Knowledge Paper
On
Powering Progress: Unlocking the Energy Potential of Eastern and North-Eastern India

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Knowledge Partner

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Foreword

Economic growth in the modern day world is highly **energy intensive**. Global energy demand rose by **2.2%** last year and **emerging and developing economies** accounted for over **80% of this increase**. **India,** slated to remain the **fastest-growing large economy** in the world for the years **2025 and 2026,** with its **GDP expected to expand by 6.2% in 2025 and 6.3% in 2026** is expecting a commensurate **hike in energy demand**. India's "Viksit Bharat" vision, aiming to transform the nation into a **developed economy by 2047**, has also laid significant focus on energy consumption and production. India has to meet this hike in energy demand factoring in its **net zero commitments**. This energy transition is creating varied opportunities for **sustainable energy pathways** in the country. Fitch Ratings expects India's power demand to grow by **4–5% over the medium term. Capex among power utilities is expected to remain high in the medium term, particularly for renewable generators**. Renewable capacity addition is projected to remain high in FY26 after an increase of 30 GW in FY 25.

The Eastern and North-Eastern states of India are moving away from fossil fuels and adopting renewable sources (solar, wind, hydro, biomass and electric mobility, etc.) and cleaner energy solutions. Governmental support is coming in the form of **subsidies, grid infrastructure upgrades and decentralized energy solutions**. States are actively **leveraging PPPs for capacity creation and management of renewable energy projects**. The Eastern and North-Eastern states of India are sitting at the cusp of a high growth trajectory. The average State GDP growth rate of Eastern Region is 5.75%, while that of the North-Eastern Region is 6.3%, the latter being higher than that of India's overall GDP. They are the Gateway to the ASEAN and a **natural bridge for South and Southeast Asia trade and commerce connectivity**. With robust investments in physical, digital and social infrastructure development and boost in entrepreneurship ventures, the region is slated for high growth, creating a higher demand for energy. This brings out the need to **optimize regional opportunities for balanced and inclusive growth**.

There are some ground level challenges in ensuring energy security in the region. While Eastern India is traditionally more dependent on coal with limited RE penetration, Northeast India suffers from issues such as seasonal floods, difficult natural terrain, high transportation costs, intermittent supply, shortage of skilled professionals, adverse impact of climate change on hydropower availability, and limited access to finance.

The way forward lies in **decentralized renewable energy, grid modernization, enhanced policy frameworks, energy storage, PPPs, capacity building, increased community engagement, and institutional coordination.** India aims for 50% renewable energy mix by 2030 and NITI Aayog is preparing the policy and investment blueprint for this green energy shift. The sectors in focus for empowering India's green transition are **power, transport, industry, and construction**. These are the very sectors, which are extremely important for sustaining the growing economy of East and North-Eastern India. This Knowledge Paper shares a compendium of actionable recommendations for government, industry and financing stakeholders for ***Unlocking the Energy Potential of Eastern and North-Eastern India***. I hope, you will find it an insightful read.

Mr Abhyuday Jindal,
President, Indian Chamber of Commerce

About TERI

The Energy and Resources Institute (TERI) has a long record of producing rigorous, scenario-based analyses that underpin India's clean-energy policymaking. Its flagship study **"India's Electricity Transition: Pathways to 2050"** models four demand–supply trajectories for the power sector, quantifying investment needs of USD 1.2–1.6 trillion and showing how a four-fold rise in electricity demand can be met with high shares of renewables, storage and flexible thermal assets. Complementing this mid-century lens, TERI's 2022 discussion paper **"Roadmap to India's 2030 Decarbonization Target"** maps sector-wise abatement options consistent with India's updated NDC, identifying least-cost pathways to reach a 50 per cent non-fossil power share and 45 per cent emissions-intensity reduction by 2030. TERI also delivers granular, state-level action plans: the **"Low-Carbon Pathways for Madhya Pradesh"** report (2023), prepared with the state government, details technological and fiscal measures that could cut MP's power-sector emissions 35% below BAU by 2030 while boosting jobs and GDP. These studies along with TERI–Shell assessments of national low-carbon trajectories and numerous policy briefs on green hydrogen, battery storage and just transition, demonstrate the institute's breadth of expertise and its sustained commitment to data-driven insight for India's energy transition, providing valuable context for stakeholders across Eastern and North-Eastern India.

1. Introduction

India is undergoing a pivotal shift in its energy trajectory, driven by the dual imperatives of economic growth and climate responsibility. At the 26th United Nations Climate Change Conference (COP26) held in Glasgow in 2021, the Hon'ble Prime Minister of India, Shri Narendra Modi, announced the country's commitment to achieve net-zero greenhouse gas emissions by 2070. This was accompanied by a set of intermediate clean energy targets for 2030, including the installation of 500 GW of non-fossil fuel capacity, meeting 50% of energy requirements through renewables, and reducing the carbon intensity of GDP by 45% from 2005 levels.[1]

India's clean energy expansion has since accelerated significantly. As of 2024, the country has achieved over 220 GW of renewable energy capacity, positioning itself as the third-largest producer of renewable energy globally.[2] However, realizing the broader vision of a just and inclusive energy transition requires a regionally balanced approach, particularly focusing on the regions that have historically remained underrepresented in the national energy narrative.

The Eastern and North-Eastern states of India—comprising Bihar, Jharkhand, Odisha, West Bengal, Assam, Sikkim, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Tripura, and Nagaland—possess significant untapped renewable energy potential, particularly in solar, hydro, and biomass sectors.[3] These states also offer geostrategic advantages, rich natural resources, and growing energy demand, making them essential contributors to India's long-term clean energy goals.

Despite these advantages, the region faces persistent challenges such as low per capita electricity consumption, grid infrastructure, AT&C losses, and limited private sector participation.[4] Furthermore, difficult terrain, dispersed populations in the North East add layers of complexity to implementation.

Recognizing the need to bridge these gaps, this knowledge paper seeks to identify the key challenges, emerging opportunities, and actionable strategies to facilitate a robust energy transition in these regions. The goal is to ensure that the energy transition is not only technologically sound and economically viable but also socially inclusive and regionally equitable.

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1 *https://unfccc.int/sites/default/files/resource/India_LTLEDS.pdf*

2 *https://mnre.gov.in*

3 *MNRE RE Statistics 2023-24,*

4 *Central Electricity Authority (CEA) 2023*

2. Current Energy Landscape in Eastern and North-Eastern India

The Eastern and North-Eastern regions of India, encompassing states such as Bihar, Jharkhand, Odisha, West Bengal, Sikkim, Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura, play a pivotal role in India's energy sector. These regions are characterized by a mix of challenges and opportunities in their energy landscapes.

2.1 Electricity Mix: Coal-Dominated East and Hydropower-Rich Northeast

As of April 2025, the combined **Installed Power Generation Capacity** of the **Eastern and North- Eastern regions** of India stood at approximately **~42 GW**, representing about **~9%** of the nation's total installed capacity of **~473 GW**. The Renewable Energy generation capacity in India was **~224 GW**, reflecting a significant growth during the past decade. Out of total RE installed capacity, Eastern and North Eastern States stood at approximately **~10 GW**.

Eastern India

The Eastern India, comprising states of Bihar, Jharkhand, Odisha West Bengal, and Sikkim has a significant reliance on coal for electricity generation. The region's electricity mix is heavily skewed towards coal, owing to abundant coal reserves.

Table 1: Installed generation capacity in Eastern India (as of April 30, 2025)[5]

State	Coal (MW)	Hydro (MW)	Renewable Energy (MW)	Total (MW)
Bihar	7073.11	72.88	539.26	7685.25
Jharkhand	2607.31	176.98	224.06	3008.35
Odisha	5701.21	2179.23	809.19	8689.63
West Bengal	8443.34	1483.3	770.98	10697.62
DVC	3037.02	221.26	0	3258.28
Sikkim	76.54	643.27	62.67	782.48
Central Unallocated	1836.33	85.5	0	1921.83
Total	**28774.86**	**4862.42**	**2406.16**	**36043.44**

North-Eastern India

The North-Eastern region is rich in hydropower resources. However, the installed capacity varies across states.

[5] *IC_April_2025_allocation_wise_final-1.pdf-CEA*

Table 2: Installed generation capacity (in MW) in North-Eastern India (as of April 2025[6])

State	Coal	Gas	Diesel	Total Thermal	Hydro	RES	Total
Assam	874.52	741.92	0	1616.44	522.08	248.45	2386.97
Arunachal Pradesh	37.05	46.82	0	83.87	544.55	155.46	783.88
Meghalaya	51.6	109.69	0	161.29	417.38	73.11	651.78
Tripura	56	486.94	0	542.94	68.49	37.25	648.68
Manipur	47.1	81.58	36	164.68	87.24	19.24	271.16
Nagaland	32.1	73.93	0	106.03	66.33	35.84	208.2
Mizoram	31.05	60.46	0	91.51	97.94	75.86	265.31
Central Unallocated	112.60	63.62	0	176.22	140	0	316.22
Total NE	**1242.02**	**1664.96**	**36**	**2942.98**	**1944.01**	**645.21**	**5532.2**

2.2 Per Capita Electricity Consumption

In terms of per capita electricity consumption, India has surged to 1,255 kWh in 2021–2022, marking a 31.1% increase from 957 kWh in 2013–14.[7] However, Eastern and North-Eastern states invariably lag behind the national average. For example, Bihar's per capita consumption remains below the national average, highlighting the need for continued development and support.

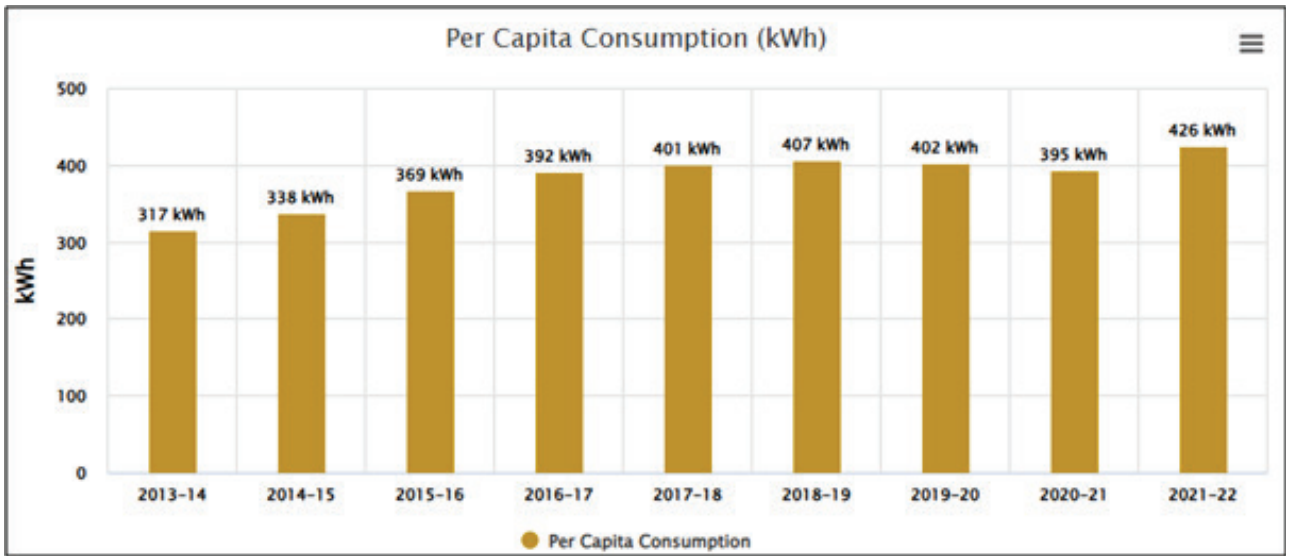

FIGURE 1: Per capita energy consumption of North-Eastern States from 2013–2022

[6] *IC_April_2025_allocation_wise_final-1.pdf-CEA*

[7] *Central Electricity Authority*

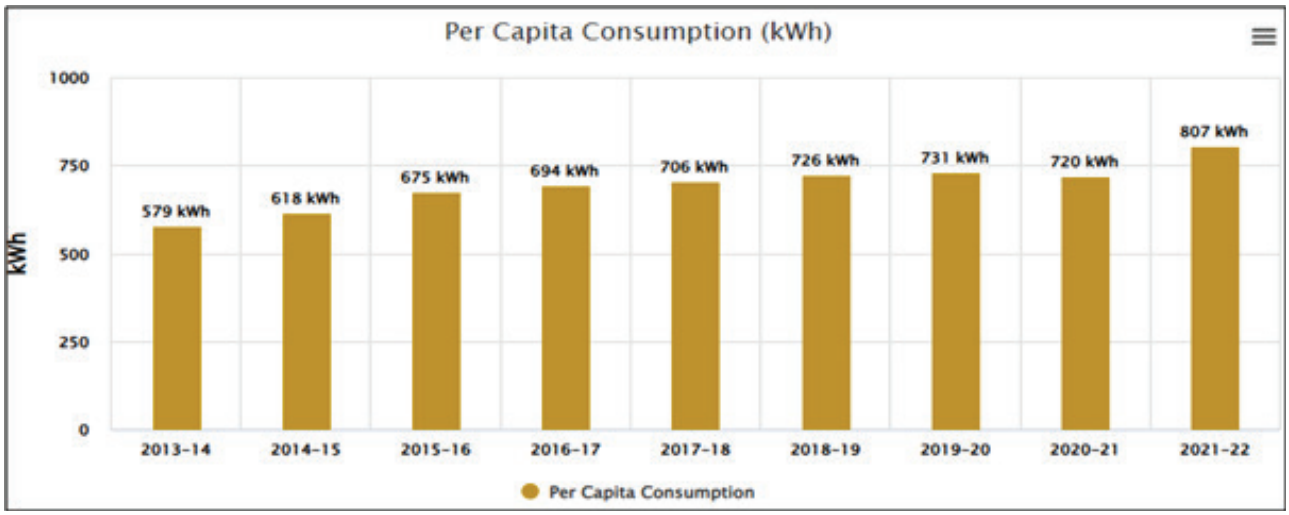

FIGURE 2: Per capita energy consumption of Eastern States from 2013–2022

2.3 Grid Status

The Eastern and North-Eastern regions have distinctive features and challenges related to grid infrastructure:

Eastern Region:

» Relatively well-connected to the National Grid

» Acts as a power-surplus region due to coal-heavy generation

» Transmission systems managed primarily by Power Grid Corporation of India (POWERGRID) and state utilities.[8]

North-Eastern Region:

» Weak intra-regional links, especially in hilly and remote areas.

» Need for augmentation of downstream network from sub-transmission to distribution level.

Transmission & Distribution (T&D) Losses[9]

Compounded by low billing efficiency, outdated meters, low revenue collection

Renewable Energy Integration Issues

» **Reverse Power Flow** and voltage regulation issues with rooftop solar.

» **Curtailment risks** during peak RE generation hours due to technical minimum of coal plants and inadequate energy storage.

» **Quality of Supply**: Lack of round the clock supply and poor quality hinder the effective use of electricity.

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[8] *Central Electricity Authority*

[9] *CEA, POSOCO, State Electricity Boards (SEBs)*

2.4 Regional Challenges

Difficult Terrain, Floods, and Cyclones in the Northeast

The North-Eastern region's geography poses significant challenges:

» **Terrain**: Hilly and forested areas make infrastructure development and upkeep difficult.

» **Floods**: The 2020 Assam floods affected over 5 million people, damaging infrastructure and disrupting power supply.[10]

» **Cyclones**: Frequent cyclones lead to power outages and damage to transmission lines.

Legacy Coal Dependence in Eastern States

India plans to increase its coal-fired generation capacity from 235 GW to 260 GW by 2031–32 to meet rising demand.[11] Eastern states have historically relied on coal:

» **Coal Production**: Jharkhand, Odisha and West Bengal are the major coal producers.

» **Environmental Concerns**: Dependence on coal increases environmental and health issues.

Private Investment and Limited Renewable Energy Penetration

Challenges in attracting private investment:

» **Perceived Risks**: Investors are wary of economic and regulatory risks in developing regions.

» **Infrastructure Gaps**: Lack of infrastructure deters investment in renewable energy projects.

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[10] *2020 Assam floods, Icy flood in India's northeast*

[11] *CEA NEP Generation Report*

3. Emerging Opportunities in the Energy Sector

The Eastern and North-Eastern states of India are poised to become significant drivers of the country's clean energy future. Despite comprising over one-fifth of India's land area, the two regions currently account for approximately only **~6% of the national total installed renewable capacity**, underscoring a vast untapped potential. This section explores the emerging opportunities across renewable energy, energy storage, smart grids, green hydrogen, and inclusive energy access – focusing on state-wise resources and forward-looking initiatives.

3.1 Renewables: State-wise Potential and Initiatives

Untapped Renewable Energy Potential: The stark gap between the ~218,433 MW renewable energy potential and the mere ~11,030 MW installed capacity (just 0.05%) in the Eastern and North-Eastern states highlights a huge opportunity to scale up renewables.

Table 3: Estimated RE potential in North-Eastern States (NE) (in MW)[12]

STATES / UTs	Wind Power	Small Hydro Power	Bioenergy		Solar Power	Large Hydro	Total
			Biomass Power	Bagasse Cogeneration			
Arunachal Pradesh	246	2,064.92	18.46	0	8,650	50,394	61,373.38
Assam	459	201.99	321.89	0	13,760	643	15,485.88
Manipur	0	99.95	62.31	0	10,630	615	11,307.26
Meghalaya	55	230.05	68.54	0	5,860	2026	10,239.59
Mizoram	0	168.9	2.90	0	9,090	1,926.7	11,188.5
Nagaland	0	182.18	53.90	0	7,290	325	7,851.08
Tripura	0	46.86	34.35	0	2,080	0	2,161.21
***Total**	**760**	**2,995**	**562**	**0**	**57,360**	**55,930**	**119,607**

*Rounded Figures

[12] *MNRE RE Statistics 2023-24, 2024*

Table 4: Estimated RE potential in Eastern States (in MW)[13]

STATES / UTs	Wind Power	Small Hydro Power	Bioenergy		Solar Power	Large Hydro	Total
			Biomass Power	Bagasse Cogeneration			
Bihar	4,023	526.98	964.37	346.6	11,200	130.1	17,691.05
Jharkhand	16	227.96	146.31	0	18,180	300	18,870.27
Odisha	12,129	286.22	298.72	0	25,780	2,824.5	41,318.44
Sikkim	0	266.64	4.73	0	4,940	6,051	10,862.37
West Bengal	1,281	392.06	1,741.74	0	6,260	809.2	10,084.00
***Total**	**17,449**	**1,700**	**3,156**	**347**	**66,360**	**10,115**	**98,826**

*Rounded Figures

Resource Hotspots: Each Eastern and North-Eastern state has distinct renewable energy strengths and opportunities. Odisha leads in solar (25.78 GW) and wind (~12 GW) potential, while Jharkhand has around 18 GW solar potential, with opportunities on reclaimed mine lands. Bihar and West Bengal, though land-constrained, can adopt distributed solar solutions. The NE states have an aggregate solar potential of ~63.7 GW, especially in Assam, Manipur, and Mizoram, despite cloud cover. The region is also rich in hydro resources—Arunachal Pradesh alone has over 50 GW large hydro and ~2 GW small hydro potential.

Solar Energy – Ground Mounted, Floating, and Rooftop

Solar power is set to drive the clean energy transition in Eastern and North-Eastern India, with a focus on utility-scale parks and innovative uses like rooftop and floating solar. Odisha aims to install 10 GW of renewables by 2030, mainly solar, under its 2022 RE Policy, developing parks on unused land with support from partners like NTPC. Bihar, despite land constraints, is utilizing non-arable land and ash ponds for solar projects, including a 200 MW park and collaborations with NTPC for distributed solar and agrivoltaics.

Floating Solar: Floating solar PV offers strong potential in East and North-East India, leveraging the region's plentiful reservoirs and lakes to generate power without using land. Notable projects include Tripura's planned 130 MW plant on Dumbur Lake[14] and assessments for large-scale floating solar on Odisha's Hirakud dam and Manipur's Loktak dam. Odisha alone could host up to 33.5 GW of floating solar using just 5–10% of its reservoir area.[15] These projects also offer co-benefits like reduced water evaporation and opportunities for fish farming.

Rooftop Solar: Rooftop solar is key to meeting rising urban energy demand in states like West Bengal and Bihar. States have net/gross metering policies, with initiatives like West Bengal's mandate for solar on new government buildings and Bihar's "Har Ghar Solar" in urban areas. These systems enhance energy access and ease grid pressure, but adoption has been slow due to financing challenges, prompting the use of RESCO models and credit support to boost deployment.

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13 *1MNRE RE Statistics 2023-24, 2024*

14 *(Sentinel, 2024)*

15 *(iForest, 2024)*

Table 5: State-wise implementation of the PMSGMY in the Northeast (as of March 19, 2025)[16]

State	No. of applications	No. of households benefitted	No. of CFA allotments released	CFA released (Rs. million)
Arunachal Pradesh	94	–	–	–
Assam	304,859	10,142	6,262	524.480
Manipur	772	220	154	13.130
Meghalaya	2,050	18	16	0.830
Mizoram	666	129	88	7.260
Nagaland	245	8	6	0.460
Sikkim	58	4	2	0.170
Tripura	3,533	168	106	8.860
Total	**312,277**	**10,689**	**6,634**	**555.190**

Assam leads significantly with over 10,000 households served and ₹524 million in CFA released. Other states show minimal progress, with many having fewer than 200 households benefitting and limited fund disbursements. Arunachal Pradesh reported no implementation yet.

Wind Energy: New Projects in Select Pockets

Wind energy in East and North-East India is site-specific but promising, especially in coastal Odisha and hilly ridgelines of Arunachal Pradesh, Assam, and Meghalaya. Odisha has approved its first major wind project (97.5 MW).[17] The North-East has an estimated 300–500 MW potential,[18] though development is hindered by terrain and infrastructure challenges. Wind-solar hybrid systems and low-speed turbines offer future options for remote and moderate-wind areas. While wind would not dominate, it complements solar by generating power during evenings and monsoons.

Small Hydro and Biomass: Niche Opportunities in North-East

The North-East holds ~3,261 MW of small hydro potential, mainly in Arunachal Pradesh, Sikkim, Meghalaya, and Assam, but only ~382 MW has been developed so far. Dozens of mini/micro hydro projects have been identified, especially on mountain streams. To boost deployment, the government has offered ₹22.5 million/MW capital support,[19] and states like Arunachal and Sikkim are inviting private developers with streamlined approvals. These projects can power remote villages and support local grid stability.

Biomass and bioenergy offer localized clean energy options in Eastern states like Bihar, West Bengal, and Assam, which have abundant crop residues and cattle waste. Assam alone has ~322 MW potential, though

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16 *Renewable Watch Magazine*

17 *(Sain, 2024)*

18 *(Bansal, 2024)*

19 *Invest India, 2022*

current deployment is limited. Projects include rice-husk gasifiers, bagasse cogeneration, and waste-to-energy initiatives in West Bengal. Policies like feed-in tariffs and the SATAT scheme are promoting growth.[20] While smaller in scale than solar or hydro, biomass provides dispatchable power and rural jobs, making it a valuable part of the region's energy mix.

3.2 Energy Storage: Pumped Hydro and Battery Systems

Achieving a high share of renewables will require robust **energy storage solutions** for grid flexibility. **Pumped Storage Plants (PSP)** and **Battery Energy Storage Systems (BESS)** are two promising avenues for the Eastern and NE regions to balance intermittent solar and wind generation.

Pumped Storage Projects (PSPs): Pumped hydro storage (PHS) is ideal for Eastern India's hilly terrain, using power during off peak hours to pump water uphill and generate electricity on demand. The region already hosts the 900 MW Purulia PSP in West Bengal,[24] with a new 1,000 MW Turga project underway. Odisha is exploring solar-plus-PSP projects at existing dam sites, while North-Eastern states like Meghalaya and Sikkim are assessing PSP potential. PSPs offer large, low-cost storage to balance renewable energy, especially solar, and are now classified as renewable for policy and financing benefits. They provide inertia to the grid, thereby contributing to stability and security of the grid.

Battery Energy Storage (BESS): Declining lithium-ion battery costs are driving grid-scale Battery Energy Storage Systems (BESS) projects in Eastern India. West Bengal's Damodar Valley Corporation (DVC) is implementing a 250 MW/500 MWh BESS,[21] while Assam's power companies plan a 250 MW system to boost solar use.[22] Jharkhand and Odisha are incorporating battery storage in solar park tenders to firm up evening supply. Nationally, a `3,760 crore fund aims to support 4,000 MWh of BESS, benefiting states like Assam and Bihar for grid stability. By 2032, requirement of 236.22 GWh of BESS has been noted in the National Electricity Plan 2022–2032.[23]

3.3 Smart Grids: Modernizing the Electricity Network

Integrating large-scale renewables and distributed energy resources will require smart, resilient grids in the East and North-East. Historically, these regions have faced weak grid infrastructure, high losses, and reliability issues. Emerging technologies in grid management are now creating opportunities to transform this landscape.

Advanced Metering and Digitalization: Under the Revamped Distribution Sector Scheme (RDSS), Assam and Bihar lead Eastern India in smart meter deployment, with 6.2 million and 3.1 million prepaid smart meters installed respectively by March 2025.[25] These meters enable remote monitoring, prepaid billing, and have

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20 *PIB, 2023*

21 *DVC, 2025*

22 *NGEAL, 2024*

23 *cea.nic.in/wp-content/uploads/irp/2023/05/NEP_2022_32_FINAL_GAZETTE-1.pdf*

24 *ELRD, 2023*

25 *Enirac, 2025*

reduced losses while improving revenue. Assam's rural areas received 80% of the new meters, enhancing service and outage detection. The region aims for 100% smart meter coverage to enable advanced tariffs and demand response programmes.

Grid Automation and Resilience: Eastern and North-Eastern India are upgrading power grids with automation like SCADA and Distribution Management Systems to manage renewable energy better. West Bengal is expanding SCADA system to smaller substations for quicker fault response; while POWERGRID is investing ₹158 billion under projects like North Eastern Region Power System Improvement Project (NERPSIP) to strengthen sub-transmission networks and grids in seven NE states and Sikkim. Upgrades include new high-voltage lines, voltage-stabilizing devices, and automated fault management. These efforts aim to build a more resilient grid, reduce outages, and support growing solar and wind integration.

Smart Grid Pilot Projects: Eastern India is piloting next-gen grid solutions to enhance flexibility and reliability. Assam is testing demand response by cycling large AC loads, reducing peak demand. Meghalaya is using a 1 MWh battery at a substation to manage power quality amid rising rooftop solar installations. Cities like Bhubaneswar and Kolkata are deploying smart EV chargers that adjust charging based on grid frequency. These pilots mark the region's digital power transition, paving the way for a fully smart grid by 2047 with features like automated restoration, AI-based forecasting, and advanced grid communications.

3.4 Green Hydrogen: Industrial Decarbonization in the East

Green hydrogen – produced from renewable electricity – is emerging as a game-changer for decarbonizing industries, and Eastern India's industrial belt is poised to be a major beneficiary. The region hosts a concentration of hard-to-abate industries: steel plants in Odisha, Jharkhand and West Bengal, oil refineries in Assam and Bihar, fertilizer and chemical plants in West Bengal and Assam, and a sizeable cement sector. These sectors currently rely on coal, natural gas, or oil; but green hydrogen offers a clean alternative feedstock and fuel.

National Mission and Targets: India's National Green Hydrogen Mission aims to produce 5 million tonne per annum by 2030. Eastern states like Assam are planning hydrogen hubs near refineries and fertilizer plants, leveraging local hydro and solar power for green hydrogen production.

Steel Industry Initiatives: Odisha's steel sector is leading in green hydrogen use, with JSPL set to produce 4,500 tonne annually at its Angul plant by end-2025, powered by 3 GW of renewables.[26] This aims to halve coal use in DRI furnaces. Tata Steel and SAIL are also testing hydrogen in Jamshedpur, Bokaro, and Durgapur Steel plants. Successful pilots could make Eastern India a green steel hub by 2040, significantly cutting CO_2 emissions.

Refineries and Fertilizers: Refineries in Assam and Bihar are exploring on-site green hydrogen production to reduce reliance on natural gas. Oil India has set up India's first high-purity green hydrogen pilot in Jorhat. Fertilizer plants in Assam and Jharkhand also have the potential for green ammonia production. With abundant solar and water resources, and access to ports like Paradip, Eastern India could emerge as a green ammonia hub for domestic use and export.

Green hydrogen can drive Eastern India's economy by decarbonizing industries and creating a new value chain. With strong renewable potential and industrial demand, states like Odisha and Assam could become green hydrogen and ammonia export hubs, boosting solar and wind deployment.

3.5 Inclusive Energy Access: Micro-grids and Decentralized Solutions

While utility-scale projects grab headlines, ensuring inclusive energy access for all communities is an equally critical opportunity. Eastern and North-Eastern India have made huge strides in village electrification and grid extension (under schemes like Saubhagya), yet pockets of energy poverty persist – especially in remote NE hamlets, forested areas, and riverine islands where grid supply is erratic or non-existent.

Solar Micro-grids: Solar micro-grids with battery storage are transforming remote villages in Northeast India, providing reliable power where grid extension is unviable. Projects in areas like Meghalaya , Arunachal Pradesh and Nagaland are improving livelihoods, supported by government funding covering up to 60% of costs. Over 200 villages in Arunachal Pradesh alone could be electrified with renewable micro-grids by 2030, reducing diesel use and boosting local development.

Solar Home Systems and Lighting: Despite grid access, unreliable supply still forces many in Eastern India to rely on kerosene.[27] To improve access, states like Assam, Jharkhand, and Odisha have distributed solar home systems and lanterns, enhancing education, safety, and savings. Advanced solutions like solar DC nano-grids are being piloted, aiming for universal, reliable, and clean electrification across the region by 2047.

Inclusive Business Models: Decentralized renewable energy in Eastern India is driving social change by creating local jobs and empowering communities. Initiatives involve women-led solar servicing, youth-run micro-hydro, and public-private solar mini-grids, linking energy access with livelihoods, clean cooking, and digital inclusion.

4. Recommendations and Way Forward

Renewable Energy Transition Strategies

Accelerate Renewable Energy Deployment

1. **State-Specific RE Roadmaps**: Each state may develop a clear roadmap with targets for solar, wind, hydro, and biomass, contributing to achievement of national goal of 500 GW non-fossil capacity by 2030; For North eastern region With lower solar potential compared to other regions, opportunity of increasing ground mounted solar plants is less, more efforts to be put on Rooftop solar through PM-Suryaghar Scheme;
2. **Leverage Untapped Potential:** Prioritize high-potential zones—solar in Odisha and Jharkhand & Bihar, hydro in Arunachal Pradesh and Sikkim, and biomass in Assam, West Bengal and Bihar.
3. **Promote Floating and Rooftop Solar**: Utilize water bodies for floating solar (e.g., Hirakud, Dumbur lake) and mandate rooftop solar on public buildings; Increasing solar capacity through use of floating Solar PV in Dams and other water bodies in the Eastern States.

Strengthen Grid Infrastructure and Smart Systems

1. **Modernize Transmission & Distribution System:** North-Eastern Region Power System Improvement Project (NERPSIP) and similar schemes to reduce T&D losses (currently 20–35%) and improve reliability of electricity supply.
2. **Smart Metering & Automation**: Expand smart meter deployment (e.g., Assam, Bihar) and upgrade of SCADA systems for real-time monitoring and demand response.
3. **Grid Resilience:** Invest in weather-resilient infrastructure, especially in flood- and cyclone-prone areas.

Scale Up Energy Storage Solutions

1. **Pumped Storage Projects (PSPs):** Fast-track PSPs such as Turga to balance solar and wind variability; For eastern states explore opportunity for setting up pumped hydro storage plants in down streams of existing hydropower plants as well as in abandoned mines as closed loop PSPs.
2. **Battery Energy Storage Systems (BESS):** Deploy grid-scale BESS in urban centres and solar parks; support community-level storage in remote areas.

Foster Green Hydrogen and Industrial Decarbonization

1. **Hydrogen Hubs:** Establish green hydrogen clusters near steel plants (Odisha, Jharkhand), refineries (Assam), and fertilizer units (Bihar).
2. **Policy Incentives:** Provide land, tax breaks, and offtake guarantees to attract private investment in hydrogen and ammonia production.

Promote Inclusive and Decentralized Energy Access

1. **Solar Micro-Grids:** Electrify remote villages using micro-grids with battery backup, especially in Arunachal Pradesh and Meghalaya.
2. **Solar Home Systems:** Expand programmes like PMSGMY to improve household-level access and reduce kerosene dependence.

3. **Community Ownership Models:** Encourage women-led and youth-run energy enterprises for local job creation and empowerment.

Enhance Policy and Institutional Support

1. **Regional Coordination:** Establish an East & North-East Energy Transition Council for coordinated development, sharing of best practices, and resolving inter-state issues, if any.
2. **Private Sector Participation:** Create enabling policies for PPPs in transmission, energy storage, and RE generation.
3. **Capacity Building**: Train local workforce in RE technologies, grid management, and energy entrepreneurship.

Mobilize Finance and Innovation

1. **Green Bonds & Blended Finance:** Use innovative instruments to attract ESG-focused investors and de-risk early-stage projects.
2. **Support R&D and Pilots:** Fund pilot projects in hydrogen, smart grids, and bioenergy through public-private innovation hubs.

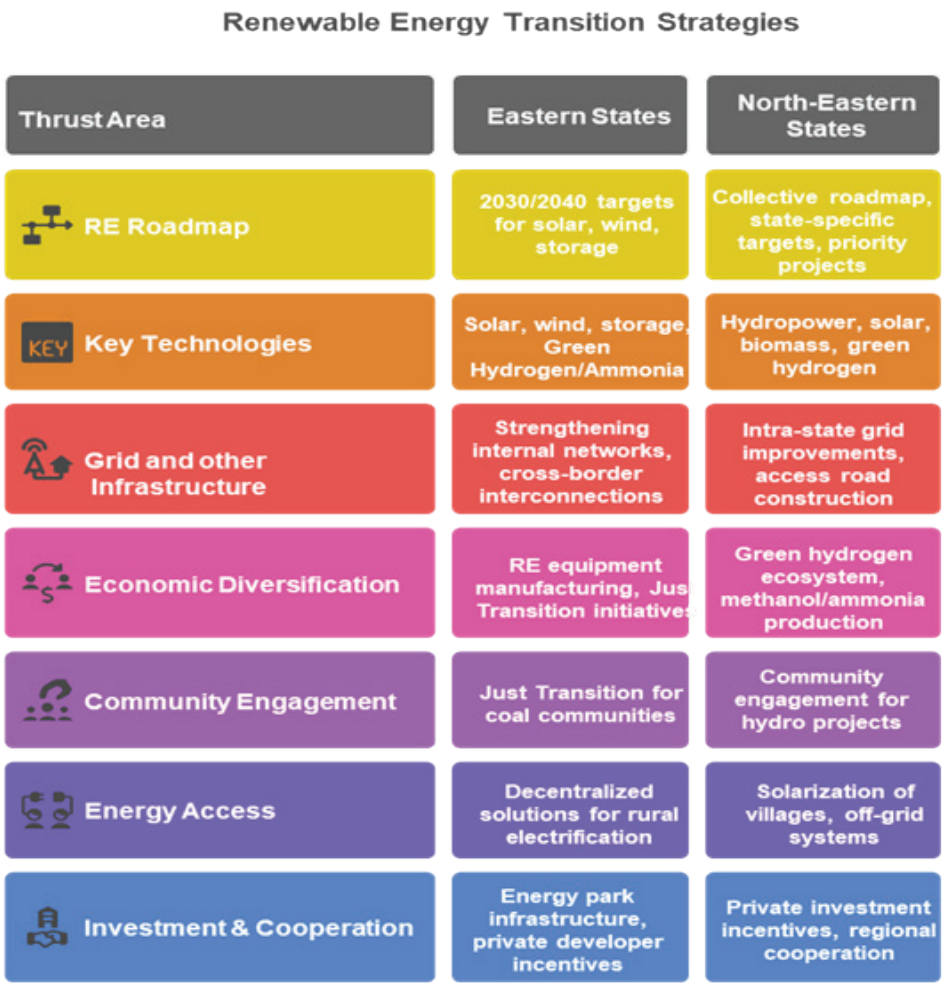


Figure 3: Renewable energy transition strategies

Implementation Roadmap

Achieving the vision for 2030 and 2047 requires a phased implementation plan. Below is a high-level roadmap divided into three phases, charting the course from immediate actions to long-term goals as well as the milestones:

Phase I: Laying the Foundation (2025–2030)

» **Targets & Institutions:** States to release updated RE policies and roadmaps by 2025; establish the East & NE Energy Transition Council.

» **Capacity Addition:** Add 10–15 GW of new non-fossil capacity, focusing on solar PV, wind, and hydro including import from Bhutan.

» **Projects & Pilots:** Launch solar parks in eastern states; pumped storage plants; start BESS (50–100 MWh), green hydrogen (linked to refineries/fertilizers).

» **Grid & Reforms:** Strengthen NE-grid; aim at meeting RDSS targets; establish Distribution System Operators (DSOs). Plan for meeting the incremental demand from Non-fossil fuel + Storage.

Milestones by 2030: ~25 GW clean energy capacity, electricity reliability for all villages, emissions intensity begins to plateau drop.

Phase II: Scale and Innovate (2030–2040)

» **Massive Scale-Up:** Deploy 5–10 GW hybrid systems; expand distributed energy; large-scale BESS and expedite construction of PSPs (e.g., West Bengal, Odisha).

» **Tech Integration:** Scale green hydrogen (Odisha, Assam), smart grid automation, AI-based forecasting, EV integration (e.g., V2G).

» **Cleaner Generation Mix:** Assess the need for starting new coal plants from techno-economic & social consideration; plan for phase-out of inefficient and high emission coal plants.

» **New Frontiers:** Consider SMR construction based on success of R&D, deepen cross-border energy trade (e.g., with Southeast Asia).

By 2040: High share of clean energy in the generation mix; near-universal e-mobility and clean cooking; rapidly falling emissions.

Phase III: Consolidation and Net-Zero Prep (2040–2047)

» **Final Coal Exit:** Begin phase out of inefficient and high emission coal plants.

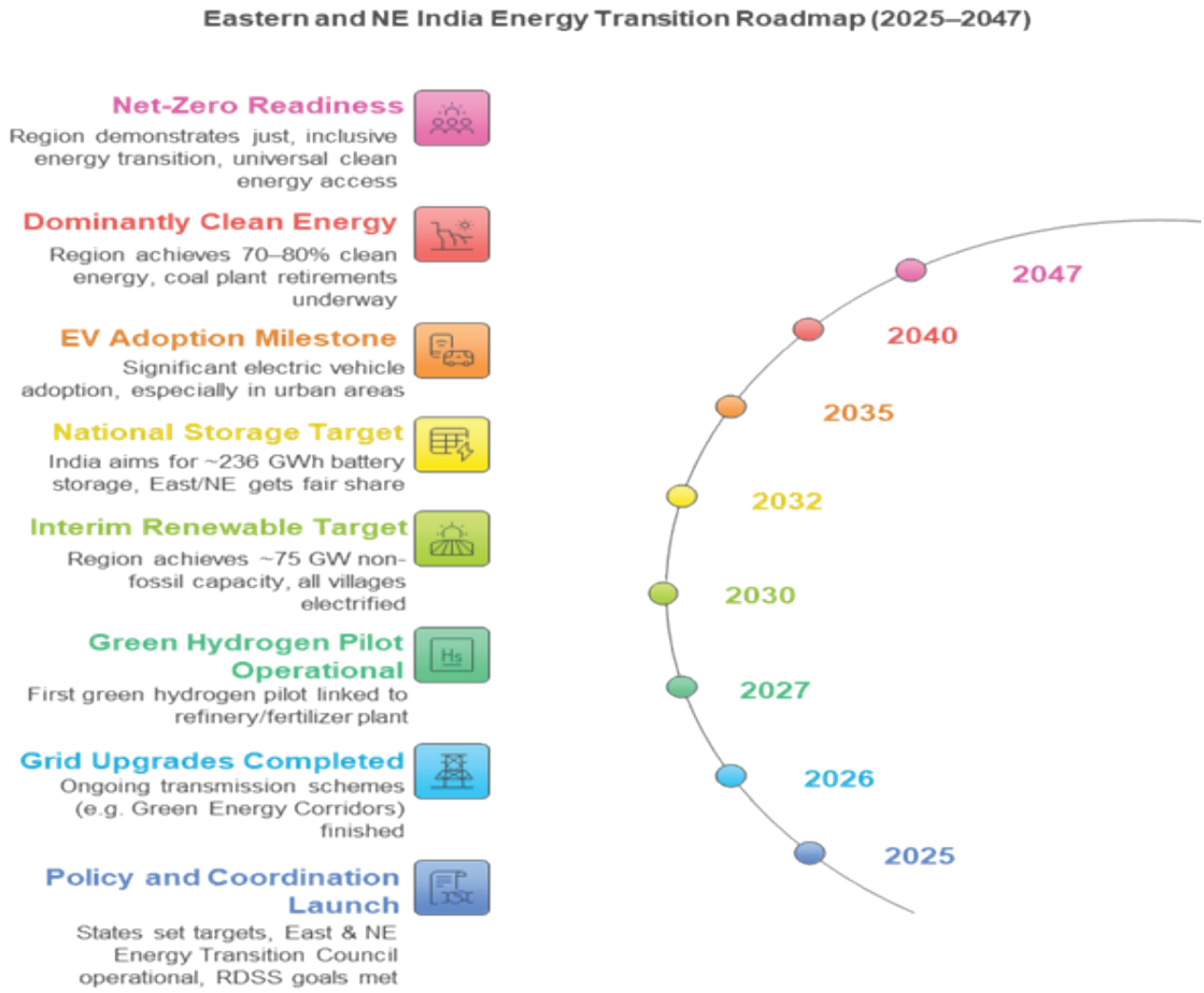
» **Hydro & Storage:** Harness NE hydro potential; implement seasonal storage and hydrogen-based solutions.

» **System Resilience:** Ensure grid reliability, cyber-security, affordability, and market efficiency, Strengthen DSOs.

» **Equity & Access:** Achieve SDG7 – universal access to clean energy, productive use in rural areas.

» **Economic Transition:** Aim at setting up of Green industry hubs (batteries, hydrogen, solar manufacturing); complete inclusive and equitable transition in former coal regions.

2047 Vision: A clean, inclusive, and resilient energy system showcasing just transition as India celebrates 100 years of independence.



Eastern and North-Eastern India hold vast untapped potential in solar, hydro, wind, and emerging technologies. A phased, well-governed, and inclusive transition—rooted in local strengths, innovation, and regional cooperation—can turn this potential into sustainable prosperity. By 2047, the region can lead India's clean energy revolution, becoming a model for just and resilient transitions in the Global South.

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