



THE ENERGY FORUM

ROUNDTABLE CONFERENCE

REPORT ON

Importance of Green Energy for India's Energy Transition: Challenges and Prospects

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India International Centre, New Delhi





Inagural Session



Welcome Address

Shri Sidhartha Pradhan, Trustee, The Energy Forum, in his welcome address, thanked the audience for their presence at the roundtable conference on 'Importance of Green Energy for India's Energy Transition: Challenges and Prospects'. He highlighted the critical role of such platforms in fostering meaningful dialogue among stakeholders and emphasised that India's transition to a greener energy mix requires collaborative efforts, innovative solutions, and a clear policy roadmap to address existing challenges while unlocking future opportunities.

Mr. Pradhan expressed special gratitude to Padma Vibhushan (Dr.) Anil Kakodkar for his presence as the keynote speaker. As a towering figure in India's nuclear journey, Dr. Kakodkar has witnessed everything from scientific innovation to national security. As a former Chairman of the Atomic Energy Commission and a pivotal figure in the civil nuclear agreement with the U.S., Dr. Kakodkar was recognized for his integrity, leadership, and vision. His steadfast support for India's strategic autonomy was described as akin to a "Rock of Gibraltar."

The speaker expressed hope that the insights shared during the roundtable, and the legacy of leaders like Dr. Kakodkar, would guide India's future policy decisions and technological priorities. He concluded by inviting further discussion and collaboration in the sessions to follow, emphasising the need for indigenous innovation and a realistic, multifaceted energy strategy to meet India's development and climate goals.

Special Address



Shri Bhupinder Singh Bhalla, IAS (Retd), Former Secretary, Ministry of New & Renewable Energy (MNRE), delivered the special address for the event. Drawing from his extensive experience and leadership at MNRE, he provided a comprehensive overview of India's progress in green energy and the road ahead. His remarks reflected a deep understanding of the opportunities and challenges facing India as it undertakes one of the largest energy transitions in the world.

India's renewable energy sector, he noted, has undergone a remarkable transformation over the past decade. In terms of national goals, Shri Bhalla highlighted that the Indian

Prime Minister's vision of achieving 500 gigawatts (GW) of renewable energy capacity by 2030 appears well within reach. In 2014, the country had an installed renewable energy capacity of 76 GW. As of June 2025, this figure had surged to 234 GW, representing more than a 2.7-fold increase. The growth trajectory continues to gain momentum, with 80 GW added in the previous year alone and a further 40–45 GW expected to be installed this year. This rapid expansion underscores the private sector's constant endeavour and the government's sustained commitment towards the framework of renewable energy.

He also highlighted that India currently has 180 GWs of projects under implementation, which are likely to become operable within the next two-three years. He noted that even if 25 per cent gets delayed for some reason, there is still around 150 GW that will be added. Furthermore, India's international commitment to achieving 50 percent electricity capacity from non-fossil fuel-based sources by 2050 is likely to be fulfilled five years ahead of schedule, which signals the country's proactive stance in tackling climate change and aligning with global sustainability efforts.

However, Shri Bhalla cautioned that several challenges must be addressed to sustain and scale up in this regard. Foremost among them is the need for significant financial investment. In the last decade there has been an investment of \$80 billion in the renewable energy sector, out of which around \$10 billion was foreign direct investment (FDI). He estimated that over the next five to six years, there is a need to ramp up these investments to \$300 – \$400 billion. To mobilise this capital, there is a pressing need to deepen financial markets and create investor-friendly mechanisms that supports the ecosystem.

Simultaneously, he stressed the importance of upgrading energy infrastructure, particularly in enhancing grid stability (due to variability of energy), strengthening transmission networks, and deploying large-scale battery storage systems to manage the intermittent nature of renewable sources.

He also highlighted that while land availability is a challenge in some parts of the country, a more pressing concern is the availability of land that is located near existing transmission infrastructure. Rajasthan and Gujrat, which are among the most favoured destinations, face the issue of

rapid transmission congestion, which threatens to delay project implementation. To achieve the lowest cost of energy production, therefore, solar projects need to be located in areas with the highest solar irradiance — primarily industrial developed states. As a result, Rajasthan and Gujarat remain the most attractive locations for solar installations due to their superior solar potential and cost advantages, further compounding the pressure on local transmission infrastructure. Wind energy, by contrast, can only be deployed in select parts of the country.

Regarding battery storage, he noted that India would need about 230 GW of battery storage capacity by 2029-30, comprising approximately 210 GW that would be from battery storage and 20 GW from pumped hydro storage. In recent times, the decline in battery storage tariffs has been a positive development and is expected to fall further.

Shri Bhalla also spoke of the importance of decarbonising hard-to-abate sectors and emphasised the strategic role of the National Green Hydrogen Mission in this context. He pointed out that green hydrogen and its derivatives, such as green ammonia, could play a transformative role in reducing emissions in industries like oil refining,

fertilizers, steel, and heavy transport. He shared insights into emerging initiatives that aim to substitute imported grey ammonia with domestically produced green ammonia, thus enhancing both environmental and energy security.

In conclusion, the Former Secretary of MNRE, presented an optimistic vision for India's green energy future. Despite the financial and infrastructural challenges, he reiterated India's robust policy framework, technological advancements, and unwavering commitment to position it as a global leader in renewable energy. The transition promises not only to deliver environmental benefits but also to open up significant avenues for economic growth, job creation, and technological innovation.

Keynote Address



Padma Vibhushan (Dr.) Anil Kakodkar, began by acknowledging that energy transition is a disruptive process, not only technologically and economically, but also socially and politically. The speaker emphasised that to achieve meaningful transformation, disruption must also occur within the discourse itself. A shift in the way we think and talk about energy is essential.

A key theme of his address was the inherent contradiction between India's developmental needs and global climate targets, i.e., between Vikshit Bharat and Net Zero

emissions. India's goal of achieving a standard of living comparable to that of developed countries implies a significant increase in energy consumption. Developed nations currently consume around 2400 kg oil equivalent per year per capita. Even with major improvements in energy efficiency, India would require around 1400 kg of oil equivalent per year per capita, which translates to approximately 28,000 TWh per year of energy for India's stabilised population. This figure is more than three times the total energy currently consumed in India. Additionally, to achieve Net Zero, it becomes essential to achieve all this energy with minimum carbon footprint.

Dr. Kakodkar highlighted that while renewable energy has made considerable progress and is essential for the transition, it has limitations in the Indian context. Projections indicate that India can realistically produce less than 8000 TWh per year through renewable sources. This leaves a substantial shortfall that cannot be met by renewables alone. Therefore, there is a critical need to broaden the definition of clean energy beyond the conventional understanding of "green energy."

To address this gap, the speaker proposed a distinction between "green energy" and

“clean energy,” focusing on the carbon footprint of the energy source rather than its label. This approach opens the door to options like nuclear energy, which, despite its controversies, remains one of the lowest carbon-emitting energy sources. India’s own resources and technological capabilities make thorium-based nuclear energy particularly promising. The emphasis was placed on leveraging such clean technologies to ensure energy security and sustainability.

In addition to renewables and nuclear energy, hydrogen was identified as a vital element in India’s clean energy strategy. Its role in decarbonizing hard-to-abate sectors such as heavy transport and industrial manufacturing was underscored. The speaker concluded by stressing the importance of a diversified and realistic energy mix that balances development imperatives with climate responsibilities. A successful energy transition for India will depend on embracing this broader, more inclusive approach to clean energy.

The speaker underscored the evolving nature of energy production and consumption in India. Historically, primary energy was largely fossil-based, supplied in the form of heat, which was then converted into

electricity. However, in the clean energy future, the dominant form of supply will increasingly be electricity, whether through solar, wind, or nuclear power.

On the demand side, electricity will continue to grow in importance, especially for domestic, commercial, and industrial use, as well as in transportation, which is rapidly transitioning from fossil fuels to electric and hydrogen-based mobility. However, a nuanced view was presented: while electricity can power smaller vehicles and intra-city transport, hydrogen is better suited for long-distance, heavy-duty transport and industrial processes requiring high-temperature heat or chemical reduction (e.g., steel manufacturing).

The cost and technology behind hydrogen production were discussed in depth. The speaker emphasised that while the cost of electrolyzers is often cited, the dominant cost driver is the energy input for water splitting. Producing hydrogen through high-temperature electrolysis (e.g., steam electrolysis or SOEC) can dramatically lower energy requirements. In this context, solar thermal energy which is long available but commercially neglected can provide the necessary heat more efficiently than electricity.

Additionally, thermochemical processes such as copper-chlorine or sulfur-iodine cycles, already researched in Indian institutions like BARC, ICT, and IIT Delhi, offer a promising path for affordable hydrogen production without waiting for Western commercial models. The speaker urged that India must lead, not follow, in advancing these technologies.

While many advocate for a complete phaseout of fossil fuels, the speaker took a more pragmatic stance. He expressed serious doubts about India achieving net zero without incorporating fossil fuels combined with Carbon Capture, Utilization, and Storage (CCUS). Fossils, when paired with technologies that either sequester CO₂ or convert it into non-emissive solid forms (like carbon nanotubes), can still play a role in a clean energy system.

This, he argued, is an area where India should invest in disruptive innovation, not blindly follow Western trajectories. The fixation on imported solar PV technology was cited as a cautionary tale of how copying others has led to technological dependency.

The speaker reaffirmed his long-standing belief in the immense potential of bioenergy,

particularly compressed biogas (CBG). He argued that India could match its entire gasoline consumption through properly managed bioenergy systems, although the sector currently struggles with commercial viability and subsidy dependence. In the context of clean cooking, where hydrogen remains impractical, biogas emerges as the only feasible clean gaseous fuel. It also has significant potential in agriculture and rural energy access, offering a sustainable, domestically sourced solution for multiple challenges.

The speaker strongly advocated for advancing thorium-based molten salt reactors (MSRs) as a long-term, indigenous, and sustainable solution. Unlike uranium, thorium is abundantly available in India, and MSRs offer several advantages — including safety, fuel efficiency, and non-proliferation.

This approach is consistent with India's Three-Stage Nuclear Program, and noted that while other countries, notably China, have already developed MSR prototypes, India must accelerate its own progress. MSRs could represent a leap forward in clean energy, enabling small modular reactor (SMR) designs that are both efficient and safe for decentralised deployment.

However, the speaker cautioned that entrenched mindsets remain a barrier. SMRs are often promoted as a financial or land-use solution in the West, yet the speaker questioned their economic viability, especially without a significant manufacturing order book. He advocated instead for a focused push on next-generation SMRs powered by thorium, tailored to India's unique resource base and security needs.

Touching on geothermal energy, the speaker acknowledged its appeal as a clean and stable source. Although there are claims of up to 150 GW of potential, he expressed skepticism, suggesting that realistic potential may be closer to 10–20 GW. Ladakh was identified as a promising region, with ONGC already involved in a plant under construction. Despite its localised potential, geothermal energy was not included in the clean energy projections due to its limited national-scale impact. However, it remains an area of strategic interest for regional development and energy diversification.

The speaker addressed the underperformance of India's nuclear sector, attributing the delays to a combination of historical and systemic challenges. Initially, the development of nuclear technology took

place under strict international embargoes, limiting access to advanced technologies and global collaboration. This was compounded by persistent constraints in uranium supply, which restricted the sector's ability to expand and operate at full capacity. Additionally, institutional protectionism, while once necessary to safeguard national interests and ensure strategic autonomy may now be impeding the sector's ability to scale efficiently and integrate with broader energy transition goals.

Dr Kakodkar argued for restructuring the civil nuclear sector by allowing greater participation of non-governmental players and creating a clear distinction between civil and military programs to enable faster growth. India's nuclear program must now move from strategic isolation to commercial viability and global leadership, particularly with thorium-based technologies.

Questions and Discussions

Question 1.

Grid stability is critical to energy transition, especially when integrating renewables. Beyond importing technology, how do we ensure that India develops its own capabilities to operate and apply these systems effectively? Also, how can our academic institutions be better aligned with industry requirements to support this transition?

Answer:

The concern around grid stability and technical capability is valid and important. The government has taken steps to strengthen battery storage integration into renewable energy tenders, specifically through regular Firm and Dispatchable Renewable Energy (FDRE) bids that include components of battery storage. Thus, the ecosystem for getting more battery storage is there and is increasing.

In terms of manufacturing, the Ministry of Heavy Industries has launched a Production Linked Incentive (PLI) bid, specifically targeting stationary battery storage for grid use, aiming to boost local manufacturing.

On the skills development front, the Ministry of New and Renewable Energy (MNRE) could coordinate with the Ministry of Skill Development to ensure emerging skill requirements, such as those needed to manage and stabilise the grid using new technologies are incorporated into training curricula. Moreover, this is not limited to new students; existing professionals in the electricity sector will be upskilled to handle next-generation energy systems. Collaboration with ITIs and technical institutions will be key to achieving this.

Question 2.

Are there similar challenges or cooperative ventures in the neighbouring countries supported by India?

Answer:

At present, India does not have formal programs directly supporting development in neighbouring countries. However, the country maintains energy cooperation with nations such as Sri Lanka and Bhutan through Memorandums of Understanding (MoUs) and broader collaboration frameworks. While specific technical skill development or operational training has not yet been a major focus of these agreements, there is strong potential. India's energy

institutions such as the Central Electricity Authority, Ministry of Power, and various state utilities, possess significant expertise that could be shared with neighbouring countries upon request. The willingness to collaborate is there, and India is well-positioned to support capacity-building across the region and therefore formal frameworks need to be established.

Question 3.

Given the focus on battery storage, especially lithium-ion, what is India's approach to securing lithium resources and are there any efforts to explore alternative battery technologies?

Answer:

India is currently placing considerable emphasis on lithium-ion battery storage due to its commercial viability and compatibility with renewable energy systems. However, recognising the limitations and geopolitical dependencies associated with lithium, the government is actively exploring domestic lithium reserves across several regions. In parallel, substantial research and development are underway to find alternatives to lithium-based technologies. Institutions such as the Council of Scientific and Industrial Research (CSIR), IIT

Roorkee, and IIT Bombay are engaged in developing alternatives like sodium-ion batteries, which could offer a more sustainable and accessible option for large-scale energy storage. While the Ministry of Mines is responsible for critical mineral exploration, the Ministry of New and Renewable Energy is supporting R&D efforts through dedicated funding. The long-term vision is to reduce dependency on scarce critical minerals and promote battery technologies that are more aligned with India's resource availability

Session - I

Session Moderator

Mr. Sudeep Kanungo

(Senior Fellow, The Atlantic Council
GeoTech Center)

**Industry perspective on energy
transition: How prepared India is?**

Shri Ranjan Nair

(Business Head – Renewable Energy,
BPCL)

**Prospects and Challenges to
Maximizing the Role of Green
Energy Transition:
Importance of Critical Mineral
Supply Security**

Shri Sunit Roy

(Ex-Group General
Manager, ONGC)

**Green Hydrogen Generation and
Commercialization Aspects**

Prof. Suddhasatwa Basu

(Professor, IIT Delhi)



Dr. Sandeep Kanungo, Senior Fellow, The Atlantic Council Geo Tech Centre, moderated the first session. He began by extending a warm welcome to the audience and thanking the organisers. Acknowledging the distinguished panel and attendees, the moderator emphasised the significance of addressing one of India's most critical development challenges — its energy transition.

The moderator highlighted the session's core theme – India's rapidly growing energy demand and the urgent need to shift toward clean and renewable sources such as solar, wind, geothermal, biofuels, and hydropower. While India has made significant strides, ranks fourth globally in renewable energy capacity and aiming for 500 GW of

renewables by 2030, the path ahead is marked by complex challenges. These include technological limitations, financing gaps, and geopolitical considerations.

The session aimed to unpack these hurdles and opportunities, focusing particularly on the roles of critical materials, technological innovation, institutional collaboration, and strategic public-private partnerships in enabling and accelerating India's clean energy transition.



Shri Ranjan Nair, Business Head – Renewable Energy, BPCL, introduced his presentation with some context-setting, aimed at showcasing how the industry, particularly Bharat Petroleum Corporation Limited (BPCL), is engaging with and contributing to India's ongoing energy transition. Highlighting key data, he pointed out that while India's installed energy capacity is growing steadily, with a cumulative growth rate of 2.55 per cent and a rise in per capita consumption, there still remains significant scope for renewable energy adoption. He emphasised the country's progress toward its 2030 renewable energy targets, noting that India has already achieved around 234 GW out of

the 500 GW target, reflecting close to 50 per cent of the goal.

The speaker detailed the various government interventions that are aiding the sector, including improved module and cell manufacturing under ALMM and ALCM policies, expansion of solar irrigation pumps, and rapid registration of electric vehicles. He highlighted the increasing momentum in battery energy storage systems and electric mobility, citing the registration of over 4 million EVs. He touched upon the evolution of compressed biogas (CBG) and ethanol blending as transition strategies before a full-scale switch to hydrogen. With regard to green hydrogen, he referenced the National Green Hydrogen Mission and discussed India's plans to produce 5 million metric tons by 2030. He stressed the need to develop a hydrogen economy regardless of colour classification and mentioned alternative production methods, such as using biomass or biogenic routes. BPCL, for example, is already working toward producing 2,000 tons of green hydrogen by next year via such methods.

Addressing challenges in the energy transition, the speaker noted concerns such as energy security, high dependency on coal,

and India's current reliance on imported technologies — ranging from hydrogen compressors to EV components. Land availability, water use, and delays in power purchase agreements (PPAs) also pose bottlenecks. He pointed out the high cost of green hydrogen compared to grey hydrogen, underscoring the need for further cost reduction to enable scaling.

On a positive note, he identified India's strengths, such as high solar irradiance, a strong policy environment, increasing domestic manufacturing capabilities, and growing international interest — especially from European nations — for green hydrogen and ammonia imports. He also underlined the strategic leadership India is offering globally, including through the International Solar Alliance (ISA). On the corporate side, he commended Indian industry's growing commitment to net-zero goals, citing BPCL's own roadmap.

BPCL has laid out a robust net-zero plan extending to 2040, with investments exceeding ₹1 lakh crore over the next five years. The speaker described their ongoing initiatives, including installing indigenous electrolyzers and launching the country's first hydrogen refuelling station in Kochi. They have also set up a 5 MW Delta

electrolyzer at Bina, and signed various MOUs with industry partners for hydrogen mobility and indigenous fuel cell development. A hydrogen-powered bus is slated to operate at Kochi Airport, which visitors are welcome to inspect.

He also mentioned biomass and solar-wind hybrid projects, and underscored BPCL's commitment to the transition. Concluding, he reaffirmed the company's strategic and technological investments in hydrogen, renewables, and carbon capture as key levers to support India's broader green energy transformation.



Shri Sunit Roy, Ex-Group General Manager, ONGC, began by emphasising on the significance of such forums in enabling important discussions around energy transition and critical resource security. His presentation commenced with an overview of the historical evolution of energy, tracing humanity's progression from the use of natural elements like fire and wind to the modern use of coal, oil, gas, and renewable energy sources such as solar and bioenergy. The speaker noted that while coal and oil became commercially viable around the 19th and early 20th centuries, their long-term usage has significantly contributed to environmental degradation. This historical context underpinned the need for a rapid transition to renewable energy in light of climate challenges.

The speaker cited global data, including IEA statistics, noting that despite the rise in renewable capacity, a majority of global energy consumption remains dominated by fossil fuels — particularly coal (13.8%), oil (4.4%), and natural gas (32.8%). The speaker argued that renewable energy deployment cannot succeed without the secure and reliable supply of critical minerals, which are essential for manufacturing technologies such as solar panels, batteries, wind turbines, and hydrogen electrolyzers.

A key part of his discussion focused on critical mineral supply vulnerabilities, drawing attention to the 2010 geopolitical incident between Japan and China. When Japan detained a Chinese fishing vessel captain, China responded by halting its export of rare earth elements (REEs) to Japan. This disruption forced Japan to pursue domestic R&D and global sourcing strategies to reduce dependency, despite not having its own rare earth reserves. Today, Japan imports low-grade ore, refines it domestically into high-quality materials, and re-exports globally. The speaker emphasised this model as a benchmark for India to consider.

The speaker presented an overview of rare

earth elements (REEs) and their classification into light (LREEs) and heavy (HREEs) categories. LREEs are commonly used in electronics and telecommunications, while HREEs are vital for clean energy technologies. Despite being the fifth-largest holder of rare earth reserves globally, India's contribution to REE production is negligible, and the country remains highly import-dependent for minerals like lithium, germanium, tellurium, and more. This, the speaker emphasised, poses a significant risk to the energy transition roadmap.

Further, the speaker highlighted how geological conditions in India, particularly in the Himalayan and Northeast regions suggest high potential for critical mineral discovery. Specific mention was made of Arunachal Pradesh and areas formerly part of Myanmar. However, foreign influence, particularly China's growing presence in Myanmar has weakened India's access to these mineral-rich areas.

Referring to recent findings by the Geological Survey of India (GSI), the speaker noted that several exploration blocks are now at G3 stages and available for investment. Yet, there has been no significant industry response. The speaker also pointed out that India's petroleum

sedimentary basins, especially abandoned wells and exploratory fields, could offer another avenue for identifying rare earth elements and geothermal potential. Techniques such as gamma-ray spectrometry and mud logging, typically used in oil exploration, can also assist in detecting critical minerals.

In particular, the speaker focused on geothermal brines and waste fluids produced during oil and gas drilling. These fluids may contain trace elements such as lithium, which can be extracted sustainably. Existing facilities like ICP-MS laboratories at NGRI can support such trace analysis, capable of detecting elements down to parts per billion (ppb), making even low-concentration sources economically viable.

Drawing parallels with countries like Chile and the U.S., the speaker noted that lithium extraction from geothermal water is already underway globally, and India could replicate this model with existing oil infrastructure. Additionally, this process aligns with India's climate commitments, as it can be powered by renewable geothermal energy instead of fossil fuels.

The speaker concluded by emphasising the urgent need for industry-academia

collaboration. India's R&D investment stands at just 0.64 per cent of GDP, compared to Japan's 3.41 per cent. Without increased funding and cross-sector partnerships, India may struggle to emerge as a leader in green energy technologies. The speaker strongly recommended that oil companies, private industry, and academic institutions collaborate to explore new mineral resources and support the long-term sustainability of India's energy transition.



Professor Siddhasatwa Basu, IIT Delhi, a leading expert in electrochemical systems and hydrogen energy, opened his address by highlighting the evolving journey of hydrogen research, marked by repeated cycles of global interest and setbacks. He emphasised that the current momentum driven by climate imperatives and strong policy backing makes this moment particularly significant for the advancement of green hydrogen, especially in industrial sectors such as refining, steel production, ammonia, and methanol synthesis. While green hydrogen has limited immediate commercial feasibility in electricity and transport sectors, it is rapidly gaining traction in hard-to-abate industries.

Professor Basu stressed that India must not rely solely on government interventions for progress in this area. He called upon Indian industries, particularly oil companies, to take proactive roles in R&D and infrastructure investments. He referenced ongoing policy efforts such as the National Green Hydrogen Mission (NGHM) and initiatives for hydrogen hubs as promising enablers. He also noted the potential of reforms like market-based economic dispatch (MBED) and the idea of a decentralised, button-click electricity market, akin to mobile telecom service switching, to support renewable hydrogen growth.

The technical section of his talk delved into the three key electrolyzer technologies—Alkaline Electrolyzers, Proton Exchange Membrane (PEM) Electrolyzers, and Solid Oxide Electrolyzers (SOECs). He explained that his team is primarily working on alkaline and solid oxide systems, which currently offer a more viable cost-performance balance for India. He described the electrode materials involved—nickel-based catalysts for alkaline systems, platinum group metals like iridium and ruthenium for PEM systems, and complex oxide materials like lanthanum

strontium ferrites and zirconia for SOECs. Professor Basu emphasised the urgent need for indigenous development of critical materials such as membranes and porous transport layers (PTLs), which are currently imported and contribute significantly to system cost.

Another key message was the breakdown of costs in green hydrogen production. Professor Basu noted that approximately 35 per cent of capital expenditure lies in the electrolyzer stack itself, while an additional 30 per cent resides in balance-of-plant (BoP) components like rectifiers, transformers, compressors, and gas conditioning units. He stressed that India has strong manufacturing capabilities for BoP components, which can be leveraged to localise production and reduce costs. However, materials like gold-plated or platinum-coated titanium meshes used in PTLs remain a significant barrier due to their cost and corrosion sensitivity — areas where alternatives such as tantalum coatings are being explored.

He outlined several technological goals for reducing the cost of hydrogen production, aiming to bring it down from the current ₹250–₹400/kg to a target of ₹80–₹100/kg. Achieving this requires advancements in catalyst efficiency, membrane durability, and

system integration. For alkaline systems, increasing current density, reducing diaphragm thickness, and improving integration between electrodes and PTLs are critical. In PEM systems, reducing reliance on expensive PGMs and developing indigenous, efficient membranes are key.

Professor Basu also discussed the challenges of hydrogen storage and transport. While compressed storage is costly, he highlighted green ammonia as a more efficient and scalable carrier. He stressed that system-level integration such as siting hydrogen production near industrial consumers that can drastically reduce costs and increase adoption.

In conclusion, Professor Basu argued for a distinctly Indian model of innovation, one that optimises for local economic realities, manufacturing strengths, and operational flexibility. Drawing an analogy, he compared car ownership in India and the West, while Western consumers prefer expensive cars that require no maintenance for years, Indian consumers would rather buy a less expensive car and pay for occasional servicing. He emphasised that for India, a cost-effective and durable green hydrogen ecosystem can be built by focusing on affordability, modularity, and

local engineering solutions, even if the technologies do not perfectly match global benchmarks. He closed by highlighting his own lab's ongoing collaborations with government and industry, expressing hope that these efforts would contribute meaningfully to India's energy transition.

Questions and Discussions

Question 1:

How could India further enhance domestic production of critical minerals, especially in light of global competition and dependence on imports, referring to the recent launch of India's Critical Minerals Mission and related policy developments?

Answer:

In response, Mr. Roy highlighted three main strategies to boost India's critical mineral production. First, he proposed leveraging the existing infrastructure of over 30,000 oil wells across India, many now abandoned but still equipped with casing and pipelines. These wells could be used to extract high-salinity water for lithium extraction, minimising the need for new drilling and infrastructure. Second, he suggested directing oil companies to perform surface logging in unexplored areas rich in shale formations, using techniques like spectral gamma-ray and ICP analyses to detect uranium, thorium, and other rare elements, particularly in the "middle shale section" that is typically overlooked. Finally, he stressed that China's dominance in critical

minerals stems from decades of early investment and dedicated research institutions, urging India not to repeat past mistakes of relying heavily on imports or foreign mines. Instead, he encouraged tapping into India's own mineral-rich regions, such as the Indian Shield, to build a self-reliant supply chain.

Question 2:

How much freedom PhD and postdoctoral students have to pursue innovative, indigenous research instead of following conventional technological paths, and raise concerns that fear of failure and funding risks might discourage bold, creative research?

Answer:

Professor Basu responded by emphasising the critical importance of fostering creativity and freedom among young researchers. He noted that many Nobel Prize-winning breakthroughs have come from researchers in their 30s and 40s who dared to think unconventionally. He strongly supported allowing students to explore unorthodox ideas, even if most fail, because even one success can lead to major advancements. While acknowledging the need for responsible use of funding in a developing

country, he stressed that failure is an inherent and necessary part of research and development. Drawing from his own 30-plus years of experience, he assured that despite some failures, most funded projects yield results. He concluded by reaffirming that students in his lab and across India's R&D ecosystem are encouraged to experiment and innovate without fear, as long as they remain committed and accountable.

Session - II

Opening remarks & context setting
by Session Moderator

Dr. Uttam Kumar Sinha
(Senior Fellow, MP, IDSA)

Hydro Resources in India, Green
Transition and the Neighbouring
Countries

Prof. Mahendra Lama,
(Professor, JNU)

India and COP: Carbon Emission/ Net
Zero Commitment

Dr. Aman Malik
(Programme Lead, Council on Energy,
Environment and Water)

Technology and Transition: Can India
Overcome its Coal Dependent Energy
Production

Dr. Bhupendra Kumar Singh
(Chief-Energy Security, CII)



Dr. Uttam Kumar Sinha, Senior Fellow, MP-IDSA, moderated the second session of the roundtable. He commenced the session by setting the tone for the session, emphasising that India's energy transition is akin to an investment in the future, particularly through green energy initiatives. However, he cautioned that the transition is not without its significant challenges, referring to what he calls "two sides of the same coin." These include bridge stability, financing, policy inertia, and local resistance, all of which complicate the socio-economic landscape of energy transformation. He stressed that these elements must be integrated into any conversation about green energy planning and policy.

He outlined three interlocking challenges that would serve as the framework for the session. First, India's energy demand is projected to double by 2040, necessitating a rapid and sustainable scaling-up of green energy infrastructure without compromising reliability. Second, India remains heavily reliant on coal, which generates about 70 per cent of its electricity. Transitioning from coal or more accurately, phasing it down rather than phasing it out, will demand a nuanced understanding of the socio-economic implications for coal-dependent regions, especially in eastern India. Third, India has made bold international commitments, including generating 500 GW of non-fossil fuel electricity by 2030 and achieving net zero carbon emissions by 2070. These targets, originally articulated from the Copenhagen COP in 2009 to the Paris Agreement in 2015, represent ambitious benchmarks that frame the nation's energy future.



Professor Mahendra Lama, JNU, started by emphasising the importance of cross-border interdependence in ensuring sustainable energy transitions across South Asia. Drawing on years of institutional research and field experience, particularly at the Jawaharlal Nehru University (JNU), he highlighted how India's geographical centrality positions it as a natural energy hub in the region, surrounded by enabling and partner countries such as Bhutan, Nepal, Bangladesh, and Myanmar.

Professor Lama underscored the evolution of borders from static lines of national security to dynamic zones of opportunity. He discussed emerging “border junctions”

across India's northern, eastern, western, and southern frontiers that are increasingly facilitating energy exchanges. According to him, India has matured into not only a major energy producer and exporter, but also a key transit provider — a role that enhances its strategic and diplomatic clout. Concrete examples include robust grid integration and bilateral projects with Bhutan and Nepal, significant transmission and supply partnerships with Bangladesh, and regional interconnections involving Myanmar and Southeast Asian countries.

The Professor outlined five evolving models of energy cooperation: bilateral (e.g., India–Bhutan, India–Nepal), sub-regional (e.g., Mekong-type cooperation), local (e.g., Tripura–Comilla interconnection), regional integration with transit provisions, and multilateral frameworks involving power pools. These frameworks are supported by policy shifts, such as India's recent guidelines enabling cross-border power trading, and reflect a growing political and institutional maturity that has moved beyond past tendencies of resource nationalism. He observed that earlier hesitations, especially around sovereignty concerns have gradually been replaced by cooperative energy diplomacy, economic pragmatism, and

non-traditional security priorities.

Professor Lama also pointed out the growing role of civil society, academic institutions, and Track-II diplomacy in facilitating these integrations. His team's involvement in drafting the North East Vision Document 2047 further supports plans to develop a Northeast India–Southeast Asia energy corridor, linking hydroelectric power generation in Arunachal Pradesh and Meghalaya with neighbouring countries through trilateral transport and energy routes.

He concluded by stressing that, given the inescapable geography and shared regional challenges, cooperation in energy and especially in clean, low-carbon initiatives is not optional but imperative. The dictum “you cannot change your geography or pick your neighbours” perfectly encapsulated his call for deepened energy inter-dependence in South Asia.



Dr. Aman Malik, Programme Lead, CEEW, focused on the crucial yet under-discussed topic of when and how India should peak its greenhouse gas emissions as a milestone on the path to achieving net-zero by 2070. He argued that while net-zero is the long-term target, the more immediate and critical task is to determine the emissions peak year, as delaying the peak would necessitate far steeper and more disruptive reductions later. Drawing on the Kaya Identity, the speaker explained that India's emissions have been primarily driven by GDP growth, while carbon intensity has remained unchanged due to continued coal dependence, and energy intensity has only marginally

improved, partly thanks to energy efficiency schemes and a declining share of manufacturing in the economy.

The presentation made a comparative analysis with China, which is expected to peak its emissions by 2025 — earlier than its official 2030 target — due to a rapid decoupling of emissions from GDP. China's success, the speaker noted, has come from decarbonising its energy mix and aggressively electrifying industrial and end-use sectors, leading to both lower carbon and energy intensity. For India, the speaker proposed a two-pronged strategy: decarbonisation (cleaner power generation) and electrification (especially of industrial and residential sectors). He stressed that industrial electrification in India is constrained by high power tariffs, which could be addressed through reforms like removing cross-subsidies or introducing schemes akin to the FAME incentive model.

In the residential sector, the key challenge is clean cooking. While most urban buildings already use electricity for cooling, cooking still relies heavily on biomass or LPG. The speaker emphasised the need to promote electric cooking as a cleaner and more energy-efficient alternative, rather than replacing biomass with fossil LPG. He

concluded by asserting that while India shares some structural similarities with China, it must chart a context-specific, economically sound path to peak emissions, that prioritises early planning, smarter electrification, and energy efficiency across sectors to enable a smoother, less disruptive transition to net zero.



Dr. Bhupendra Kumar Singh, Chief-Energy Security, CII, spoke on technology and transition. He offered a sobering and pragmatic take on India's energy future, arguing that coal will remain a dominant part of India's primary energy mix despite the ongoing transition discourse. He framed the conversation through the lens of energy security, emphasising that India's economic growth trajectory, especially its ambitions to become the third-largest global economy by 2030 requires substantial and reliable energy inputs, the majority of which are still supplied by coal. Drawing from multiple national and international datasets, he highlighted the correlation between GDP growth and primary energy consumption,

noting that while renewable energy is growing, it lacks the scale, reliability, and consistency to fully meet India's rising demand. As of 2023–24, coal still accounts for nearly 60 per cent of India's energy supply, and its consumption is increasing alongside economic growth.

While acknowledging the rise of green technologies and the enthusiasm for hydrogen, solar, and wind, he stressed that these sources are not yet ready to fully replace coal for baseload power. He also outlined systemic and structural challenges, such as the large existing coal infrastructure, employment in the coal sector, and financial bottlenecks in renewable project execution — especially due to payment delays from DISCOMs and investment constraints.

The speaker concluded with a multi-pronged recommendation approach: promoting community integration, ensuring financial mechanisms like credit lines and joint ventures, procuring affordable clean technologies, improving data forecasting and clean coal technologies, and increasing investment in R&D and energy storage solutions. He emphasised that a just and strategic transition must balance the goals of sustainability with India's developmental and energy security imperatives.

Questions and Discussions

Question 1- How can economic integration help promote regional stability and reduce geopolitical tensions?

Answer:

By highlighting real-world examples—such as India’s electricity cooperation with Bangladesh and the interlinked power grids between Canada and the United States—the speaker argued that when countries are economically intertwined, particularly through energy trade, they become less likely to engage in political or military confrontation. The development of gas infrastructure in India’s northeastern state of Tripura was cited as a domestic example, where cross-border logistical support from Bangladesh enabled the transport of heavy turbines, turning Tripura into a power-surplus state. This case demonstrated how regional infrastructure and economic collaboration not only improve energy security but also build resilience against potential conflict.

Question 2- What is the role of the private sector in subregional cross-border energy projects, and is the Indian government prepared to support it?

Answer:

Although political ties may fluctuate, the South Asian region has seen increasing institutional and economic interdependence. India’s new guidelines for cross-border electricity trading now allow private firms to invest in neighbouring countries and transmit energy through India, opening new avenues for business. With greater political stability and improved transmission infrastructure, the speakers of this session agreed that private sector involvement in cross-border energy is not only feasible but necessary.

Question 3- How is India progressing toward its 2070 Net Zero target, and what challenges remain?

Answer:

In response, the speakers noted that India is on track, citing projections of adding 45 GW of renewable energy annually, and more than 180 GW of projects already tendered. According to recent research, India is likely to surpass its 2030 emissions intensity target, potentially reaching a 52 per cent reduction. However, another speaker pointed out a crucial gap: while renewable energy is meeting most of India’s new electricity demand, it is not yet displacing coal in the

energy mix. The real milestone, they argued, will be when renewables begin to replace rather than just supplement fossil fuel-based generation.

Question 4- How can India ensure grid stability while scaling up intermittent renewables like solar and wind?

Answer:

Grid stability was a recurring concern during the roundtable. Some speakers stressed that while solar and wind energy are expanding rapidly, they are inherently intermittent, making India's reliance on firm baseload power — such as nuclear, hydropower, or clean coal with carbon capture — still critical for stability. However, this view was challenged by others who emphasised the growing potential of demand-side flexibility. They argued that with the rollout of smart meters, time-of-day pricing, and industrial responsiveness to electricity costs, demand patterns can become more dynamic and better aligned with renewable supply. This approach could reduce the need for constant baseload generation, shifting focus toward smarter grid management and investment in storage solutions.

Question 5-What is the future outlook for India's energy transition and regional

cooperation?

Answer:

The session concluded with broad agreement on several fronts. India is making solid progress on the supply side, with rapid growth in renewable energy deployment. However, the next phase of the energy transition will require deeper reforms — especially in grid modernisation, demand-side flexibility, and storage technologies. Clean coal with carbon capture, nuclear, and pumped hydro will likely play transitional roles.

On the regional front, the speakers agreed that cross-border energy trade is a strategic tool for fostering peace and prosperity. Going forward, enhanced interdependence and a stronger role for private investment will be crucial for building a resilient and cooperative South Asian energy future.







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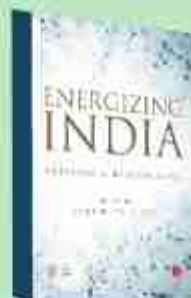


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