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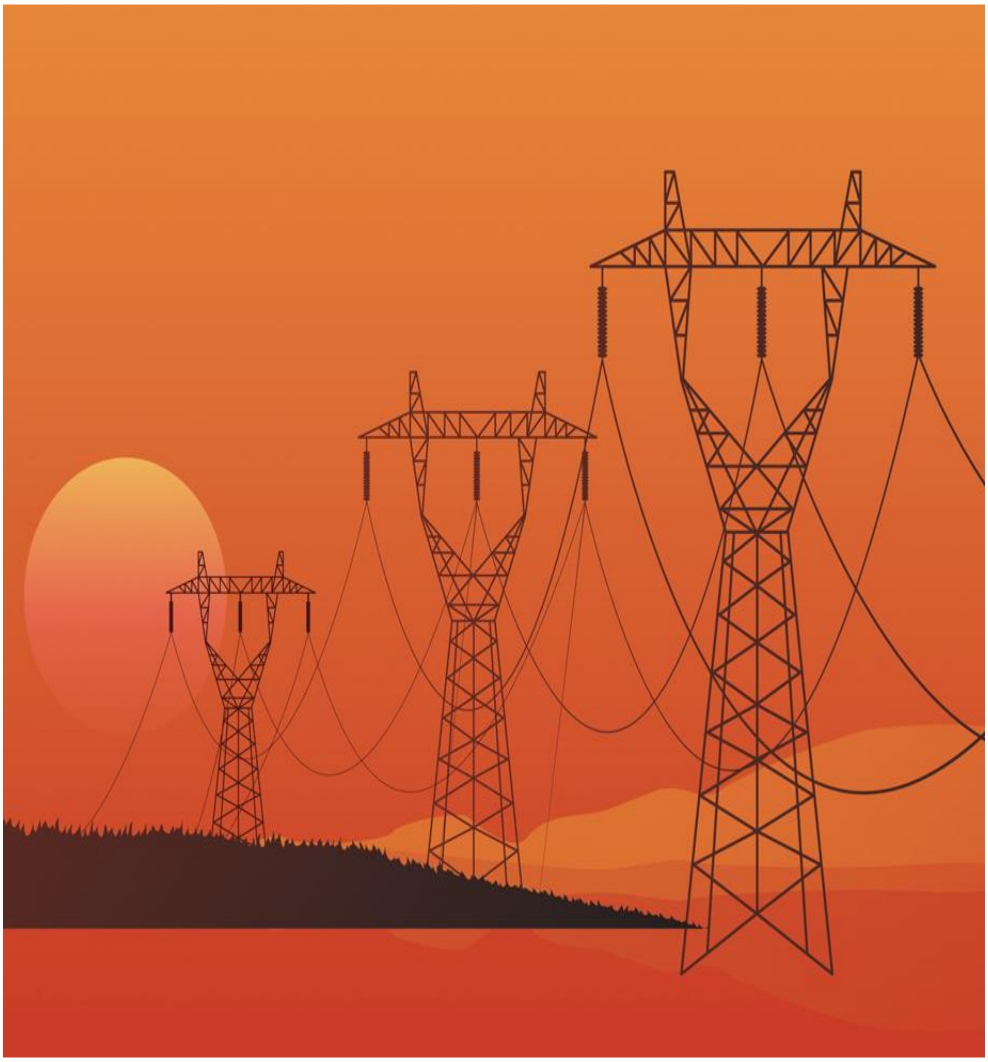

The 'Great Indian Blackout': Why India's Electricity System Needs a Technological Revolution

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One of the major challenges facing modern India today is undoubtedly a reliable and widespread power supply. The strain between rising demand, frequent blackouts, and the lack of a reliable and secure electricity grid has long passed crisis point. The extent and severity of the problem came to the fore when India experienced its worst ever blackout at the end of July 2012. The blackout lasted two days and estimates of the numbers left without any electricity vary from anywhere between 600 million to 700 million people; this is equivalent to double the population of the US which is why this warrants further examination. The blackout is evidently an event India can ill afford to happen again. From the outset, for the affected population the inconvenience caused by being left without any power is huge. Furthermore, the loss in terms of economic output and the damage to the country's image overseas as an 'emerging economy' are very significant.

The all too familiar and well-documented problems of frequent blackouts, rural electrification, unreliable coal supplies, and lack of investment in the infrastructure, suggests that neither state-ownership or privatisation have delivered the results needed to turn around the sector and bring about the necessary improvements up until now. Looking forward, they are even less likely to. A look at the experience of privatisation in Orissa provides enough evidence to lay bare the fact that previously tried solutions to these problems are well past their sell by date. Orissa emerged as a 'test bed' for a major reform programme, despite one of the lowest per capita GDPs in India, principally because of its small agricultural sector and weak level of resistance within it. In 1996 the State Electricity Board (SEB) was restructured whereby transmission and distribution were separated from one another. Orissa was divided up into four distribution zones that were then privatised. On top of this, Orissa's generation and transmission was also restructured and hived off into separate entities. This bold move on the generation side was replicated elsewhere such as Karnataka. The new private entities were expected to cut transmission and distribution losses, improve managerial efficiency and make capital investments to improve technical efficiency. Many of the reforms were implemented by consulting firms. However, it is now widely accepted that privatisation was unsuccessful in Orissa as the sector's problems went unresolved. The exact cause(s) of this failure is subject to much debate (Kale, 2004). All in all, the generation side was opened up but the distribution side has remained state-run.

In retrospect, if the ultimate objective of privatisation was the transfer of a large portion of the electricity sector to the private sector, then the exercise 'failed' according to the statistics. According to the IEA (2010), as of 31st July 2009, India had a total of 151, 073 MW of installed capacity of which 86.5% was publicly owned, either by the states or by the central government. The state governments possessed the largest share with 52.5% or 76,364 MW, and the central government's share was 34% or 48,970 MW. Whether it has been the failure to introduce competition with an 'incomplete' grid and chronic electricity shortages or the near complete lack of interest of private buyers to purchase public assets (in Delhi there were only two bidders for the purchase of three distribution firms) the state is still left to tackle the many challenges associated with an electricity system under strain (Dubash & Singh, 2005). Where there has been a change is how it approaches these challenges. A distinct change of tack can be detected away from the over reliance on the orthodoxy of restructuring and promotion of competition and choice in the sector towards the development of more partnerships with private firms and the fostering of renewable energy technologies. If there are any important legacies of privatisation one of these must be the opening up of the sector to the private sector.

Faced with the harsh reality of a long-standing power crisis and a continued reliance on fossil fuels (coal), India needs a radical new approach. A technological revolution in the sector is the only serious available option. Further elaboration here is required to emphasise what the true scale of the change proposed entails. An excellent starting point is Perez (2010) who argues, that 'on a first approximation a *technological revolution* (TR) can be defined as a set of interrelated breakthroughs, forming a major constellation of interdependent technologies, a cluster of clusters, or a system of systems' (Perez, 2010: 189). She further states that what makes a technological revolution stand out in relation to a random collection of technology systems are two main characteristics. The first is a 'strong interconnectedness and interdependence of the participating systems in their technologies and markets', and the second is a 'capacity to transform profoundly the rest of the economy (and eventually society)' (Perez, 2010: 189).

An already bad situation in the power sector has continued to deteriorate. With an abundance of evidence available to show the current infrastructure is not fit for purpose. With the emergence of new technologies, declining costs (as in solar), innovative technological combinations, and other countries making improvements to increase their own levels of electrification, India has an ideal opportunity to build a new electricity infrastructure in many respects and begin the process to find solutions in earnest to its endemic problems. The technological revolution that has swept through the telecommunications sector over the last 15 years provides the power industry with some very useful lessons. Prior to the advent of mobile phones there had been a long-standing concern that vast swathes of the population in developing countries would be excluded from access to a telephone without a national landline infrastructure. With the growth of mobile technology, however, countries have been able to 'leapfrog' any need to build a landline infrastructure and provide access to telecommunications to the masses as the mobile phone has become ubiquitous across the globe and costs have plummeted ('*Learning from the Cell Phone Phenomenon: How Microgrids Can Help Developing Countries Leapfrog into a New Energy Paradigm'*, 29 July 2013). If the Indian telecommunications can leapfrog an old infrastructure, its electricity sector has an equal incentive and potential to follow suit.

1.1 New Energy Paradigm

At the dawn of the new energy paradigm, along with many other countries that want to make the transition to a low carbon energy system, India has found it must forsake the 'top-down' approach and adopt a 'bottom-up' approach and in order to realise its ensuing objective. The former approach incorporates state-regulation with a focus on strong grid connections and large power plants. The emphasis of the latter approach is on locally based solutions with small power plants that include renewable energy and micro-dedicated grids. This type of grid has a potential to be connected to other grids over the long-term. Unlike in the previous paradigm where the state managed the assets it owned; in the emerging paradigm it takes on a role as an 'enabler'. Here, through different initiatives and partnerships and by providing financial guarantees and backing, it works in collaboration with other parties, for example, to promote the adoption and diffusion of renewable energy technologies, build and install off-grid systems or develop the right policy environment. The transition to a low carbon economy is not just in India's national interest to rectify the deficiencies in its current electricity system, it is necessary for other reasons: to mitigate climate change and foster wider social and economic development. A ‘vision of the future’ can be found in the Danish island of Samso which is the world’s first 100% self-sufficient island based on renewable energy. The island gets its electricity predominantly from the 11 onshore and 10 offshore wind turbines, which generate a total of 34 megawatts. By 2030 the island aims to be completely free of any form of fossil fuels (oil, coal and gas) (‘*Samso: World’s First 100% Renewable Energy Powered Island is a Beacon for Sustainable Communities*’, 1 May 2014). To develop a low carbon economy India will be heavily dependent on imported technology from abroad, predominantly Western technology. Its successful introduction, adoption and diffusion is by no means a fore gone conclusion. Henry (1995) serves to remind us of some historical examples during the Raj when new technologies were introduced into different sectors and failed for some very specific reasons. One of the examples is the sugar-refining industry that despite 40 years of government efforts prevented the introduction of a ‘foreign’ technology because of the social barriers erected against it. At a wider level he goes on to state that where ‘…social and economic factors were ignored, the transfer of technology failed’. Having said that, the likelihood of success is greater when there is ‘…a rare combination of modern technology, careful judgement and local understanding’. This is as relevant today as it was then.

There are fewer areas of greater need for affordable and reliable electricity than in the rural areas of India. The central government recognised the scale of the challenge several years ago and the enormous benefits there we are to be gained if electricity could be made accessible to the entire population. Modi’s (2007) analysis reveals it is a ‘win-win’ situation if the rural areas are properly electrified as the likelihood is an increase in productivity in agriculture and labour, an improvement in communications (mobile communications and radio), improvement in the delivery of health and education, reverse the disempowerment of women and reduce levels of illiteracy. One such development that promotes the tremendous benefits of rural electrification, and at the same time validates Modi’s analysis, is the Shared Solar initiative (pioneered by the Earth Institute at Colombia University, USA). Its key objective is to develop and promote the viability of new power infrastructures to provide affordable grid-like services to remote, rural communities.

In February 2005 the Ministry of Power (MOP), under its ‘Power for All by 2012’ initiative, launched the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) programme to improve the rate of rural electrification. This was a flagship initiative aimed at bridging the long standing urban-rural divide in electricity and was to provide a minimum of between 6-8 hours a day of quality and reliable power. It included three highly ambitious targets to be achieved within a 4-year timeframe. The targets stated were the electrification of the 125, 000 villages without electricity, to connect the estimated 23.4 million households below the poverty line (subsidised by the MOP), and to strengthen and upgrade the grid network which connected all 462,000 electrified villages (IEA, 2010). The expected long-term success of the programme was based on the assumption the centralised grid system could be 'easily' extended as and where necessary and where grid penetration was not feasible or cost-effective, some type of decentralised grid generation (DGG) system could be supplemented in its place. The programme does not *per se* encourage the adoption of low carbon energy technologies, or that small villages become independent producers and feedback any surpluses back into the grid, or incorporate regional demands and variations. Little does anything appear to have been learnt from the privatisation experiment where major changes and reforms failed, amongst other things, due a combination of deeply embedded vested interests and implementation moved at a glacial rate. The lack of appreciation of the myriad of practical hurdles to be overcome, added to the fact the original programme had some major structural flaws designed into it, has led the programme to fall well short of the original targets. The date for when the programme was due to expire has been extended to the 13th Five Year Plan (2017-2022) and access to a reliable and quality source of electricity to the huge rural population where it has had a real and visible impact remains no more than a distant prospect which is still a long way over the horizon (IEA, 2010, greenpeaceIndia.org, 2011a).

Greenpeace (India) has highlighted the state of Bihar as an example of what has gone wrong with the RGGVY programme. The organisation's own assessment of the situation in Bihar is it is very challenging. To begin with it has the highest peak power deficit which stands at -33.7%. In the Madhuban district, the villages that qualify for the scheme fall into the categories of 'un-electrified and de-electrified' and 'previously electrified and taken up for intense electrification'. Where a village does have a connection, 95.3% families in dwellings with metered access to the electricity have experienced a supply that is very erratic, unreliable and very low voltage. An often cited problem is the voltage can be so low it is insufficient to power a light bulb. The power supply is often only available after midnight when it is not required. Even in villages already with a connection there is no electricity, for example, in Parwalpur (Madhepura Block) that was connected in 2010 (greenpeaceIndia.org, 2011c). More generally, within Bihar, there are extremely few electricity connections to schools, health centres or for employment generating activities (greenpeaceIndia.org, 2011a). Certainly, in the case of Bihar the RGGVY scheme has not delivered the expected outcomes due to the dilapidated condition of the existing infrastructure and widespread graft. An article in the *Economist* analyses how endemic graft is and the damage done to the economy generally. Power projects have certainly not been immune from the effects of graft (*Economist*, 15 March 2014). Any remedies to the situation in the first instance would need to include a complete culture change.

An additional front aimed at tackling the shortage of generation capacity and improving the level of electrification in the rural areas is the Jawaharlal Nehru National Solar Mission (JNNSM). Launched in 2010, the JNNSM has two overarching policy objectives; the installation of 20 gigawatts of solar capacity by 2022 and to turn the country into a world leading solar hub in low-cost, high-quality solar manufacturing across the entire value chain. How successful the JNNSM is over the long-term remains to be seen as the creation of a new industry from the very beginning is a mammoth and highly complex task. Its success or failure depends on the country's ability to create what is described as an 'Enabling Environment'. In practical terms, this encompasses the whole spectrum of activities ranging from land acquisition, planning and implementation, the manufacture of solar technologies, research and development programmes, to the grid-connection of large solar plants. The core approach of the JNNSM can be found in the mission statement that emphasises the exploitation of solar technologies at both the centralised and decentralised levels. The actual wording of the mission statement is interesting in itself as it is a subtle admission that the former once dominant top-down approach is no longer sufficient and alternative approaches are needed if the current and future demand for electricity is to be met.

One other feature of the JNNSM is it aims to be technology-neutral inasmuch it does not seek to promote one specific technology at the expense of others. The hazards of 'picking winners' are well known and there is a probability the exercise will be prove wasteful. Nuclear power is one example that was expected to generate large returns but in the end the technological expectations were never realised. Solar technologies incorporate concentrated solar power (CSP) and photovoltaics (PV) of which there are a number of different technologies within each of these different categories where the scope for innovation for each specific technology varies widely. Within the two categories, the two technologies which have emerged whose rate of adoption is on upward trajectory are solar thermal (CSP) and thin-film (PV). The actual progress made by the JNNSM to date varies according to different reports. The amount of installed solar capacity ranges from 1,685 megawatts to 2.1 gigawatts for the first phase of the scheme ('*India sets 10 GW solar target by 2017'*, 26 September 2013,'*India 'keen to work with Qatar on solar plans*', 22 November 2013). Whatever the real amount is, progress of the right kind has been made. As the JNNSM heads into its second phase concerns have already been voiced over the potential of the JNNSM to falter. One critic is K. Sivadasan, a retired former top official of the Kerala State Electricity Board. From his perspective, there are a number of potential sources that could well generate problems in the future. His first observation is the lack of focus on the infrastructure on which the JNNSM is based. His other observations include: the JNNSM's lack of a global vision, rigid policy structures and lack of adaptability, the lack of scope for creative entrepreneurship, and flaws in the financial model used ('*India's solar mission failing to recognise country's potential, says top researcher*', 26 September 2013).

Whatever the problems that may materialise in the future, the JNNSM is testimony to the fact India is determined to exploit solar technologies as it has few other options. Nevertheless, the insights of Sivadasan raise the important question about the overall efficacy of the JNNSM's current structure as without the right 'formula' India's ability to really maximise its solar potential will be much diminished with serious repercussions. More immediately, India's dispute with the US and China over the production of solar panels and the local content provisions contained within the JNNSM awaits a resolution by the World Trade Organisation (WTO) ('*India US Solar Dispute Escalates'*, 10 June 2014).

1.2 Future Potential Scenarios

Following on from this are the two pathways in the 'solar arena' that India ideally needs to follow. The first of these pathways relates to the construction and establishment of large solar parks in regions such as Gujarat and Rajasthan. These are essential in their own right if adopted with a careful eye to environmental planning as they increase the overall level of installed generation capacity and are vital if the high demand for electricity is ever going to be met. The growing evidence would suggest this pathway has already been embraced albeit without careful thought to the environmental implications on desert ecologies, land use implications and impact on bird and insect life and the process of consolidation is well and truly underway. The environmental regulation of this technology has not kept pace with as its potential promise unfolds. The second pathway concerns off-grid systems, especially microgrids, as a potential low-cost and effective solution for providing electricity to households and villages in the rural areas. With this pathway microgrids do not seem to have received wide attention. A third pathway and one that is still a long way off over the horizon, but the signs of it developing are already apparent, is the Asian Super Grid. This initiative is an added component of the Desertec Foundation's original concept to link the electricity grids of European countries to sources of renewable energy (mainly solar) in the deserts of North Africa, again with environmental implications that need serious consideration (Showers, 2011). With the Asian Super Grid the long-term vision is to initially link the electricity systems of Japan, China, South Korea, and Russia together with renewable sources such as large wind farms situated in the Gobi desert in Mongolia. Later on, the grids of India, the Philippines and Thailand could be included (Matthews, 2012). This third pathway could well provide India with an additional source of electricity, help it to tackle climate change, and contribute to its energy security.

For more than two decades India has been attempting to 'fix' its decrepit electricity system. It now stands at a crossroads where it has another opportunity to redeem the situation afforded to it by the opportunities presented by a new technological revolution. This is where India ought to focus the majority of its attention as this is where the future lies, and where other countries are also heading as they seek to build their own low carbon energy systems. The fact is India's old centralised power model cannot even meet the demands of the present let alone the future. One question that does not appear to being asked but should is what is the actual physical condition of the electricity system across the country? In view of all the problems it is known to suffer from there remains a distinct possibility it is beyond 'effective repair'. In other words, the scale and depth of the problems are such that for all the reforms introduced they cannot make a marked and fundamental difference if the physical infrastructure is in very poor condition and highly inefficient. Any attempts to modernise it on a large scale will require huge investment and take years to bring up to standard. The type of huge investment required can be found in one recent report which has stated India needs to spend $250 billion within the next five years to address its power requirements ('*India Must Spend $250 Billion by 2019 to Meet Its Power Needs*, 7 November 2014).

The impact on ordinary peoples' lives that the lack of electricity continues to have was again illustrated when thousands rioted across northern India in early June 2014. In the midst of a severe heat wave, where the temperature reached 117°F, Uttar Pradesh with a population of 200 million experienced major power cuts. Even under normal conditions the state cannot provide anywhere near a reliable 24 hour supply of electricity to the population assuming they are connected to it, the grid 'tripped' as demand soared from 8,000 megawatts to 11,000 megawatts. Air conditioning, fans and city water pumps all failed. People angry at the situation set fire to electricity substations and even took power officials hostage (‘*Indians Riot Over Power Cuts During Heat Wave'*, 7 June 2014).

Official acknowledgement that ‘drastic action’ is needed came in the first budget of the new Prime Minister Narendra Modi’s government. Renewable energy (particularly solar) was given a high priority in it. A number of on and off grid measures were announced. These included an allocation of $93 million for large solar projects to be constructed in Rajasthan, Gujarat, Tamil Nadu, and Ladakh in Jammu and Kashmir. There were further allocations of $73 million that would go towards 100,000 solar-powered irrigation pumps and water pumping stations for off grid areas, and $18.5 million for developing 1 MW solar parks along canal banks (‘*Government’s first budget promotes solar energy, safety for women*’, 11 July 2014, ‘*India Pledges $250 Million to Grid Improvements, Solar Power'*, 18 July 2014, ‘*Modi accelerates India solar revolution, doubles tax on coal*’, 11 July 2014).

Even more ambitiously, Modi has promised that every household will have at least one solar light by 2020 as part of the ‘saffron revolution’. The government is keen to use the lessons learnt from the successful development of solar power in Gujarat and apply them more widely across the country. In the recent budget speech the finance minister Arun Jaitley sought to give a push to solar power setting aside Rs 500 crore for developing four ultra-mega solar power projects in Rajasthan, Gujarat, Tamil Nadu and Ladakh. Work on one such 4,000-megawatt project, near the Sambhar Salt Lake in Rajasthan, is on with an estimated investment of Rs 7,500 crore. (*Business Standard*, July 11 2014). The state of Gujarat was the first to attempt the Canal Solar project, to use the 12,000 miles long network of Narmada canals across the state for setting up solar panels to generate electricity as an attempt to obviate the requirement to acquire vast tracts of land and to limit evaporation of water from the 750-meter long canal.

India derived huge benefits from the technological revolution that swept through telecommunications. Likewise, there is nothing to stop it from taking advantage of a similar type of revolution in electricity. India has no time to lose.

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