demand.

In-efficient ones are also resource wasteful

More of coal, water and land are consumed in dated and in-efficient plants. Excess use goes to waste.

Inefficient plants consumes more quantity of coal, water and land. Where the efficient plants consume 0.5-0.6 kg coal per unit of power, the in-efficient ones need around 1.0kg. Whereas a good plant consumes 2 m3 water per MWh of power generation, dated ones having once-through cooling system require around 100 m3/Mwh. Similarly, a high technology plant with larger size units requires less land compared to plants with smaller units and dated technology. All indicate our need to improve.

Pollution from the sector is a serious threat

Environment and public health is of utmost importance. Business, as usual, is not sustainable. Stringent norms need to be implemented

The coal-based power sector is one of the most polluting sectors. The emissions have high impact on the environment and public health. The sector is highly polluting owing to reasons like sub-standard pollution control technology and lenient pollution norms.

The Indian coal-based power sector has very lenient pollution norms. Pollution norms have been stipulated only for PM that too very loose (150-350 mg/Nm3) compared to countries like China, European Union, USA (14.5-30mg/Nm3). A recent study, "Heat on Power", released by Delhi-based research and advocacy non-profit, Centre for Science and Environment, New Delhi, states that, despite having lenient pollution norms, nearly 55 per cent of the power generating units are highly polluting on ground while reporting compliance on paper. Around 80 per cent of these units were state-owned. CEA's performance review report of thermal power plants indicates that nearly 30 per cent of the power generating units report their non-compliance to the norms but still operate. All this is happening despite having lenient pollution norms compared to other leading coal-based power generating countries like China, USA etc.

There are no norms in India for other major pollutants- sulphur-dioxides and nitrogen-oxides, which have been proved critical in other coal-based power producing countries like USA and China. These countries were forced to adopt the Acid Rain Programme to deal with the issue. Since there are no norms and emission controls are also missing, there is constant rise in the poisoning of air and health issues. A study by American nonprofit "Resources for the Future" in 2012 says that every coal-based power plant in India is responsible for around 650 deaths every year: approximately 500 deaths are associated with SO2, 120 with NOx and 30 with PM 2.5.

Mercury is another dangerous pollutant, a neurotoxin, released by the sector, which has no control regulation in India. India is the second largest mercury emitter after China: the coal-based power sector contributes around 90 per cent of it. Missing norms for control of mercury emission (nearly 58 per cent through air and 38 per cent through ash), can lead to bigger problems in the future. Minamata Disease (1956), Niigata Minamata disease (1965) in Japan and Minamata Disease (1980) in Ontario are some dreadful examples of the disastrous health impacts of mercury. India is the signatory of The Minamata Convention Agreement of the United Nations (2013) under which it has to take action to control and wherever possible phase out the mercury emission.

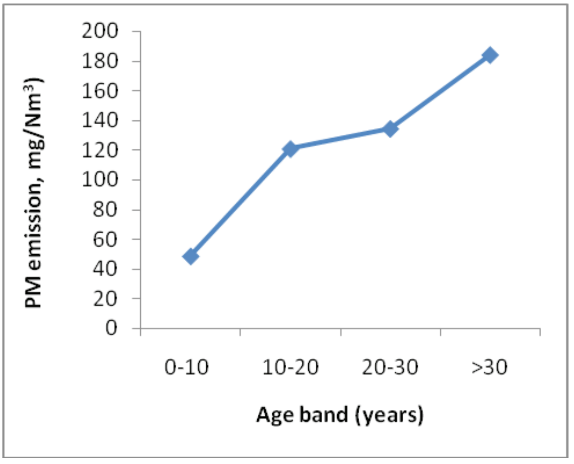
The most discussed and infamous complicacy related to coal-based power is GHG (CO2) emission. Since the sector ranks the highest in CO2 emissions, it has to go for emission reduction, as international pressure is also piling up. Since CO2 emission is directly related to efficiency, only a higher efficiency fleet can lead in this direction. The carbon capture and storage (CCS) technology which is expected to give some respite, has not been implemented so far in India. Besides, it has its own consequences.

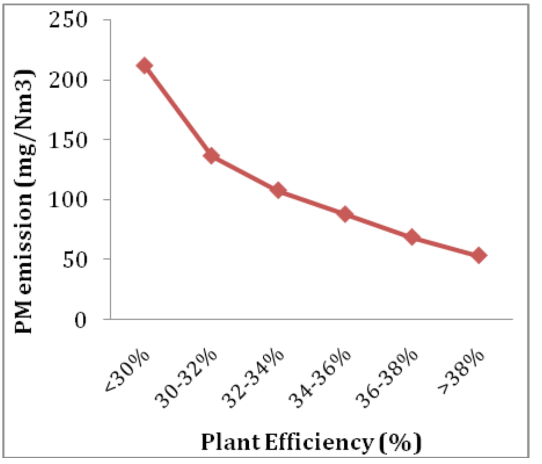
The in-efficient and dated units are likely to have higher pollution problems. Since the technology is outdated, emission control is poor. This also indicates that there is a need for up-gradation of the sector.

Efficiency and age correlate to PM emissions level

Poor efficiency, more age and high emissions are co-related, though the causal relationship is weak

It is not only the case with air pollution control, dumping and improper handling of high quantity of ash generated in the sector have resulted in water and land pollution. The thermal power sector study of CSE finds more than 30 per cent of the plants contaminating water resources through illegal ash disposal. There are only a few plants which have made





Source: Green Rating Project, 2013-14, CSE, New Delhi

successful attempts to utilize all its generated ash. However, this has to be adopted by all in the sector. This would require government action on implementation as well, which has not been seen so far.

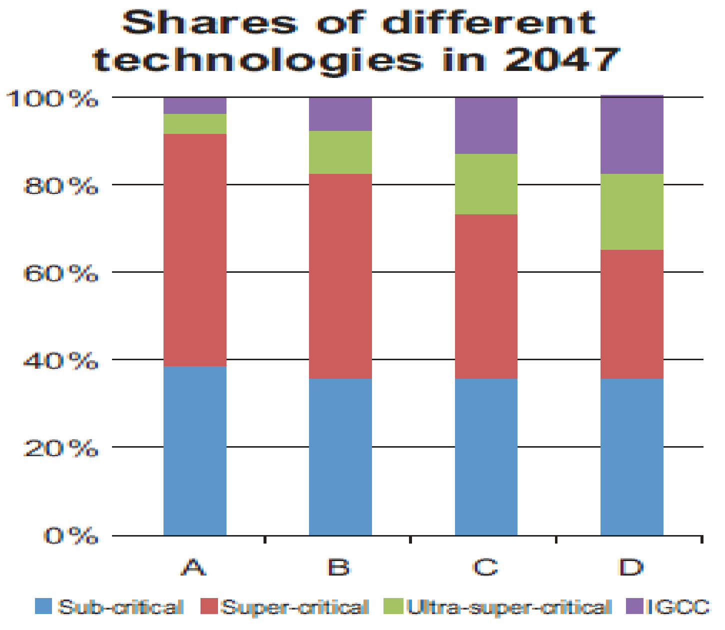
Indications of improvement are there, firm actions are awaited

The Government has announced many steps for improvement in the sector, but actual implementation is yet to happen. Not only regulation but encouragement to the industry is also required.

While the government has announced for more renewable energy source, it has also adopted initiatives for improvement in the coal-based sector. One of them is Perform, Achieve and Trade (PAT). India's National Action Plan on Climate Change (NAPCC), 2008, under its National Mission on Enhanced Energy Efficiency (NMEEE) under its PAT scheme has set an energy saving target of 6.6 million tonnes oil equivalents across nine energy intensive sectors. The power sector is expected to contribute for around 50 per cent of this saving. Since energy is directly related to CO2 emission, the GHG burden will also be reduced. The first cycle of the PAT has just been completed; a more rigorous one is expected next.

The government has committed that only super-critical technology plants will be promoted and installed in larger projects such as "Ultra Mega Power Projects (UMPP)". The plants installed after 2017 will have only SC technology and will all be indigenous. This is though a welcome step, it must also be noted that around 40-GW Sub-C capacity has already been cleared by the government, which is now in the pipeline and India doesn't have the indigenous capacity to produce many SC technology plants.

As per Niti Ayog's report (2015), USC and IGCC technology will be commercialized after 2017 and 2027 respectively. This will lead to an increase in domestic coal demand to 1345 million tonnes by 2047. To deal with the CO2 emission problem arising due to increasing coal use, Niti Ayog's report suggests that the Government use carbon capture and storage (CCS) technology- 1 GW generation capacity with CCS in 2022 will increase to 35 GW capacity by 2047.



However, there remains the fear of pollution potential because of increase in coal use in the future. The way out still demands many precautions and preparation. Up-gradation in pollution control technology, tighter pollution control norms, real-time monitoring and reporting systems and development of market-oriented pollution control plans and supporting incentive plans need to be adopted.

It is good to know that the government has also taken steps to upgrade the pollution norms for the sector. The Ministry of Environment, Forest and Climate Change (MoEF&CC) has issued the draft notification of pollution norms. It has not only tightened the norms for PM, but has also introduced norms for SO2, NOx and mercury. Water consumption limits have been also introduced.

MoEF&CC (Draft) notification for new standards for coal-based power plants

Pollutants	Unit size	Installed before Dec 31st, 2003 (shall meet within 2 yrs)	Installed during 2003 to Dec 31st, 2006 (shall meet within 2 yrs)	Installed Jan 1, 2017 onwards (Includes accorded EC, under construction)
PM	All	100mg/Nm^3	50 mg/Nm^3	30 mg/Nm^3
SO2	<500MW	600 mg/Nm^3	--	--
	>=500MW	200 mg/Nm^3	200 mg/Nm^3	100 mg/Nm^3
NOx	All	600 mg/Nm^3	300 mg/Nm^3	100 mg/Nm^3
Hg	>=500MW	0.03 mg/Nm^3	0.03 mg/Nm^3	0.03 mg/Nm^3
Water Use	OTC plants	Install cooling tower (CT) within 2 years		
	CT plants	Reduce sp. water consumption upto max 3.5 m^3/MWh		Zero Liquid Discharge (sp. water consumption max 2.5 m^3/MWh)

Source: MoEF&CC, Govt. of India

Apart from setting up tighter norms, an initiative to mandate real-time pollution monitoring has also been initiated. By now, the government has mandated installation of real-time pollution monitoring and reporting devices in the industries, though, a full-fledged system with protocol is yet to be implemented.

In order to deal with the waste (ash) generation problem from the sector, the government has issued a notification (draft) intending to ensure 100 per cent fly ash utilization. The notification demands that only fly ash bricks be used in construction activities happening 500 km around power plants. And power plants, which generate this ash, have to bear the cost of ash transport up to 100 km for use in private sector-owned construction and up to 500 km for government projects. This notification has brought only a little change over the existing regulation, which demands ash utilisation up to 100 kms from the power plant and that the plants provide ash for free. This notification, however, may see failure like the earlier one, if the implementation plan is not strengthened. Successful implementation requires policies to increase ash demand and supply side push, mandate for use, skill development etc. 100 per cent ash use can not only reduce the pollution, but will also save land required for disposal. Right now, around 40 per cent of land is required only for disposal.

Challenges ahead

Issues are known to all, whether industry or the government. Action requires collaborative efforts.

Domestic coal is of poor quality; high in ash and low in energy content which is a barrier for efficient and clean power generation. Solution can be made by developing adequate infrastructure like coal washing facility and coal supply. To meet the requirements of the tightened pollution norms, high-end and costly pollution control devices are also required which increase the cost of power as well. The question of techno-economic feasibility demands government support for level-playing field among plants, change in MOD approach, financial incentive to the industries etc.

The system of regulation in the sector also needs to change. Power is a concurrent subject, therefore, overlapping responsibilities create conflicts which lead to no coherence on regulation on energy generation, tariff decision, capacity expansion and shuttering policies, etc. The centre formulates the policies while implementation is left to state level. Adding to it, the state electricity boards have no money for investment on new technology and R&M. Since electricity is needed, shuttering is also a far-flung option. Most of these plants have cheaper long-term coal access, almost free and dedicated water resources and least investment on pollution control. Since electricity is produced is cheap, unfair MOD allows them to sell electricity first while industries, which invest on technology and pollution control, don't get priority because of their cost of increased cost of electricity. This discourages high-end technology investment and forces them not to run on full capacity utilization.

For pollution regulation, the real time pollution monitoring (continuous emission monitoring system; CEMS) is at the initial stage in India and requires skill development and capacity building for both regulators and industries. All this may need time and investment, all before the regulation is put in place.

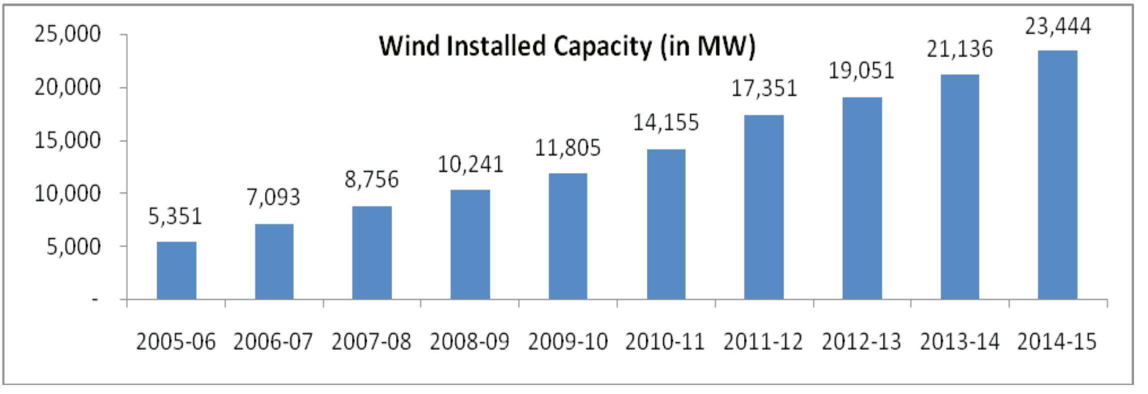
These initiatives are welcome steps of the government. However, actual implementation is wanted that too on time. Many industries and stakeholder groups have positive sounds for these regulations while others have not. It is yet to be seen if we successfully adopt it or not. At-least, all these bring some hope and indicate positive changes in idea, attitude and approach.

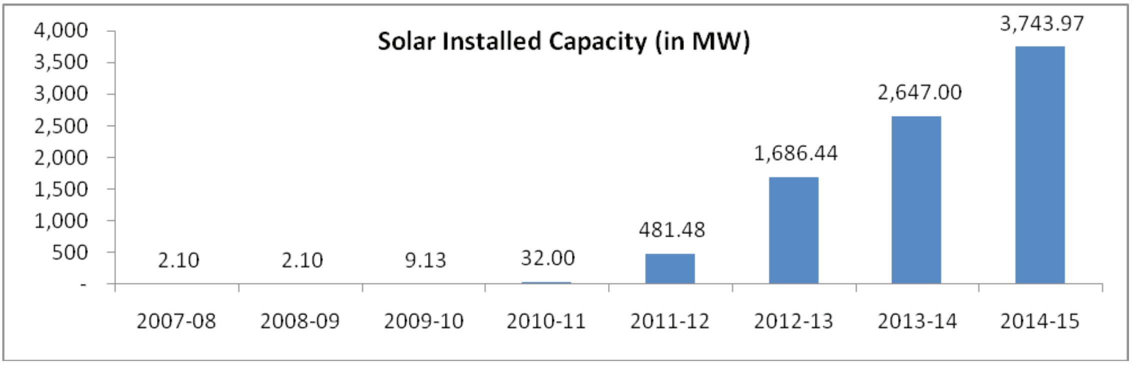
The renewable energy scenario in India

In a country with about 275 giga-watts (GW) of power-generating capacity with 65 per cent of it coming from coal, the ambition is that there would be 175 GW of renewable energy by 2022. The renewable energy sector has indeed garnered a place in the Indian energy scenario.

Renewable energy has done immensely well in the last decade or so. Wind installations have increased at a compounded rate of 18 per cent and solar installations have increased at a rate of 198 per cent from 2007 till March 2015. That is development at its best possible rate. Given this trajectory, by the end of financial year 2021-22, India can install the targets of 100 GW of solar power and 60 GW of wind power.

However, there are so many question associated with renewable energy development. How will a country with limited resources manage to achieve this target? Whether this enhancement will be able to provide electricity access to the 300 million people in India who do not have electricity and many more that do not have sufficient amount of power to cater to their basic needs? What this development means to the energy mix, whether thermal power would be phased out with subsequent increase in renewables? And what about the environmental impact of these installations, has that been accounted for in the development?





Managing limited land resources

Land in India is scarce and heavily contested for. Hence, there are three important concerns to keep in mind with respect to land:

- Land is used optimally based on the technology adopted
- The land used is not forest or agricultural land
- Local communities are benefitted from the plant in terms of adequate compensation for land purchase/land lease, employment and energy access

The Rajasthan Solar Policy 2014 states that an SPV or a CSP plant would be allotted a maximum of 3.5 hectares per mega-watt (MW) depending on their capacity utilization factor. However, according to CERC, the average land area required for a solar PV plant is 2.2 hectares per MW.

The government intends to develop 100 GW of solar and needs to encourage innovative solutions to address the non-availability of land. Solar park, canal top plants and rooftop solar are the chosen option for the government for large scale solar development. Wind power turbines, on the other hand, have a total height of 100-150 meters on an area of not more than 10 x10 square meters.

The Ministry of New and Renewable Energy (MNRE) has announced its plan to spend Rs 4,046.25 crore on developing parks in a scheme to set up 25 solar parks across the country. The capacity of each park would vary between 500 to 1,000 MW. Piyush Goyal, minister of state (independent charge) for power, coal and new and renewable energy, said, “The estimated cost for development of a solar park would be around Rs 0.95 crore per MW.” Back in December 2014, MNRE had received applications of setting up solar park with a total capacity of 22.1 GW. Essentially that comes down to an investment of more than Rs 21,000 crores in an area of 48.6 thousand hectares of land.

There are reports suggesting that barren land would be utilized for setting up of these solar parks. India’s only operational solar park – Charanka - is spread over 2,000 hectares of wasteland in Gujarat with an ambition of setting up 600 MW of solar and 100 MW of wind generation. Water for the projects comes from a canal and a large human-made pond. A check-dam was demolished by the project proponent. Gujarat State Petroleum Corporation (GSPC, the petroleum company is one of the developers in Charanka) has provided an above-ground tank for the village, but that remains nonoperational.

This is one of the contentions with acquiring large masses of land in a technically deemed waste land that there are still people depending on that land for grazing, foraging fruits and firewood. Acquiring these lands will affect the local community.

In Kalpavalli region in Andhra Pradesh’s Anantapur district, for instance, people from eight villages toiled for a decade or two to convert the wasteland into forests of 2,833 hectares (ha). However, the state government allotted 28 ha of ‘wasteland’ to German company Enercon through its subsidiary Enercon (India) Ltd, to set up a 50.4 MW wind energy project. Apart from this land, the company used 79.3 ha for building roads. State biodiversity board chairperson, R Hampaiah, says, “It’s true that this was revenue wasteland. But it has been regenerated and has a forest which is common property”. Enercon paid Rs 20 lakh to the Kalpavalli tree growers’ society for the damage done by its wind mills. Aggrieved parties say the cost of damage is Rs 20 crore.

Leasing the land from the farmers, instead of buying, in order to generate a steady income for the farmer can be a solution since farmers tend to earn a fortune by selling their land to project developers; but in the long run, they are led to poverty because they are unable to find another source of income. Also, solutions like rooftop solar and canal top solar plants are an innovative way of reducing the impact on land in India.

Out of the 100 GW of solar, 40 GW has been dedicated to achieve through rooftop solar installation. There are inherent advantages of installing solar plants on rooftops:

- Using idle lands on rooftops - creation of value from under-utilized rooftops. 1 KW of solar PV – crystalline or thin-film requires an area of around 7-15 square meters.
- Savings in developing transmission infrastructure
- Savings in transmission and distribution losses

For wind, since off-shore is an expensive alternative, most developers focus on on-shore wind installations. Forest diversion is also a concern when it comes to wind installations. A large number of wind power projects have been commissioned on forest land, mostly in Karnataka, Maharashtra, Andhra Pradesh and Madhya Pradesh.

There should be a nationwide study to assess the potential of different renewable energy resources. Resource assessment is very imperative, especially with the mapping of transmission lines, substations, roads and forest areas along with the potential. For hydro projects, a carrying capacity study over a river basin should be executed for all rivers. The distance between projects and the overall percentage of river length affected must be decided on the basis of the carrying capacity study.

However, after this resource assessment is complete, there should be a zonation of no-go areas based on this assessment. There should be clear demarcations of areas where there would be no renewable energy plant allowed to be set up.

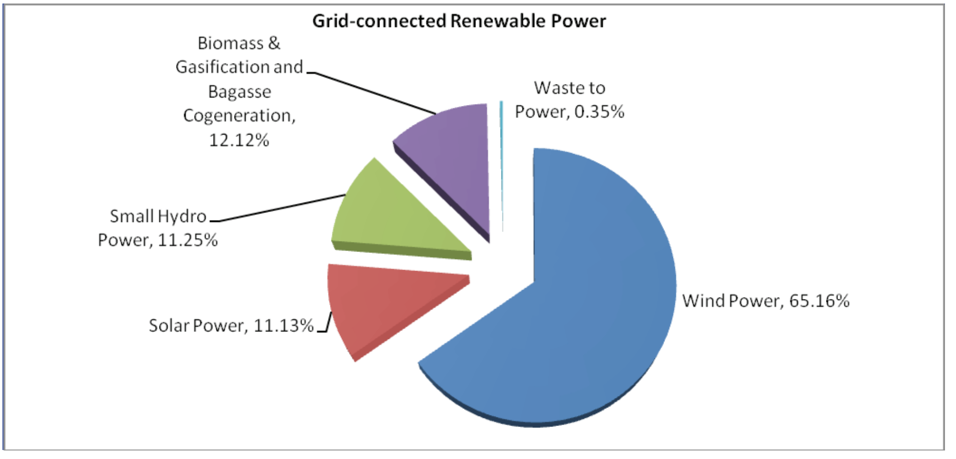
Benefiting the community

Renewable energy must benefit the local community. Communities must have the first right over the electricity from renewables.

In Rajasthan, the solar plants have to power the national grid, as per JNNSM. There are no special allocations to provide power to the local community, who are largely deprived of electricity. Solar PV plants have a good production curve that can easily accommodate the demand curve of a typical community. On the other hand, the project developers argue that as per the contract, the plant is not obligated to supply power to the local community. This needs to change since there are still around 300 million people in India who have no access to electricity.

Renewable sources for energy access

India has accomplished a lot in renewable power generation. As on June 30, 2015, India has an installed capacity of 274,817.94 MW of power generation out of which 13.02 per cent i.e. 36,470.64 MW is renewable power.



However, even after 68 years of independence, there are 306 million in India who do not have any access to electricity. If we include households that do not even receive 6 hours of electricity in a day, this number would increase manifolds. The Modi Government announced that they plan to supply 24x7 power to all by 2019. This seems an enormous task ahead given the fact that even in the national capital region, there are huge power cuts especially in summers.

The biggest social and economic impacts of renewable energy will be in providing clean energy to the energy poor. Decentralised renewable energy can provide basic energy access to all.

The focus with grid-connected projects are encouraged, the government however needs to shift the attention to set up decentralised distributed renewable energy plants. Mini-grid projects should be provided with a feed-in-tariff (FiT) or Viability Gap Funding (VGF), like grid-connected projects. The current mini-grid projects charge the customer an exorbitant amount for one unit of power, much higher than what their urban counterparts pay for the same unit of electricity.

The cost that is expected from the rural consumer should coincide with what consumers in the villages are willing to pay (say equivalent to the replacement cost of kerosene). But this does not mean that the developers should suffer losses. Feed-in-tariff (FiT) or

Viability Gap Funding (VGF) would encourage entrepreneurs to decide their own mix of renewable energy to achieve the lowest price for a pre-defined service quality. Such projects can be made grid interactive. When the grid reaches villages, the mini-grids can be used to export power to the grid, as well as import from it depending upon growing needs or deficits.

The draft renewable energy act has given various incentives for decentralised distributed generation (DDG) both in rural and urban areas. It wants to encourage grid connectivity for the DDG systems along with ensuring energy access. They have also introduced the idea that renewable energy based DDG system can be used to fulfill renewable purchase obligation for Discoms, open access consumers and captive consumers.

Centre for Science and Environment (CSE) envisions a system that enable modern, distributed, people-centred and decentralized renewable energy power generation from a large range of sources and developers. In the future energy system there will need to be millions of small and medium-sized entities that act as both producers and consumers of electricity, mixed with traditional large-scale generation.

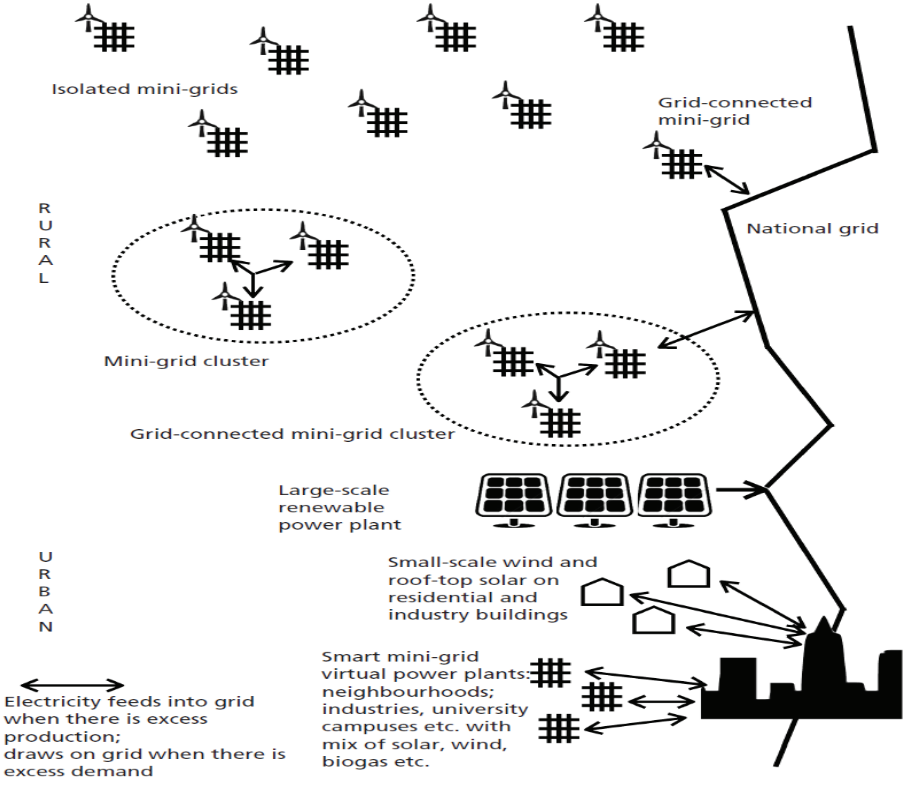


Figure: Future Energy System - distributed, decentralized renewable energy power

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Mr. Sanjeev Kanchan is an environment and sustainability professional associated with CSE for the last seven years. His area of expertise includes resource efficiency, pollution control, clean technology, life cycle assessment, monitoring and reporting, policies and regulations and CSR. He has also worked closely with ministries, government bodies, large scale industries, think tanks, leading educational and research institutions and civil societies. Mr. Kanchan has authored/co-authored and contributed to a few reputed books on industrial pollution and control, best technology and sustainability: Into The Furnace (A Life Cycle Assessment Of Steel Sector), Heat On Power (Coal Based-Power Sector Research), Best Available Techniques And Technology For Integrated Iron & Steel Sector, Excreta Matters- Citizens Report (7th)- State Of India's Environment.

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Centre for Science and Environment (CSE):

CSE is a public interest research and advocacy organization based in New Delhi. CSE researches into, lobbies for and communicates the urgency of development that is both sustainable and equitable. The challenge is to work towards a balance between a biomass based subsistence economy, people living margins of survival and On the other hand, rapid industrialization, growing toxification and a costly disease burden. Their aim is to raise these concerns, participate in seeking answers and transforming these into policy termed as knowledge-based activism.