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People-centric Energy Transition

Navigating India's Coal Transition: From Macroeconomic Realities to People-Centric Repurposing and Clean Energy Pathways

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About the Ashoka Centre for a People-centric Energy Transition (ACPET)

The Ashoka Centre for a People-centric Energy Transition (ACPET) is a research-focused, transdisciplinary centre within Ashoka University, India, established to drive a sustainable, equitable, and "people-centric" shift towards net-zero emissions. It bridges the knowledge gap in energy transition by collaborating with industry and government to create scalable solutions, covering areas like renewable energy, policy, and technology. For further information about ACPET, please visit: acpet.ashoka.edu.in

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We are deeply appreciative of these contributions, which have enriched the study and reinforced its relevance to ongoing policy discourse. Some recommendations of the Policy Brief have also emerged out of the 'Coal Gasification Workshop' jointly organised by Chintan Research Foundation (CRF) and Ashoka Centre for a People-centric Energy Transition (ACPET) as a part of the knowledge partnership between CRF and ACPET.

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Navigating India's Coal Transition: From Macroeconomic Realities to People-Centric Repurposing and Clean Energy Pathways

Background & Context

Marking three years of sustained research and policy action in service of a "people-centric" energy transition in India and the Global South, the Ashoka Centre for People-centric Energy Transition (ACPET) convened its flagship showcase event on March 20, 2026. Titled "Translating Vision to Value: A People-Centric Energy Transition," the event brought together policymakers, industry leaders, and researchers to reflect on ACPET's journey bridging policy ambition and ground realities. The discussion about the past, present, and future of India's people-centric coal transition focused on key structural and policy questions shaping the country's journey towards its Viksit Bharat 2047 and Net Zero Emissions (NZE) 2070 Goals.[1]

At its core, these discussions underscored that India's coal transition is not limited to phasing down consumption and production, but rather about transforming India's energy mix responsibly through prioritizing short- and medium-term energy security, meeting national renewable energy targets, and building sustainable, resilient coal regions. As the world's second-largest consumer and third-largest producer of coal, India must carefully balance its growing energy needs with a gradual transition away from fossil fuels,[2] which will entail coal continuing to play a critical role in the short to medium term, while a phase-down unfolds over time. This trajectory reflects a pressing need to reconcile immediate energy security priorities with long-term climate commitments.

Despite its environmental and health consequences, decades of coal production have supported rural economic growth, and coal companies have provided communities necessary social services including schools, healthcare, and community centres. However, many coal-producing regions have also been transformed into "monoculture societies", where fossil fuel retirement will not only cause significant unemployment among formal and informal mine workers but also significantly reduce the income of local businesses, force outmigration, and cause rapid sociocultural upheaval.[3] This, in turn, affects the regions' livelihoods, infrastructure,

[1] Viksit Bharat 2047 is the Government of India's ambitious vision to transform the nation into a fully developed entity by the 100th anniversary of its independence in 2047. Net Zero 2070 refers to India's official commitment to achieve carbon neutrality—a balance between greenhouse gases produced and removed from the atmosphere—by the year 2070.

[2] NITI Aayog. (2026). *Scenarios towards Viksit Bharat and net zero: An overview (Vol. 1)*. Government of India. ; Adhikari, A., Navya, Goyal, A., & Goswami, A. (2025). *Viksit Bharat @ 2047 goal may pause coal phase down in India: An opportunity for people centricity in transition (Working Paper #2)*. Ashoka Centre for a People-Centric Energy Transition (ACPET), Ashoka University.

[3] Kime, S., Jacome, V., Pellow, D., & Deshmukh, R. (2023). Evaluating equity and justice in low-carbon energy transitions. Environmental Research Letters, 18(12), 123003, Banerjee, S. (2023). Ensuring a People-centric Energy Transition: The Case of Informal Workers in Coal Regions. *POWERING INDIA'S FUTURE*, 99.

environmental conditions, state revenues, and quality of life.[4] A central issue remains managing the socio-economic impacts of coal phase-down, particularly through reskilling workers for new modes of employment and enabling alternative livelihoods.[5]

In addition to socioeconomic and developmental considerations, coal-to-gas and coal-to-chemical pathways have emerged as an increasingly central piece of India's broader energy landscape, reflecting a shift towards diversifying the use of coal for the production of fuels, chemicals, and industrial feedstocks, with potential implications for energy security and economic value addition. For example, the 2026 Union Budget announced an outlay of INR 20,000 crore for Carbon Capture, Utilization, and Sequestration (CCUS) technologies - targeting commercial deployment in hard to abate industries such as steel and cement.[6] At the same time, the development of "cleaner coal" technology pathways is embedded in larger concerns about technological feasibility, capital intensity, and environmental impacts.

ACPET's Framework for a People-Centric Energy Transition

The notion of a "people-centric energy transition," as developed through ACPET's previous research, is informed by a wide range of definitions and frameworks discussing people-centricity and related concepts (e.g., energy justice) within the broader energy transition literature (see Table 1). At its core, this approach emphasizes that transitions must be economic, just, equitable, socially, and culturally inclusive, and environmentally sustainable, while prioritizing the lives, livelihoods, and well-being of coal-dependent communities.

Table 1: Definitions and frameworks discussing people-centricity[7]

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[4] Bhushan, C., Banerjee, S., & Agarwal, S. (2020). Just Transition in India: An inquiry into the challenges and opportunities for a post-coal future.

[5] https://coal.gov.in/sites/default/files/2025-01/31-01-2025a-act.pdf

[6] Ministry of Finance, Government of India. (2026). *Budget highlights 2026–2027* (Union Budget).

[7] International Renewable Energy Agency (IRENA). (2026). Fostering a just energy transition: A framework for policy design. IRENA.; International Energy Agency (IEA). (2021). *World energy outlook 2021: People-centred transitions*.;

World Economic Forum. (2022). Fostering effective energy transition 2022 edition.; Rielli, L. E., & Wang, J. J. X. (2026). Fairing the energy transition: A policy framework for integrating stakeholder concerns in solar energy development. *Energy Research & Social Science*, *131*, 104511.;

Pillan, M., Costa, F., & Caiola, V. (2023). How could people and communities contribute to the energy transition? conceptual maps to inform, orient, and inspire design actions and education. *Sustainability*, *15*(19),14600;.International Energy Agency (IEA). (2025). *Blueprint for action on just and inclusive energytransitions*.IEA;.https://iea.blob.core.windows.net/assets/c8ceff9c-1997-4d00-a1e8-b36694d86432/BlueprintforActiononJustandInclusiveEnergyTransitions.pdf, ;Chowdhury, P. K., Almeida, N., & Tyagi, A. (2025). *How can India enable a people-centric clean energy transition? Framework for responsible renewable energy deployment*. Council on Energy, Environment and Water (CEEW), Schmidt, M., Pande, V., Nor, A. M., Stinglhamer, K., Srinivasan, A., Yeung, P., Eidnani, S., & Maheshwari, S. (2025). *The people-centric energy transition in Asia Pacific: A framework for inclusive and measurable solutions*. Boston Consulting Group (BCG) & AVPN.

Category	Framework	Description	Associated organization
I. Foundational Principles	Inclusivity & Active Participation	Engaging citizens, marginalized communities, and local organizations as proactive stakeholders rather than passive recipients.	International Labour Organization (**ILO**), United Nations Environment Programme (**UNEP**)
	Workers & Decent Jobs	Focusing on workforce transition, protecting labour rights, and creating high-quality green jobs in renewable sectors.	International Labour Organization (**ILO**)
	Consumer Protection & Affordability	Ensuring equitable energy access, managing price volatility, and safeguarding low-income households from rising costs.	International Monetary Fund (**IMF**)
	Social & Economic Development	Aligning energy goals with local and national sustainable development plans to improve livelihoods.	United Nations Department of Economic and Social Affairs (**UNDESA**)
	Gender Equality & Inclusion	Actively addressing the gender gap in energy sectors and enhancing women's participation in decision-making.	United Nations Development Programme (**UNDP**)
	Human Rights & Dignity	Upholding human rights, land rights, and labour standards across the entire energy supply chain.	United Nations High Commissioner for Refugees (**UNHCR**)
II. Responsible Deployment Frameworks (CEEW / Asia-Pacific Focus)	Prioritising Local Communities	Focusing on community engagement and value creation to minimize negative impacts from renewable projects.	Council on Energy, Environment and Water (**CEEW**)
	Regenerative Local Economy	Developing projects that aid local economic growth, such as benefit-sharing mechanisms and SME involvement.	United Nations Industrial Development Organization (**UNIDO**)

Schmidt, M., Pande, V., Nor, A. M., Srinivasan, A., Yeung, P., Eidnani, S., & Maheshwari, S. (2025). *The people-centric energy transition in Asia Pacific: A framework for inclusive and measurable solutions*. Boston Consulting Group (BCG) & AVPN, Boston Consulting Group (BCG), & AVPN. (2025). *The people-centric energy transition in Asia Pacific: A framework for inclusive & measurable solutions*.,Chowdhury, P. K., Almeida, N., & Tyagi, A. (2025). *How can India enable a people-centric clean energy transition? Framework for responsible renewable energy deployment*. Council on Energy, Environment and Water., Ullah, A., Nobanee, H., Ullah, S., & Iftikhar, H. (2024). Renewable energy transition and regional integration: Energizing the pathway to sustainable development. *Energy Policy*, *193*,114270,FasterCapital. (2025, April 12). *Energy management: Energy conservation: Energy conservation techniques for sustainable management*.Chowdhury, P. K., Almeida, N., Tyagi, A., & Ferenz, M. (2025, October). *Enabling an inclusive, people-centric, and ecologically just renewable energy transition in the G20*. Council on Energy, Environment and Water.

	Ecological Sustainability	Ensuring renewable energy infrastructure acts in harmony with local biodiversity, rather than causing new environmental damage.	United Nations Environment Programme (**UNEP**), Ministry of Coal, Government of India (**GoI**)
	Transparency and Accountability	Providing clear information and setting up accountability mechanisms for developers and investors.	Transparency International (TI)
	Responsible Land Use	Implementing low-impact renewable energy siting and ensuring fair compensation/engagement with landowners.	United Nations Convention to Combat Desertification (**UNCCD**)
III. Social Justice and Human Centricity	Distributive Justice	Ensuring the benefits (e.g., jobs, clean energy) and burdens (e.g., job losses, land use) of the transition are distributed fairly.	United Nations Department of Economic and Social Affairs (**UNDESA**), International Labour Organization (**ILO**), United Nations High Commissioner for Refugees (**UNHCR**)
	Recognition Justice	Acknowledging the rights and needs of communities affected by the shift away from fossil fuels, particularly in coal-mining regions.	United Nations High Commissioner for Refugees (**UNHCR**), International Energy Agency (**IEA**), United Nations Development Programme (**UNDP**)
	Procedural Justice	Facilitating inclusive, transparent decision-making processes where communities feel heard and respected.	United Nations High Commissioner for Refugees (**UNHCR**), United Nations Development Programme (**UNDP**) , International Energy Agency (**IEA**)
	Capabilities-Based Approach	Enhancing human agency by providing tools, education, and resources to enable adaptation.	Amartya Sen, Jean Dreze
	Energy Security and Reliability	Ensuring that the transition improves the quality, access, and reliability of energy for all users.	International Energy Agency (**IEA**)

In the context of India's broader development trajectory, any coal transition aligned with the goals of *Viksit Bharat 2047* and NZE 2070 must address key dimensions such as equity, social well-being, livelihoods, environmental sustainability, ecology, cultural integrity, inclusive technological transitions, and the preservation of community identities and social capital, alongside wider macroeconomic implications.[8] Such a transition must also be aligned with the

[8] Banerjee, S. (2023). Ensuring a People-centric Energy Transition: The Case of Informal Workers in Coal Regions. *POWERING INDIA'S FUTURE*, 99.

Sustainable Development Goals (SDGs) 7, 8, 10, 13, and 15,[9] ensuring coherence between national goals for energy access, economic growth, inequality reduction, climate action, and ecosystem protection.[10]

This policy brief synthesizes ACPET's research and policy work on India's coal transition and draws on key insights from a recent stakeholder conference (see description above). It focuses on the central importance of otherwise overlooked issues such as mine repurposing, and coal-to-gas/coal-to-chemical pathways, as pathways to achieving India's short- and long-term policy goals, and identifies key challenges associated with these interventions achieving an inclusive and growth-oriented transition.

Energy Security vs. Climate Commitments

India possesses vast coal resources, estimated at over 400 billion tonnes, yet continues to rely on imports to meet a significant share of its demand, particularly due to quality and supply constraints, underscoring the importance of domestic coal for energy security.[11] In recent years, policy reforms have strengthened domestic coal production, with captive and commercial mines now contributing approximately 200 million tonnes, thereby strengthening energy security and reducing supply constraints.[12]

India's transition pathway is expected to be accompanied by a substantial rise in electricity demand across sectors such as transport, industry, manufacturing, services, and heating, driven by growing economic activity and rising societal aspirations (see Figure 1). Projections indicate that by 2070, India's Gross Domestic Product (GDP) could expand by nearly 15 times, while per capita electricity consumption may increase fourfold by 2047, underscoring the scale of electrification required.[13] At the same time, India has articulated ambitious climate

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[9] SDG 7 – Affordable and Clean Energy: Ensure access to affordable, reliable, sustainable, and modern energy for all.

SDG 8 – Decent Work and Economic Growth: Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.

SDG 10 – Reduced Inequalities: Reduce inequality within and among countries.

SDG 13 – Climate Action: Take urgent action to combat climate change and its impacts.

SDG 15 – Life on Land: Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt biodiversity loss.

[10] Cappellaro, F., D'Agosta, G., De Sabbata, P., Barroco, F., Carani, C., Borghetti, A., ... & Nucci, C. A. (2022). Implementing energy transition and SDGs targets throughout energy community schemes. *Journal of Urban Ecology*, *8*(1), juac023.

[11] Ministry of Coal, Government of India. (2025). Coal & lignite resource.

[12] Press Information Bureau, Government of India. (2026, March 13). *Record coal production from captive/commercial & othermines*.

[13]ibid.

commitments under its updated Nationally Determined Contributions (NDCs), including a 47% reduction in emissions intensity by 2035, achieving around 60% non-fossil fuel-based electricity capacity by 2035.[14]

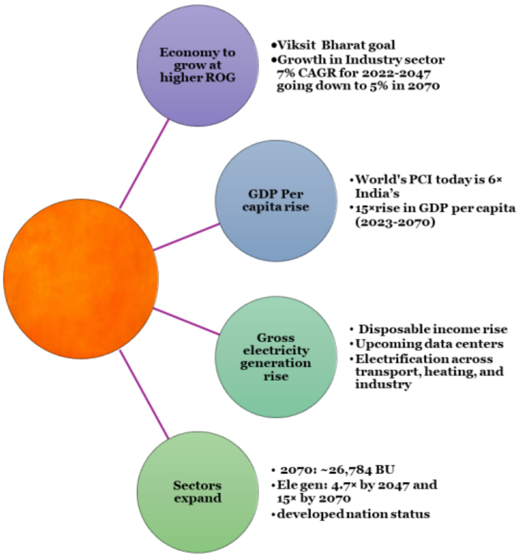

Figure 1: Larger Picture of Transition

Coal, which accounted for 70.54% of India's electricity generation in 2022–23,[15] continues to provide reliable baseload power across all sectors and remains integral to grid stability, particularly in the context of intermittency in renewable energy, limited storage capacity, and the persistent "duck effect" in daily load patterns.[16] Real-time grid dynamics further reinforce this dependence, as declining solar generation during evening peak hours necessitates ramping up coal-based power, supported by thermal and hydro sources.[17] Accordingly, NITI Aayog (2026) projects that coal will remain central to India's energy mix in the near to medium term, with dependence likely to persist for at least the next two to three decades.[18] This dependence is not only technical but also socio-economic, as coal underpins livelihoods, regional economies, and social structures in states such as Jharkhand, Odisha, and Madhya Pradesh. While sustained growth will inevitably lead to rising emissions, balancing this trajectory with

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[14] Press Information Bureau, Government of India. (2026, March 25). *Cabinet approves India's Nationally Determined Contribution (2031–2035) to be communicated to the United Nations Framework Convention on Climate Change*.

[15] Ministry of Power, Government of India. (2023, August 10). *Unstarred Question No. 3456: Production and availability of coal*.

[16] The **duck effect (or duck curve)** is a pattern in electricity demand where high solar generation during the day reduces the need for conventional power, followed by a steep increase in demand from other sources in the evening as solar output declines and consumption rises.

[17] Sachdeva Michael, S., Rakheja, K., Garg, V., & Konda, C. (2025, July 15). *Clean energy key to addressing India's power demand peaks*. Institute for Energy Economics and Financial Analysis.

[18] NITI Aayog. (2026, February 9). *Scenarios towards Viksit Bharat and net zero: An overview (Vol. 1)*. Government of India.

climate commitments requires a calibrated approach, including distributional measures to reduce inequality, and transition technologies such as coal-to-gas and coal-to-chemical pathways.[19] In this context, any abrupt transition away from coal risks exposing residential, commercial, and industrial sectors to energy supply vulnerabilities, highlighting the need to carefully navigate the trade-off between energy security and climate goals.[20]

ACPET Macroeconomic Study

The purpose of ACPET in developing a macroeconomic model to assess the present and future of India's coal economy was to evaluate transition pathways and inform strategies for a gradual and sustainable phase-down of coal. This regression-based study evaluates electricity demand and the share of electricity generation from different fuels under various energy mix scenarios. It aims to analyse how economic and sectoral growth influences the future electricity demand, while assessing the evolving role of renewables across alternative transition pathways.

The results of the study indicate that by 2070, India's GDP will increase 18-fold if the manufacturing share of GDP stays steady at 30% and the service sector share hovers around 54-60%, with the remaining share coming from agriculture. Such a rise in GDP will increase the baseload demand from sectors of the economy and will sustain the continued reliance on coal. As of 2025, while renewable energy accounts for around 50% of the total installed capacity, its share in actual electricity generation is only about 28%.[21] However, if there is development of additional renewable energy-based electricity generation, supported by optimal storage capacities, the demand for coal-based electricity can stabilise in the long term.

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[19] Dhakal, S., Minx, J. C., Toth, F. L., Abdel-Aziz, A., Figueroa Meza, M. J., Hubacek, K., Jonckheere, I. G. C., Kim, Y.-G., Nemet, G. F., Pachauri, S., Tan, X. C., & Wiedmann, T. (2022). *Emissions trends and drivers*. In P. R. Shukla et al. (Eds.), *Climate change 2022: Mitigation of climate change (Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change)*. Cambridge University Press.https://energyandcleanair.org/analysis-chinas-coal-to-chemicals-growth-risks-climate-goals.

[20] International Energy Agency. (2021, May 18). *Net zero by 2050: A roadmap for the global energy sector*. IEA.

[21] MINISTRY OF NEW AND RENEWABLE ENERGY Government of India. (2025) ANNUAL REPORT,2024-2025.

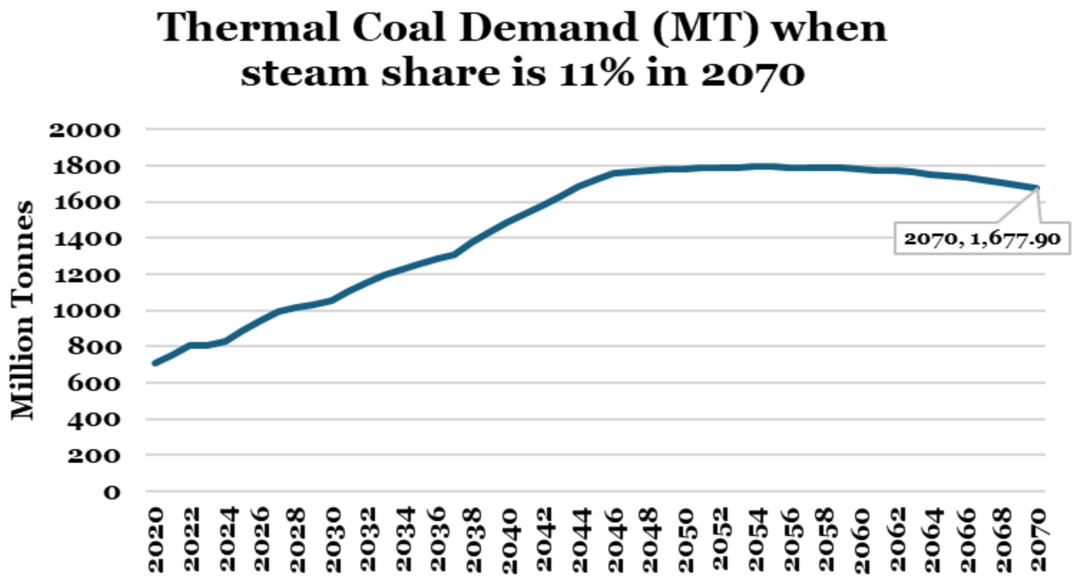

Figure 3: Thermal Coal Demand by 2070 (Source: ACPET macroeconomic study)

Figure 3 shows thermal coal demand remaining steady and levelling off around 2055 through 2070, while the industry sector reaches 30% of GDP. Under this scenario, demand-side efficiency improves by 15%, renewables account for 77% of generation, and the remaining mix is 12% diesel, natural gas, and large hydro plus nuclear, with coal at 11%. Coal demand still holds at about 1.7 billion tonnes by 2070. To meet long-term climate targets despite that level of coal use, India must rapidly scale up ancillary services like frequency regulation, voltage support, and battery storage, alongside upgraded infrastructure to manage renewables' intermittency as their share of generation rises. In the near term, with coal remaining a major part of India's energy mix, transition technologies like coal-to-gas, coal-to-chemicals, and coal-to-liquids should be pursued. These pathways enable India to utilize its large coal reserves while offering a means to technologically and industrially reconfigure coal's role within a lower-carbon economy. Given the above evidence of coal's continued importance in India's energy mix, the focus must shift from *whether* coal will remain in the system to *how* it can be utilised differently and through a clean coal transition pathway towards *Viksit Bharat* and NZE goals of the Indian economy. In this context, addressing the persistent inefficiencies in coal utilisation, outlined in the following section, becomes critical, as they continue to constrain both sustainability outcomes and overall system performance.

Coal Utilization and Efficiency

India's coal-based thermal power sector, accounting for over 70.54% of total electricity generation,[22] operates well below its potential. The average efficiency of Indian thermal power

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[22] Ministry of Power, Government of India. (2023, August 10). *Unstarred Question No. 3456: Production and availability of coal*.

plants stands at approximately 32%,[23] lagging significantly behind global peers. India's efficiency trails China's (39%) and Japan's (43%), with the country recording the second-highest specific CO_2 emissions intensity at 983 gCO_2/kWh, roughly 22% above comparable nations.[24] The dominance of subcritical technology is a primary driver: less than one-third of India's coal capacity is supercritical, only 1% is ultra-supercritical, and the remainder operates on older subcritical designs.[25]

The efficiency gap carries direct environmental and economic consequences. Replacing a subcritical unit with an advanced ultra-supercritical unit can reduce CO_2 emissions by up to 30%,[26] while also reducing local pollutant loads, particulate matter, nitrogen oxides, and fly ash that impose significant public health costs. Advanced Ultra Supercritical (AUSC) technology can achieve plant efficiency of 46%,[27] compared to ~38% for subcritical and 41–42% for supercritical plants, delivering an 11% reduction in coal consumption and CO_2 emissions relative to supercritical designs.[28] Accordingly, Budget 2024 announced that NTPC and BHEL would jointly establish an 800 MW commercial-scale AUSC plant using indigenously developed technology, with fiscal support from the Government[29].

India's heterogeneous coal endowment presents further strategic opportunities. While the average ash content of Indian coal is approximately 40%, the Raniganj coalfield produces some of the country's best-quality coal at around 20% ash[30] and sulphur content across the Jharia and

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[23] Agrawal, M., & Turlapati, Y. (2024, July 23). *Budget 2024–25: NTPC & BHEL to set up a hi-tech coal power plant—How will it work?* Down To Earth.

[24] Centre for Science and Environment. (2020). *Reducing CO_2 footprints of India's coal-based power (factsheet)*.

[25] REDUCING CO2 FOOTPRINTS OF INDIA'S COALBASED POWER,2020 https://cdn.cseindia.org/attachments/0.07369700_1608086849_reducing-co2-footprints-of-india%E2%80%99s-coal-based-power-factsheet.pdf.

[26] REDUCING CO2 FOOTPRINTS OF INDIA'S COALBASED POWER,2020 https://cdn.cseindia.org/attachments/0.07369700_1608086849_reducing-co2-footprints-of-india%E2%80%99s-coal-based-power-factsheet.pdf.

[27] **Advanced Ultra Supercritical (AUSC)** technology is a high-efficiency, low-emission thermal power generation technology, designed to reduce coal consumption and emissions by approximately 11% compared to conventional supercritical plants. Developed in India by BHEL, IGCAR, and NTPC, it operates at higher steam pressures and temperatures, offering roughly 46% efficiency.

[28] Ministry of Heavy Industries, Government of India. (2026). *Advanced ultra supercritical (Adv. USC) technology for thermal power plants*.

[29] Agrawal, M. (2024, July 23). *Budget 2024–25: NTPC & BHEL to set up a hi-tech coal power plant. How will it work?* Down To Earth.

[30] google.com/url?q=https://usispf.org/research/coal-gasification-opportunities-in-india/&sa=D&source=docs&ust=1775550557740631&usg=AOvVaw1U2okej5bgLOOK-hRS4KRU.

Raniganj coalfields remains comparatively low, between 0.28% and 0.55%[31], making these reserves well-suited to coal-to-gas conversion. Pairing coal gasification with CCUS could enable blue hydrogen production from indigenous sources at an estimated cost of USD 1–1.5 per kilogram[32], one of the more competitive low-carbon hydrogen routes available to India.

A coherent clean coal transition must therefore combine technological upgradation from subcritical towards AUSC designs, with differentiated resource utilisation and systematic CCUS deployment. Carbon capture and storage (CCS) retrofitted onto high-efficiency supercritical plants, capturing up to 90% of carbon emissions, has been identified as among the most impactful decarbonisation scenarios for India's power fleet[33]. This integrated approach can reinforce near-term energy security while progressively aligning the sector with India's Net Zero 2070 commitments, with technological upgradation of existing and upcoming plants as its critical foundation.

Clean Coal Transition Pathways

Coal To Methane Capture

Coal-to-gas and coal-to-chemical pathways present emerging opportunities as potential transitional revenue streams within the evolving coal sector; however, their advancement is shaped by persistent gaps in both research and on-ground implementation. For instance, significant opportunities lie in enhancing the robustness of non-CO_2 emissions estimates within national policy pathway models like NITI Aayog's Indian Energy Security Scenarios 2070.[34] This is of particular salience as Greenhouse Gas (GHGs) like methane have a short-term global warming potential approximately 80–85 times greater than CO_2 over a 20-year horizon.[35] While India has regularly submitted methane emissions estimates from the coal mining sector to the UNFCCC, there is an opportunity for the country to lead research in underexplored domains such as characterizing emissions from coal exploration efforts and post-mining

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[31] Gopinathan, P., Singh, A. K., Singh, P. K., & Jha, M. (2022). Sulphur in Jharia and Raniganj coalfields: Chemical fractionation and its environmental implications. *Environmental Research*, *204*, 112382.

[32] Ministry of Coal, Government of India. (2022). *Report of the Committee on the Roadmap for Coal Gasification in India*.

[33] Stauffer, N. W. (2025, May 6). *How can India decarbonize its coal-dependent electric power system?* MIT News.

[34] IESS 2070 refers to India's Net Zero by 2070 target, a crucial climate commitment announced by Prime Minister Narendra Modi at the COP26 summit in November 2021.

NITI Aayog. (2023). *India energy security scenarios (IESS) 2047: Version 3.0—One pager*. Government of India.

[35] United Nations Environment Programme (UNEP). (2024, July 19). *Facts about methane*.

handling activities.[36] Such research can build off India's existing efforts to commercialize Coal bed methane (CBM) resources as part of its energy diversification strategy.

CBM has emerged as a promising unconventional hydrocarbon in India, driven by rising energy demand and declining conventional gas reserves. Produced during coalification and stored in coal seams, CBM offers a relatively cleaner energy source if effectively recovered. India's CBM exploration began in the mid-1990s, with commercial production starting in 2007 in the Raniganj coalfield.[37] The country holds significant CBM potential, with total resources estimated at around 2600 bcm and 1,767.07 bcm across 33 identified blocks, concentrated primarily in Jharkhand, Rajasthan, Gujarat, Odisha, and Chhattisgarh.[38] As of FY 2025–2026, CBM exploration and production spans approximately 7,010 sq.km. across 15 blocks under operation (7 in exploration, 3 in development, and 5 in production stages), with cumulative CBM production reaching 7.14 bcm up to FY 24–25. These activities have contributed USD 148 million in royalties to State Governments and USD 7 million to the Central Government.[39] Despite progress, CBM production in India remains modest (2.8 mmscmd) compared to countries like the United States and Australia, constrained by technical challenges such as low permeability and heterogeneous seams, alongside economic, infrastructural, and regulatory barriers.[40]

Coal mine methane (CMM) presents an additional opportunity for methane mitigation and energy recovery, though its deployment in India remains largely at the pilot stage. Past initiatives, including United Nations Development Program (UNDP) - and Global Environment Facility (GEF)-supported demonstration projects at Moonidih and Sudamdih, and feasibility studies in coalfields such as Sawang and Chinakuri, have demonstrated technical viability using approaches like in-seam horizontal boreholes and reservoir simulation models.[41]

[36] Joshi, D., Prajapati, P., Sharma, P., & Sharma, A. (2023). Past, present and future of Coal Bed Methane (CBM): a review with special focus on the Indian scenario. *International Journal of Coal Preparation and Utilization*, *43*(2), 377-402.

[37] Singh, A. K. (2022). Evolution and future prospects for coalbed methane and coal mine methane in India: Approaches for addressing mine safety, climate change, and energy security. In *Innovative Exploration Methods for Minerals, Oil, Gas, and Groundwater for Sustainable Development* (pp. 101-126). Elsevier.

[38] Vedanti, N. I. M. I. S. H. A., Vadapalli, U., & Sain, K. A. L. A. C. H. A. N. D. (2020). A brief overview of CBM development in India. Proceedings of the Indian National Science Academy, 86(1), 623-629.

[39] Directorate General of Hydrocarbons (DGH). (2025). *India's hydrocarbon outlook 2024–2025 (Annual publication)*. Ministry of Petroleum and Natural Gas, Government of India.

[40] Meel, H., & Lokhande, R. D. (2025, October). Advancements in Coal Bed Methane Technology in India: A Global Comparative Analysis with Strategic Recommendations. In *Asian Mining Congress* (pp. 569-589). Cham: Springer Nature Switzerland.,Singh, A. K., & Sahu, J. N. (2018). Coal mine gas: a new fuel utilization technique for India. *International Journal of Green Energy*, *15*(12), 732-743.

[41] Hummel, J. A., Ruiz, F. A., & Kelafant, J. R. (2018). Quantifying the benefits of coal mine methane recovery and use projects: Case study on the application of in-mine horizontal pre-drainage boreholes at gassy coal mines in India and the optimization of drainage system design using reservoir simulation. *Environmental Technology & Innovation*, *10*, 223-234.

More recent pilots, such as the Jharia CBM Block-I initiative,[42] indicate continued interest, supported institutionally through agencies like Central Mine Planning & Design Institute Limited, (CMPDI) and the CMM/CBM Clearinghouse. However, commercialization is constrained by limited gassy coalfields, inadequate infrastructure, low methane concentrations (especially in ventilation air methane), and weak economic incentives.[43] Case studies from coalfields such as Raniganj and Jharia highlight site-specific potential, with high methane content and energy recovery prospects, while also underscoring the need for targeted technologies, improved policy support, and integration with broader energy systems.[44]

Building on previous measurement efforts by CSIR-CIMFR, ACPET is spearheading a methane field measurement project in collaboration with IIT Bombay, aiming to update the emissions factors and pathways associated with the coal production module of the IESS 2070. This project will not only create new datasets consisting of methane emissions from India's underground/surface mines and coal exploration boreholes/handling activities but will also provide policy-relevant insights about the *future of methane capture and utilization as a clean coal transition pathway for India*.

Coal Gasification

Apart from electricity generation coal gasification also offers multiple pathways for value addition across India's industrial sectors. Coal gasification as a power-generation technology is gaining popularity due to the ready global availability of the raw material, but beyond syngas, coal gasification also produces various byproducts such as energy fuel (methanol & ethanol), ammonia for fertilisers and petro-chemicals (i.e., solvents, and synthetic materials).[45] Syngas from coal gasification can substitute coking coal and natural gas in major production technology routes of essential manufacturing sectors like steel and cement.[46] Syngas derived from gasification processes contains a significant amount of hydrogen which can be further increased through water-gas shift (WGS)[47] and readily separated into a pure H2 product meeting industry product quality standards. The cost of hydrogen produced from coal can be

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[42] Global Methane Initiative (GMI). (2024). *Landscape of methane abatement finance*.

[43] Singh, U., Vishwanathan, S. S., Garg, A., Singh, A. K., & Iyer, S. H. (2025). Socio-technical feasibility of coal transitions in India: Results from stakeholder interviews. *Energy and Climate Change*, *6*,100188.Sinha, S. K., & Panigrahi, D. C. (2018, August). Leveraging Coal Mine Methane/Ventilation Air Methane for Improving Ventilation Standards in Indian Underground Coal Mines and to Reduce Its Carbon Footprints. In *Proceedings of the 11th International Mine Ventilation Congress* (pp. 355-363). Singapore: Springer Singapore.

[44] Ojha, K., Karmakar, B., Mandal, A., & Pathak, A. K. (2011). Coal bed methane in India: difficulties and prospects. *International Journal of Chemical Engineering and Applications*, *2*(4), 256.

[45] Ministry of Coal, Government of India. (2021). *National Coal Gasification Mission (NCGM): Policy document and framework.*

[46] Joshi, H. (2024, March 30). *Carbon omissions: India's coal gasification plans are ambitious but face an uphill task*. Newslaundry.

[47] Ministry of Coal, Roadmap for Coal to Hydrogen Production in India, Government of India, 2022.

cheaper and less sensitive to import dependency compared with hydrogen production through electrolysis or natural gas, though carbon capture will play an important role in managing emissions.[48] Other important chemicals that can be produced using coal gasification are Ammonia and methanol. India currently imports over 90% of its ethanol consumption and a significant share of its methanol.[49] Methanol production is also essential for API production, and the domestic supply chain can be a gamechanger for the Indian pharmaceutical sector.

NITI Aayog's Methanol Economy programme aims to reduce India's oil import bill and greenhouse gas emissions by converting coal reserves and municipal solid waste into methanol. Blending 15% methanol with gasoline is expected to lower crude oil imports by approximately 1-5%..[50] India consumes about 15.7 million metric tonnes of ammonia annually and to reduce the import dependence the government is increasingly shifting focus toward domestic coal-based ammonia and urea production .[51] In steel-making, iron reduction using syngas is being explored, where both carbon monoxide (CO) and hydrogen (H_2) act as reducing agents in Direct Reduced Iron (DRI) plants. [52]Jindal Steel & Power Ltd's (JSPL) Angul plant in India operates the country's only syngas-based coal gasification plant for steelmaking, demonstrating a working industrial application of coal gasification in the steel sector.[53]

Deliberations at ACPET's flagship showcase event underscored that realizing the full value-addition potential of coal-to-gas and coal-to-chemical pathways in India is contingent on addressing persistent structural constraints. These include the high ash content of domestic coal, prohibitive capital costs, significant water requirements, and the absence of mature CCUS systems, factors that collectively influence both the economic viability of gasification pathways and their alignment with India's broader climate commitments.

Within this broader transition context, the discussions also emphasized that reconfiguring coal's industrial use represents only one dimension of the challenge, managing its localized socio-economic and environmental impacts is equally critical, positioning coal mine repurposing as a key pillar that centres employment, land use, and community well-being.

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[48]Press Information Bureau, Ministry of Coal, Government of India. (2021, September 7). *Ministry of Coal constitutes task force and expert committee to prepare road map for coal-based hydrogen production*.

[49] Joshi, H. (2024, March 21). *India's coal gasification plans: More glitter than gold?* CarbonCopy.

[50] Ministry of Coal, Government of India. (2021). *Policy framework for promotion of coal gasification projects in India*.

[51]https://usispf.org/research/coal-gasification-opportunities-in-india/.

[52] Press Information Bureau, Ministry of Coal, Government of India. (2021, September 7). *Ministry of Coal constitutes task force and expert committee to prepare road map for coal-based hydrogen production*.

[53]Ministry of Coal, Government of India. (2021, September 21). *National coal gasification mission (NCGM): 100 MT coal gasification by 2030*.

Coal Mine Repurposing

A people-centric approach to transforming abandoned**,** decommissioned or underutilised coal mines into alternative, sustainable land uses requires prioritizing the livelihoods, socioeconomic and cultural needs of affected populations.[54] Global experience demonstrates that abandoned mines can be repurposed for a wide range of uses, such as CO_2 removal, biodiversity enhancement, and regional economic revitalization, with examples from countries including Germany,[55] the United States,[56] China,[57] and India.[58] These efforts extend beyond mine pits to encompass the full spectrum of mining landscapes, including land, infrastructure, and water bodies.

In the Indian context, repurposing closed and abandoned mines offers a significant opportunity to advance climate, biodiversity, and rural development objectives, while enabling long-term socioeconomic transformation in coal-bearing regions. In coal-bearing regions such as Munidih near Dhanbad, the on-ground reality shows deep structural dependence on coal, where agriculture declines within close proximity to mines and livelihoods shift toward daily wage labour and informal coal-based activities. Limited alternative opportunities outside mining zones reinforce reliance on companies like BCCL for employment and infrastructure. The areas are marked by low socio-economic indicators, including limited skills and inadequate social security coverage, increasing vulnerability during mine closure. Environmental degradation further fragments traditional livelihoods, while cultural and ethical dimensions, particularly among indigenous communities, create a perceived moral claim over resources, often resulting in informal or illegal mining as a survival strategy.[59] This context necessitates a shift from viewing mine closure as a purely technical process to adopting people-centric repurposing frameworks that prioritize long-term regional development, livelihood diversification, and community engagement. Abandoned mines also present a strategic opportunity for multi-sectoral repurposing. Post mining land uses (PMLUs) recommended by the GoI and MoC's 2025 mine closure guidelines include agriculture, irrigation, pisciculture, development of eco-

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[54] Banerjee, S. (2023). Ensuring a People-centric Energy Transition: The Case of Informal Workers in Coal Regions. *POWERING INDIA'S FUTURE*, 99.

[55]. Matanzima, J., Schramm, K., Uhrmann, H., Heberle, F., Vonderau, A., Weber, T., ... & Werner, T. (2026). Repurposing mines for renewable energy: Socio-environmental implications for local communities in Australia and Germany. *Energy Research & Social Science*, *131*, 104508.

[56] Bertrand, S., & Pelliccio, C. (2022, July 18). *Spurring clean energy development on reclaimed mine lands*. Environmental and Energy Study Institute (EESI).

[57]Zhong, A., Gen, Y., Wang, Z., & Hu, C. (2025). Evaluation of the effect of ecological restoration in mineral resource cities and analysis of driving factors. *Scientific Reports*, *15*(1), 14543.

[58] Singh, A., Agarwal, S., & Prabhat, A. (2024). A multi-criteria decision framework to evaluate sustainable alternatives for repurposing of abandoned or closed surface coal mines. *Frontiers in Earth Science*, *12*, 1330217.

[59]Pandey, J. G., Gaurav, K., Singh, A. K., & Kumar, A. (2025). Just transition beyond extraction: A spatial and comparative case study of two coal mining areas in India. *Energy Research & Social Science*, *126*, 104136.., https://sanhati.com/excerpted/3798.

parks, tourism and recreation, arts, crafts and heritage, landscaping, waterbody conservation/creation, solar and green energy, and micro, small, and medium green industries.[60] Projects are expected to create local jobs and help people learn new skills during and after the repurposing work, while also working closely with self-help groups/NGOs, mine workers, and local communities to design repurposing plans together.[61] Where possible, these guidelines recommend drawing on local knowledge in the realms of a) developing arts, culture, and heritage-related projects; b) promoting local species, fruit-bearing plants, water conservation, wildlife conservation, flora and fauna conservation, and topsoil management; and c) creating horticulture, agriculture, and pisciculture spaces.[62] The guidelines call for focused investments in skill development, livelihood diversification, and public services, requiring that at least 25% of the five-yearly escrow amount and 10% of the Just Transition allocation be used for community development and livelihood-related activities in consultation with district authorities, local institutions, and key stakeholders.[63]

The Ministry of Coal has identified over 20 abandoned mines for feasibility assessments of Pumped Storage Projects (PSPs). Neyveli Lignite Corporation India Limited is also conducting feasibility studies for such projects. The Ministry has directed stakeholder consultations to explore implementation interest, identify additional potential sites, and refine viable business models such as Engineering, Procurement and Construction (EPC) and Public-Private Partnership (PPP). These projects are expected to be implemented through collaborations involving state governments, private sector players, and research institutions.[64]

India's People-Centric Repurposing Frameworks

India's 2025 Mine Closure Guidelines mark a decisive shift from technical and environmental remediation toward integrated frameworks that embed socio-economic and community sustainability at the core of closure planning. The new guidelines mandate the inclusion of restoration, remediation, and regeneration measures in mining plans, with the aim of minimizing environmental impacts, addressing community concerns, and promoting continuous improvement.[65] It emphasizes that mines cannot be abandoned or backfilled alone, but must undergo a deliberate process of reclamation, regeneration, and ultimately repurposing

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[60] Ministry of Coal, Government of India. (2025, August 14). *Comprehensive mine closure and repurposing policy*.,India Brand Equity Foundation (IBEF). (2025, August 7). *Development of closed coal mines as tourist places*.

[61] Pal, T. (2023, November 23). *Policy analysis: Mine closure in India*. Centre for Social and Economic Progress (CSEP).

[62] Coal Controller Organisation, Ministry of Coal, Government of India. (2025, January 31). *Guidelines for preparation of mining plan and mine closure plan for coal and lignite* .Chakraborty, D. (2025, August 7). *Closed mines to be developed as tourism spots: Coal minister*. The Statesman.

[63] India Brand Equity Foundation (IBEF). (2025, August 7). *Development of closed coal mines as tourist places*.

[64] Shetty, S. (2023, November 10). *Coal ministry identifies 20 abandoned mines to develop pumped storage projects*. Mercom India.

[65] IANS. (2025, August 6). *Closed coal mines repurposed into ecoparks, tourism sites: Centre*. Prokerala.

to benefit affected communities.[66] These closure stages require technical planning alongside a robust system of criteria and frameworks to assess if a site is environmentally stable, economically feasible, socially acceptable, and technically suitable for future use. The guidelines emphasize transforming mines to minimize the environmental footprint of closure, mitigate adverse impacts on local communities and ecosystems, and facilitate the preservation of natural habitats.

The RECLAIM Framework,[67] developed by the Ministry of Coal (MoC) and the Coal Controller Organization (CCO), promotes a people-centric approach, emphasizing inclusion, long-term responsibility, and shared decision-making. It integrates resources from international best practices and guidelines to create a comprehensive document on the mine repurposing framework. A new mine repurposing tool, SUVIKALP,[68] has been developed by the CCO which reflects the community-centric focus of RECLAIM to support users to select mine repurposing projects based on biophysical and socioeconomic criteria.

Most recently, MoC and CCO developed the L.I.V.E.S handbook,[69] which adopts a structured approach to mine closure, emphasizing key themes such as land reclamation, community engagement, post-closure development, ecosystem rehabilitation, and sustainability. It defines mine repurposing as "Viable Post-Closure Development" and outlines four essential pillars: transforming degraded land, restoring ecosystems, aiding communities in transitioning to diverse livelihoods, and fostering participatory planning. Its main recommendations prioritize sustainable economic opportunities, diversification beyond extractive industries, and the necessity of ecological restoration, enhancing plant diversity and addressing pollution, before pursuing social and economic repurposing projects.

ACPET's Approach to People-Centric Mine Repurposing

Building on this, ACPET has operationalized a people-centric approach to repurposing India's closed and abandoned mines through the development of decision support systems to assess the suitability of PMLUs and on-ground interventions in coal-bearing regions. As a first substantial step of our relationship with CIL, ACPET piloted the Transmine Project from 2023-2024.[70] We began work with the Central Colliery Limited (CCL) in one of their discontinued coal mines in Rajhara, Jharkhand, home to some of the country's most vulnerable rural populations. Jharkhand is a region highly reliant on coal-related jobs for its primarily unskilled and semi-skilled population, most of whom returned to farming following the closure of the

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[66] Ministry of Coal, Government of India. (2025, August 14). *Comprehensive mine closure and repurposing policy*.

[67] https://coal.gov.in/sites/default/files/2025-08/14-08-2025a-wn.pdf.

[68] https://coalcontroller.gov.in/suvikalp.html.

[69] Coal Controller Organisation, Ministry of Coal, Government of India. (2025). *L.I.V.E.S framework for mine closure*.

[70] Sambodhi Research and Communications. (2024). *Survey to understand impact of energy transition interventions in coal mine regions*. Ashoka Centre for a People-Centric Energy Transition (ACPET), Ashoka University.

mine. Central to the Transmine project was the implementation of a) a Solar-Powered Lift irrigation (SLI) system to improve agricultural irrigation by harnessing solar energy (where diesel pumps were previously used), ensuring farmers in the area have reliable access to water, and b) the development of a Farmer Produced Organization (FPO) in collaboration with local NGOs to enhance the subsistence farmers' incomes in areas where coal production has ceased.[71]

Bottom-Up Approach: Implementing and Assessing the Success of On-Ground Pilots

Solar Lift Irrigation: Solar Lift Irrigation (SLI) represents a practical example of repurposing mine assets for sustainable livelihoods, wherein abandoned mine voids, often water bodies formed post-closure, are utilized as reliable irrigation sources for agriculture. The intervention integrates solar-powered pumps and approximately 1,000 metres of PVC pipeline infrastructure to channel water directly to farmlands, eliminating recurring fuel costs and improving energy efficiency. By reducing dependence on rain-fed agriculture, SLI enables farmers to transition from single-crop to multi-crop cultivation, thereby enhancing income stability. Early implementation has already benefited around 25 households, with the potential to expand coverage to additional communities. As a low-cost, community-governed model, it demonstrates strong scalability across coal-bearing regions, while also contributing to climate resilience by transforming former environmental liabilities into productive agricultural assets.

Farmer Producer Organisation: FPO strengthens agricultural outcomes by organizing farmers into a collective enterprise that enhances bargaining power, enables bulk procurement, and improves market access. It aggregates produce for premium markets, provides quality inputs and climate-smart training, and reduces dependence on intermediaries. Built on over 200 women-led Self-Help Groups across Rajhara and Chechana villages, the FPO leverages existing institutional and infrastructure assets. Its vision is to create a thriving agricultural ecosystem where farmers can access fair prices and institutional finance.

Together, SLI and FPO form an integrated, self-sustaining system, where irrigation boosts production and collective organization ensures profitability driving long-term economic resilience in post-mining regions.

Impact Evaluation of SLI and FPO

The impact evaluation highlights strong early outcomes from the SLI and FPO interventions, with clear potential for scaling. While 34.9% of households currently rely on single-crop farming, there is a universal aspiration (100%) among farmers to shift toward year-round multi-cropping. Early SLI adopters are already benefiting, with the model proving effective across the 43 surveyed households by reducing dependence on rain-fed agriculture and enabling multi-season cultivation through reliable, solar-powered irrigation. At the same time, FPO-based aggregation is unlocking access to better inputs, training, and fair market prices, leading

[71] Ashoka Centre for a People-Centric Energy Transition (ACPET). (2025). *Transforming life and livelihood of coal mine communities*. Ashoka University.

to higher economic returns. The findings emphasize that combining physical infrastructure (SLI) with social and financial capital (FPOs) creates a powerful pathway for sustainable, climate-resilient rural transformation in post-mining regions.

In parallel, through collaborations with Coal India Limited (CIL) and its subsidiaries, ACPET is advancing a holistic and systematic India-centric framework to assess the suitability of a wide range of PMLUs. It integrates technical analyses, such as Geographic Information Systems (GIS) and remote sensing to assess the biophysical characteristics of mining landscapes, with socioeconomic data about community and stakeholder needs and preferences to co-design and implement social and economic infrastructure in post-mining contexts, ensuring that repurposing pathways are both locally relevant and scalable.

Top-Down Approach: Building a Decision Support System

ACPET is advancing a systems-based approach to coal mine repurposing through the development of a framework and web-based Decision Support System (DSS) building on its contributions to existing government approaches such as the SUVIKALP platform developed by the CCO, and REVITA framework proposed by Southeastern Coalfields Limited (SECL).[72]

ACPET's framework is organized into three interlinked phases, aligned with existing research that underscores the importance of early action to safeguard environmental quality, align land rehabilitation with regional development needs, and ensure long-term community benefits. The first phase focuses on compiling comprehensive information on the mine site, key stakeholders, and the broader regional context. The second phase involves analysing the social-ecological system within which the mine operates, including environmental conditions, resource linkages, and community dynamics. The third phase builds on these insights to develop PMLU recommendations that are both technically feasible and responsive to stakeholder priorities, ensuring context-specific and sustainable outcomes (see Figure 6).

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[72] https://coalcontroller.gov.in/suvikalp.html. ACPET has collaborated with the CCO to expand the range of PMLUs listed in SUVIKALP, as well as additional biophysical and socio-economic criteria, and developing a supporting resource library of case studies, standards, and implementation pathways, thereby improving its practical applicability.

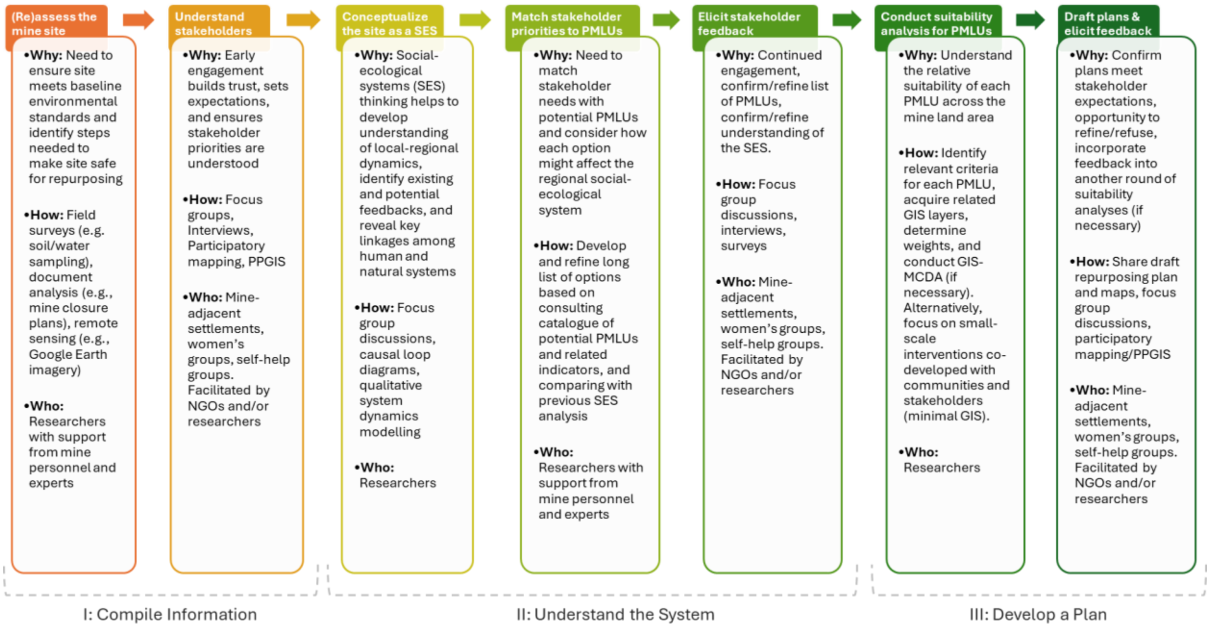

Figure 6. Three phases of a people-centric approach to coal mine repurposing

Pilot work with SECL in North Chirmiri demonstrates how this approach can be operationalized in practice. By integrating GIS and remote sensing datasets with findings from a community needs assessment commissioned by the mining company, the exercise identifies and spatially maps suitable PMLUs, such as solar parks, agroforestry, forest and eco park using multi-objective land allocation (MOLA) (see Figure 7).[73] These insights underscore the importance of integrating landscape-level datasets with participatory approaches to inform policy design about closure and repurposing, drawing on the conclusions of existing frameworks like RECLAIM, L.I.V.E.S, REVITA.

[73] **Multi-Objective Land Allocation (MOLA)** is a spatial optimization method used in environmental science and urban planning to assign specific land uses (e.g., agriculture, residential, conservation) to land units, while simultaneously satisfying multiple, often conflicting, objectives and constraints. It is a decision-support tool that seeks to maximize suitability across different land uses rather than focusing on a single purpose.

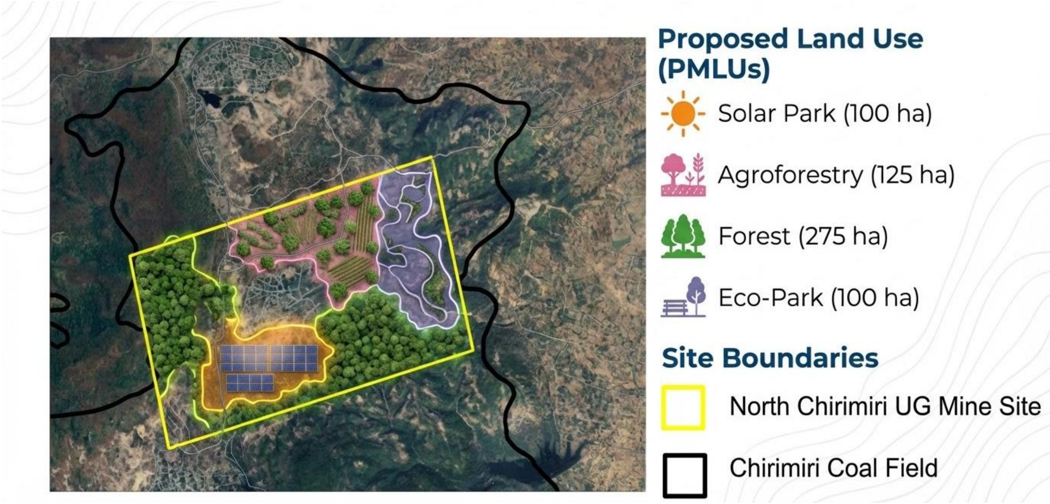

Figure 7: Output result from MOLA

Effective implementation of aforementioned frameworks can enable a clean coal transition anchored in socially inclusive repurposing.

Policy Recommendations

Synthesising insights from economic modelling, technological pathways, and ground-level transition challenges, the following policy recommendation matrix presents a comprehensive framework to support India's clean coal transition while ensuring regional resilience and community well-being: -

Figure 8 - Policy Matrix and Recommendations

1. **Adopt a phased, people-centric transition framework** that recognises coal's medium-term role in ensuring energy security, while embedding principles of distributive justice, livelihood resilience, and regionally balanced development within transition planning.
2. **Mainstream mine closure and repurposing within the policy architecture** by mandating concurrent closure planning, strengthening participatory and multi-stakeholder governance, and deploying context-specific, livelihood-linked PMLU frameworks aligned with RECLAIM and L.I.V.E.S guidelines.
3. **Accelerate clean coal transition pathways** through targeted deployment of high-efficiency technologies (supercritical, ultra-supercritical, AUSC), alongside scaling coal gasification and coal-to-chemical value chains integrated with CCUS to reduce emissions intensity while enhancing domestic value addition.
4. **De-risk emerging transition pathways through innovative financing and market mechanisms**, including offtake guarantees, blended finance models, and public-private partnerships, while prioritising pilot and demonstration projects to enable technology validation and scalability.
5. **Integrate coal transition within broader energy system planning**, ensuring alignment with electrification trajectories, grid modernisation, and storage deployment, including the utilisation of repurposed mine infrastructure for applications such as pumped storage and renewable integration.
6. **Institutionalise methane mitigation within regulatory frameworks** by strengthening measurement, reporting, and verification (MRV) systems, while promoting coal mine methane (CMM) and coal bed methane (CBM) capture and utilisation as part of a low-carbon transition strategy.
7. **Operationalise a just transition at the regional level** through targeted investments in skilling, livelihood diversification, and social infrastructure, while enhancing institutional capacity and embedding procedural justice through sustained community engagement in coal-dependent regions.

Conclusion

India's coal transition is not defined by the pace of phase-down alone, but by the effectiveness with which it manages structural trade-offs between energy security, economic growth, and climate commitments. As this policy brief demonstrates, coal will remain integral to India's energy system in the near to medium term, necessitating a shift from a binary "phase-out" narrative to a calibrated strategy of transformation. This includes improving coal utilisation efficiency, advancing coal-to-gas and coal-to-chemical pathways where viable, and embedding methane mitigation and carbon management within the broader transition architecture.

At the same time, the transition must be grounded in people-centric principles. Coal-dependent regions face deep socio-economic vulnerabilities, and without deliberate policy intervention, the transition risks exacerbating regional inequalities and livelihood disruptions. Mine repurposing emerges as a critical bridge between macro-level transition pathways and local development outcomes, offering opportunities to convert degraded landscapes into engines of economic diversification, ecological restoration, and clean energy generation.

Frameworks such as RECLAIM, L.I.V.E.S, and ACPET's data-driven, participatory approaches demonstrate that a just transition is both technically feasible and institutionally actionable. However, their success will depend on consistent implementation, strengthened governance, and the integration of community participation into formal decision-making processes. Scaling such approaches through tools like decision support systems, coupled with targeted financing and institutional capacity building, will be essential to move from pilots to nationwide impact.

Ultimately, a clean coal transition for India must be multi-dimensional, combining technological upgradation, efficient resource utilisation, and socially inclusive repurposing. It must align national development goals with local aspirations, ensuring that communities are not passive recipients but active participants in shaping post-coal futures. Achieving this balance will be central to advancing India's Viksit Bharat 2047 vision and its Net Zero 2070 commitments, while ensuring that the transition remains equitable, resilient, and sustainable.

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