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Confederation of Indian Industry

New Age Power Systems For 21st Century India

Challenges, solutions and opportunities

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Foreword

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India is set to become the biggest demand centre in the world by 2030 with about 1.5 billion people, surpassing China's population to become the most populous country in the world. In terms of GDP growth, India is one of the fastest growing economies. Though India's per capita electricity consumption annually is about 1,122 kWh - which is much lower than the world average of 2,674 kWh per year; but this number too is one of the fastest-growing, per the United Nations..

India set an ambitious target of 175 GW of renewable energy capacity addition by 2020 – and rightly so. This is a nation rich in availability of sun, wind, biofuels and water. The Prime Minister's call for "One Sun, One World, One Grid" set the tone for a strong transmission system that will support India's Renewable Energy growth, also integrating the growth of renewables in the world. India is already well-positioned in the subcontinent, being surrounded by the SAARC nations. Therefore, India is an important faculty in planning grid interconnections with these countries to optimize regional resources and look at inclusive growth and development of the region. A blueprint for efficient transmission system is necessary for power to be disseminated effectively to the end-consumer.

The electricity transmission and distribution network traverses through the length and breadth of the country to connect every Indian household, industrial facilities, a host of essential amenities like schools, hospitals etc., and the vast expanse of agricultural lands. The last decade saw electricity in India striving to reach the farthest of India's households in the remotest of villages. With steady national efforts, the country is at the threshold of 100 per cent electrification of households. Nevertheless, the larger goal of the Government of affordable, secure, '24x7 Power for All' remains on the horizon. Electricity is vital for the livelihood of our diverse, young and ambitious population, Economical prices and sound commercial viability is important. India having become a power-surplus nation, this is dream is not too far away either.

Yet India continues to be an importer of electricity. One of the key challenges in the linkage between electricity generators and electricity consumers, is that the sources for electricity generation are not uniformly located across India. But electricity must be evacuated to all consumers, uniformly. So far thermal power generation has been more than 80 per cent of India's power mix. But renewable energy sources (RES) are catching up fast owing to reduction in solar and wind tariffs, and India naturally being an RE-rich nation.

At present the transmission and distribution (T&D) losses in power is around 22 per cent. While some of this loss is inevitable owing to technical losses, some of this loss is because of pilferage. A new and efficient transmission system can be the final linkage for optimized distribution of power, reduction of emissions, and demand management.

CII's white paper on New-Age Power Systems for 21st Century India, culls out eight short-term and seven medium-term imperatives and possible action-points for nurturing a competitive transmission sector

I am hopeful that this white paper will prove to be an easy guide on how to support futuristic T&D policies that will help forge the growth of a strong nation and lay the bedrock for a "National Transmission Mission".

Acknowledgements

The CII National Committee on Power has been conceived as a high-level CEOs Forum to steer the policy advocacy work of CII in this key sector. The Committee was instrumental in conception and drafting of this report. CII would like to thank the CII Core Group on Transmission 2018-2019 formed under the aegis of the National Committee for its participation in helping shape the vision for New-Age Power Systems in India. This report would not have been possible without complete involvement and suggestions by the members of the CII National Committee on Power.

In 2018, the National Committee conducted relevant workshops attended by officials of GOI and delegates from companies operating transmission networks, globally. Presentations were held to highlight how futuristic transmission models are planned and built in countries comparable to India, such as Brazil, leveraged on well-rounded policies. The insights of all the participants of these workshops are acknowledged deeply.

The CII National Committee on Power is grateful to the Co-Chairs – Mr. Praveer Sinha and Mr. Rajiv Ranjan Mishra for their strong leadership support and guidance in planning and executing this report.

The committee would also like to thank McKinsey & Company for their research and knowledge support especially in bringing out the industry prespectives and international best practices.

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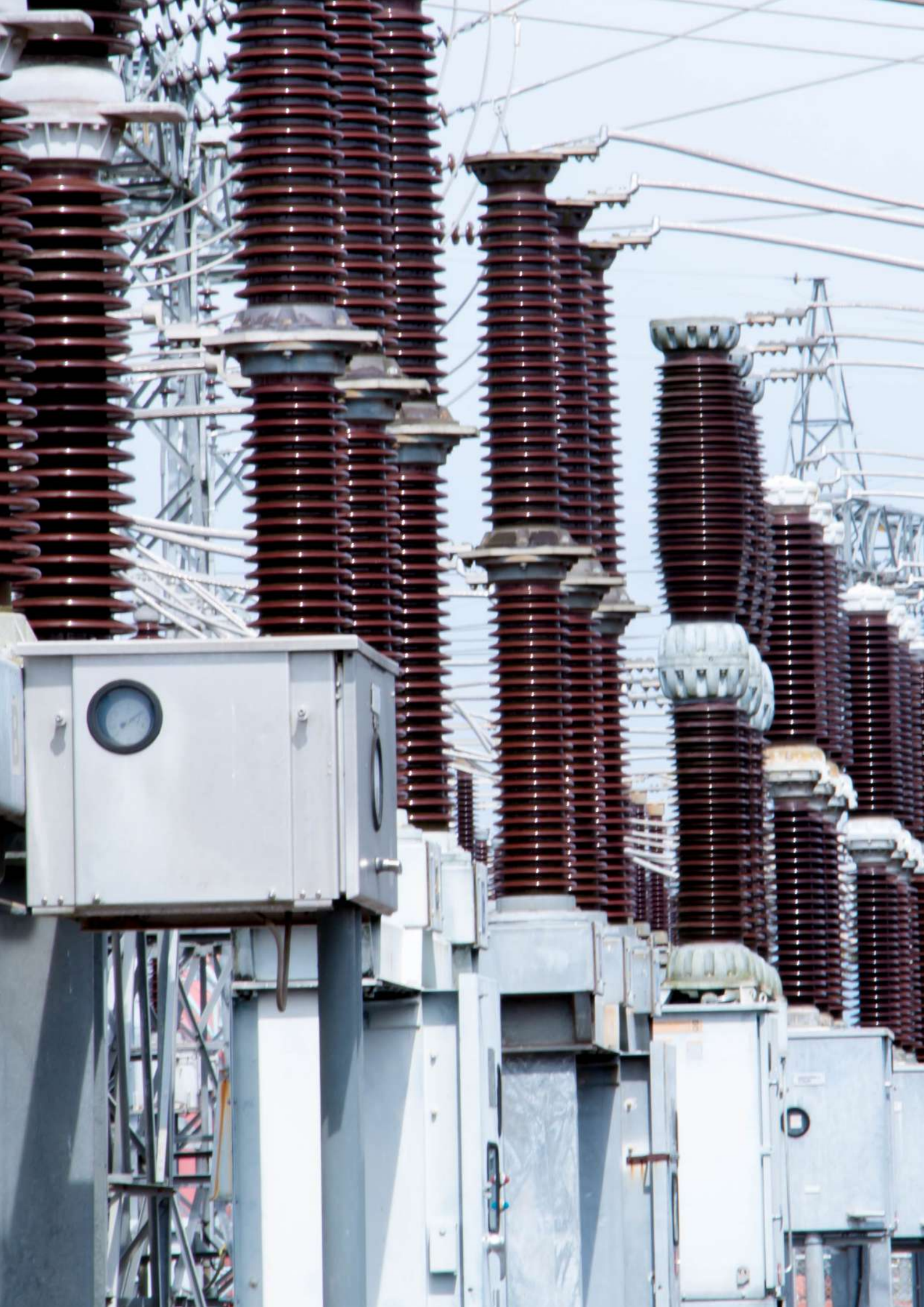

1. Executive summary

India has the fifth-largest power generation capacity (installed capacity) in the world. We ranked third globally in terms of electricity production as of December 2018.[1] Electricity production in India was 1,201.543 Billion Units (BU) during FY18.[2] A growing population along with increasing electrification and per capita usage is expected to drive growth in power consumption to more than 1,800 TWh by 2022.[3] A strong policy push and schemes such as Deen Dayal Upadhyay Gram Jyoti Yojana (DDUGJY), Integrated Power Development Scheme (IPDS) and Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya) are increasing the pace of electrification in the country. The benefit of these schemes can only be realized if we strengthen the transmission and sub-transmission elements of the grid. This calls for a sharper focus on the sector in light of its readiness to meet the transmission objectives of the future.

The passage of the Electricity Act, 2003 promoting competition represented a landmark moment for the Indian power sector, and its effective implementation has attracted and nurtured private participation. The Tariff-Based Competitive Bidding (TBCB) mechanism opened development of transmission projects to the private sector. The private sector accounted for 41 per cent out of a total of INR 1030 billion invested on transmission asset creation since 2011.[4] A very important enabler of private-sector participation was the revenue security brought in by the Point of Connection (PoC) mechanism in the Inter State Transmission Network (ISTN).

India is one of the fastest growing, sizable power markets around the world, although per capita consumption at 1000 kWh remains lower than other comparable countries.[5] Currently, 31 per cent of India is urbanized and expected to touch 60 per cent by 2050.[6] A recent report from Oxford Economics suggested that 17 of the top 20 fastest growing cities in the world are in India.

The power sector in India is undergoing several shifts:

- It is moving from a traditional energy-deficit position to an energy-surplus one.
- Fewer long-term power purchase agreements (PPAs) are being signed between discoms and IPPs, with discoms increasing their procurement through shorter tenure PPAs or day/week ahead market.
- A transition is underway, with the share of renewable resources growing in India's generation mix (from 12.3 per cent in 2013 to 22 per cent in 2018)[7] a significant move away from coal-based power. Distributed solar in the form of rooftop and ground-mounted modules is also expected to grow rapidly.
- The private sector is playing a greater role across the generation and transmission value chain, representing around 45 per cent of total investments over the past six years.[8]
- The Government of India is pushing for 100 per cent household electrification through programs such as 'Saubhagya' which aims to provide electricity to 20 million new households.[9]
- Electricity is expected to penetrate sectors such as transportation, with growth in electric buses, two-wheelers, fleet cars and e-rickshaws.

The transmission sector must respond to and take advantage of these shifts to achieve the twin objectives of energy access and affordability in the country.

Eight critical essentials that could shape the trajectory of India's transmission sector with near-term options:

1 https://qz.com/india/1237203/india-is-now-the-worlds-third-largest-electricity-producer/
2 https://www.ibef.org/archives/industry/indian-power-industry-analysis-reports/indian-power-industry-analysis-december-2018
3 https://www.ibef.org/download/power-nov-2018.pdf
4 Analysis of Central Transmission Utility (CTU) orders
5 McKinsey Insights
6 https://www.orfonline.org/expert-speak/energy-use-in-indian-cities-a-case-for-district-energy-systems-47506/
7 https://mnre.gov.in/physical-progress-achievements http://www.cea.nic.in/reports/monthly/executivesummary/2013/exe_summary-03.pdf
8 Central Electricity Authority Analysis
9 https://www.recindia.nic.in/saubhagya

- **More flexible transmission network planning**
  Traditional coal-fired power plants took five to six years to build compared to three to four years for construction of transmission lines required for power evacuation. In comparison, wind or solar plants take 12 to 18 months to build, implying the need for advance planning of transmission projects.[10]
  The nature of transmission planning needs to change from deterministic to anticipatory (probabilistic). The Central Transmission Utility (CTU) has limited oversight on the last-mile intrastate transmission planning. To be future-ready with optimized network planning, all 220 kV and above intra-state transmission networks could be centrally planned by the CTU in deep coordination with the State Transmission Utility (STU).
  Recommended Actions
  Central Electricity Regulatory Commission (CERC) to notify General Network Access (GNA) Regulation.

  All 220 kV and above network to be centrally planned by CTU.

- **Separation of CTU from Power Grid Corporation of India Limited (PGCIL)**
  The Central Transmission Utility (CTU) takes care of planning and coordination of the interstate system. Currently, CTU is part of PGCIL. This creates a conflict of interest between the role of a planner and a developer. The National Committee on Transmission (NCT) and Empowered Committee on Transmission (ECT) decide the route under which a project will be developed—through a regulated tariff mechanism (RTM) or tariff-based competitive bidding (TBCB). PGCIL is an integral part of the ECT and RTM projects are automatically awarded to it. Significant information asymmetry also favours PGCIL, as it is a planner of the schemes which are eventually bid out, giving it great competitive advantage. PGCIL, as a CTU, also decides the technical standards and parameters for projects which further accentuates the scope of information asymmetry.

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Recommended Actions
Clear separation of embedded functions into mutually exclusive functions of a) planning, and b) development and operations, via the creation of an independent CTU, completely distinct from any developer.

- **Tightening of grid performance parameters in the context of increasing renewable energy (RE) integration**
  The current 15-minute cycle of scheduling, forecasting and deviation settlement is not fully capable of seamless and flexible integration of renewable energy resources in the country as they have variability in energy injection even in the 15-minute window. India could consider tightening grid performance parameters by moving to a 5-minute forecasting and scheduling window.
  Recommended Actions
  CERC to introduce 5-minute scheduling, metering, accounting and settlement mechanism in a phased manner.

- **Improved reliability of the network by developing contingencies in the system**
  The Interstate Transmission Network (ISTN) currently operates at an average line utilization of around 30 to 40 per cent which is in line with utilization levels seen at similar national grids (UK, Germany, Brazil).[11] Although this utilization level appears low, the additional capacity is not necessarily available for certain contingencies, such as a line snapping (N-1), two lines snapping simultaneously (N-1-1), generator failing (N-G) or other 'credible contingencies (N-2)' like tower collapse, pole fault in HVDC line, etc., which call for an N-2 contingency plan to be built in the system.
  Nearly every year, there is tower damage or collapse for different reasons which leads to long-duration power cuts in some cities and towns across India.[12] Adopting an N-2 redundancy in the network planning, specially for critical energy-delivery requirements could be considered. Since incidents of generator failure are

11 Expert Interviews
12 Expert Interviews

relatively rare, planning around that should not be a critical requirement

Recommended Actions

CTU to develop N-2 redundancies in critical energy-delivery corridors such as Tier 1 cities, areas of high generation capacities, and for cross-border energy transmission in a phased manner.

- **Compression of project timelines from notification to start of construction by 40 per cent**

  Currently, the average time taken from the notification of a project to the start of its construction is around 760 days, caused by huge time overruns in the bidding and forest clearance process.[13] More efficient modalities of the bidding process and forest clearance procedures will need to be adopted while preserving the integrity of the original process.

  Recommended Actions

  Bid Process Coordinator to adopt a single-stage two-envelope bidding process wherein the RFQ and RFP are submitted together. Liability of qualification is on the bidder, secured by heavy security deposits.

  Access to all relevant GIS data (already available with concerned organizations) to private transmission asset developers

  The Ministry of Power (MoP) and Ministry of Environment, Forest and Climate Change (MoEFCC) could consider changing relevant rules such that Compensatory Afforestation (CA) can be carried out in parallel, secured by financial commitments from transmission asset developers.

  MoEFCC could also issue guidelines de-linking FRA certification from Stage 1 clearance for linear projects.

  Creation of a Land Compensation Determination and Dispensation Committee (LCDDC) chaired by the district collector whose members include the relevant ADMs, SDM, Tehsildar, and Superintendent of Police (if required) and representatives of asset developers for compensation determination and dispensation.

  Replace the existing system of Schedule Commercial Date of Operation (SCOD) with a system of Schedule Commercial Period of Operation (SCPO). SCPO could be a two to three month time period, such that, If the asset is commissioned within the SCPO it could be eligible to start earning revenues.

- **Promotion of innovation through greater freedom of design**

  The construction of transmission lines is mandated to follow design and technology prescriptions of the Central Electric Authority (CEA). Requests for Proposals (RFPs) often do not leave enough scope of adopting new relevant technologies, which in most cases unduly increase the asset's capex, thereby increasing per unit tariff. Hence, RFPs must specify the technical performance matrix instead of specifying materials and designs.

  Recommended Actions

  In transmission-bid documents, RFP to allow freedom of design in tower design structures and choice of conductors.

- **Capacity augmentation of existing transmission**

  Increasing urbanization, evolving demographics, expanding renewables and changing market dynamics have placed extraordinary pressure on utilities to solve energy-delivery challenges in an economical manner in the shortest possible time with minimum disruption. It is important for system owners, operators and planners to consider increasing capacity of existing infrastructure and take full advantage of existing right of way (RoW).

  Recommended Actions

  Mandate use of transmission solutions, aimed at capacity augmentation of existing infrastructure (such as reconductoring, voltage upgradation, multi-circuit-multi-voltage transmission) in the State electricity grid code.

13 Interactions from transmission asset developers

State regulators to carry out objective evaluation of transmission plans against factors such as capital efficiency, minimal completion time, limited environmental impact and least service disruption. Reference of such evaluations can be drawn from the Network Options Assessment followed by the National Grid (UK). Capex plans to be approved by SERCs after objective evaluation of transmission plans.

Third-party audit of transmission plans to be carried out by the state regulator to ensure compliance with electricity grid codes and objective evaluation put in place are adhered to.

- **Incorporation of energy-storage solutions as transmission system elements to meet flexibility requirements**

  Constant and rapid balancing of the required load and generation is key to maintaining grid reliability. Currently, the challenge faced in balancing the two is ramp-up time, determined by flexible-energy resources present in the grid. There is a critical need to increase capacity of fast ramp-up energy storage systems in the grid.

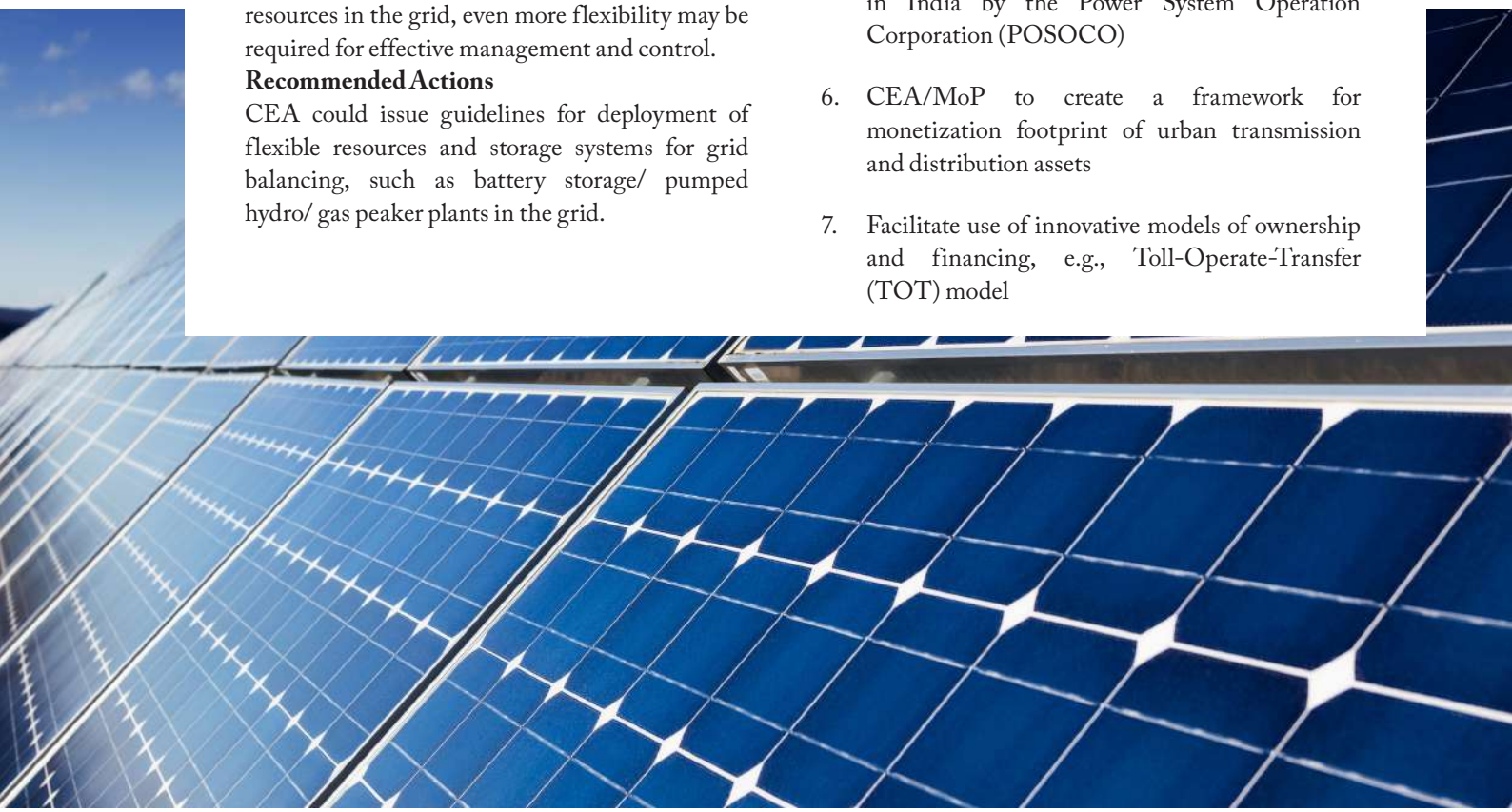
  With the growth of renewable generation resources in the grid, even more flexibility may be required for effective management and control.

  Recommended Actions

  CEA could issue guidelines for deployment of flexible resources and storage systems for grid balancing, such as battery storage/ pumped hydro/ gas peaker plants in the grid.

In addition to these options, seven stand-alone requirements in the medium term could be considered in a span of three years:

1. STUs to make underground intracity power transmission mandatory in top 50 cities
2. CERC to bring a policy for shareability and transferability of long-term open access licensees (LTOA)
3. SERCs to create a revenue-pooling method for states (similar to Central PoC pooling concept) so that developers feel more comfortable investing in states
4. MoP to issue guidelines for mandatory representation of major power transmission asset developers on committees like the National Committee on Transmission (NCT), Empowered Committee on Transmission (ECT) and Regional Power Committee (RPC) to ensure a level playing field in the decision-making process
5. CERC to create a framework for creation and maintenance of an ancillary services market in India by the Power System Operation Corporation (POSOCO)
6. CEA/MoP to create a framework for monetization footprint of urban transmission and distribution assets
7. Facilitate use of innovative models of ownership and financing, e.g., Toll-Operate-Transfer (TOT) model



2. Introduction

India's power grid has been in a state of rapid development over the past 25 years. As early as 1975, public sector entities such as NTPC and NHPC developed Inter State Generating Stations (ISGS), planned by the central government with known counter-parties. This simplified the transmission planning process, as approval and implementation for transmission ran concurrent to generation planning.

The past decade of sustained growth has seen substantial changes in the Indian power ecosystem. Demand has grown with a rapidly urbanizing population. The recent opening up of the power generation and distribution sector to private participation has led to significant capacity expansion and increased investment. The policy push on wind and solar since 2014 has resulted in a rapid expansion of renewable resources connected to the national and state grids.

The growth in demand is increasingly driven by the residential and commercial sector, with industrial demand expected to grow at a slow rate. If electric vehicle (EV) penetration accelerates in the coming decade, these segments will only grow in dominance, and the shape of electric demand could become increasingly uncertain.

India is at the global forefront of renewable power development with an unprecedented expansion in solar and wind capacity and ambitious goals for further growth. India has the fifth-largest power generation capacity in the world. We rank third globally in terms of electricity production, as of 2018.[1]

The thermal generation sector is going through a transition, with installed generation capacity in excess of peak demand, average plant load factor (PLF) significantly lower than historical levels, and a large number of independent power producers (IPPs) in financial distress. Distribution utilities are deferring signing of long-term power agreements and opting for short-term and medium-term contracts instead. The quantum of power traded on power exchanges has also steadily increased.

The **Levelized Cost of Energy (LCOE)** of renewable power has dropped steadily over the past few years, while the corresponding cost of traditional power projects has steadily increased.[2] Battery technology that would enable renewable projects to provide round-the-clock power is also becoming a reality, with the cost of battery-backed solar projects expected to equal that of thermal power plants by 2025.[3] While the average coal and nuclear projects allowed for a six- to ten-year development window to set up transmission, renewable projects are erected far more quickly (in less than three years).

A policy push and schemes like the Deen Dayal Upadhyay Gram Jyoti Yojana (DDUGJY) and Integrated Power Development Scheme (IPDS) are increasing the pace of electrification in the country. **Deen Dayal Upadhyaya Gram Jyoti Yojana** is a Government of India scheme to provide continuous power supply to rural India. The government plans to invest INR 756 billion (USD11 billion) for rural electrification under this scheme.

An Integrated Power Development Scheme (IPDS) has been launched with an outlay of INR 440 billion and promises to help in reduction of AT&C losses. It has also established an IT-enabled energy accounting and auditing system and improved energy billing collection efficiency based on metered consumption.

The current transmission planning process is still oriented towards providing long-term access for the transaction of power. However, changes in consumption and distribution require a shift to more short-term access that can move power anywhere in the country.

The benefit of these schemes can only be reached if transmission and sub-transmission elements of the grid are strengthened. This calls for a sharper focus on the transmission sector in light of its readiness to meet the transmission objectives of the future.

1 Press Search – Business Standard 2018

2 McKinsey Insights – (largely because of cost reductions and technological improvements)

3 Expert Interviews

3. Celebrating 15 years of appropriate policy support

The passage of the Electricity Act, 2003 represented a landmark moment for the Indian power sector. It aspired to create a liberal framework for the development of the power sector and promote competition. Prior to the Act, the setup and purchase of power was largely the function of the Government of India. The Act granted freedom to buy and sell power as a function of market principles, which introduced necessary competition. As independent power producers (IPPs) began to engage in power generation, cheaper power to the end consumer became a growing reality.

Around 41 per cent out of a total of INR 1030 billion spent on transmission asset creation from 2011 onwards has gone to the private sector.[1] The Tariff-Based Competitive Bidding (TBCB) mechanism opened development of transmission projects to the private sector. A very important mechanism that enabled the success of the private sector is the revenue security brought in by the Point of Connection (PoC) mechanism. The central Point of Charge (PoC) pooling mechanism affords to the transmission developer two sets of benefits. Firstly, it assures them payment security as the CTU collects the transmission charges from beneficiaries and transfers the amount duly owed to the transmission developers. Secondly, there is no cost of tariff collection for transmission asset developers as they do not have to bill each and every beneficiary. All cumulative transmission bills are raised to the CTU. This gives private transmission players the necessary confidence to invest in the sector.

The year 2013 saw synchronous interconnection between the southern and northern grid. The western and eastern grids were connected synchronously in 2006. Southern grid connectivity was achieved through commissioning of the Raichur-Solapur 765 kV single circuit transmission line by PGCIL as a final step towards establishment of an "All India Synchronous National Grid (One Nation, One Grid and One Frequency) facilitating transfer of energy across states.[2]

In 2015, two very important changes in the governance structure and guidelines were actioned with the creation of a regional MoEF for grant of forest clearances and clear articulation of guidelines for Right of Way (RoW) compensation and a RoW committee was formed.

Finally, in 2017, the General Network Access regulations for inter-state transmission systems were drafted after multiple rounds of stakeholder deliberations.

1 CERC Reports and Analysis of all projects awarded

2 Central Transmission Utility Report

Year	2003	2011		2013	2015		2017
Area	Legislation	Bidding mechanism	Payment security	Synchronous interconnection	Governance	Guidelines	Regulatory
Intervention	Electricity Act, 2003 - Replaced Earlier Laws, mandated creation of SERCs and Introduced Open Access	Tariff Based Competive Bidding - Opened entry of the private sector participation in transmission	Point of Connection- Afforded the necessary revenue security to private sector transmission players	Northern and Southern Grid connected synchronously via the Raichur-Solapur 765 kV single circuit transmission line	Creation of Regional MoEF for Grant of Forest clearance instead of Central MoEF and Forest Minister of GOI	Right of Way (RoW) compensation guidelines and RoW committee formed	General Network Access to the Inter-State Transmission system regulations drafted

4. Meaningful shifts in the power sector

India continues to be one of the fastest-growing sizable power markets around the world although per capita consumption at 1122 kWH remains lower than other comparable countries.[1] Currently 31 per cent of India is urbanized and is expected to touch 60 per cent by 2050.[2] A recent report from Oxford Economics suggested that 17 of the top 20 fastest-growing cities in the world are in India.

Several meaningful shifts are underway in the power sector in India

- We are moving from a traditional energy-deficit position to an energy-surplus position. The installed power-generation capacity in India has risen to 344 GigaWatts (GW) and its energy deficit, which stood at over four per cent in 2014, shrunk to less than one per cent in 2018.[3]
- Fewer long-term power purchase agreements (PPAs) are being signed between discoms and IPPs, with discoms increasing their procurement through shorter tenure PPAs or day/week-ahead market.
- The share of renewable resources in India's generation mix grew from 12.3 per cent in 2013 to 22 per cent in 2018 (Installed Capacity)[4] signaling a significant transition away from coal-fired power. Distributed solar in the form of rooftop and ground mounted modules is also expected to grow rapidly.
- The private sector is playing a greater role across the generation and transmission value chain, representing around 45 per cent of investments over the past six years.[5]
- The Government of India's push towards 100 per cent household electrification through programs such as 'Saubhagya' which aimed to provide electricity access to 20 million new households by December 2018. Certain households identified via will be eligible for free electricity connections, while others will be charged INR 500. The total outlay of the project is INR 16, 320 crore. The beneficiary household will get five LED lights, one DC fan, one DC power plug and repair and maintenance (R&M) for five years.[6]
- Electricity is expected to penetrate sectors such as transportation, with growth in electric buses, two wheelers, fleet cars and e-rickshaws. Rather than electric cars, it is the two and three-wheeler segment that is seeing the most growth in India, with about 1.5 million battery-powered, three-wheeled rickshaws, more than the total number of electric passenger cars sold in China since 2011.[7]

1 http://mospi.nic.in/sites/default/files/publication_reports/Energy_Statistics_2017r.pdf.pdf?download=1
2 https://www.orfonline.org/expert-speak/energy-use-in-indian-cities-a-case-for-district-energy-systems-47506/
3 NITI Ayog official release
4 https://mnre.gov.in/physical-progress-achievements http://www.cea.nic.in/reports/monthly/executivesummary/2013/exe_summary-03.pdf
5 Central Electricity Authority Analysis
6 http://pib.nic.in/newsite/PrintRelease.aspx?relid=171101
7 https://www.bloomberg.com/news/features/2018-10-25/india-s-rickshaws-outnumber-china-s-electric-vehicles

5. Eight essentials and possible actions to take advantage of these shifts

To take advantage of the shifts in the sector eight essentails have been identified to shape India's power development trajectory.

5.1 More flexible transmission network planning

5.2 Separation of Central Transmission Utility (CTU) as the custodian of the grid

5.3 Tightening of grid performance parameters

5.4 Improve survivability of the network by developing contingencies in the system

5.5 Compress project timelines from notification to start of construction by 40 per cent

5.6 Promote innovation through greater freedom of design

5.7 Capacity augmentation of existing transmission infrastructure

5.8 Incorporate energy storage solutions as transmission system elements to meet flexibility requirements

For each of the above , a set of options that the Government could address in the short-term are laid below.

Eight short-term imperatives and recommended actions for a well-supported transmission network

5.1 More flexible transmission network planning

In 2017, more renewable generation capacity was installed globally than capacity from coal, gas and oil combined. The global economy is in the middle of a fundamental energy transition. Over the last two decades, an increasing share of the primary energy demand has shifted away from fossil fuels towards renewables.

These trends are increasingly visible in the Indian context Traditional coal-fired power plants took five to six years to build compared to three to four years for construction of transmission lines required for power evacuation. In comparison, wind or solar plants take 12 to 18 months to build, implying the need for advance planning of transmission projects. There remains an inability to energize the RE plants as evacuation infrastructure is still under construction when these plants are commissioned. The current process only plans new power lines once generation projects have been declared. More importantly, the optimal utilization of power lines has in many cases limited the growth of the state grids. New lines are not being commissioned in many states because these are expected to reduce utilization (currently at around 80 per cent) and therefore increase the cost per unit. A utilization of around 20–30 per cent is a reasonably good utilization of lines considering the intermittency of RE generation and managing peak usage.

Historically, whenever new central/state power projects came up with known beneficiaries, additional drawl capacity for the states was created on request by the STU. This considered the quantum of allocated power and grid requirements after an agreement in the Standing Committee for power system planning.

Current CERC regulations allow system strengthening (fresh investment) based on application for long-term access (LTA). At present, no system strengthening is available for connectivity, medium-term open access (MTOA) and short-term open access (STOA). The investment in the transmission system is made on the assurance of payment of transmission charges for a longer period by LTA users. The existing philosophy is based on the premise that long-term PPAs are predominant while short-term market seeking MTOA/STOA shall be addressed through margins available in the grid. This needs to change to consider MTOA and STOA as important components of power in a more dynamic grid with intermittent generation and distributed consumption centres. The General Network Access (GNA) mechanism has been proposed as one means of addressing many current transmission issues.

Inter-state network planning and development without commensurate planning and development of intra-state network by STUs will not yield the benefits of a robust, reliable and flexible grid capable of absorbing infirm generation from RE and changing demand patterns. The planning of intra-state transmission networks by STUs must be coordinated with the CTU. Presently, the CTU has limited oversight on the last-mile intra-state transmission planning.

To be future ready with optimized network planning, all 220 kV and above intra-state transmission network must be centrally planned by the CTU in deep coordination with STUs.

RECOMMENDED ACTIONS

- Central Electricity Regulatory Commission (CERC) to notify General Network Access (GNA) Regulation
- All 220 kV and above network to be centrally planned by CTU

5.2 Separation of Central Transmission Utility (CTU) from PGCIL

The introduction of the tariff-based competitive bidding (TBCB) mechanism in 2011 encouraged competition and innovation resulting in tariff reduction by 30-40 per cent compared to regulated tariff mechanism rates (RTM).

The Electricity Act 2003 entrusts the Central Transmission Utility (CTU) with planning and co-ordination of inter-state transmission system functions. PGCIL has in practice played the dual role of being a planner, as CTU, and of an asset developer. With TBCB enabling project awards to be competitive, a conflict of interest arises as the National Committee on Transmission (NCT) and Empowered Committee on Transmission (ECT), decide the development route (TBCB or RTM) and PGCIL is a member of the ECT.

Currently, the CTU is a part of PGCIL and the interface and interaction between the two is opaque. RTM projects are decided by the ECT, of which PGCIL is an integral part. For projects awarded through the bidding route, there is information asymmetry which places the private sector at a significant disadvantage.

PGCIL as CTU, along with the CEA decides the technical specifications (tower designs, conductor type, etc.) for each transmission project, which tilts the playing field against private competitors.

RECOMMENDED ACTIONS

Clear separation of embedded functions into independent functions of a) planning and b) development and operations via the creation of an independent CTU, completely distinct from any developer.

5.3 Tightening of grid performance parameters

The scheduling, metering, accounting and settlement mechanisms need to be relooked at, specially in the light in the renewable energy penetration.

Currently, a 15-minute framework is used for forecasting, scheduling and deviation settlement in the ISTN. This window of 15 minutes works just fine with traditional coal-fired power plants as they are capable of injecting their declared capacity accurately. The situation changes dramatically with the integration of solar and wind-power plants as they are subject to the vagaries of nature and not able to inject the quantum of energy as accurately as forecast for a 15-minute time interval and significant variations are seen.

Essentially, even in the small window of 15 minutes there are massive deviations in the declared capacity of all RE power plants in the grid compared with the total energy injected by them in the grid. This causes an increase or decrease of frequency between the tolerance of 49.8 Hz to 50.2 Hz, which, if not controlled, can lead to grid failure.

To achieve the target of 175 GW of RE capacity and seamless integration of variable renewable energy generators across the country, grid performance needs to be tightened by adopting a 5-minute scheduling, metering, accounting and settlement mechanism. Firstly, it results in reduction in reserve requirements such as of ancillary services like battery storage used for grid balancing and secondly, lowers the per unit cost to the end user.

RECOMMENDED ACTIONS

CERC to introduce 5-minute scheduling, metering, accounting and settlement mechanism in a phased manner.

5.4 Improved reliability of the network by developing contingencies in the system

The ISTN currently runs at average line utilization capacity of about 30 to 40 per cent across the country. Most often this is interpreted by many to mean the lines are underutilized and there must be a contingency requirement which could be provided for by the unutilized line capacity of the system. This is a popular misunderstanding which can be clarified as below:

- Globally, the average line utilization of any large grid (national/provincial) is between 30 to 40 per cent.[1] This is kept low for good reasons—e.g., when there is peak demand during the day, utilization increases to around 80 to 90 per cent, and during certain times of the year for festivities, this touches a similar utilization level. If the transmission network continuously runs at this high level of line utilization, it will damage the conductor and pose a serious threat to grid integrity. If the line utilization is above 90 per cent for 10 per cent of time in a year considered normal, however if the line utilization 50 per cent for 50 per cent of the time during the year then the system is said to be under stress and calls for augmentation.

- Developing contingencies in the grid is an entirely different concept than line utilization. Contingency planning means the network is capable of not disturbing the quantum of energy delivery to its load centres even in these scenarios: one line snaps (N-1), two lines snap simultaneously (N-1-1), a generator fails (N-G) , a line and generator fail together (N-G-1) or a 'credible contingency' like a tower collapse or pole failure (N-2).

- Currently the ISTN has N-1 contingency built in the system as mandated by the CTU. However, it is observed in many parts of India that at least 10–15 towers fall or are severely damaged annually by weather disturbances or other reasons, leaving large parts of the country in darkness for around 24 hours.[2]

  N-2 contingency planning is designed for just these 'credible contingencies' like HVDC pole trips or tower collapse which should be factored into the planning process. In Bhutan a 'Tower Collapse' is considered a 'credible contingency' and N-2 contingency is accounted for in their network planning. India too needs to account for N-2 contingency and consider it in the grid planning stage specially where there are critical energy delivery requirements.[3]

1 Expert Interviews – Indian and Global

2 Expert Interviews and Press Search

3 Expert Interaction

RECOMMENDED ACTIONS

CTU to develop N-2 contingencies in critical energy-delivery corridors such as Tier 1 cities, areas of high generation capacities, and for cross-border energy transmission in a phased manner.

5.5 Compression of project timelines from notification to start of construction by around 40 per cent

Currently the average time taken from the notification of a project to the start of its construction is about 760 days,[1] caused by time overruns in the bidding process and forest clearance process. More efficient modalities need to be adopted in the bidding process and forest clearance procedures while preserving the sanctity of the original process. Additionally, the effectiveness of current early incentive structure needs to be looked at.

5.5.1 Better utilization of the competitive bid process

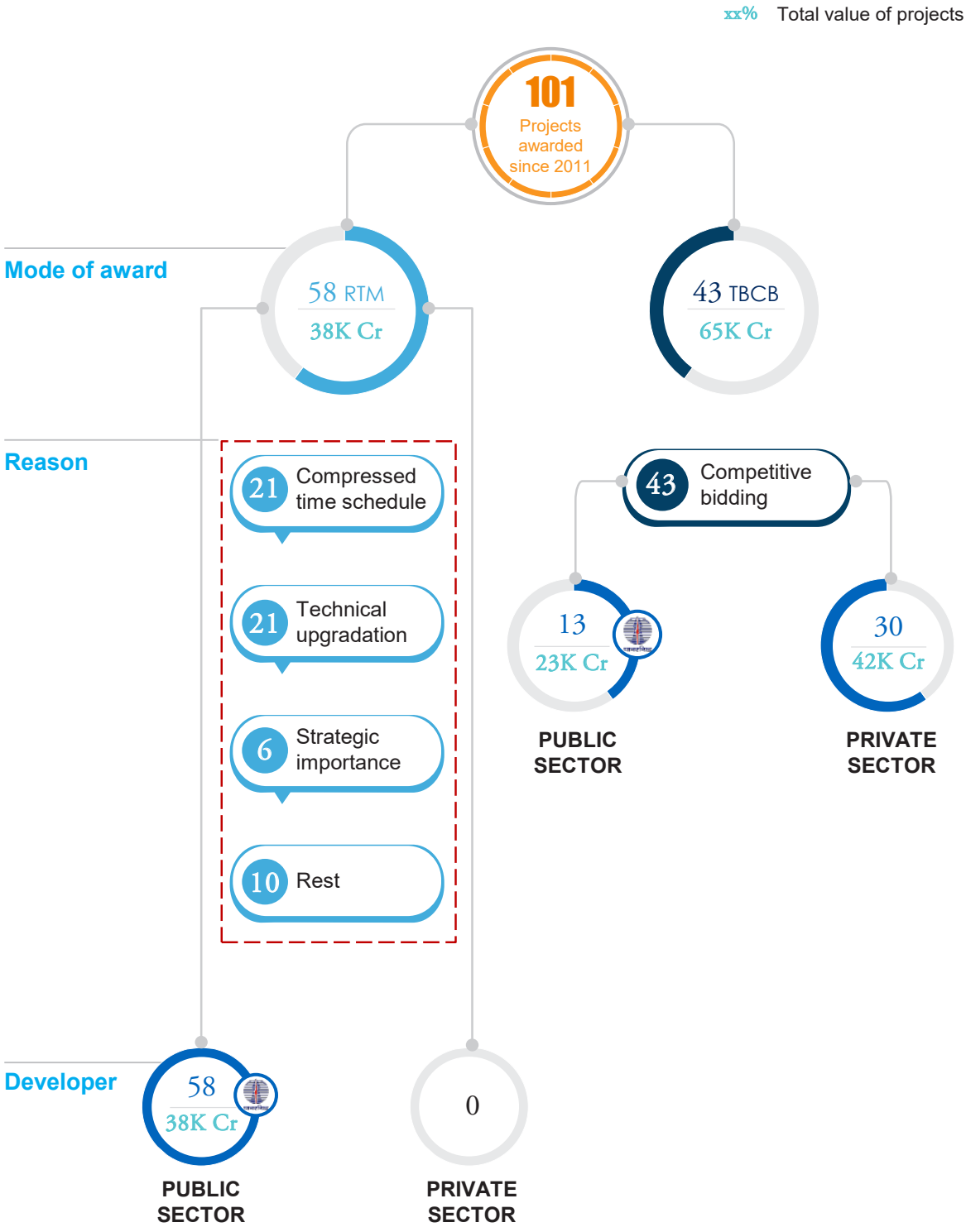
The development of the TBCB route opened up transmission development projects to private sector participation. Since 2011, there have been 101 projects, of which only 43 projects were awarded under the TBCB route (Exhibit 1) . This is surprising, given that a) tariff policy mandates development of transmission projects under competitive route and b) TBCB projects have proven to be up to around 30 per cent cheaper had the same projects commissioned under cost plus route (Exhibit 2). The Central Electricity Regulatory Commission (CERC), in its recent tariff approach paper, mentioned that the cost of the inter-state transmission has increased by around 69 per cent in the last seven years. This has been largely due to a significant share of projects being awarded under the regulated tariff mechanisms. This gives the developer little incentive to optimize cost and reduce tariffs, with realized tariffs much higher than those discovered through competitive bidding. Interestingly, in the same period the cost of generation dropped by 21 per cent because 60 per cent of incremental capacity was added through competitive bidding.[2] So why have more projects not made it into the competitive bidding pipeline? The primary reason projects have been allocated through RTM has been the 'Compressed Time Schedule' (36 per cent of projects awarded). Sending projects to RTM due to urgency is based on two key premises:

a) RTM projects will be reliably faster in execution compared to TBCB projects. Better planning processes could not have reduced the time constraints. While project-specific comparisons are hard, TBCB projects have had similar execution timelines to projects awarded under RTM. There is no reason to believe that private sector players cannot complete projects on an accelerated basis. The key challenge in moving urgent projects through TBCB is the extended bid process. If the bid process itself requires nearly a year, projects will flow to RTM. Bid durations can be dramatically reduced through process optimization, resulting in urgent projects moving through the cost-effective TBCB route instead of RTM.

In the longer term, improved planning processes could also reduce the frequency of projects becoming categorized as 'urgent'. Regulatory bodies may consider setting targets to reduce the number of projects tagged as urgent. Another 21 projects were allocated as RTM because they qualified as modifications or augmentations ('Technical Upgradation'). It is unclear why such projects would require an RTM designation – this is not common practice across international markets where private players are engaging in transmission development. Current proposals to provide exemptions for work to be done by the incumbent asset owner indicate a willingness to explore alternatives. However, this distinction between augmentation/modification projects and new lines is not made in foreign markets.

1 Expert Interactions
2 Central Electricity Regulatory Commission (CERC) approach paper on tariff

Exhibit 1 – ALLOCATION OF PROJECTS TO PUBLIC AND PRIVATE PLAYERS[1]

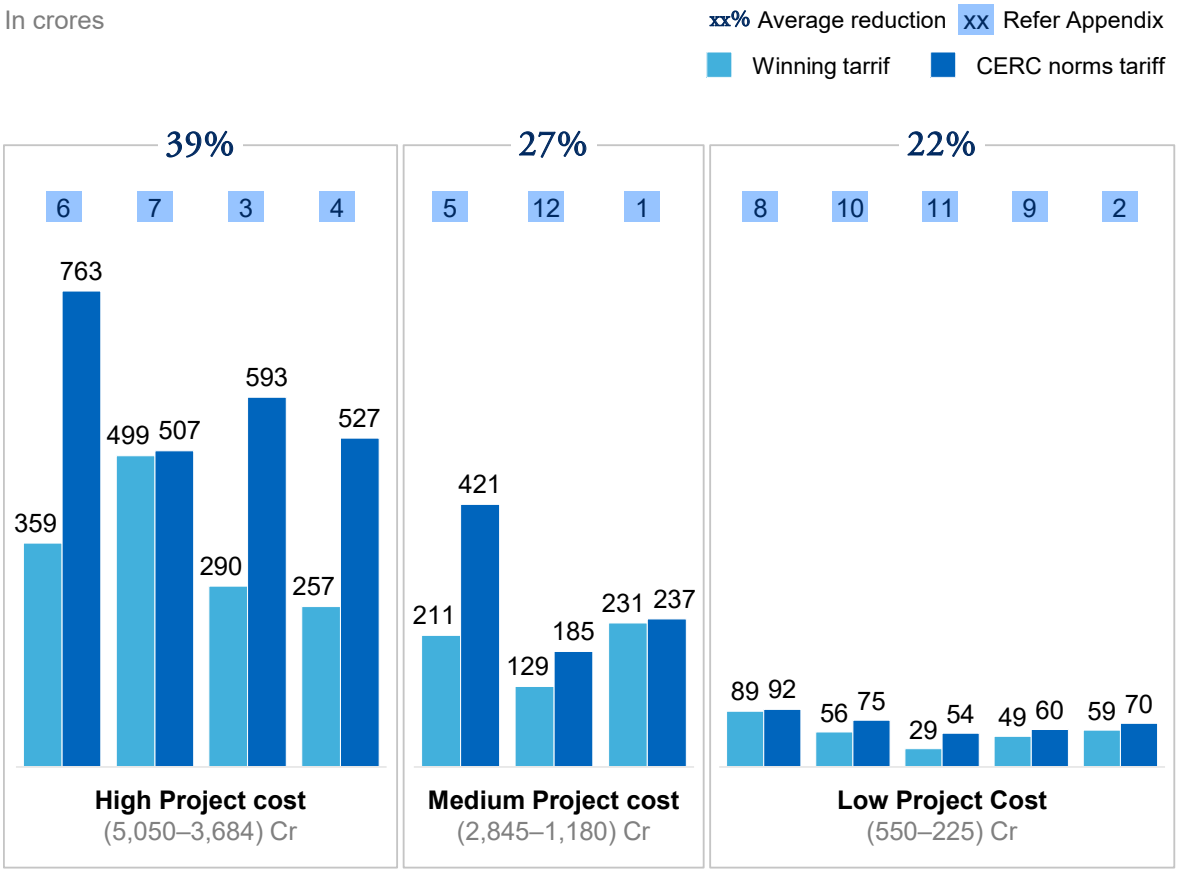


1 Compilations of minutes of Empowered Committee on Transmission (ECT)

Exhibit 2 – COMPARISON OF COSTS ACROSS TBCB AND RTM PROJECTS[1]

Tariff Comparison of TBCB Projects and CERC tariffs

In crores



Higher Cost TBCB Projects typically offer **~30% lower tariff** than same project awarded on RTM basis

1 CERC tariff orders compilation

In Brazil, all augmentation work is awarded through an open auction process, with substation owners mandated to provide site access to the winning developer. This is usually achieved through an access-sharing agreement, with rates for access approved by the regulator.[1]

Comparison of tariffs discovered through the competitive bidding framework in Brazil (Exhibit 3) and Peru (Exhibit 4) show similar results as in India.

1 Expert interactions

In both cases, the unit tariff has reduced significantly, in some cases by 50 per cent. Regulators in both the US and UK make no distinction between seeking competitive bids on new lines and on augmentations. Defining what is an augmentation can also get murky when considering adding new lines in large multi-phase projects. The current situation creates an unnecessary incentive for developers to broaden the definition of what is considered augmentation to secure rights to a project.

Exhibit 3 – BRAZIL AUCTION TRACK RECORD – TRANSMISSION

Year	2014	2015	2016	2017	2018
Number of auctions	03	04	01	01	02
Average tariff reduction	10.22%	8.05%	36.47%	40.46%	55.26%
Number of lots	10	76	35	11	20
Winner participants	5.5	30	17	10	11

Source: Information from ANEEL's site (http://www.aneel.gov.br/transmissao4)

Exhibit 4 – INFORMATION OF WINNING BIDS FOR TRANSMISSION LINES IN PERU (1998-2013)

Year of award	Project	Length of line (km)	Capital investment ($ million)	Annual transmission cost ($ million)		Reduction cost estimate (%)
				Winning bid	Cost estimate (price cap)	
2010	Tintaya-Socabaya and associated substations	207	43.6	6.7	12.3	46
2010	Talara-Plura	102	14.6	2.3	2.5	9
2010	L.T. Machupicchu-Abancay-Cotaruse	204	62.5	9.8	14.2	31
2011	Trujillo – Chiciayo	325	101.4	15.6	15.8	1
2012	Carhuaquero-Cajamarca Norte-Cdclic-Moyobamba	402	106.9	16.2	22.2	27
2013	Machupicchu-Quencoro-Onocora-Tintaya and substations	356	114.3	16.7	28.5	41
2013	Mantaro-Marcona-Socabaya-Monfalvo	900	278.0	41.4	63.5	35

Source: S. Oguah and P. Sanchez, "Private Sector Participation in Transmission Systems: Making It Work. Live Wire," (World Bank Group), 2015, http://documents.worldbank.org/curated/en/337861467990990322/pdt/100989-BRI-VC-PUBLIC-ADD-SERIES-Box 393254B-Knowledge-Notes-LW52-OKR.pdf (accessed March 10, 2017).

RECOMMENDED ACTIONS

TBCB to be made the mode of award of all power transmission projects irrespective of 'compressed time schedule', 'technical Upgradation' or 'strategic importance'.

5.5.2 Availability of accurate GIS information

Accurate GIS data is critical for the transmission asset developer, as this data forms the basis of transmission planning and is the predominant driver of the tariff quoted.

The current GIS data set made available to all asset developers captures information such as contour maps, elevation, the location of water bodies and population densities. This provides a reasonable starting point for planning but is three to four years old and has some gaps. The current dataset also lacks information on land use and ownership. For example, the GIS data does not specify if the land is allocated for defence, if it falls in a forest reserve, or is in an aerodrome —all critical factors for assessing the time of execution and quoting an accurate bid tariff. Given the need for accuracy, developers need to commission new studies to verify the GIS data and supplement it. The relevant data is, however, already available with the Survey of India, National Remote Sensing Centre, Geological Survey of India, Forest Survey of India and Wildlife Institute of India. It is just inaccessible to private transmission developers.

While making the layered data available will understandably take a long time, an immediate step could be to revise and update Geological Survey of India maps. The National Remote Sensing Centre (operated by ISRO) can share proximity satellite images on a commercial basis after the transmission asset developer gets an NOC from the MoP.

Providing complete GIS data to prospective transmission asset developers (Exhibit 5) could reduce costs, time and errors for all stakeholders involved in managing India's grid.

RECOMMENDED ACTIONS

Provide access to all relevant GIS data (already available with concerned organizations) to private transmission asset developers

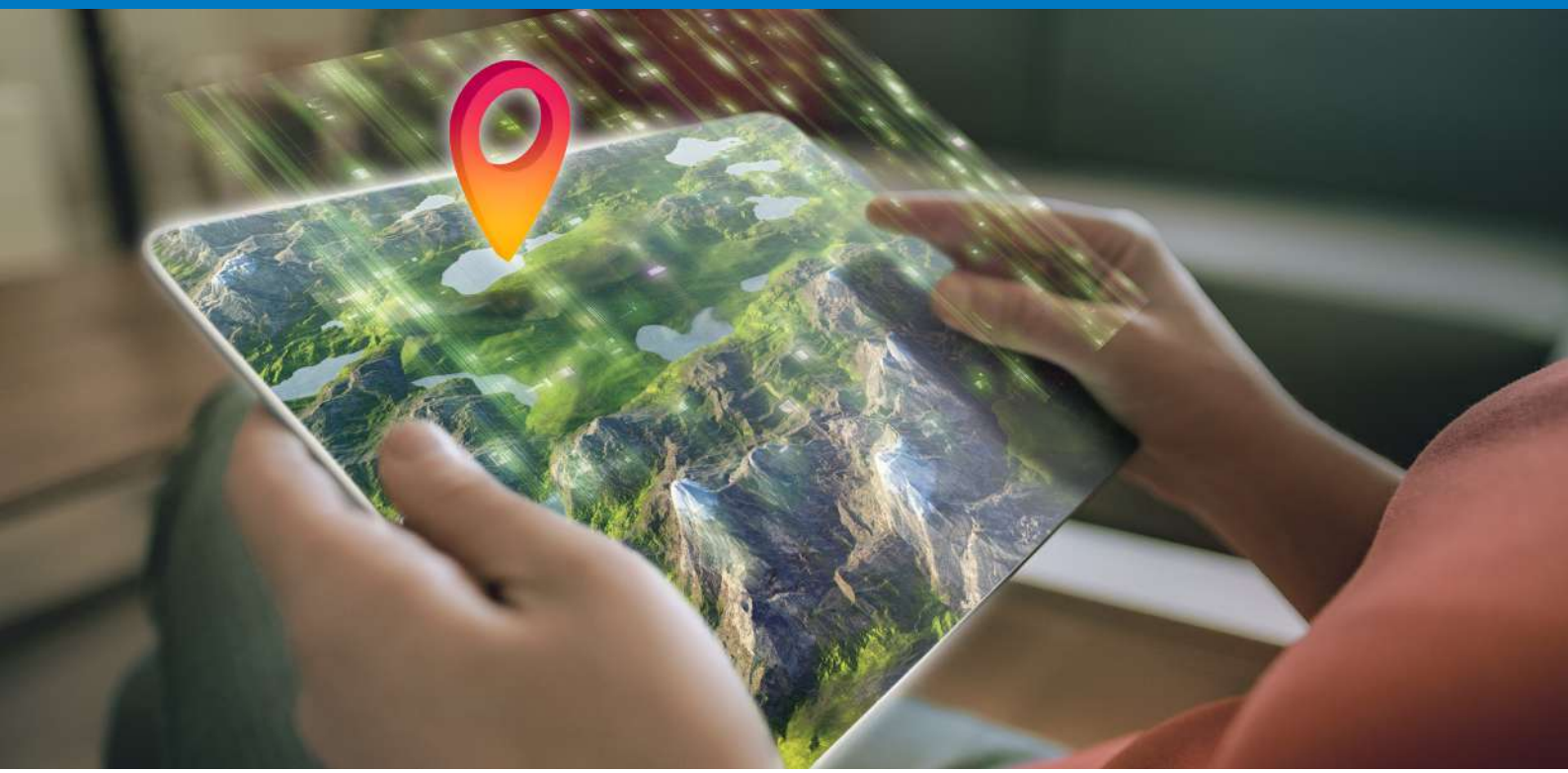
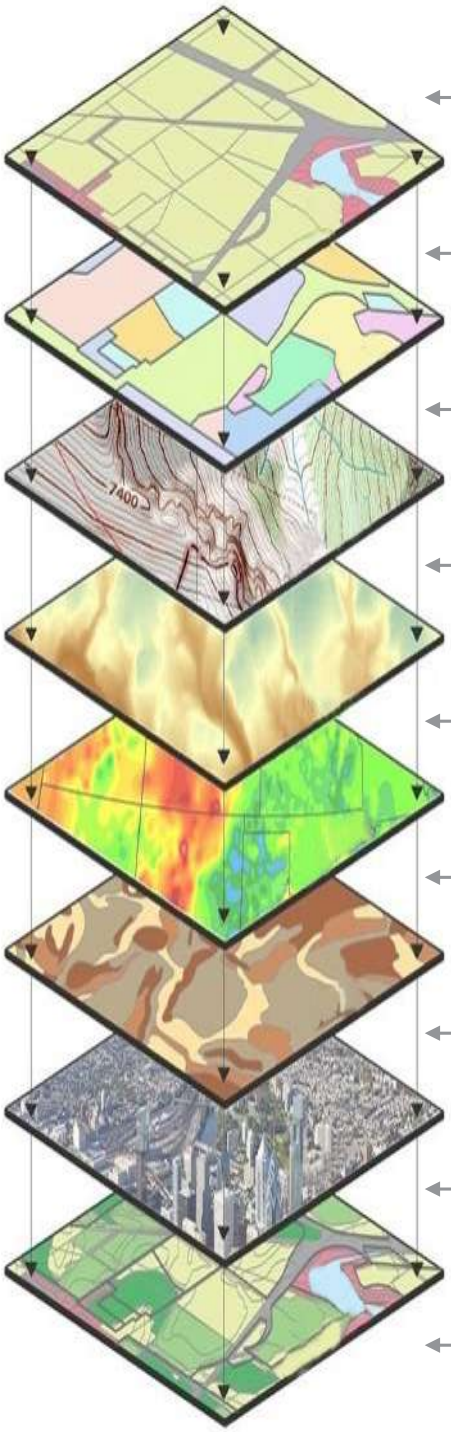


Exhibit 5 – PROPOSAL FOR GIS DATA INTEGRATION AND ACCESS

Data access required from concerned organizations



	Data	Nodal Ministry/ Agency
1	Defense Land	Ministry of Defense
2	Aerodrome	Ministry of Civil Aviation
3	Reserve Forest	Forest Dept of State Govt./MoEF
4	Tribal Land	Ministry of Tribal Affairs
5	Water Bodies Map	Irrigation Dept, State Govt.
6	Topographic Data	Dept of Science and Technology
7	Railways Map	Ministry of Railways
8	Mineral Deposits	Ministry of Mines/Coal
9	Archeological Sites	Archeological Survey of India

Data fully available with these agencies

- Survey of India
- Geological Survey of India
- Forest Survey of India
- National Remote Sensing Center
- Wild Life Institute of India

5.5.3 Improvements in the current TBCB framework

In the current TBCB framework, the average time to award contracts varies between 200 to 400 days.[2] The Ministry of Power guidelines state that the bid process must not take more than 145 Days (Exhibit 6). Across the 12 activities that make up the bid process, starting from the 'Issue of Request for Quote (RFQ) Document' to 'Signing of RFP project documents and 'Transfer to developer', the two activities most prone to time overruns are 'Submission of RFQ, RFP' and 'GIS Mapping' – cumulatively contributing to nearly 80 per cent of the delay. The RFQ and RFP delays are mostly due to multiple sets of changes in the tender requirements, clarifications and resubmission of RFP.

Adopting a single-stage bid process where the RFQ and RFP are merged into one document would significantly reduce both the expected timeline and the potential for delays (Exhibit 7). All bidders would be required to post a heavy security deposit to ensure that no underqualified players attempt to participate in the bidding process. A bidder found to be underqualified by the competent authority forfeits the deposit. Brazil follows this practice, where the total time from the issue of the RFP document to signoff and transfer is around 100 days. Adopting something comparable would improve the bid durations without undue risk of unqualified bidders entering the process.

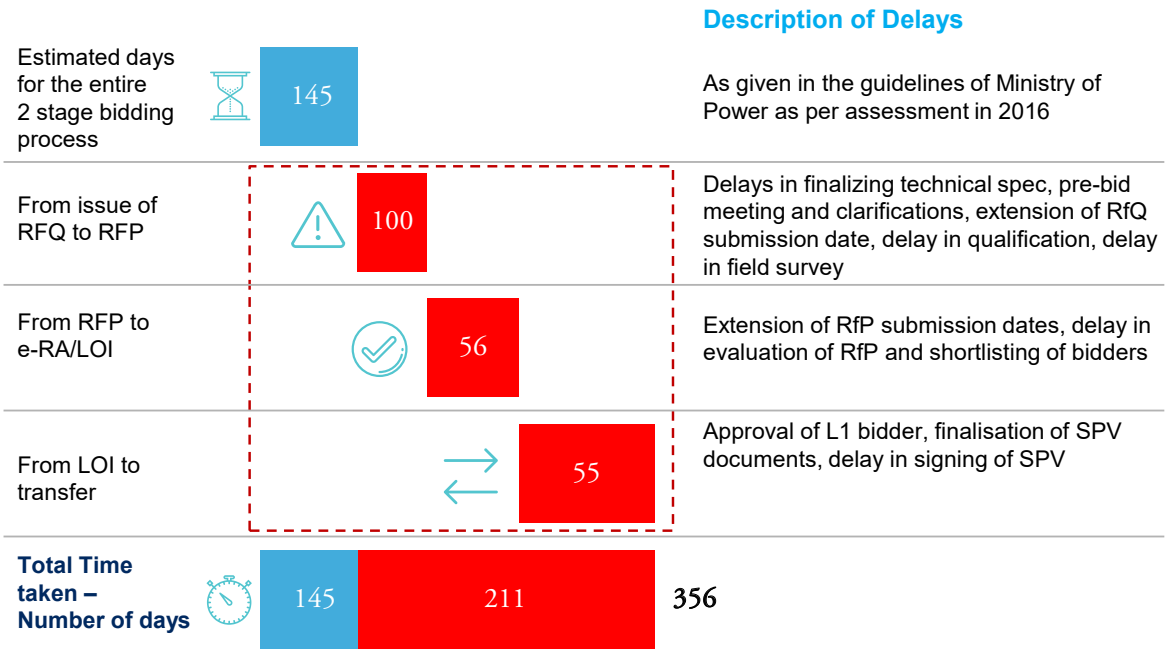
2 Interviews with transmission asset developers

RECOMMENDED ACTIONS

Bid Process Coordinator to adopt a single-stage, two-envelope bidding process wherein the RFQ and RFP are submitted together. Liability of qualification is on the bidder, secured by heavy security deposits.

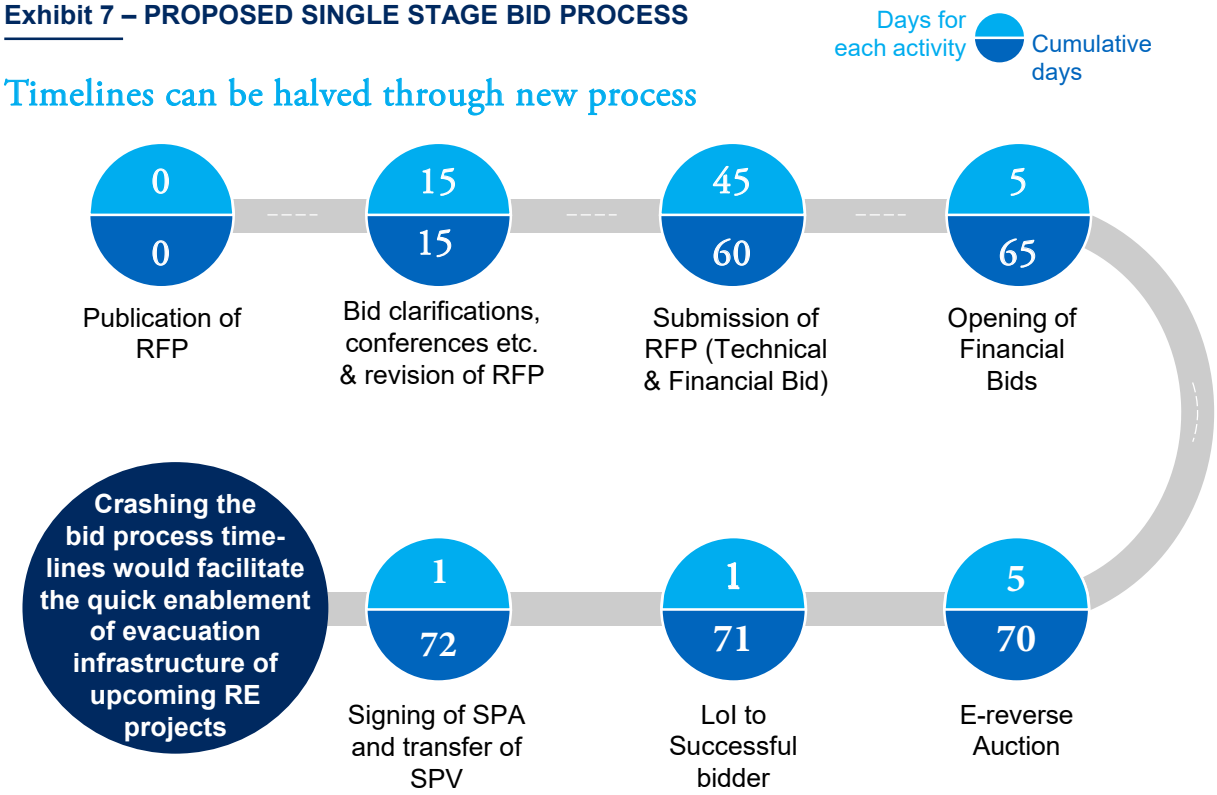
Exhibit 6 – BREAKDOWN OF DELAYS IN CURRENT 2-STAGE BIDDING PROCESS[1]

Average time over run in the current 2 stage bidding process for a sample of 14 projects over and above the guidelines



1 Interaction with multiple transmission asset developers

Exhibit 7 – PROPOSED SINGLE STAGE BID PROCESS



5.5.4 Overcoming clearance bottlenecks

Once a project has been awarded, its on-time commissioning remains a significant challenge. One of the biggest tasks both public and private developers face is the timely completion of approvals (forest clearance, RoW, railway and highway crossing, and use of new technologies). The developer cannot control the timelines for these clearances, and often suffers unexpected delays in completion. A review of the bottlenecks in these critical clearance projects indicates significant potential to streamline and resolve them. The time taken for forest clearances, for instance (currently around 550 days) could drop by 45 per cent.

5.5.5 To optimize forest clearance process

The government could cut clearance time in three ways:

- **Delink identification of compensatory afforestation (CA) land activities from stage-I clearance (secured through financial commitments from the developer)**

  Typically forest clearance takes anywhere between one to two years (Exhibit 8), a major reason for delay being the task of identifying double degraded area for afforestation. This responsibility lies with the concerned officials of the Forest Department. The developer is responsible for depositing the cost for raising Compensatory Afforestation, and hence is often simply waiting for the Forest Department to identify the land and provide the relevant compensatory figures. As part of easing the clearance process, delinking the activities related to CA land from commencement of transmission work will help the timely completion of transmission projects.

RECOMMENDED ACTIONS

MoP/MoEFCC could change relevant rules such that the Compensatory Afforestation (CA) to be carried out in parallel, secured by financial commitments from transmission asset developers.

- **Delink Forest Right Act, 2006 certification process from clearing stage-I**
  Obtaining an FRA certificate ensures that the indigenous population is not severely affected by these projects. Linear projects like power transmission lines cause minimal damage to forests and zero displacement due to their small land footprint. Presently, the developer must obtain an FRA certificate before they can be granted Stage I clearance, which delays project execution. Given the low risk of substantial displacement issues for transmission lines, the requirement could be applied to Stage-II clearance. This would speed up the clearance process substantially without increasing risk to the local population (Exhibit 8).

- **RoW reforms—states to abide by central government guidelines of 85:15 compensation for tower footing and RoW Corridor**
  Right of Way (RoW) compensation to construct transmission lines and towers lacks uniform standards and guidelines. Despite existing guidelines for providing 85 per cent and 15 per cent of circle rates[3] for areas covered by towers and conductors respectively, every state makes its own judgement for compensation settlement. DMs have the right to decide all disputes on RoW compensation and land holding rights. Even after obtaining RoW approval under Section 164 of EA-2003, which entails completing due procedures and guidelines, developers often have to run from pillar to post in all districts to ensure the process is completed. Commendably, the government has digitized the application process, but developers must visit multiple offices to verify documentation, adding to delays. There is significant apparatus for sharing transmission routing information. Routes are published in newspapers and time allowed for dispute resolution. The CEA and Ministry of Power publish route notifications through Gazette u/s 164 of EA-2003. Still, multiple developers often clash on routing issues. This primarily relates to the two very important aspects of compensation for tower footing and RoW Corridor which are determination and dispensation of the 85:15 compensation respectively.

The major problem faced by transmission asset developers is determination of the rightful owner and then deciding the right amount of compensation owed. Most of the land records are not regularly updated hence identifying the rightful owner becomes difficult and most often the owner refuses to agree to the 85:15 compensation as mandated by the center and demands a sum more than that, thus resulting in individual negotiations along the RoW corridor. This results in massive time and cost overruns for the developers.

It is therefore suggested that the compensation value be calculated and communicated to the asset developer by the district magistrate/ deputy commissioner and the developer simply transfer the decided amount to the district treasury and thereafter the district administration carries out the process to pay the farmers.

It has been noticed that Railways/ Municipalities levy very high cost/fees[4] for granting RoW over their asset crossing, hence some degree of rationalization (broad guidelines) should be provided for RoW over asset crossings.

3 Ministry of Power Government of India, guidelines

4 Interactions with transmission asset developers

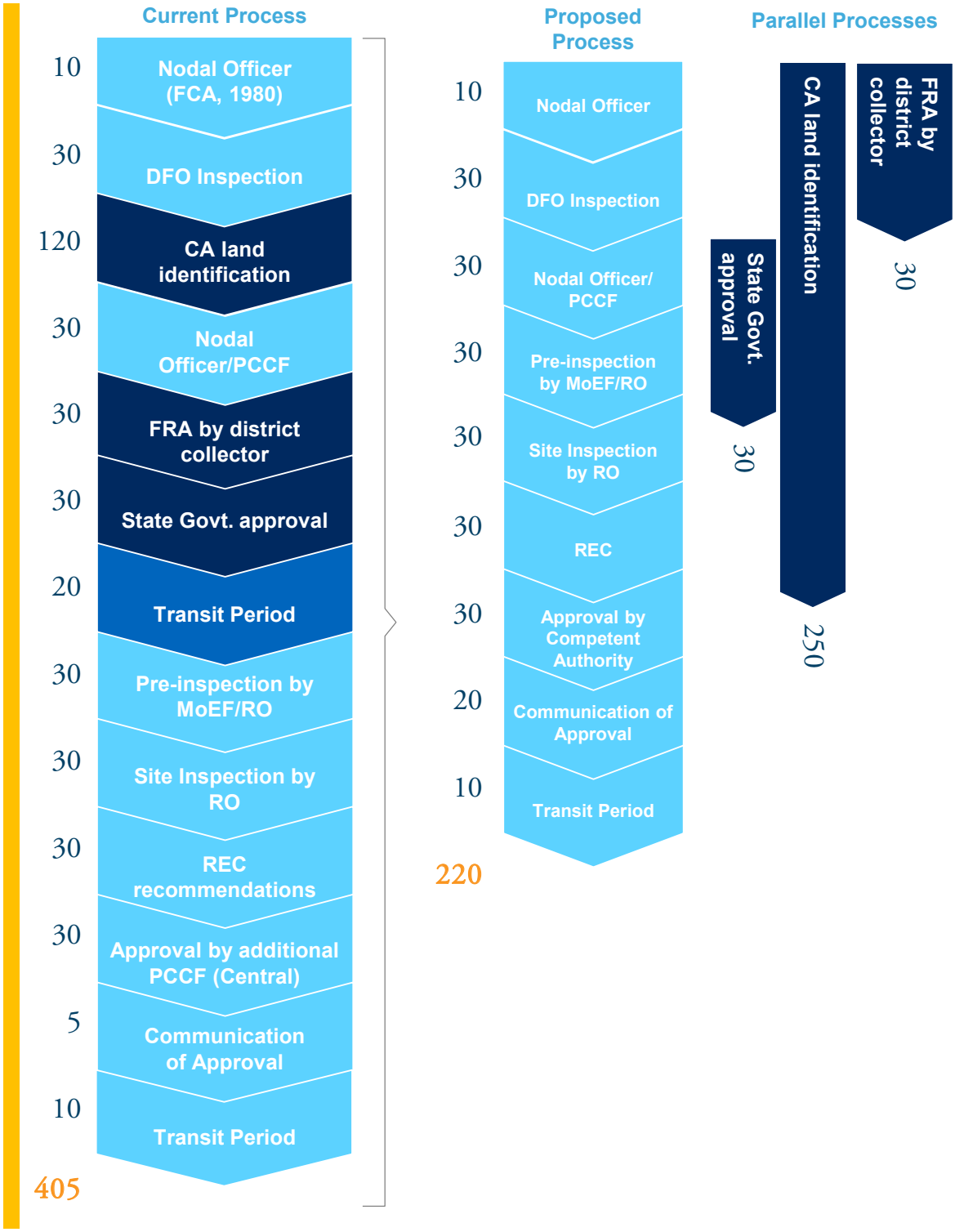
RECOMMENDED ACTIONS

MoEFCC to issue guidelines De-linking of FRA certification from stage 1 clearance for linear projects.

Exhibit 8 – POTENTIAL TO REDUCE FOREST CLEARANCE TIME BY 45 PER CENT

xx Days at each level xx Total number of days Parallel step Step not required

Current process for forest clearance with land area >400 ha.



In Brazil and several European countries like France and Norway, an updated database on land ownership is available municipality-wise. Land is identified and the land-owner intimated regarding the activities to commence on his/her land. There are clear steps that are outlined for land identification, negotiation and access. After negotiation, there is a public declaration mentioning project details, land specifications and the negotiated amount, following which payment is made.

In Brazil, the Energy Regulator, ANEEL authorizes the administrative easement for the areas necessary for the license term through declaration of public utility (DUP), which facilitates negotiations to obtain the rights to use land.

The authority puts public interest above private interest. Although both parties can resort to court in case negotiations fail, project activities continue unhindered.

Ease other approvals – Railways, National Highways, Canal crossings These other approval processes are also longwinded and cause delays in the absence of a single window system. The Railways, National Highways and Canal authorities do not even recognize private players for giving RoW for crossing work. They often reject the proposal, asking that it be routed through the Ministry, thus causing inadvertent delays.

5.5.6 Early commissioning incentives

It is most often that asset developers complete the construction of the transmission lines well before the SCOD and are in a position to energize the segment before the scheduled commercial date of operation (SCOD) but often they express their inability to do so because either the upstream or downstream is not complete or they were not able to predict their date of energization before currently stipulated time of 24 months.

Hence it is proposed that the early commissioning incentive structured be changed to one which offers a time band for energizing the segment. This can be achieved if we move from a scheduled commercial date of operation (SCDO) to a scheduled commercial period of operation structure (SCPO) wherein a developer is given a period to energize the system which may be six months or one year. If the developer completes the construction between the first and last day of the period, he is able to start recovering revenue and if he goes past the last date of period he is liable to liquidated damages.

How Brazil addressed this[5]

The transmission developer anticipates its COD vis-a-vie the 'necessity date' established through ANEEL (Regulator) If the anticipated COD is earlier than the necessary date, the developer request for an anticipation date three months in advance, if agreed by the user.

The transmission developer is then entitled to revenue recovery from its actual COD to the end of the license period.

5 Expert interview

RECOMMENDED ACTIONS

- Creation of a Land Compensation Determination and Dispensation Committee (LCDDC) chaired by the district collector whose members include the relevant ADMs, SDM, Tehsildar, and Superintendent of Police (If required) and representatives of the asset developers for compensation determination and dispensing function.
- Replace the existing system of Schedule Commercial Date of Operation (SCOD) with a system of Schedule Commercial Period of Operation (SCPO). SCPO could be a two- to three-month time period such that if the asset is commissioned within the SCPO it must be eligible to start earning revenues.

5.6 Promote innovation through greater freedom of design

The construction of transmission lines is mandated to follow CEA Technical Regulations 2010. These are commendably wide enough to leave scope for the adoption of new technologies. RPFs, on the contrary, tend to be prescriptive in the use of technologies and designs, which leaves little room for the developer to optimize time and cost. (Exhibit 9). A potent example are the constraints around tower design. While CEA leaves flexibility on the tower design to developers, more than 99 per cent of RFPs in India make it mandatory to use lattice structures. Developers outside India (such as in Canada and the US) have used monopoles liberally to optimize for time of construction. These are easier to install (typically through three parts which can be pre-fabricated). While the Indian monopole manufacturing market is still in a nascent stage, a demand side push through RPF specification, as well as standardization of design could further accelerate supply. RFPs could also permit other tower designs such as guy towers, hybrid towers and FRPs. Conductors are another area allowing scope for flexibility. ACSR/AAAC are commonly prescribed conductors, used widely in India. Other conductors such as HTLS/HPC (which has the lowest sag) are not typically prescribed in RFPs. Offering greater design freedom will need to be paired with better oversight mechanisms to ensure safety and manage risk. The risk of the status quo is that India might continue to underutilize innovations necessary for the grid of the future.

BIS standards for materials and design new technologies in design, better construction methods and more robust materials are fast emerging in the power transmission sector.

These make it more important to update existing standards and specify new standards to enable transmission utilities to adopt these new technologies in upcoming projects. For example, while standards are in place for lattice towers, there are no specifications for the use of monopole towers, insulated cross arms, guyed towers and special foundations like micro-piling or grillage. This deters transmission utilities from adopting and benefitting from new developments.

Use of aviation-related technology during survey and construction of transmission lines

The use of LiDAR and drones, stringing with helicopters and air patrolling could help to finalize routes. Transmission Line route optimization through LiDAR survey is one of the advanced technologies adopted globally by private players while undertaking survey for projects. Light detection and ranging technology is deployed to conduct topographic mapping and functions well in cloudy conditions and can penetrate through dense vegetation. Similarly, technologies like use of drones for stringing and heli-cranes can help in reducing man-hours as well as cost and time involved in physical construction of transmission lines.

However, use of aviation related technology requires aviation and District authority approvals and for a 1,000-km route spanning many districts and states, this could entail hundreds of approvals.

RECOMMENDED ACTIONS

- In the transmission bid documents CEA/CTU to allow freedom of design in tower design and conductors
- MP and MOD to facilitate in appointing a gazetted security officer who can act as the custodian of the LiDAR data

Exhibit 9 – RANGE OF DESIGN CHOICES AND RESTRICTIONS BY RFP

🟢 Prescribed by most RFPs 🟡 Prescribed by a few RFPs 🔴 Generally not prescribed by RFPs

Design choice offered by RPFs

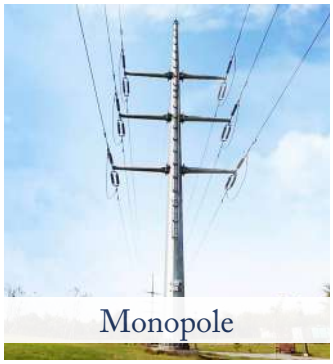
Key design parameter	Design choices possible	Design choices available in RPFs
1 Tower design	Lattice structure	🟢
	Monopole	🔴
	Guy structure	🔴
2 Conductor Design	ACSR/AAAC	🟢
	HPC	🔴
	HTLS	🔴

We should **specify the technical performance matrix instead of specifying material** and design


Lattice structure


ACSR


AAAC


Monopole


HTLS


HPC

5.7 Capacity augmentation of existing transmission infrastructure

With urban evolution, evolving demographics, expanding renewables and changing market dynamics, the transmission sector will need to adopt innovative means of solving energy delivery challenges:

a. Urban growth: Around 31 per cent of India is urbanized and the figure is expected to touch 60 per cent by 2050[1]. According to a recent report from Oxford Economics, 17 of the top 20 fastest-growing cities in the world are in India. There is a growing demand for access to basic utilities, reliable and quality power to improve the quality of life. Our cities are not being planned for this urban evolution and shifting demographics.

b. Changing energy mix: Renewables becoming mainstream and competing head-on with fossil fuels will lead to a change of supply from newer locations where the capacity of lines would need to be increased. As a corollary, transmission lines from fossil stations would see lower usage.

c. Electricity market disrupting load flows: Recent trend change in power procurement by Power utilities from long-term contracts to shorter term contracts and availability of power from cheaper sources is the first stage of disruption. Grid parity and expiry of LTAs would bring about subsequent stages of disruptions.

d. Changing demand patterns, penetration of EV and various consumption side factors will contribute to future disruption.

The net result of these megatrends would be in bringing energy from green sources spread over a wider geography into large centres of consumption where space becomes a limiting factor and leveraging existing infrastructure is an imperative.

Hence, transmission system owners, operators and planners could consider sufficiently wide range of solutions that

a. Exploit additional capacity of the existing system without compromising safety margins such as Dynamic Line ratings/Power Flow Controllers, etc.

b. Augment transmission capacity in the same Right of Way (RoW) such as reconductoring, voltage upgradation, Multi-Circuit- Multi-Voltage transmission lines etc.

To improve the efficiency of capital spend by transmission utilities following steps could be considered

a. Mandating the use of transmission solutions, stated above, in the State Electricity Grid Code. States such as Karnataka has been early adopters of such transmission philosophy.

b. Before finalizing the transmission scheme, STU must publish the details of all probabilistic scenarios and suggested transmission schemes on its website and seek stakeholder's comments. STU must finalize the transmission scheme after considering the responses received from stakeholders.

c. State regulators to approve CAPEX only after prudent scrutiny of the 'optimal' transmission plan is proposed by the STU. Optimal transmission plan must consider to minimize capital expenditure, shorten time to completion, limit environmental impact and cause minimal service disruptions to people.

d. Adopt competitive bidding route for developing intra-state transmission system, in accordance to the tariff policy.

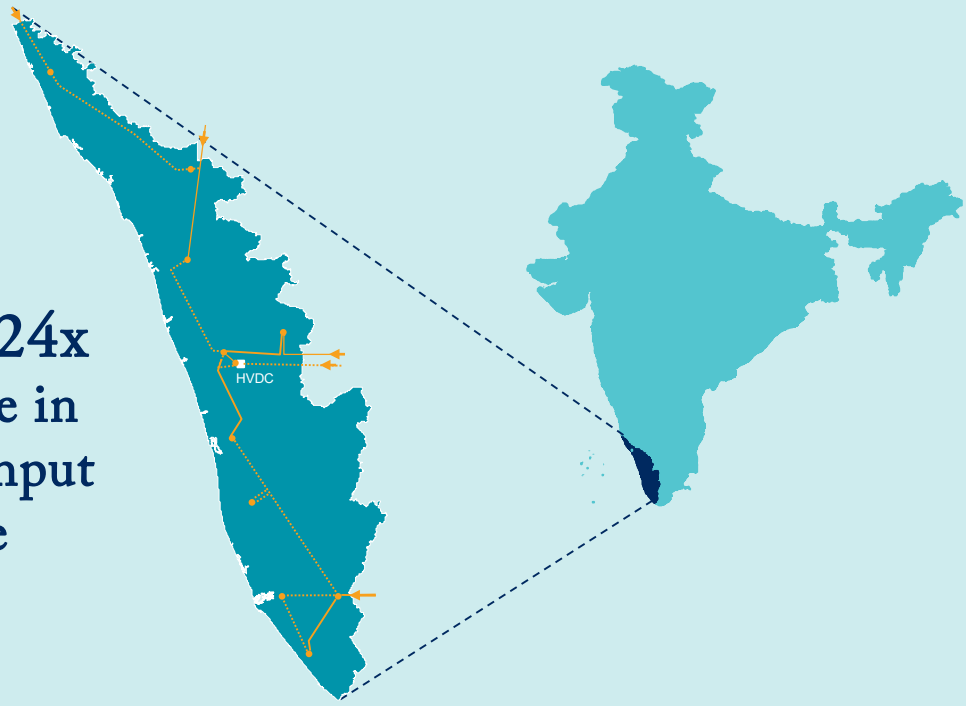
Case in point is the state of Kerala a highly inhabited region where the entire state had to be treated as an extended metro city for all purposes of transmission planning considering the RoW is at a premium and exceedingly hard to get. After exercising considerable amount of reflection, multiple stakeholder discussions, it was decided that in all important corridors voltage upgradation will be done along with use of high capacity conductors on narrow-base multi-circuit towers.

It is for the first time in India, a state utility decided to undertake such an extensive voltage upgrade and current uprate exercise. Kerala's choice will result in significant savings to the state power utility in terms of time, space and capital. This new method has the potential to serve as a one of the most significant contributors for meeting transmission objectives in energy planning and asset improvisation in 21st century India.

1 https://www.orfonline.org/expert-speak/energy-use-in-indian-cities-a-case-for-district-energy-systems-47506/

Uprate and Upgrade in Kerala – revolutionising power transmission[1]

15x – 24x Increase in Throughput Rate



Context

- Meet **projected demand growth** for next 20 years
- **Limited expansion of generation** possible within state
- **Planned and approved high capacity ISTS corridors** for importing power into state

Strategic imperative

- **Transmit power from ISTS points** to major high capacity grid substations
- **Strengthen downstream network** to meet growing demand

Planner's Dilemma

- **Limited scope of new transmission corridors** due to lack of RoW
- **Challenging timelines**
- **'NIMBY' Not In My Backyard** specter

Solutions deployed

1. **Upgrading existing corridors** to higher voltage levels
2. **Reconductoring existing network** with High Performance conductors

Technologies
MCMV, monopoles, HPC/ HTLS, and alternate construction techniques such as aerial techniques, micro pilling

1 Expert Interactions

RECOMMENDED ACTIONS

- Mandating use of transmission solutions, aimed at capacity augmentation of existing infrastructure (such as reconductoring, voltage upgradation, Multi-Circuit-Multi-Voltage transmission), in State Electricity Grid Code
- State regulators to carry out objective evaluation of transmission plans against factors such as capital efficiency, minimal completion time, limited environmental impact and least service disruption. Reference of such evaluations can be drawn from Network Options Assessment followed by National Grid (UK). Capex plans to be approved after objective evaluation of transmission plans
- Third party audit of transmission plans to be carried out to ensure compliance with electricity grid codes and objective evaluation put in place by state regulator

India's first use of air crane for power transmission project in Jammu and Kashmir, 2017.[1]

It enabled the commissioning of the project two months ahead of schedule

1 Press Search

5.8 Incorporate energy storage solutions as transmission system elements to meet flexibility requirements

Energy storage for grid balancing
Constantly and rapidly balancing the difference between required load and generation is key to maintaining grid reliability. The challenge often faced in balancing the two is ramp times: the rapidity with which a generation source can increase or decrease power output expressed in MW/min. When a grid lacks balancing capacity, utilities are left only with the option of load-shedding or face rolling blackouts. Increasing share of renewable solar and wind on the Grid poses its own unique new challenges to grid management and planning. The grid now needs to be resilient and flexible enough to absorb or replace the fast ramping solar-based RE assets in the morning or evening respectively. In developed countries, two most commonly used methods for ramping are gas "peaker" plants and pumped-hydro storage.[1] India will need ramping resources of around 400 MW/Minute, which cannot be met by existing gas peaker and pumped storage plants. This is because India has very limited reserves of natural gas and very few gas power plants that are operational and can be used for ramping. While pumped-hydro plants have long asset lives and are economically attractive in theory, they are limited by location availability, associated with environmental impacts and have historically faced significant time overruns taking more than 8–10 years to build. This restricts pumped-hydro's potential to addressing India's ramping requirements to less than single digits.

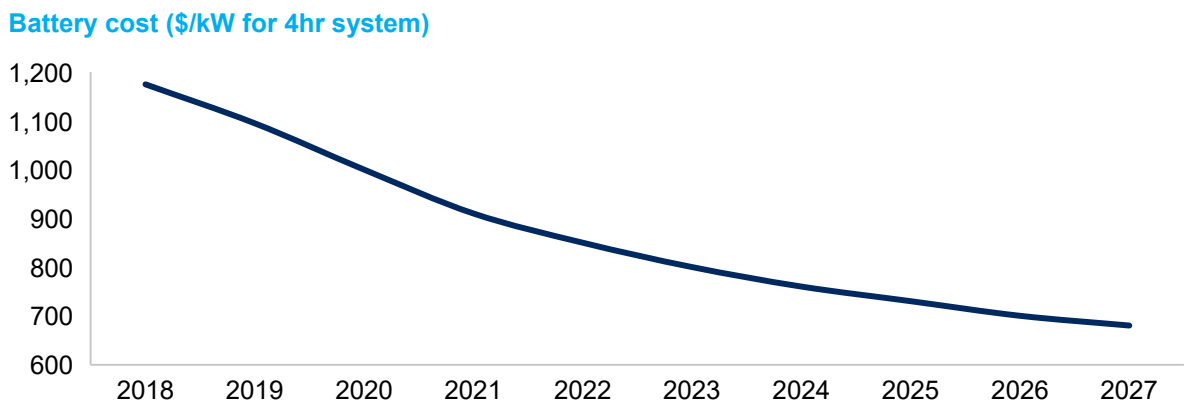
1 Grid balancing expert interaction

Some studies done in the past showed that 175 GW RE could be absorbed into the grid through existing hydro assets and flexible operation of thermal assets resulting in minimal RE curtailments.[2] However, such studies do not adequately account for the technical limitations and costs of flexible operation of thermal assets deployed in India which are vintage technologies. Such studies also do not account for the losses and congestion encountered in balancing relatively remote generation sources. This presents a very real and significant need for a resource that can help balance the grid.

Electrochemical energy storage technologies can address such a need. Firstly, battery storage is one of the most versatile balancing technologies: it has millisecond-level response times, can ramp from 0–100 per cent output in less than 60 seconds and can be commissioned in less than six months, enabling quick deployment[3]. Secondly, battery storage is modular and has a small footprint; this means that grid operators can deploy as much as they need at the exact locations in the grid where such assets can have maximum benefit. Thirdly, battery costs have fallen 75 per cent in the last seven years and are expected to fall another 50 to 55 per cent by 2027[4] making them cost competitive with the pumped-hydro and gas peaker plants available in developed countries.

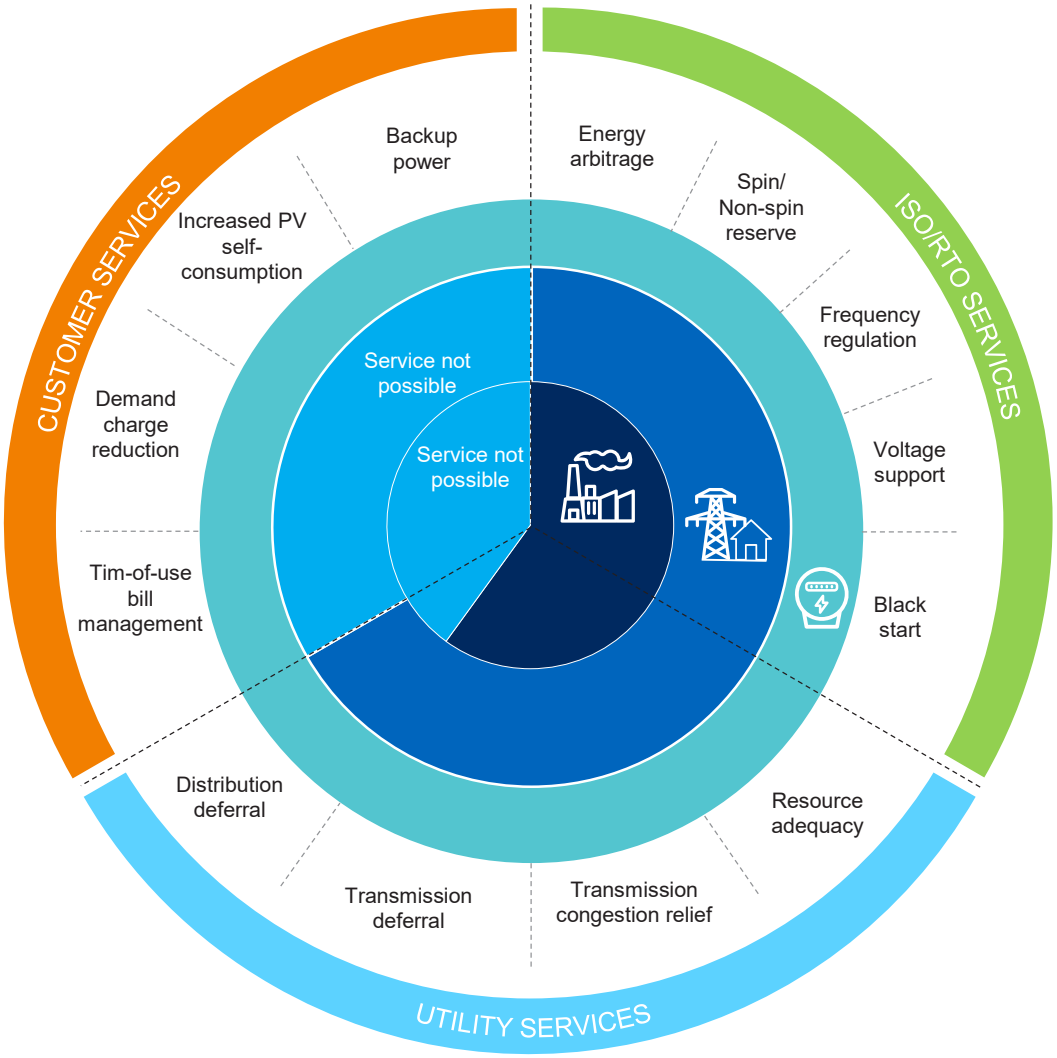
2 http://www.cea.nic.in/reports/others/thermal/trm/flexible_operation.pdf
3 Grid scale Lithium Ion battery storage experts
4 Expert interviews and press search

Exhibit 10 – FALLING STORAGE COSTS WILL OPEN UP FURTHER APPLICATION POTENTIAL



Source: GTM research

Exhibit 11 – STORAGE ASSET SERVES MULTIPLE VALUE STREAMS



Source: GTM Research Aug 2018

RECOMMENDED ACTIONS

CEA could issue guidelines for mandatory deployment of fast energy ramp-up and storage systems for grid balancing like battery storage / pumped-hydro/ gas peaker plants in the grid (whichever is the most cost effective on a case-by-case basis).

Seven medium-term requirements for a futuristic transmission system

6. Address seven stand-alone medium-term requirements

1. **STUs to make underground intracity power mandatory in top 50 Cities**

   In many of the top 50 cities (by population) in the country, there have been multiple incidents of high-tension lines snapping and falling in residential or commercial establishments, causing casualties, loss to property and even death in some cases. Recently in Hyderabad a woman was burnt alive when a high-tension wire fell on her car.[1] In the last two decades, the separation between residential and commercial establishments and sub-transmission high tension lines has only reduced. This has happened as new residential colonies and commercial establishments have come up in areas which were earlier earmarked for open spaces in the city's original master plans made in the 1980s. With the increase in population and income levels in the country, the rate of construction of residential houses has been growing, often so much, that it has now come close to dangerous limits with sub-transmission lines posing a serious safety hazard. Even though the cost of underground power transmission is four to five times the cost of over-ground transmission, it must be mandated, at least in the top 50 most populous cities of India.

2. **CERC could bring policy for shareability and transferability of long term open access (LTOA) Capacity**

   The power generation sector is witnessing major shifts with many large IPPs shutting down or operating less than 50 per cent of their capacity (to be economically feasible). These trends in the generation space need to be appropriately factored into the transmission planning process. Currently such changes in the generation space are not reflected in transmission planning as it is based on total LTOA capacity recorded between generation stations and consumption centres. This poses a serious problem thus can result in 'excess' installed capacity of upcoming Renewable Energy plants which may either overload the transmission network or underload (underutilization) it. Current rule position does not permit the transferability of the LTOA and its surrendering process is full of red tap therefore followed by few. Hence is suggested LTOA be permitted for transfer by generators much like the telecom sector where spectrum licenses can be traded between telecom players wherein the regulator is duly informed of each deal. Creation of a framework for tradability of LTOAs is essential in light of significant changes in the generation space where CERC can play an important role to ensure no illegal hoarding of LTOA is done.

3. **SERCs could create a pooling method for states (similar to the central PoC pooling concept) so that lopers lopers more comfortable investing in states**

   The Point of Charge (PoC) pooling mechanism affords two sets of benefits of benefits transmision developers. Firstly, it assures them payment security as the CTU collects the owed amount on their behalf and simply transfers the money to them. Secondly, there is no cost of tariff collection for transmission

   asset developers as they do not have to bill each and every beneficiary. All cumulative bills are sent to the CTU.

   This framework gives confidence to transmission asset developers for timely payments of dues, because the CTU collects the dues directly from beneficiaries and is in a better position to penalize or force compliance.

   This has led to private investment in transmission of approximately 41 per cent of the total spend in the ISTN since 2011.[2]

   Whereas in the states such a mechanism is not present. If private transmission asset developers decide to invest in the state grid, they will have to chase beneficiaries for dues which may not be received in full on time. This creates a perception

1 https://www.indiatoday.in/india/story/hyderabad-woman-burnt-alive-high-tension-wire-falls-car-highway-976845-2017-05-13

2 Compilation of CERC orders

of risk, leading to limited private investment in the state transmission network. A state PoC polling mechanism could be considered for all states, which would be a critical enabler for development of the state grid.

4. **MoP could issue guidelines for mandatory representation of major power transmission asset developers in the National Committee on Transmission (NCT), Empowered Committee on Transmission (ECT) under the MoP and RPCs.** With the private sector playing an increasingly significant role in the power sector, contributing over 41 per cent of the total spend in power sector since 2011.[3] Having built over 20,000 Km of transmission lines in almost all states including sensitive states like Jammu and Kashmir.[4] It is only pertinent that they be given a representation in committee such as RPCs, NCTs or ECTs owing to the value they add because of their vast experience in different regions, situations and most importantly the knowledge of practicing the most time, capital and Row efficient practices to meet the given transmission objectives.

5. **CERC could create a framework for creation and maintenance of ancillary services market in India by POSOCO.** Ancillary Services are an integral part of the electricity ecosystem all over the world. They mean in relation to grid operations, the services necessary to support the power system (or grid) operation in maintaining power quality, reliability and security of the grid (e.g., active power support for load following profile, reactive power support).

   As there are multiple shifts affecting the grid, e.g., increase in RE integration which comes with generation variability, use of power in the transportation sectors, shutting down of some traditional coal-fired power plants, underutilization of LTOAs, etc. which makes it increasingly important to ensure the grid parameters like frequency remains within tolerance limit of (49.8 Hz to 50.2 Hz), harmonics remain at a minimum (less than 5 per cent) the voltage remains within its tolerance limit (±5 per cent @220 kV) for ensuring grid integrity.

   To enable provision of these services, specific support services are required to complement reliable grid operations – Frequency support, Load following, Reactive power support. This can be achieved by creation of an ancillary services market wherein developers install and manage specialized instruments and systems to ensure grid parameters stay within tolerance limits and charge the system operator for correcting deviations beyond the tolerance limits.

6. **CEA / MoP could create a framework for monetization footprint of urban transmission and distribution assets** There is often a case where utilized land remains with the transmission assets / distribution assets. Such land can be put to much better use by hosting an asset that requires interrupted high energy for its functioning (e.g., data centers, more so because high speed data can be carried on the power grid using an Optical Ground Earth Wire (OPGW) which is two core wire with fiber optic cable inside the earth wire, capable of transferring data at over 1gbps. Also, this can host Common Service Centers (CSC) which form a centralized collaborative framework for delivery of services to each and every village of the country as part of the Digital India program.

7. **Could facilitate use of innovative models of ownership and financing** The country in recent times has seen a very successful implementation of an innovative model of infusing the competitive efficiency in operational assets belonging to the road sector.

   With a view to monetize operational national highways, the National Highway Authority of India (NHAI) introduced the Toll Operate and

3 Compilation of CERC orders
4 Press Search and Interaction with transmission asset developers

Transfer (TOT) model for partnership with private developers in the road sector. Under this model, NHAI passes on the toll collection rights and operation and maintenance obligations for 30 years to the private developer against payment of upfront, one-time, lump sum concession fees quoted by the private developer as part of the comprehensive bidding process.[5] The model has met the major success and NHAI is expecting to monetize 75 public-funded national highways with a road length of around 4,500 kilometres that can together fetch around INR 1 trillion for the Government which will in turn help NHAI raise upfront capital to fund road projects based on EPC and hybrid annuity models[6]

Power transmission is akin to the road infrastructure when it comes to the scale of capital investment requirement. Currently there are over INR 5 lakh crore worth of operational transmission assets in the country both in the national grid and in the state grids.[7] Renovation and modernization of the grid requires substantial capital investment. The CTU and most of the state transcos are facing severe financial crunch in deploying funds for operations and maintenance and timely upgradation of transmission and sub-station system. It has also been observed that there is lack of trained manpower for technical and financial management of operating assets. Unavailability of funds and lack of skilled manpower when sustained over a period of time can have serious consequences.

Globally business models allow asset management companies to acquire operating assets and undertake their maintenance and earn revenue from it till the end of its economic life. Such models of ownership help the asset developers to keep their focus primarily on further asset development as they are rest assured that timely maintenance, upskilling and efficiency maximization is well taken care of by the AMC (Asset Management Company) to which the asset has been transferred.

These AMCs enable global pension funds, sovereign funds, large insurance to park their funds with them because the transmission asset under management have a steady and secure cash flow.

Thus, there is a merit in considering a model like TOT of roads for transmission sector where the operational assets could be put out to bidding for the residual life of the assets which would ensure investments enabling the renovation and modernization on these assets. Further, as the sector have gained significantly on account of the competitive bidding in green field projects, this model for operational assets could work not only modernizing the brown field projects, enhancing their life but would also reduce the running annual tariff being paid by the discoms, directly passing on the benefits of competition to the consumers.

In addition to these models of ownership and financing, the government can reconsider other instruments of credit like use of External Commercial Borrowings (ECBs) in the power sector.

5 http://www.mondaq.com/india/x/751372/cycling+rail+road/Toll+Operate+Transfer+Model+Gateway+To +New+Opportunities+In+Highway+Sector
6 Expert interactions and press search
7 Industry expert interactions

Short-term suggestions for policy makers

8 Short-term suggestions for policy makers

1

More flexible transmission network planning

- Central Electricity Regulatory Commission (CERC) to notify General Network Access (GNA) Regulation
- All 220 kV and above network to be centrally planned by CTU

2

Separation of CTU from Power Grid Corporation of India Limited (PGCIL)

Clear separation of embedded functions into mutually exclusive functions of a) planning, and b) development and operations, via the creation of an independent CTU, completely distinct from any developer

3

Tightening of grid performance parameters in the context of increasing renewable energy (RE) integration

CERC to introduce 5-minute scheduling, metering, accounting and settlement mechanism in a phased manner

4

Improved reliability of the network by developing contingencies in the system

CTU to develop N-2 redundancies in critical energy-delivery corridors such as Tier 1 cities, areas of high generation capacities, and for cross-border energy transmission in a phased manner.

5

Compression of project timelines from notification to start of construction by 40 percent

- Bid Process Coordinator to adopt a single-stage two-envelope bidding process wherein the RFQ and RFP are submitted together. Liability of qualification is on the bidder, secured by heavy security deposits
- Access to all relevant GIS data (already available with concerned organizations) to private transmission asset developers
- The Ministry of Power (MoP) and Ministry of Environment, Forest and Climate Change (MoEFCC) could consider changing relevant rules such that Compensatory Afforestation (CA) can be carried out in parallel, secured by financial commitments from transmission asset developers
- MoEFCC could also issue guidelines de-linking FRA certification from Stage 1 clearance for linear projects
- Creation of a Land Compensation Determination and Dispensation Committee (LCDDC) chaired by the district collector whose members include the relevant ADMs, SDM, Tehsildar, and Superintendent of Police (if required) and representatives of asset developers for compensation determination and dispensation
- Replace the existing system of Schedule Commercial Date of Operation (SCOD) with a system of Schedule Commercial Period of Operation (SCPO). SCPO could be a two to three month time period, such that, If the asset is commissioned within the SCPO it could be eligible to start earning revenues

6 Promotion of innovation through greater freedom of design

- In transmission-bid documents, RFP to allow freedom of design in tower design structures and choice of conductors

7 Capacity augmentation of existing transmission

- Mandate use of transmission solutions, aimed at capacity augmentation of existing infrastructure (such as reconductoring, voltage upgradation, multi-circuit-multi-voltage transmission) in the State electricity grid code
- State regulators to carry out objective evaluation of transmission plans against factors such as capital efficiency, minimal completion time, limited environmental impact and least service disruption. Reference of such evaluations can be drawn from the Network Options Assessment followed by the National Grid (UK). Capex plans to be approved by SERCs after objective evaluation of transmission plans
- Third-party audit of transmission plans to be carried out by the state regulator to ensure compliance with electricity grid codes and objective evaluation put in place are adhered to

8 Incorporation of energy-storage solutions as transmission system elements to meet flexibility requirements

CEA could issue guidelines for deployment of flexible resources and storage systems for grid balancing, such as battery storage/ pumped hydro/ gas peaker plants in the grid

Medium-term suggestions for policy makers

7 Medium-term suggestions for policy makers

1. **STUs to make underground intracity power transmission to be made mandatory in top 50 Cities**

2. **CERC to bring policy for shareability and transferability of the Long Term Open Access (LTOA)**

3. **SERCs to create a pooling method for states (similar to Central POC pooling concept) so that developers feel more comfortable investing in states**

4. **MoP to issue guidelines for mandatory representation of major power transmission asset developers in the National Committee on Transmission (NCT), Empowered Committee on Transmission (ECT) under the MoP and RPCs**

5. **CERC to create a framework for creation and maintenance of ancillary services market in India by POSOCO**

6. **CEA/MoP to create a framework for monetization footprint of urban transmission and distribution assets**

7. **Facilitate use of innovative models of ownership and financing**

7. The Texas versus California case study

Case example – comparing RE integration in Texas and California

Texas and California are large, geographically diverse states in the US with substantial renewable capacity and growing urban load centres. Despite these similarities, Texas was able to commission renewable power far quicker, and at a lower cost, than California, largely because of how Texas used predictive planning.

In 2007, Texas used advanced predictive planning to incorporate wind generation into the grid. High wind velocity areas were marked, their generation capacity projected and transmission lines constructed accordingly. The entire new build for these wind farms was fully financed by private wind farm developers (Exhibit 12). Developers in West Texas can energize their plants without point-to-point interconnection, simply by connecting to the pre-existing grid.

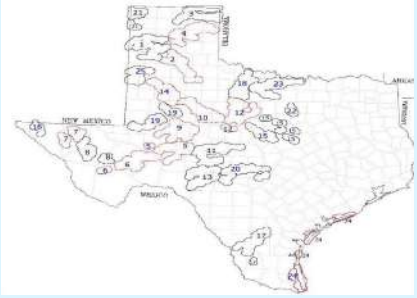
On the other hand, developers in California had to find partners to pool generation so that they could justify the construction of new transmission assets. This significantly delayed the expansion of renewable power in CAISO (California Independent System Operator).

To take full advantage of its high-potential RE zones, India could adopt a similar approach to building infrastructure that gives developers the certainty to proceed, thus enabling better planning, lower costs and faster growth.[1]

1 https://cleanenergysolutions.org/sites/default/files/documents/jeff-billo_webinar-ercot-crez-process.pdf

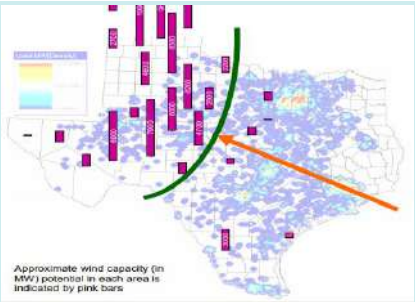
Exhibit 12 – RENEWABLE INTEGRATION IN THE TEXAS POWER GRID, USA

1

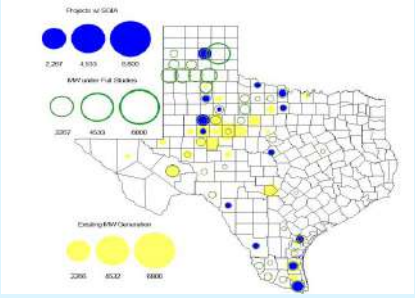


25 High Wind Potential Zones were marked, and 25 unique areas identified

2 Estimates of maximum wind energy generation potential was calculated and mapped

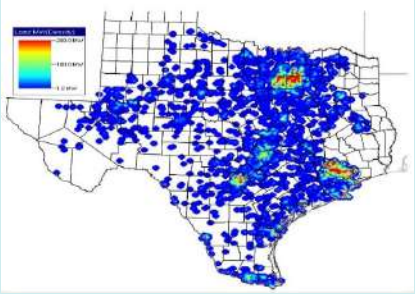


3



Location of Inter-connections decided with stakeholder consultations

4 The special distribution of load centers in the state with a peak load of 62,000 MW in 2007



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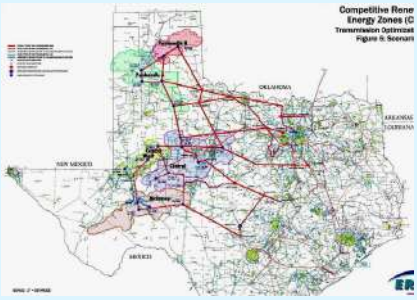

After extensive stake holder consultations, evacuation modeling a detailed transmission plan was drawn to interconnect the current and emerging load centers and current and potential wind energy farms in western Texas.

Post which a RFP was floated and was commissioned under EPC route

Appendix

12 PROJECTS WHERE NORMATIVE COST INFORMATION AVAILABLE PUBLICLY

Project	Project Name	Petition numbers
1	Transmission system for Strengthening in Southern Region for import of Power from ER	192/TT/2013
2	NR System strengthening Scheme-NRSS-XXXI (Part-A)	93/TT/2014
3	Transmission System associated with Gadarwara STPS (2x800 MW) of NTPC (Part-A)	125/ADP/2015
4	Transmission System associated with Gadarwara STPS (2x800 MW) of NTPC (Part-B)	127/ADP/2015
5	Transmission System Strengthening associated with Vindhyachal- V	88/ADP/2015
6	Strengthening of Transmission System beyond Vemagiri	299/ADP/2015
7	Eastern Region Strengthening Scheme-XVIII(ERSS-XVIII)	84/AT/2017
8	Northern Region System Strengthening Scheme(NRSS) - XXXI (Part-B)	89/TT/2014
9	System strengthening in northern region (NRSS XXXVI) along with LILO of Sikar-Neemrana 400 kV D/C line at Babai (RVPNL)	162/AT/2016
10	Immediate evacuation for North Karanpura(3x660MW) generation project of NTPC(ERSS-XIX)	121/AT/2016
11	Transmission System Associated with Krishnapattnam UMPP-Synchronous interconnection between SR and WR (Part-B) (Raichur - Sholapur)	6/2011
12	Transmission system strengthening in Indian system for transfer of power from new HEP's in Bhutan	4/ADP/2016

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The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering industry, Government, and civil society, through advisory and consultative processes.

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