Current Ecological Concerns in the Power Sector: Options to Avoid or Minimise Impacts

Dr. T. R. Shankar Raman
Dr M. D. Madhusudan

Can India reconcile the needs of ecology and equity against the demands of energy and economy? This is one of the major questions that confronts this developing nation undergoing major demographic, social, and economic changes. India's renewed emphasis on power generation, transmission, and distribution, and associated infrastructuredevelopment, plays a significant role in this growing economy. And yet, this carries both promises and problems for the country's ecology and society.

India is extraordinarily rich in biological and cultural diversity. Four global biodiversity hotspots (Himalaya, Western Ghats, Indo-Burma, and the Sundaland portion in the Nicobars) range within its borders. The country has over 660 wildlife protected areas, such as wildlife sanctuaries, national parks, and tiger reserves, which occupy less than 5% of the land area. Further, there are thousands of wetlands and other natural ecosystems such as grasslands, mangroves, and more: from hot deserts to trans-Himalayan cold deserts and coral reefs to high mountain ecosystems. These are home to hundreds of endangered species and unique endemic species that are found nowhere else in the world.

There is also constitutional recognition and protection to uphold India's vast ethnic and cultural diversity of our people (over 2750 communities have been identified by the Anthropological Survey of India's People of India project, Joshi et al. 1993). Further, many laws and government policies (such as the Forest Rights Act 2006) are built on these constitutional provisions to enable communities to develop in a manner that does not erode their cultural identity, needs, and values. As India undergoes an epochal shift in its development trajectory, it is critical to find and adopt sustainable and equitable ways to ensure that growth does not result in avoidable and irreversible damage to ecology and human communities.

In India, power generation, distribution, and related aspects including maintenance fall within the purview of the Electricity Act (2003, with amendments as on 2007) and the Indian Electricity Rules 1956 (amendments up to 2000). The Electricity Act of 2003 has among its stated objectives the 'promotion of efficient and environmentally benign policies'. Further, social and environmental impact assessment and mitigation procedures are mandated for infrastructure projects under environmental laws and regulations, but these have been strongly criticised both by developers and conservationists. Project developers see in them hurdles and delays, while social and environmental scientists question their credibility, utility, compliance and post-project monitoring. Failure to attend to critical social and ecological concerns often results in litigation and delays. Identifying and adopting pro-active and ecologically-appropriate solutions can help avoid confrontations and foster positive ways of developing infrastructure. For this, the recognition of the kinds of impacts (and their seriousness) and the availability of solutions needs to be more widely recognised and better understood.

Power Generation

India has a current installed capacity 274 GW, of which nearly 40% is produced by the private sector, 35% by the States and about 25% by the Centre[1]. By source, thermal power accounts for nearly 70% of the power output (of which coal-based thermal power accounts for >85%), and hydroelectric power, and power from renewable sources (including small hydel) account for 15% and 13%, respectively. Over the last 25 years, national per capita power consumption has risen by 300%, while the country remains chronically power deficient. This has provided the impetus for expansion in the power sector, where year-on-year growth targets for power generation in India have hovered around the 10% mark.

Why is power generation and transmission a wildlife conservation issue?

Worldwide, almost all countries now acknowledge anthropogenic climate change and the environmental footprint of energy production, especially carbon emissions. Climate mitigation efforts have become integral to mainstream policy-making and to many market-based initiatives. Yet, the impacts of power production and transmission on biological diversity, habitats, and ecological processes from which people derive various services, barely gets adequate attention.

For example, the foundational resources for thermal power generation—key coal-bearing areas—overlap with landscapes where our last forests remain, and where some of our most fragile and unique animals and plants reside[2]. Similarly the foundational

1 http://powermin.nic.in/power-sector-glance-all-india

2 http://cseindia.org/mining/forest_minerals.htm

resources for hydroelectric power generation—major river systems—are key habitats in larger ecosystems on which myriad species depend, and on which humans depend for a range of ecological services (irrigation, drinking water, transport, fish) besides power. The overlap would be of little concern if the processes of harnessing these natural resources for power generation were ecologically benign. But they are not. Benefits of any sort—power generation included—are seldom generated at zero cost. In fact, present policy and practice in the power sector often comes with undeniable ecological costs that are often significant enough to put the future of many species and ecosystems in jeopardy.

If we consider that private power producers and conservationists are both striving for larger societal good, it makes eminent sense that these groups strive for an approach that responsibly acknowledges both imperatives for the nation: power generation and nature conservation. It is in that spirit—of fostering a constructive dialogue and arriving at scientifically informed solutions—that we raise ecological concerns related to areas of power production and transmission. For a start, it is important to recognise the nature and extent of ecological impact from the key sources of power in India today.

Thermal power

Since Independence, India has witnessed a staggering 223-fold expansion in thermal power generation, which today accounts for about two-thirds of the power produced in India[3]. Most of this spectacular growth has come from coal-fired thermal power, with 72% of the domestic coal produced in India being utilised for electricity generation. It is well-known that India's coal reserves are relatively lower on calorific value and high in ash. Beyond CO2 emissions, mining has had obvious social and environmental impacts in terms of land degradation, air pollution, and public health (Choudhury 2015, Guttikunda et al. 2015, Raman 2015). The expanding footprint of coal-fired thermal power has also meant an increased demand for land for coal mining, which has consumed large swathes of biologically rich and irreplaceable forests (Fernandes 2012, Venkat 2015). While coal mining practices may be tangential to a discussion on power production, it is necessary to acknowledge and count the significant biodiversity footprint of this activity among the environmental impacts of thermal power generation.

Hydroelectricity

Corresponding to the exponential growth in thermal power generation, the share of hydroelectric power (as a percent of overall power generation) has declined from 53% in 1947 to around 14% of today. However, a renewed thrust on hydroelectric power envisions a targeted expansion of about 100 GW in the coming years, with 91% of it coming from

3 http://www.cea.nic.in/reports/planning/dmlf/growth.pdf

the river basins of the Brahmaputra, Indus, and Ganges in the Indian Himalaya[4]. The locations of most of these proposed hydroelectric dams falls squarely in the middle of one of the most biodiverse and ecologically fragile regions on earth (Pandit et al. 2014).

In the effort to meet these targets in the pursuit of larger economic goals, environmental safeguards have been the casualty. Environmental and Social Impact Assessments, which were meant to be honest appraisals of the potential negative consequences of large infrastructure projects like hydroelectric dams have been reduced to a paper-pushing ritual. As a consequence, it has now become possible to remove most of the water from a river course as in the case of the River Teesta in Sikkim[5] in order to generate power, or to alter river flow regimes so enormously that the entire amplitude of an annual low water – high flood cycle is created within each day (e.g., Demwe project in northeast India). The cumulative consequences of such manipulations by multiple dams on the river—an ecological entity—has seldom been assessed. Even where such cumulative ecological assessments have been carried out, they miss crucial aspects such as habitat of threatened or culturally significant wildlife (e.g., Black-necked Crane in submergence zone of Nyamjang Chhu project, Arunachal Pradesh), or produce recommendations that are mostly ignored.

Green Energy

Given the recent historical conflicts between energy production and ecological concerns with thermal and hydroelectric power, governments and businesses have shown greater interest in non-traditional power sources such as solar, wind, and small hydro. The environmental impacts of these have been considered to be smaller, earning them the label of green power. Yet, given that a 530% increase in green energy is contemplated—from 33GW currently to 175GW over the next five years[6]—it is worth asking what the ecological impact of such an expansion might be. Specifically, current plans include a 500% expansion in solar power over the next five years to 100 GW[7], a 250% increase in wind power capacity to about 60 GW, and of small hydro to 10 GW. A key question that remains is this: how green can green energy be when it is upscaled to match the aggregate output of thermal and hydroelectric power?

Although systematic assessments on the impacts of green energy projects on biodiversity in India are few, current indications on their ecological impacts are not particularly heartening. Based on accounts, such as the report of the Karnataka Elephant Task Force

4 http://www.cea.nic.in/new_website/reports/annual/hydroreview/hydro_review-2014.pdf

5 http://www.moef.nic.in/sites/default/files/Teesta_IV_Final_Report.pdf

6 http://articles.economictimes.indiatimes.com/2015-02-28/news/59613084_1_energy-sector-welspun-energy-infrastructure-bonds

7 http://pib.nic.in/newsite/PrintRelease.aspx?relid=122567

appointed by the Karnataka High Court[8], the spate of mini-hydel projects within elephant habitats in the state are likely to have had a significant impact, especially in terms of disrupting connectivity of elephant habitats, possibly increasing conflicts with people. Similar impacts are likely, especially with open habitat species, in solar and wind energy projects. Yet, conservation concerns have simply not found their way into planning and implementation process for such power projects, despite their "green" moniker.

Powerlines as linear intrusions: ecology and impacts

Power transmission infrastructure, especially overhead transmission lines that are part of the national grid, are also a significant concern from an ecological perspective as they are often proposed to be developed or pass through ecologically sensitive landscapes.Powerlines, mostly high and extra high voltage lines, are often established along long linear clearings that cut through natural areas like forests, grasslands, wetlands, and as a result, bring up a series of ecological concerns that are still not widely recognised in the power sector.

Some of the major ecological problems caused by powerlines are similar to those caused by other linear infrastructure intrusions such as roads. These are of three broad kinds:

1) Direct habitat destruction: Powerlines passing through forests involve felling of trees and clearing vegetation along the alignment and for widths of between 10 m to 50 m or more. This implies that there is a minimum loss of 1 to 5 hectares of forest cover for every kilometre of powerline. In dense tropical wet evergreen forests this means that roughly 500 to 5000 trees may need to be felled per kilometre. The building of access roads, construction and other works may cause additional habitat loss. The effects are particularly significant when natural ecosystems (such as tropical forests) are diverted for powerlines, because they often contain mature ecosystems that cannot be replaced or restored. These mature ecosystems invariably contain a greater diversity of native plant and animal species than the artificial plantations created (afforestation or reforestation) as 'compensatory' replacements.

2) Internal fragmentation and degradation: What is less often recognised is that powerlines, like roads, can also have serious internal ecological impacts on forests and other natural areas. When powerlines pass through dense forests, they cut the existing tract of forest into two or more fragments. A growing number of scientific studies establish that such internal habitat fragmentation can negatively affect the survival of many plant and animal species, as well as lead to various forms of degradation (Goosem 1997, Laurance et al. 2009, MoEF 2011). This may include:

8 http://www.indiaenvironmentportal.org.in/files/file/Report%20of%20the%20Karnataka%20Elephant%20Task%20Force.pdf

a. Breaking canopy continuity: many tree-dwelling forest species dependent on canopy continuity are detrimentally affected when such connectivity is broken by long powerline clearings. This could affect home ranges, behaviour, foraging and movement of animals, possibly also exposing them to greater risk of predation or electrocution during attempted crossings.

b. Habitat alteration and edge effects: Higher light penetration and desiccation result due to powerline clearings, and a number of changes occur both along the clearing and penetrating to varying distances from the edge. Higher daytime temperatures, greater diurnal fluctuation in temperatures, higher wind speeds and resultant windthrow mortality of trees lead to vegetation changes. Many invasive alien species spread along the disturbance zone along the powerline clearing, adding to the degradation.

Construction and maintenancedisturbance: Habitat disturbance along the powerline clearing may be maintained and exacerbated by periodic cutting of all trees and vegetation on either side. Movement of people, disposal of wastes, pollution and fire incidence, too, may result in hitherto relatively undisturbed areas.

3) Specific Powerline Impacts: Besides these effects that are shared with roads, there are other effects and concerns related specifically to powerlines:

a. Electrocution: Electrocution of wildlife, particularly endangered species, is one major concern (Figure 1). Large animals such as elephants have suffered electrocution deaths due to sagging of powerlines and due to drawing directly from the mains to electrify fences around farms. In a 5-year period, Karnataka state alone saw the death of 78 elephants due to electrocution (KETF 2012). The Elephant Task Force has noted this problem and proposed recommendations (Rangarajan et al. 2010). Where canopy is broken due to powerlines and roads, arboreal mammals such as primates (e.g., slender loris and lion-tailed macaques) may use the powerlines to cross from one side to another; this has also led to animal mortality. Powerlines are also implicated in collisions and deaths of large birds such as bustards, flamingos, and cranes (Sundar and Choudhury 2005, Tere and Parasharya 2011, Patil et al. 2011).

b. Vegetation clearing: Another main reason for impacts on natural habitats (loss, degradation, fragmentation) is the clearing of vegetation below and on either side of these powerlines along their entire length (Figure 2). This is particularly the case where the powerlines pass through forest areas. In practice, vegetation below these lines is completely clear-felled annually over a wide swath ranging from 30 m to over 50 m width. This creates serious negative effects due to habitat fragmentation, disturbance, degradation, spread of invasive species, fires etc. The presence of multiple lines passing through an area accentuates the 'internal fragmentation' effects (Goosem 2007, Laurance et al. 2009).

Figure 1. Electrocution of wildlife, particularly endangered species is a major concern in some landscapes. Top left: an Asian elephant in Karnataka (Photo: Vinod K.); Top right: lion-tailed macaque in Western Ghats (Photo: Hari Sridhar); Bottom: critically endangered Great Indian Bustard almost the entire world population of less than 200 being found in India (Photo courtesy:Devesh Gadhavi, Conservation India).

Figure 2. Reducing habitat fragmentation due to powerlines through forests; (a) Top: clear cutting vegetation along powerline alignments disrupts forest connectivity as seen here in evergreen forests near Periyar Tiger Reserve, (b) powerlines can be established with minimal disturbance to vegetation structure and connectivity (seen here in a powerline in California).

c. Passage through remote areas: Powerlines are often established along straight alignments that pass through remote areas, often over rugged terrain that earlier remained inaccessible and undisturbed. The increased access results in entry not just of disturbances but may also expose some areas to easier access for poachers and illegal activities.

Ways forward: policy and practice to avoid and mitigate negative impacts

An ecologically sound policy framework on linear infrastructure

The following schema was proposed to the National Board for Wildlife as an overarching policy framework for linear infrastructure intrusions such as roads and powerlines in India's natural areas:

1. Prevention: According to the 'Primacy of Prevention' principle, the first option must be to prevent linear intrusions, especially in critical habitats including wildlife protected areas. This has now become vital given the trend of increasing habitat fragmentation. Similarly, scientists have also argued on the need to prevent many large hydropower projects from coming up in ecologically important and sensitive regions in the Himalaya.

2. Restoration: Many options exist to recover habitats along both abandoned and existing alignments in various parts of India. Defunct powerlines and dams may be decommissioned, removed and habitat allowed to recover naturally or carefully restored following ecological restoration principles guided by biologists and local communities. Restoration could also be used to reconnect habitat below high powerlines as well as in stretches where powerlines can traverse underground.

3. Realignment: Projects that pass through natural areas or involve significant ecological impacts should perforce consider and propose alternate alignments, balancing possible costs with long-term social and environmental gains. For instance, a powerline realigned to avoid dense forest and pass through already developed areas, may have additional short-term economic cost, but long-term gains in forest protection, ecosystem services, and lower maintenance (including the avoided considerable annual cost of clearing vegetation over dozens to hundreds of kilometres).

4. Mitigation: Mitigation which is often the first (and only) consideration presently in linear infrastructure projects, should actually be the last option. Mitigation should be considered only for existing powerlines and new cases where the above three options have been comprehensively considered and ruled out with adequate justification.

Best practices and mitigation options

A range of examples and a growing scientific literature around the world document best practices and case studies to minimise the negative impacts of powerlines on ecology, species, and habitats. While a comprehensive review is outside the scope of this piece, a few examples provided below indicate how ecological considerations can be integrated for better, more efficient and benign powerline alignments, designs, construction, and maintenance. A caveat is that even successful methods cannot be blindly replicated everywhere and have to be chosen and fine-tuned to local ecology, species, and habitats. Mitigation measures always need to be site, species, and landscape-specific, with a crucial need to be informed and guided by local scientific research and expertise in wildlife and ecology.

1. Avoiding elephant deaths due to powerlines: Increasing powerline height, prevention of sagging lines, and using insulated cables for lines passing through forests are some suggestions that have been made (Rangarajan et al. 2010, MoEF 2011, KETF 2012). Draft guidelines[9] for roads and powerlines prepared for the Ministry of Environment and Forests recommend that the height above the ground at the lowest point of the lowest conductor or grounding wires (i.e., at maximum sag point) of powerlines, whether insulated or bare, passing through all natural areas with known presence or movement of Asian elephants shall be a minimum of 6.6 m above ground on level terrain (slope <20 degrees) and 9.1 m above ground on steeper terrain (slope >20 degrees). Such measures are already implemented in some landscapes in India, but need to be more widely adopted and tested.

2. Minimising large bird deaths to powerlines: Bevanger (1994) made a number of useful recommendations to avoid bird deaths, including careful route planning supported by ecological research. In sensitive segments, marking of powerlines to make them more detectable by flying birds can also help reduce bird deaths.

3. Use of fully insulated cables: Fully insulated cables are already deployed in some powerlines passing through forests (e.g., over 20 km of insulated cable is deployed between MM Hills to Waterpoint near Gopinatham in Cauvery Wildlife Sanctuary, Karnataka).

4. Underground powerlines and pipelines: Little explored or deployed in India, the possibility of developing underground lines at least through sensitive areas, should be considered. When long-term costs (and environmental and possible aesthetic gains) are considered, underground powerlines may be a reasonable option in many areas (Vidal 2012). Similarly, options to send large pipelines of hydropower projects underground (or enable vegetation canopy overhead) are required in stretches passing through many forest areas.

9 http://envfor.nic.in/assets/FIRSTDraft%20guidelines%20roads%20and%20powerlines.pdf

5. Decreasing habitat disturbance and fragmentation: Minimising or completely avoiding vegetation cutting and disturbance along powerline alignments can go a long way to preventing habitat fragmentation, weed invasion, and degradation effects. Where powerlines pass high over valleys, vegetation is presently cleared needlessly down the valley and up the other side. This needs to be prohibited completely. Also needed are measures to promote low native vegetation underneath the powerlines to restore habitat connectivity or measures to raise powerlines well above the canopy so that vegetation cutting can be completely avoided

As the above examples indicate, there are ways to reconcile the needs of power transmission and ecological considerations if adequate effort is made through the policy framework as well as in practical implementation. For this to work, it is also critical to keep in mind the importance of local scientific knowledge and a long-term view of costs and gains to economy and ecology.

Conclusion

Energy and ecology are both critical needs for a nation in transition. Seeing ecological concerns as obstacles to energy development, or to see energy projects merely as ecological threats is not only simplistic but also unhelpful. We need sincere and serious efforts to understand the imperatives of both energy and ecology, and creative models of reconciling the two in the real world. Among other things, this requires that the energy industry strive, not merely for maximising capacity, minimising environmental regulations, and lowering compliance standards, but for a new set of forward-looking policies and practices that acknowledge and factor in environmental concerns across the power sector. Ecologists, for their part, need to engage more proactively and collaborate with the energy sector to help ensure that ecological safeguards are integrated across the sector from the stages of planning and design through implementation, maintenance, and monitoring. Better policies and practices evolved and implemented in India can also serve as a model for other developing countries. But ecologically responsible power generation and transmission will not come about automatically. It is an act of leadership. And, by helping create ways to integrate environmental and ecological concerns into energy generation, India's power producers can show the way.

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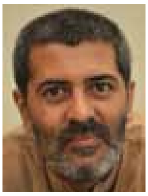
About the authors

Dr. T.R. Shankar Raman, is a scientist with NCF, based out of the long-term field research station in the Anamalai hills, Western Ghats. In his current capacity, he works on tropical forests and wildlife conservation, ecological restoration of degraded rainforests, and human – wildlife coexistence. He also writes periodically on nature and conservation for various newspapers and magazines. Dr. Shankar's blog 'View from Elephant Hills' is available for reading on the Coyotes Network.



Dr. M.D. Madhusudan is a scientist with NCF his work largely studies the biology of human-wildlife conflicts; ecology of large herbivores and carnivores; interface of conservation science with society, economy and politics; people-and-parks issues; alternate models of management of wildlife protected areas; and conservation issues in the tropics, particularly, the South and South-east Asian region and using historical and ecological data in understanding the drivers of distributional change for select large mammals and birds in the Western Ghats.

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