Volume 14 • Issue 4 • May 2025

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नवीकरणीय ऊर्जा मंत्रालय
MINISTRY OF
NEW AND
RENEWABLE ENERGY

Renewable Energy
Akshay Urja

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A bi-monthly newsletter of the Ministry of New and Renewable Energy, Government of India (Published in English and Hindi)

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Secretary's **Message...**

Over the past decade, India has achieved impressive strides in renewable energy, establishing new standards on the global stage. Despite facing numerous challenges, the country reached a total installed renewable energy capacity of 228.27 GW as of March 31, 2025 — a notable rise from the previous fiscal year. This total comprises 105.65 GW of solar energy, 47.73 GW from large hydro, 50.03 GW of wind power, 11.58 GW of bio-energy, 5.10 GW from small hydro sources, and 8.18 GW of nuclear power.

The roadmap to 2030 focuses on a diversified energy mix, encompassing solar, wind, biomass, and hydroelectric power. The National Solar Mission has already propelled India to the forefront of solar energy production, with solar power tariffs reaching record lows. For instance, the national scheme called the PM Surya Ghar Yojana is expected to take solar energy initiatives to the unreached thus far and also help many households to earn some income and livelihood out of it. Similarly, our wind energy capacity, supported by favourable policies and incentives, is poised for significant growth. The emphasis on grid modernization and energy storage solutions further ensures the reliability and efficiency of renewable energy systems.

Looking beyond 2030, India has set a visionary target to achieve net-zero carbon emissions by 2070. This long-term commitment underscores our responsibility towards global climate stewardship and reflects our strategic approach to sustainable development. To realize this vision, our Ministry is positively inclined to invest in cutting-edge technologies, foster innovation, and build robust partnerships with both national and international stakeholders.

It is to drive the various initiatives of the Ministry forward that we constantly develop policy frameworks that (a) encourage private sector participation, (b) enhance investment in R&D, and (c) facilitate the integration of renewable energy into the national grid. There is also emphasis on community-centric approaches that focus on decentralized energy (DRE) solutions to empower local populations and create green jobs. Such efforts are to ensure that the benefits of renewable energy are widespread and inclusive.

Needless to say, India's renewable energy prospects are bright and promising. By harnessing our abundant natural resources and leveraging technological advancements, we can achieve our sustainability goals and contribute significantly to global efforts in combating climate change. I am certain that the MNRE will continue to spearhead initiatives that pave the way for a greener and more prosperous future for India and the world.

Thank you for your continued support, and I look forward to working together to realize our vision for a sustainable India and for a sustainable world.

With best wishes

Santosh Kumar Sarangi

From the
Editor's Desk...

Dear readers,

As the world increasingly prioritizes sustainability, the demand for innovative solutions has become more pressing than ever. Our nation is at a pivotal moment, where renewable energy holds the potential to drive significant change in addressing climate change, securing energy resources, and fostering sustainable development.

Staying true to its tradition, this issue brings you stories that highlight the latest developments in the country's renewable energy landscape. The message from the Secretary, MNRE instills strong confidence among stakeholders about India's commitment to achieving 500 GW from non-fossil energy sources by 2030.

The article on the Indo-German wind energy initiative identifies key challenges in India's wind sector and highlights the initiative's role in driving policy reform, regulatory simplification, and technical capacity-building across renewables. Another piece discusses the NTPC Green Hydrogen Mobility Project in Leh, summarizing its role in the energy transition, its key features, and environmental impact. A separate article focuses on biogas, emphasizing its dual role as a renewable energy source and a driver of circular economy principles. Hydrogen-powered microgrids are explored as a sustainable energy option, illustrated through a case study at NTPC's NETRA campus. Additionally, another article outlines a major step in clean transport, detailing India's rollout of hydrogen-powered buses and trucks under the National Green Hydrogen Mission, reflecting the country's deepening commitment to climate action and renewable energy.

Hope you find this issue of immense value. I do look forward to your valuable suggestions and encourage our readers to share publication materials on the renewable energy sector for *Akshay Urja*.

Best wishes

Arun K Tripathi

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RE FEATURES

RENEWABLE ENERGY NEWS

Akshay Urja welcomes Shri Santosh Kumar Sarangi, Secretary, Ministry of New and Renewable Energy, Government of India, and Chairman and Managing Director of Solar Energy Corporation of India. Shri Sarangi served as the Director General in the Directorate General of Foreign Trade under the Ministry of Commerce and Industry. His administrative experience includes positions such as District Magistrate in three districts of Odisha and leadership roles in departments related to education, tourism, mining, tribal affairs, and science and technology.

NISE's New PV Lab to Set Global Benchmarks in Solar Testing Capabilities: Union Minister Shri Pralhad Joshi

Marking a major advancement in India's renewable energy capabilities, Union Minister for New and Renewable Energy Shri Pralhad Joshi, inaugurated the PV Module Testing and Calibration Lab at the National Institute of Solar Energy (NISE), Gwal Pahari, Bandhwari, Haryana. Speaking at the occasion, the Minister stated that the new lab will set global benchmarks in solar R&D, testing, training, and policy support while marking a bold step towards self-reliance, innovation, and global excellence.

Shri Joshi also said that NISE is now equipped to offer comprehensive testing, calibration, and certification services, particularly for photovoltaic modules and technologies where no established standards currently exist. He termed the lab a pioneering facility

for India and further highlighted that as Indian companies scale up the production of large modules. This lab will ensure that products meet the highest quality standards. Shri Joshi noted that the lab also aligns with BIS standards and will provide a major boost to the Production Linked Incentive (PLI) scheme and support India's aspiration to become a global manufacturing hub.

The Minister also underlined the importance of NISE as a training ground for government officials, industry professionals, and international delegates. He appreciated NISE's efforts in training over 55,000 Suryamitra technicians and for installing more than 300 solar air dryer-cum-space heating systems in Leh, which are being used by farmers to dry apricots. He said such initiatives strengthen technical capacity and foster collaboration among government, industry, and academia. Shri Joshi also stated that with the new facility, NISE will significantly improve its efficiency, quality, and research in accordance with global benchmarks.

Source: https://pib.gov.in/PressReleasePage.aspx?PRID=2123490

Union Minister Pralhad Joshi Visits World's First Integrated Renewable Energy Storage Project in Andhra Pradesh

Union Minister of New and Renewable Energy & Consumer Affairs, Food & Public Distribution, Shri Pralhad Joshi, visited pioneering, world-first and largest GW-scale Integrated Renewable Energy Project at Pinnapuram near Kurnool in Andhra Pradesh and applauded its scale and rapid progress.

A 4.2 billion USD Project includes 4000 MW of solar, 1000 MW of wind and 1680 MW of pumped hydropower generation, is set up by Greenko, a world's leading energy transition and decarbonization solutions company. With a storage capacity of 10,080 MWh per day in a single cycle, the dispatchable, carbon-free energy generation, the Pinnapuram project supports green steel, green aluminium, and green hydrogen production industries.

Speaking on the occasion, Minister Shri Pralhad Joshi said, "Witnessing an Integrated Renewable Energy Storage Project at Pinnapuram in action — the world's first and largest of its kind, right here in our country — is a matter of pride and a shining example of India's green energy potential under the visionary leadership of Prime Minister Narendra Modi". The Minister also commended the State Government of Andhra Pradesh, under Chief Minister Shri N Chandrababu Naidu, for its progressive policies that have made this pioneering effort possible.

Source: https://pib.gov.in/PressReleasePage.aspx?PRID=2122826

IREDA Reports Highest Ever PAT of ₹1,699 Crore for FY 2024–25, First Company in the NBFC and Banking Sector to Announce Audited Results

Indian Renewable Energy Development Agency Ltd. (IREDA) has announced its Audited Standalone and Consolidated financial results for the Quarter and Year ended March 31, 2025, showcasing significant growth across key financial metrics. The company reported its highest ever Annual Profit After Tax of ₹1699 crore. As the nation's largest pure-play Green Financing NBFC, IREDA has once again set industry standards by publishing its Audited Financial Results within just 15 days. This milestone positions IREDA as the first company in the NBFC and Banking Sector, and the first PSU, to publish Audited Financial Results in just 15 days.

The Board of Directors of IREDA, during a meeting acknowledged the company's outstanding performance and approved the Audited Standalone and Consolidated financial results for the Quarter and Year ended March 31, 2025.

Source: https://pib.gov.in/PressReleasePage.aspx?PRID=2121943

Union Minister Pralhad Joshi and Chief Minister Yogi Adityanath Review PM-KUSUM and PM Surya Ghar Schemes

Union Minister for Consumer Affairs, Food and Public Distribution, and New and Renewable Energy, Shri Pralhad Joshi held a review meeting in Lucknow on April 10, 2025 with Uttar Pradesh Chief Minister Yogi Adityanath to assess the progress of wheat procurement, PM-KUSUM, and PM Surya Ghar schemes. The meeting was also attended by Uttar Pradesh Energy Minister Shri A K Sharma and Secretary, Ministry of New and Renewable Energy, Government of India, Smt. Nidhi Khare. During the meeting, Uttar Pradesh reaffirmed its commitment to achieving the ambitious target of 22 GW solar energy capacity of the state.

Source: https://pib.gov.in/PressReleasePage.aspx?PRID=2120759

MNRE NOTIFIES

GUIDELINES

FOR PROTOTYPE WIND TURBINE TESTING

On April 15, 2025, The Ministry of New and Renewable Energy (MNRE), Government of India, issued revised guidelines for installation of prototype wind turbine models. The revised guidelines allow prototype wind turbines a maximum of three years to complete type testing and obtain certification from internationally accredited agencies. The guidelines form part of an updated framework for prototype wind turbine installations, to be implemented by the National Institute of Wind Energy (NIWE), Chennai.

As per the draft, prototype models will be installed solely for the purpose of type testing. A recommendation letter from the NIWE will be issued to initiate testing, and a maximum period of three years will be allowed to obtain the type certificate. The prototype certificate will remain valid during this period. In case of revisions to an existing prototype, a new recommendation letter must be obtained, and testing must be completed within the validity of the updated certificate. The prototype certificate itself will have a maximum validity of three years, with possible extensions. The draft also mandates regular operation and maintenance (O&M) of prototype turbines. Certification agencies must issue annual reports confirming O&M compliance, failing which disconnection from the grid may occur. All prototype wind turbines must be commissioned within 18 months of receiving the NIWE recommendation letter.

For detailed guidelines: https://mnre.gov.in/en/document-category/wind-schemes-guidelines/

We invite readers of *Akshay Urja* to share your stories about technology and innovations, as well as your perspectives on future advancements in the renewable energy sector. Submissions can be 400, 800, or 1600 words in length, and should include high-resolution photos that enhance your narrative. Please send your contributions to:

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India's Wind Energy Landscape: Growth, Policy and Challenges

A Discussion on an Indo–German Initiative for Realizing Enhancement of Wind Energy Potential

Enhancing the contribution of wind energy to achieve the target of 500 GW by 2030 is critical. In this article, **Kumer Singh, Bhavana Jangid,** and **Kuldeep Sharma** look at the main challenges that hinder the growth of the wind energy sector. Moving into a solution mode, a broad platform—an Indo-German initiative—has been created to support policy reforms, streamline regulations, and enhance technical expertise to address the challenges across various renewable energy technologies. Keep reading to know more...

India has surpassed 200 GW of installed renewable energy (RE) capacity and is targeting 500 GW by 2030. Wind energy, contributing 23% of the total, is a key pillar of this transition, making India the world's fourth-largest wind market.

India's wind journey began in the 1980s with its first grid-connected 40 kW turbine in Gujarat, backed by the Ministry of New and Renewable Energy (MNRE), formerly known as the Department of Non-conventional Energy Resources (DNES). The 1990s saw the introduction of tax-based incentives like accelerated depreciation (AD), which helped push wind capacity to 1 GW by 2000. Growth accelerated in the 2000s, with private investments and supportive policies driving capacity to 13 GW by 2010. Industry-driven demand and state-level incentives further shaped this growth, particularly in states like Tamil Nadu, where the textile industry leveraged favourable policies and financing mechanisms to invest in wind power as a reliable energy source.

The wind sector underwent a major shift after 2017 with the introduction of competitive bidding, which lowered tariffs but also brought challenges such as land acquisition delays, inter-state transmission system (ISTS) connectivity issues, and grid integration constraints. Most projects remain concentrated in high-wind regions, where network unpreparedness hampers execution.

Meanwhile, solar energy has experienced exponential growth, driven by aggressive bidding that reduced tariffs from ₹10.95 per unit in 2010/11 to ₹2.60 per unit in 2023/24. However, its expansion is increasingly constrained by the high cost of energy storage and the need for supportive banking regulations. This is where wind energy plays a critical role. Wind energy complements solar by balancing intermittency, especially during non-daylight hours and monsoons, enabling round-the-clock (RTC) renewable power. Its integration into hybrid systems enhances grid stability, lowers costs, and supports India's low-carbon transition.

Policy Developments

To revitalize the wind energy sector, the government has introduced key measures, including the renewable purchase obligation (RPO) trajectory notified by the MNRE in July 2022. This mandates a dedicated wind RPO, rising from 2.46% in 2024/25 to 6.94% by 2029/30, ensuring sustained demand for wind power. As per the MNRE, only projects commissioned after 31 March 2022, qualify for wind RPO compliance, which, along with ISTS waivers, aims to attract fresh investments. However, this may lead to underutilization of existing capacity and uncertainty for older projects. While ISTS waivers enhance interstate wind power procurement, their long-term availability remains crucial for investor confidence. Additionally, e-reverse auctions (e-RA) drove developers to bid unsustainably low tariffs, making projects financially unviable and causing delays in the execution.

Recognizing these challenges, the MNRE has undertaken multiple reforms to improve the viability of wind projects. One key change is the transition from e-RA to a single-stage, two-envelope bidding mechanism to address issues related to aggressive bidding and project delays. Additionally, to balance wind energy costs across the eight high-potential states, the MNRE introduced a composite bid structure for ISTS-connected wind projects. This includes state-specific sub-bids, ensuring more equitable capacity distribution. The electricity generated will be pooled, and a uniform pooled tariff—determined by averaging costs across states—will be offered to buyers, making wind power procurement more competitive. While these interventions aim to revitalize onshore wind, the sector still faces growing constraints, whereas offshore wind presents untapped potential but remains hindered by high costs and infrastructure challenges.

Growth and Challenges by Segment

On-shore wind

India's onshore wind energy potential is 300 GW at a hub height of 100 metres, with the installed capacity at 48.3 GW as of January 2025. To scale up, the MNRE has set a target of issuing 8 GW of wind energy bids annually from 2023 to 2030. However, delays in land acquisition remain a significant challenge, as the land approval process varies across states. Simplifying land acquisition through measures like Andhra Pradesh's Integrated Clean Energy Policy 4.0 (2024–29)—which waives land conversion fees and removes the non-agricultural (NA) status requirement—is a step forward. Despite this, issues like outdated revenue records, unclear property rights, and multi-agency approvals persist, highlighting the need for a single-window clearance system.

Another challenge is the reluctance of utilities to sign power sale agreements (PSAs). The Solar Energy Corporation of India (SECI) reports that over 9 GW of renewable power, mostly from private developers, remains stranded due to multiple factors, including uncertainty over transmission charges set to take effect in June 2025. Other contributing issues include the financial instability of distribution companies (DISCOMs), lack of alignment with demand profiles, concerns over long-term commitments, and a wait-and-watch approach as DISCOMs anticipate further declines in RE prices. Addressing these challenges requires long-term policy clarity on transmission costs, open access charges, and penalties, alongside measures to strengthen DISCOM finances and improve demand–supply integration.

India's wind energy supply chain remains underdeveloped despite a strong turbine manufacturing base. The sector relies heavily on imports for key sub-components—China supplies nearly 50% of castings for wind installations and 90% for gearbox manufacturing, as reported by the Global Wind Energy Council (GWEC). High-end rare-earth magnets for turbines above 3 MW, as well as power electronics and advanced bearings, are also largely imported, exposing the industry to price fluctuations and geopolitical risks (DOE). To reduce dependence, a production-linked incentive (PLI) scheme is crucial for

boosting local manufacturing, lowering costs, and strengthening supply chain resilience. Collaboration with global suppliers for technology transfer and skill development can further enhance India's position as a wind energy manufacturing hub.

Off-shore wind

Offshore wind projects are capital-intensive, long-term ventures with extended lead times, requiring coordination across multiple complex processes. A major bottleneck is the shortage of installation vessels for turbine deployment and subsea cable laying, with acquisition taking 5–8 years, further delayed by global demand and production backlogs extending into the early 2030s. Similarly, India lacks domestic manufacturing and expertise in high-voltage (HV) subsea cables, floating foundations for deep-water projects, and offshore maintenance, making technology partnerships and infrastructure investment critical.

While the viability gap funding (VGF) of ₹6.85 crore/MW offers crucial financial support, the capital-intensive nature of offshore wind projects necessitates additional measures to ensure long-term viability. Developers must bear expenses for site surveys, financing, construction, grid connectivity, and operations—unlike global markets where governments cover grid costs and streamline approvals. Without stronger financial backing and infrastructure support, the high-capital burden may deter investments and slow down project execution. Additionally, the high cost of offshore wind power (₹10–12/kWh) versus DISCOMs' preferred ₹4–5/kWh makes the offshore power PPAs unattractive. Tapping into alternative market instruments like green hydrogen production can enhance demand, leveraging offshore wind for electrolysis and port-based supply chains. Regulatory complexities also pose challenges, requiring approvals from multiple agencies like

Ministry of New and Renewable Energy (MNRE), Ministry of Environment, Forest, and Climate Change (MoEFCC), and Ministry of Defence (MoD), leading to delays and cost overruns. Implementing a single-window clearance system, like South Korea's one-stop shop (OSS) model, could fast-track approvals and boost investor confidence.

Repowering or refurbishing of wind

Repowering or refurbishing wind turbines offers a significant opportunity to maximize energy output (kWh) per square kilometre. Many high-potential wind sites are already occupied by sub-MW turbines, and to enhance energy efficiency, the MNRE introduced the repowering policy. According to the National Institute of Wind Energy (NIWE), the potential for wind turbines below 2 MW stands at 25.4 GW. However, progress has been slow due to several challenges. First, acquiring additional land for larger size turbines and obtaining multiple clearances is difficult, especially when dealing with multiple landowners, requiring family certificates. Second, in aggregation projects where multiple developers own individual wind turbines but share common infrastructure, the challenge lies in identifying all stakeholders and managing multiple individual PPAs. Some of these turbines are also used for self-consumption by industries, adding further complexity to coordination efforts. Additionally, decommissioning these older wind plants is complicated by the absence of a regulatory framework in India for disposal and the lack of skilled workers needed for dismantling.

Conclusion

India's wind energy sector is poised for expansion but unlocking its full potential will require streamlined single-window approvals, auctions aligned with evolving demand profiles of DISCOMs, and long-term policy clarity on transmission and open access. Strengthening the domestic supply chain, fostering global technology partnerships, and ensuring sustained financial and infrastructure support—especially for off-shore wind—will be critical. Equally important is the building of a skilled workforce to support emerging areas like off-shore wind, which are new to India's energy landscape. With these efforts, wind energy can play a central role in achieving the 500 GW renewable energy target by 2030.

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Geothermal Well

A Case of Substantial Collaboration for Sustainable Tomorrow

Harsh winters, brief cropping seasons and seismic activity define the topography of West Kameng district of Arunachal Pradesh and its surrounding region. How an idea to utilize geothermal energy from physical features like hot springs, born out of an international scientific collaboration, is changing the status quo, is detailed in this article written by **Tana Tage**, **Rupankar Rajkhowa**, **Kuldeep Dutta** and **Laxmi Linggi**.

Introduction

Geothermal energy is a renewable thermal energy source generated and stored within the Earth's interior. This heat emerges as various surface manifestations, including fumaroles, hot springs, boiling springs, geysers, and phreatic explosions. Among these, hot springs are the most visible indicators of geothermal activity. (White, 1973)

To meet its ambitious renewable energy goals of 500 GW non-fossil capacity by 2030 and net-zero carbon emissions by 2070, the Government of India is actively exploring and harnessing geothermal resources. Integrating geothermal energy into the national energy portfolio will strategically diversify clean energy sources, bolster sustainability initiatives, and potentially establish India as a frontrunner in global geothermal power generation.

A comprehensive study of Geological Survey of India (GSI) on 381 thermally anomalous areas in India estimates a potential of approximately 10,600 MW of geothermal power within the country. Key focus areas include regions like Ladakh, contributing to the broader goal of reducing greenhouse gas emissions through clean energy solutions.

Recognizing the geothermal potential in the northeast, the Centre for Earth Sciences and Himalayan Studies (CESHS), an autonomous organization under the Department of Science and Technology, Government of Arunachal Pradesh has conducted investigations on hot springs in the state and its bordering areas. The region's climate, characterized by warm summers (~30°C) and cold winters (0°C or lower, with temperatures at Sela Pass even dropping to -15°C in winter), is highly suitable for underground thermal energy storage. This enables the integration of heating and cooling solutions that can be adapted to the local climate, energy needs, and geological conditions.

Study Area

Dirang town is situated in West Kameng district of Arunachal Pradesh, a region making up approximately 8.86% of Arunachal Pradesh's total area. It is situated at an average elevation of approximately 1,621 metres above mean sea level, flanked by steep mountain ranges, including the Sela and Bomdila ranges. Figure 1 shows an overview of the study area with hot springs and borewell sites. According to the 2011 Census, Dirang town has a population of 3,750, with 1,928 males and 1,822 females, and a literacy rate of 80.51%. (Directorate of Census Operations, Arunachal Pradesh, 2011)

Dirang occupies a transitional zone between the lesser and greater Himalayan ranges. Its position within a valley provides a unique microclimate characterized by moderate temperatures as compared to the extremes found in the neighbouring areas. The town is located within the watershed basin of the Dirang Chu River, a significant tributary of the larger Kameng river system. The climate of Dirang varies significantly with altitude, ranging from cool temperate at higher elevation to subtropical in lower areas. The region experiences significant seasonal variations in precipitation,

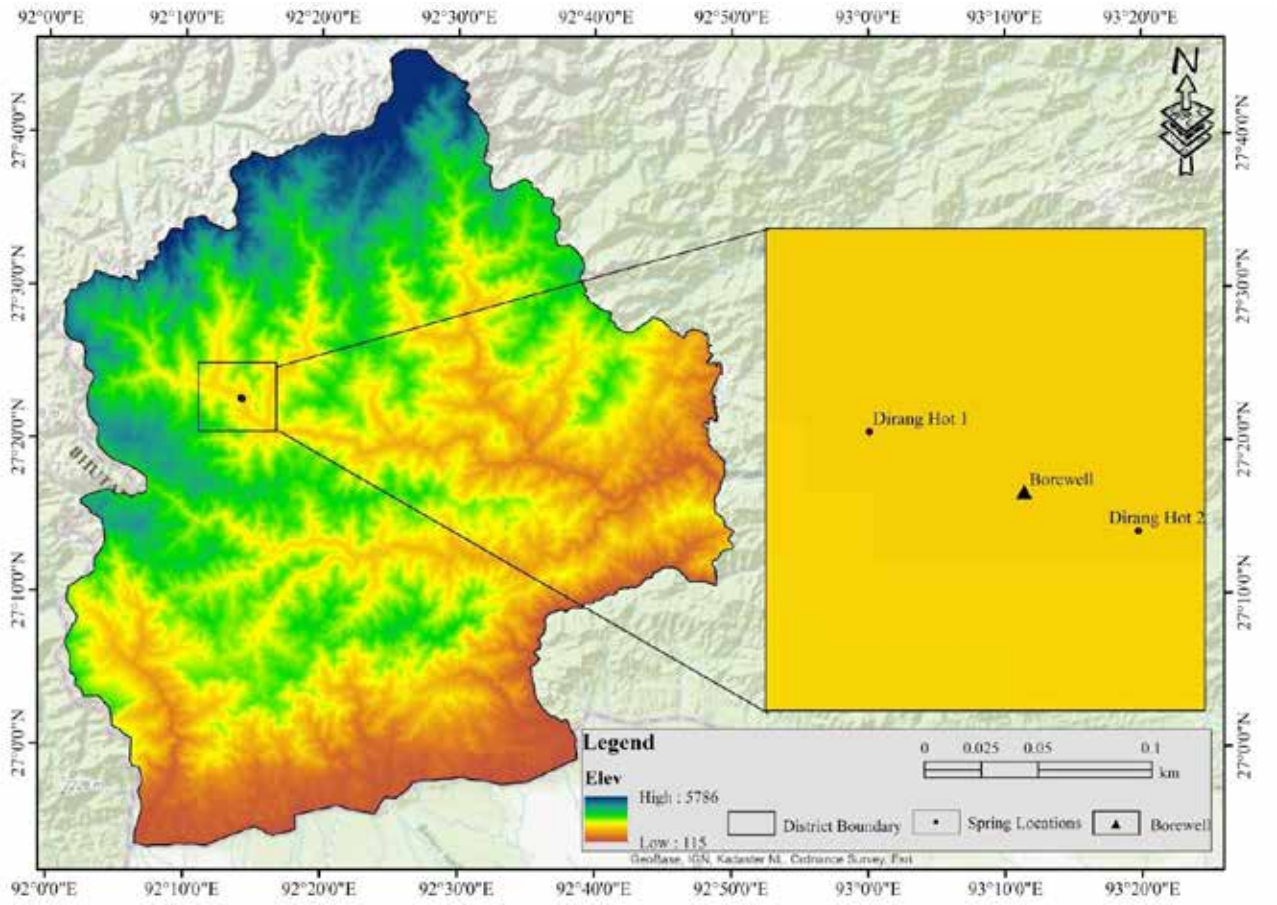

Figure 1: Elevation map of the study area with hot spring and borewell sites

with the monsoon season (June to September) bringing substantial rainfall. Rainfall tends to be higher in the foothills as compared to higher altitudes.

In Dirang, horticulture stands as a major economic driver, supported by mountainous soil and sufficient rainfall. Key crops including kiwi and apple, contribute significantly to food security in the region. However, deforestation and climate change (rising temperatures, rainfall variability), driven by increasing population and construction, have negatively impacted horticultural production in the area. Also, tourism is emerging as a relevant economic factor in the town, presenting both opportunities and challenges for sustainable development.

Arunachal Pradesh is a tectonically as well as seismically active region of the eastern Himalayas and eastern syntaxis bend, where earthquakes are frequent. Geologically, the West Kameng district comprises complex geological formations shaped by the Himalayan orogeny (Bhattacharjee & Nandy, 2008). The rocks of this region are compressed into a stack of imbricate series of thrusts and faults. The region is bordered by a major thrust known as the main central thrust (MCT) in the north and the main boundary thrust (MBT) to the south. The MCT is the most conspicuous, seismically active thrust and is located in the northern vicinity of Dirang town.

Geothermal Research and Development in Dirang

The CESHS, in collaboration with NGI and Geotropy ehf., conducted extensive geochemical analysis of hot springs across various locations in West Kameng. The water samples from the sites were meticulously bottled in HDPE bottles following the standard method as recommended by the American Public Health Association (APHA) and transported in a cold environment for laboratory testing at Roorkee and Chandigarh.

The comprehensive testing protocol analysed major elements (cations such as calcium, magnesium, sodium, potassium; anions including bicarbonate, sulphate, chloride, fluoride), minor elements, silica content, and isotopic composition (deuterium and oxygen-18). The primary objective of these analyses were to characterize the subsurface geothermal reservoirs and estimate their heat potential without the need for initial exploratory drilling.

Results revealed surface temperatures ranging from 30–35°C across the hot springs. Through various geothermometric calculations, particularly conductive quartz measurements, estimated reservoir temperatures varied between 44–150°C, followed by mixed model analysis indicating potential reservoir temperatures reaching up to 115°C, which is more than suitable for direct heat applications such as food drying, space heating, and potential small-scale agricultural uses.

After the geochemical analysis, the structural and geological mapping of the study area was carried out. The geological setting near the two hot springs in Dirang is characterized by two primary lithologies, schist & quartzite. The mapped fault has a moderate dip towards the east, characterized by a fault core of heavily crushed material. The team systematically measured foliation patterns, analysed fracture systems, and documented a significant fault line that demarcated the boundary between the quartzite and schist formations. The quartzite exhibited systematic fracturing with three distinct fracture sets, indicating higher hydrological permeability. In contrast, the schist was observed to be less fractured and consequently less permeable.

Based on these comprehensive geological and geochemical analyses, the team identified a drilling point in quartzite rock with optimal geothermal potential, characterized by a high-permeability zone ideal for geothermal well production.

Geothermal production well breakthrough

In a landmark achievement in April 2025, the collaboration between CESHS, NGI, Geotropy, and the local drilling expertise of the Guwahati Boring Service (GBS), Guwahati, resulted in a successfully drilled geothermal production well in Dirang. The temperature gradient gradually increased from a depth of 105ft with a high amount of discharge of 24 lpm and a temperature of <55°C. This significant breakthrough was a direct result of two years of intensive and meticulous geological and hydrochemical analyses, specifically focused on the hot springs at the Dirang site. The methodical preliminary investigation provided essential insights into subsurface geological conditions, characteristics of the geothermal reservoirs, and their resource potential; ultimately enabling the successful drilling operation. The production well represents a significant advancement in sustainable energy development for the region and demonstrates the value of international scientific collaboration in addressing complex geothermal engineering challenges.

Potential Benefits of Geothermal Energy Development in West Kameng

The successful drilling of a geothermal production well in Dirang marks a pivotal moment, unlocking the potential for transformative benefits across the district, in line with India's renewable energy ambitions while addressing local challenges related to energy access, environmental sustainability, and economic development.

Sustainable and efficient heating solution

Dirang experiences harsh winters with significantly low temperatures. The drilled geothermal well offers a pathway to harness geothermal energy for efficient and sustainable heating solutions. Implementing district heating systems can drastically reduce the reliance on traditional and environmentally damaging practices like burning firewood, a primary source of heating that contributes heavily to deforestation, with each household reportedly consuming a substantial number of mature trees annually during the long winter months. Direct geothermal heating in homes, schools, government buildings, and monasteries will significantly improve living conditions, especially in remote villages where access to alternative heating is limited. This shift towards geothermal heating will not only provide warmth but also contribute to improved air quality and forest conservation.

Advancement in food preservation techniques

The local communities in Dirang often rely on traditional methods like sun-drying or firewood-based drying for preserving food, particularly yak meat and mushrooms. The consistent and controlled heat provided by geothermal energy can facilitate the establishment of modern and efficient drying systems. This will lead to a more hygienic and reliable food preservation process, significantly reducing spoilage and enhanced food security for the villagers by ensuring a stable supply of preserved food throughout the year, irrespective of weather conditions.

Fostering sustainable tourism and local economic growth

Dirang is known for its natural beauty and hot springs, attracting tourists and pilgrims. The geothermal well opens up opportunities for developing eco-friendly tourism initiatives. Geothermal energy can power sustainable infrastructure such as geothermal spas and wellness centres (akin to Iceland's Blue Lagoon), heated and environmentally conscious accommodations, and green resorts. The development can significantly boost the local economy by creating employment opportunities for residents, supporting local businesses, and establishing West Kameng as an attractive and environmentally responsible eco-tourism destination.

Opportunities for agricultural and horticultural innovation

The cold climate and brief cropping season in West Kameng pose challenges for its agriculture. Geothermal energy can be utilized to power greenhouses, create controlled environments that extend the growing season and allow for year-round cultivation of a wider variety of crops. This can enhance local food production, reduce the dependence on expensive and logistically challenging imported vegetables, and improve the nutritional intake of the population.

Significant contribution to environmental conservation

The rich biodiversity and fragile ecosystems of West Kameng face threats from deforestation, largely driven by the demand for fuelwood. The adoption of geothermal energy as a primary source for heating and drying will significantly reduce this pressure on forests, playing a crucial role in preserving the region's unique flora and fauna and maintaining ecological balance. Furthermore, the transition from conventional, carbon-emitting energy sources to cleaner geothermal energy directly contributes to India's national sustainability goals and its commitment to achieving net-zero carbon emissions by 2070, positioning West Kameng as a contributor to national and global environmental efforts.

Way Forward

After the successful drilling of geothermal production well, the CESHS, with its partners, eyes on setting up a food drying unit, which will serve as a cornerstone application for the community. Implementation will follow a phased approach beginning with small pilot demonstrations that build confidence in the technology. This facility will process locally grown fruits, vegetables, and meat products, extending their shelf life and creating value-added products that command higher market prices. The drying unit will generate diverse employment opportunities as well, including facility operators, quality control personnel, and packaging workers, further benefitting the local community. The involvement of residents from the planning stage itself has ensured that applications align with local needs and priorities. Further, the CESHS will help develop local technical capacity through training programmes, creating sustainable employment while ensuring proper system maintenance. Throughout implementation, the CESHS will also monitor system performance metrics to optimize efficiency.

Secondly, space heating represents another immediate application with significant benefits. Therefore, initially, geothermal heat can be directed to government offices through a small district heating network. This approach will help to reduce fossil fuel dependence while providing reliable, consistent heating. If the pilot turns out to be successful, the network can expand to include more buildings and facilities such as schools, monasteries, homestays and hotels. According to the 2011 Census, 81% of West Kameng district's population resides in rural areas, while 19% lives in urban areas. This predominantly rural demographic presents opportunities for the local communities to engage in sustainable energy initiatives through

Figure 2: (a) CESHS scientists measuring Dip & Strike; (b) CESHS, NGI & Geotropy team after completing the structural mapping at Dirang

implementing direct heat application projects such as:

- Greenhouse heating for year-round agricultural production
- Aquaculture operations for fish farming
- Public bathing facilities that could attract tourists
- Poultry farming with controlled temperatures
- Wood products processing for local timber industries
- Food pasteurization and sterilization operations

By leveraging its geothermal resources effectively, Dirang can set an example by developing a model for sustainable energy use that strengthens the local economy, reduces environmental impact, and improves the quality of life for residents.

Figure 3: (c) and (e) CESHS director and fellow scientist collecting water samples from hot springs and measuring the discharge at sites; (d) Team measuring the temperature of the hot springs in Dirang

Conclusion

The international collaboration between CESHS, NGI, and Geotropy ehf. to identify, explore, develop, and harness geothermal energy in Arunachal Pradesh fulfils multiple objectives of the Indian Government's renewable energy agenda while delivering tangible benefits to local communities. The collaboration exemplifies how international partnerships can accelerate clean energy transitions while respecting local contexts and needs.

As this geothermal project advances from exploration to practical applications like food drying, it creates a replicable model for sustainable development that balances environmental stewardship with economic opportunity. Through continued dedication to capacity building and technology adaptation, the CESHS does not merely aim to implement the project but cultivate an enduring framework for renewable energy adoption that can transform the region's energy landscape for generations to come.

Figure 4: (f) Lama's praying before drilling at Dirang; (g) CESHS, Geotropy, and GBS preparing for drilling; (h) CESHS, Geotropy, and GBS team after successful completion of the drilling at Dirang

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NTPC Green Hydrogen Mobility Project, Leh

A Step towards Carbon Neutral Ladakh

This article explores various aspects of the NTPC Green Hydrogen Mobility Project in Leh (Ladakh), offering a brief overview of the energy transition, key features, scheme details, and environmental impact of the initiative.

Need of Energy Transition and NTPC's Role

The emission of greenhouse gases (GHGs) triggers global warming, leading to climate change and posing a serious threat to Earth's atmosphere. In response, immediate action is required for both climate change mitigation and adaptation.

NTPC Limited has been playing a major role in the energy transition of the country. It is taking various steps to make its energy portfolio greener by adding significant capacities generated from renewable energy sources. By 2032, NTPC plans to have 60 GW of capacity through renewable energy sources, constituting nearly 45% of its overall power generation capacity. From this project, NTPC helps the pristine Ladakh develop a carbon-free economy based on renewable sources.

Brief Details of the Hydrogen Re-Fuelling Station (HRS)

NTPC had signed an MoU with UT-Ladakh and Ladakh Autonomous Hill Development Council (LAHDC) for development of Green Hydrogen technologies in the UT and acquired 7.68 acres of land in Choglamsar, Palam in Leh for setting up of this HRS at Leh (Ladakh) at an elevation of 3600 m MSL which generates 80 kg of hydrogen everyday so that 5 intracity fuel cell electric buses (FCEVs) would ply in and around Leh covering 1100 km/day. It has a dedicated 1.70 MW solar station and facility for hydrogen generation, storage and dispensation at Leh (Ladakh).

The foundation stone for the project was laid by the Hon'ble Prime Minister of India on July 31, 2022. It was declared operationally ready by the Hon'ble CMD of NTPC on November 7, 2024, and hydrogen buses were flagged off by the Hon'ble Minister of Power on November 23, 2024.

Key Features of This Project

Green hydrogen mobility project is revolutionizing the transportation sector by introducing zero-emission solutions powered by renewable energy.

Some of special features of this station include:

A. Hydrogen Fuelling Station

a. World's highest altitude (3650 m MSL) Green Hydrogen Mobility Project
b. Designed for its operating temperature -25ºC
c. India's first Green Hydrogen Fueling Station & FCEVs with passenger operating at highest MSL

d. Super ECBC compliant office cum switchgear complex
e. Net-Zero energy import (BESS/ Fuel Cell System)

B. 1.7-MW Solar Plant

a. First ever MW scale solar plant @ 3650 m MSL
b. Synthetic bio oil for the transformer
c. Special anti-glare coating on the solar module
d. High-capacity solar module at high altitude
e. Special design Module Mounting Structure Foundation

During the solar hours, renewable power generated from the 1.7-MW solar plant is directly utilized to generate hydrogen gas through alkaline electrolyzer at a pressure of 30 bar and >99.97% purity and some part of RE power stored in BESS. This generated hydrogen is then compressed to 450 bar by using diaphragm compressor and stored at 450 bar in type-III hydrogen storage cylinders. This stored hydrogen is dispensed into hydrogen bus onboard cylinders through pre cooler.

During non-solar hours, the stored RE power from battery energy storage system (BESS) and power generated from stationery hydrogen fuel cell is used to power the operation of hydrogen re-fuelling facilities. With this type of arrangement, the entire facility archives net-zero energy import.

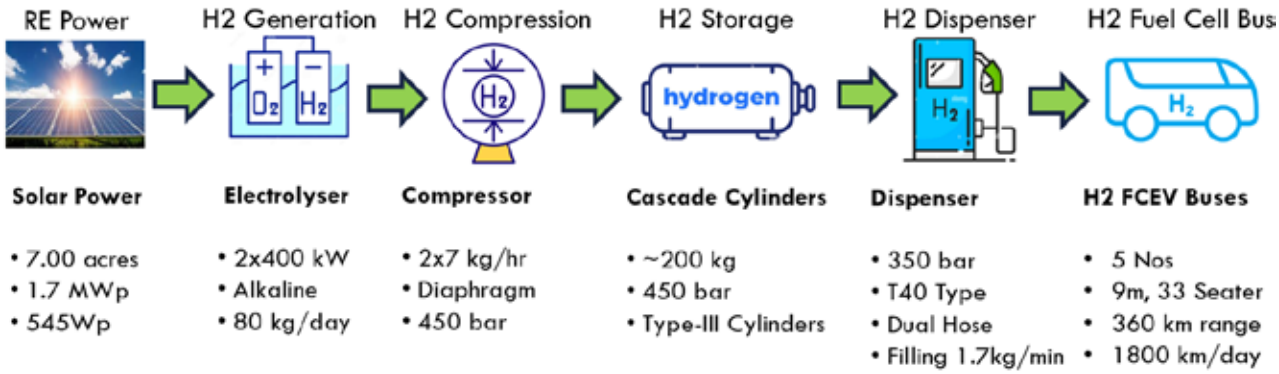

Figure 1: Scheme of this project

Figure 2: 1.7 MW solar plant

DM Unit

Electrolyzer

H_2 Compressor

H_2 Storage Cylinders

H_2 Dispenser

H_2 Fuel Cell Electric Bus

Environmental Impact and Sustainability

This station will mitigate the carbon emissions of approximately 512 MT/year and discharging 230 MT/year of pure oxygen into the atmosphere which is equal to planting of approx. 13,000 trees.

The case gets stronger considering the high solar irradiance in Ladakh regions with low temperatures, a sweet spot for producing the solar power efficiently. Production and utilization of this green fuel at these locations would eliminate the complete fuel logistics and make the locations self-sufficient and immune to road connectivity disruptions.

Conclusion

This station provides a solution for replacement of highly polluted fossil fuel vehicles operating in Leh and offer several key advantages of integration of renewable energy sources, ensuring a reliable fuel source in adverse conditions; reduce carbon emissions, promoting a cleaner and more sustainable energy ecosystem; are highly scalable, making them suitable for various applications.

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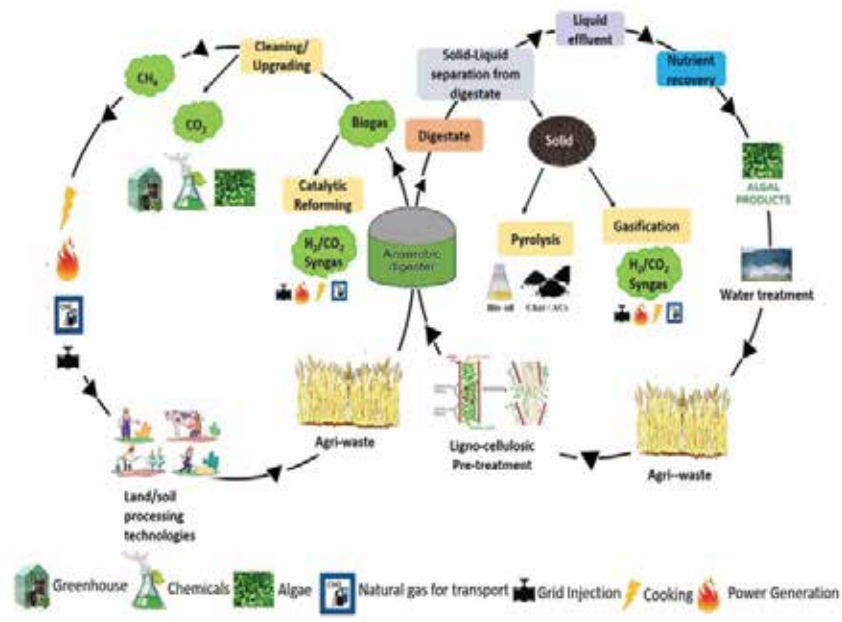
Biogas and Circular Economy in India

A Sustainable Future

Biogas technology is a viable alternative in suitably addressing organic waste. The biogas technology is not only a renewable energy source; it effectively contributes towards circular economy which focuses on minimizing waste and maximizing resource efficiency. Besides the biogas utilization is accompanied by a number of benefits discussed in this article by **Kapil Kumar Samar.**

India, with its vast agricultural landscape, growing industrial sector, and rapidly urbanizing population, faces significant challenges in managing organic waste. However, the adoption of biogas technology offers a promising solution that aligns with the principles of a circular economy. Biogas is formed by the digestion of organic material in the absence of oxygen. Biogas is produced by anaerobic digestion of biomass which is considered to be a sustainable bioconversion technology as it produces renewable gaseous fuel. Organic material may include cattle dung, agriculture waste, municipal solid waste, biodegradable waste, and seedcakes, etc. Biogas typically consists of methane (50–70%), carbon dioxide (30–45%), traces of water vapour, and hydrogen sulphide (H2S). Type of feedstock used for biogas plant affects the composition of biogas and the contaminants. Biogas technology stabilizes and reduces the volume of waste. Biogas has a heating value of 20 MJ. The digested part is used as organic fertilizer.

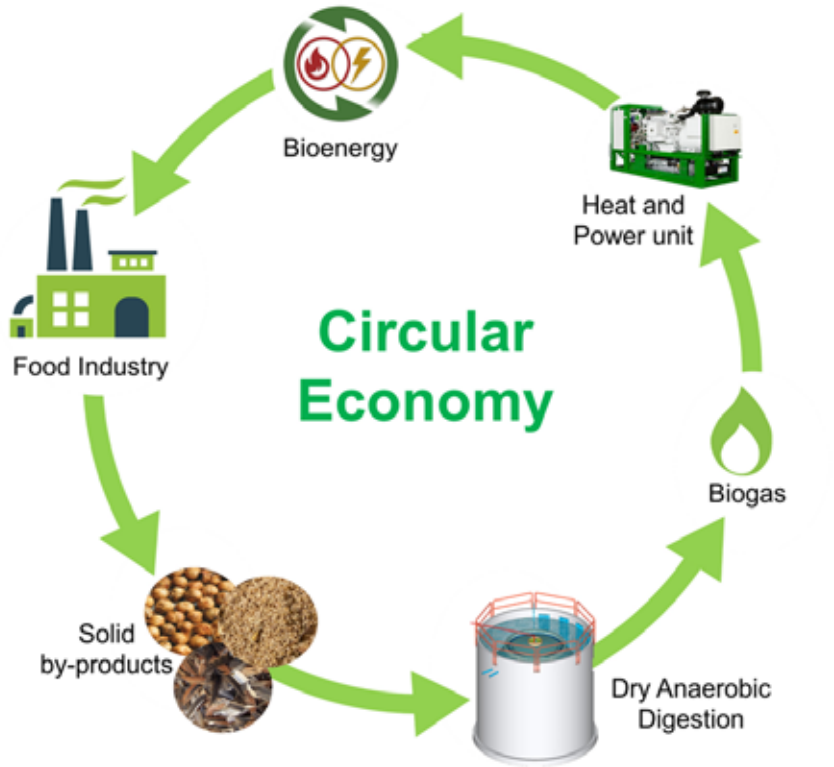


By converting agricultural residues, industrial waste, and municipal organic waste into renewable energy and organic fertilizers, biogas plants play a crucial role in India's sustainable development. According to the Ministry of New and Renewable Energy (MNRE), India has a potential to produce about 62,000 million cubic metres (MCM) of biogas annually, surprisingly, less than 10% of this potential has been tapped.

The Role of Biogas in India's Circular Economy

The circular economy focuses on minimizing waste and maximizing resource efficiency. Biogas plants serve as hubs of this model by utilizing waste streams from agriculture, industry, and households. The core advantages include:

- **Waste utilization and energy generation**: India generates about 500 million tonnes of agricultural residue annually. Biogas plants convert these waste materials, along with food waste and livestock manure, into methane-rich biogas through anaerobic digestion, providing a renewable source of energy. This reduces dependence on fossil fuels and helps meet the country's energy demands sustainably. In 2023, India had over 5.08 million household biogas plants and around 800 community/commercial plants. These plants collectively generate approximately 4.43 MCM of biogas per day. Under the Sustainable Alternative Towards Affordable Transportation (SATAT) initiative, 50 compressed biogas (CBG) plants are operational with more than 450 under development, aiming for 5,000 plants by 2025.
- **Reduction of greenhouse gas (GHG) emissions**: Agricultural waste and untreated organic matter contribute to methane emissions when left to decay. India is the third-largest emitter of methane globally, releasing around 37 million tonnes per year. Processing these wastes in biogas plants can significantly reduce GHG emissions. A single 100 m^3 biogas plant can reduce about 260 tonnes of CO_2-equivalent emissions annually. The cumulative potential of SATAT plants is to save up to 250 million tonnes of CO_2-equivalent emissions per year by 2025.

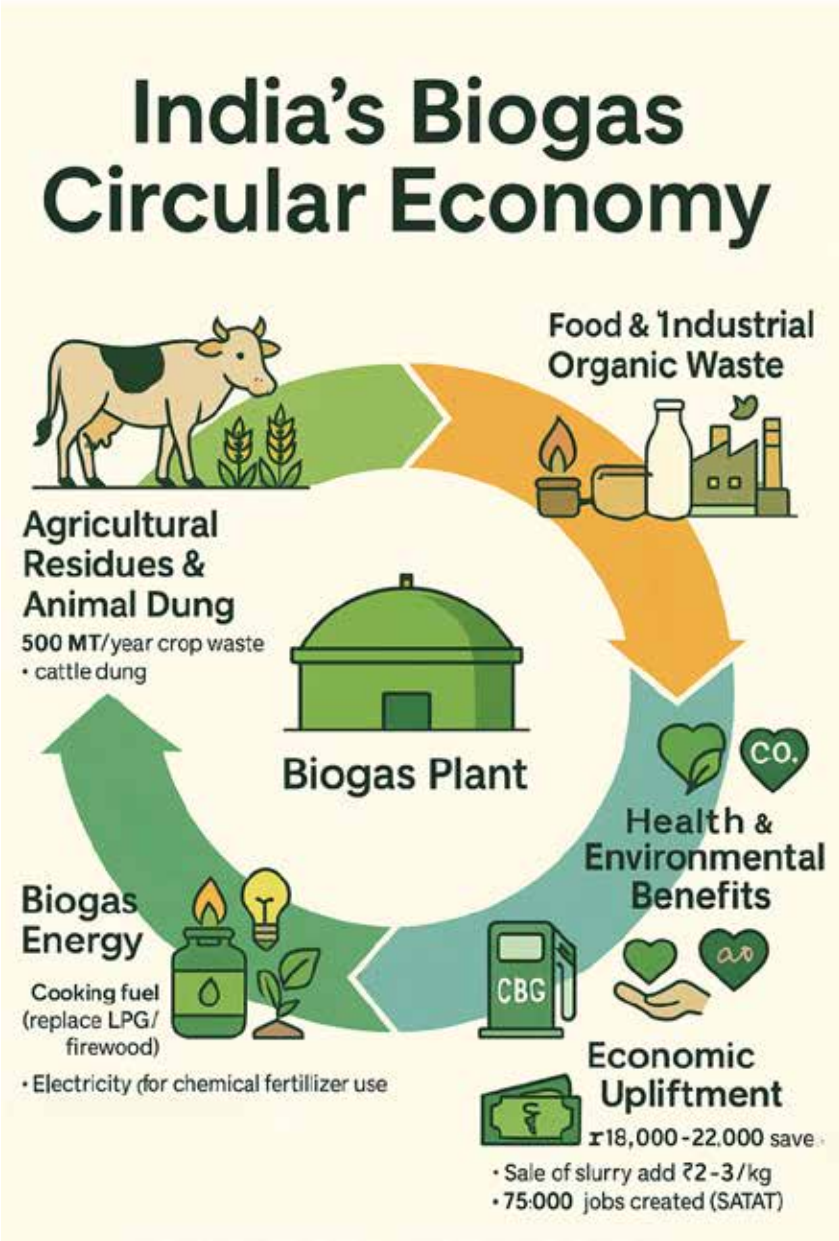


- **Production of nutrient-rich organic fertilizers**: The by-product of biogas production, known as digestate, is a highly effective organic fertilizer. It enhances soil fertility, reduces dependency on chemical fertilizers, and promotes sustainable farming practices, benefiting over 120 million small and marginal farmers in India. A study by ICAR (2023) found that biogas slurry can save approximately 50% of nitrogen, 25% of phosphorus, and 40% of potassium fertilizer requirements annually, translating to an average savings of ₹6,500–₹8,000 per hectare per year.
- **Carbon savings from biogas manure**: Application of biogas slurry reduces the need for chemical fertilizers, thereby indirectly reducing the carbon footprint associated with their production. It is estimated that using biogas slurry instead of synthetic fertilizers can save about 1.5 tonnes of CO_2-equivalent emissions per hectare per year.
- **Annual savings**: For a farmer managing 5 cattle and using a family-size biogas plant, the annual savings on liquefied petroleum gas or LPG (cooking fuel) and chemical fertilizers can amount to ₹8,000–12,000 per household. Additionally, farmers selling surplus biogas slurry as organic manure earn ₹2–3 per kg, adding supplementary income.
- **Health benefits:** The use of biogas reduces indoor air pollution caused by burning firewood, dung cakes, and kerosene. Studies by World Health Organization (WHO) and the Ministry of New and Renewable Energy (MNRE) suggest that regular biogas users experience a 60–80% reduction in respiratory diseases, eye infections, and burns. Improved sanitation from better

manure management also reduces waterborne diseases such as diarrhoea, benefiting rural health substantially.

Economic and Social Benefits

- **Income generation for farmers**: The Indian agricultural sector produces large volumes of biomass waste, which often remains underutilized. By channelling crop residues and livestock manure into biogas production, farmers can earn additional income while contributing to sustainable energy production. For instance, a 100-cubic metre plant can save up to ₹7–8 lakh annually in fuel and fertilizer costs.
- **Employment opportunities**: The establishment and maintenance of biogas plants create employment opportunities in rural areas. The SATAT and MNRE's National Biogas Programe initiative alone is projected to create 75,000 direct jobs and thousands of indirect jobs.
- **Rural electrification and energy security:** Many rural areas in India still face unreliable electricity supply. According to the Central Electricity Authority (CEA 2023), about 20,000 villages continue to experience poor grid connectivity. Small-scale biogas plants can provide decentralized energy solutions, ensuring energy security for households and small enterprises in off-grid locations, offering 3–4 hours of clean lighting and cooking gas per day.



Role of Biogas Development and Training Centres

Biogas Development and Training Centres (BDTCs) play a crucial role in promoting biogas technology and supporting India's transition to a circular economy. Their key contributions include:

- **Research and development (R&D)**: BDTCs conduct research on improving biogas plant efficiency, enhancing feedstock utilization, and developing cost-effective technologies.
- **Capacity building and training**: BDTCs provide technical training to farmers, entrepreneurs, and technicians on biogas plant installation, maintenance, and troubleshooting. By spreading knowledge, they ensure the long-term sustainability of biogas projects. To date, 8 operational BDTCs have trained over 30,000 individuals across India.
- **Standardization and quality control**: BDTCs work with the government to develop standards for biogas plant design, construction, and operational efficiency.

- **Implementation support for government programmes**: BDTCs assist in implementing National Biogas Programme that aims to install 12 million family-type biogas plants, of which 5.08 million have been completed so far as well as SATAT.
- **Awareness and outreach**: They conduct awareness campaigns, workshops, and field demonstrations to promote biogas adoption among rural communities, industries, and urban waste management sectors.
- **Policy support and advisory role**: BDTCs work closely with policymakers and stakeholders to provide insights and recommendations for improving biogas policies and incentives.
- **Waste management and circular economy contribution**: By promoting biogas technology, BDTCs help in utilizing agricultural residues, food waste, and industrial organic waste, reducing environmental pollution, and promoting a circular economy.

Policy support and government initiatives

The Indian government has recognized the potential of biogas in achieving energy security and sustainability. Various programmes and policies have been introduced to promote biogas adoption, including:

- **National biogas programme**: This initiative supports the installation of family-size biogas plants, particularly in rural areas. Over 5.08 million plants have been installed since its inception, with a long-term goal of 12 million plants.
- **SATAT initiative**: Launched in 2018, this programme aims to establish 5,000 compressed biogas (CBG) plants by 2025. So far, 50 plants are operational and 450+ are under development.
- **Waste-to-energy policy**: The government encourages waste-to-energy projects through financial incentives, tax benefits, and research support to enhance biogas production capacity in the country.

Challenges and Way Forward

Despite the advantages, several challenges, as discussed here, hinder the widespread adoption of biogas technology in India:

- **High-initial investment**: Setting up biogas plants requires significant capital investment, which can be a barrier for small farmers and entrepreneurs. A medium-sized CBG plant costs ₹2–3 crore.
- **Lack of awareness and technical expertise**: Many rural communities lack awareness and technical knowledge about biogas plant operations, leading to underutilization of available resources.
- **Efficient waste collection and management**: The success of biogas projects depends on an efficient waste collection system. India needs better infrastructure to streamline waste segregation and transportation.

To address these challenges, India must focus on:

- Increasing financial subsidies and incentives for biogas plant installation.
- Enhancing training programmes to educate farmers and entrepreneurs about biogas technology.
- Developing efficient waste management policies to ensure a steady supply of raw materials for biogas production.
- Encouraging private–public partnerships and decentralized plant models.

Conclusion

Biogas technology presents a significant opportunity for India to transition towards a circular economy. By converting agricultural and industrial waste into renewable energy and organic fertilizers, biogas plants can drive sustainable development while addressing environmental concerns. With strong policy support, increased investments, community participation, and strengthened BDTC networks, India can harness the full potential of biogas and move towards a cleaner, more sustainable future.

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Leveraging Green Hydrogen-Powered Microgrids for Cost-Effective Energy Resilience

Optimal energy generation systems should not only be renewable, reliable, and cost-effective but also environmentally sustainable. In this article, **Dr Chock Karuppaiah** examines the emergence of hydrogen-powered microgrids as a viable and sustainable energy solution. The incorporation of a case study from the NTPC Energy Technology Research Alliance (NETRA) campus serves to elucidate the concept by providing a real-world application.

As the world pursues a sustainable energy future, communities and industry alike are looking to localized energy networks such as microgrids to deliver cost-effective energy and boost the resilience and efficiency of the electrical system. Energy storage is an essential component for all microgrids, especially 'green' microgrids, which source their energy from renewables. In a recent pilot project, on-site energy developer Spirare collaborated with Ohmium to provide NTPC, India's largest integrated power company, with a green hydrogen-based power generation solution to support the NTPC Energy Technology Research Alliance (NETRA) campus. This project demonstrates the advantages of access to 24/7 firm power from a green microgrid and the specific advantages of the Ohmium's cutting-edge proton exchange membrane (PEM) technology.

Ohmium and Spirare Energy collaboration on the green hydrogen-based generation system at the NTPC NETRA campus in New Delhi, India

Microgrids Support Energy Resilience

Microgrids are localized energy networks that operate independently or alongside the main grid, providing a reliable way to support or augment existing grid infrastructure. These systems not only increase energy security but also offer a powerful means to 'green the grid' by integrating renewable energy sources. Green microgrids combine renewable energy generation, storage, and a distribution network that can generate 24/7 firm power reliably and cost-effectively.

Energy Source and Storage: Key Elements

For stable, around-the-clock microgrid operations, both energy source and energy storage are essential components. In the case of the green microgrid at the NTPC NETRA campus, the energy source is renewable, and a fuel cell system is used to convert green hydrogen to power. This green hydrogen is produced by the Ohmium PEM electrolyzers and will be converted to clean electricity and used when solar power is unavailable. Renewable sources like solar and wind are naturally variable; solar generation stops at night, and wind can be unpredictable. Only with energy storage can the microgrid deliver green power during these gaps.

Green hydrogen is generated when renewable energy powers an electrolyzer. In a properly designed storage, hydrogen has a long shelf-life and therefore, it can be converted into electricity in fuel cells as needed. This approach to energy storage and electricity generation proves useful, especially for long-duration power. Green hydrogen- powered fuel cells offer a flexible and reliable solution, capable of generating electricity on demand, regardless of time of day or the weather (once hydrogen has been generated under standard operating conditions and then stored).

High-Efficiency PEM Electrolyzers Drive Cost-Effective Green Hydrogen

Renewable energy is required to produce green hydrogen. With energy costs making up approximately 50–60% of the total production cost, electrolyzer efficiency is crucial.

The efficiency of converting renewable energy to hydrogen involves the following two key factors:

1) The inherent efficiency of the electrolyzer system: This refers to how effectively the system converts electricity into hydrogen.
2) The system's ability to adapt to fluctuating renewable energy: Since renewable energy sources like wind and solar are variable, the system must be able to adjust its operation to capture and use all available energy.

Ohmium PEM electrolyzers and Spirare Energy hydrogen storage at NTPC NETRA campus

High-efficiency electrolyzers can capture more of the renewable energy resources and therefore, deliver on lower costs than other electrolyzer types that are less efficient producers of hydrogen. Renewable energy sources like solar and wind are inherently intermittent, causing significant fluctuations in output. Electrolyzers built with PEM technology excel at capturing the full output of intermittent sources like wind and solar. They can dynamically adjust to changes in power generation, syncing within seconds to match the available energy—such as when a cloud passes over a solar array. In contrast, alkaline electrolyzers may require up to 45 minutes to make similar adjustments. This high availability is one of the reasons PEM electrolyzers are significantly efficient and can be a highly cost-effective option.

The efficiency of Ohmium cutting-edge PEM technology makes it an ideal choice for integration with renewable energy. By combining renewable energy sources and Ohmium PEM technology, Ohmium customers can achieve reliable power production, overcoming the typical intermittency challenges faced when utilizing the grid and renewable energy resources alone.

Ohmium and Spirare in Action: A Green Hydrogen-Based Power Generation Solution for the NTPC NETRA Campus

Ohmium PEM electrolyzers shine in real-world applications, as exhibited by a recent project to supply green hydrogen-based power generation system to NTPC NETRA. The NTPC chose Spirare Energy, an innovative onsite energy generation systems provider, to develop a green hydrogen-based power generation pilot project at its NETRA campus in New Delhi. The project combines Ohmium PEM electrolyzer technology, capable of producing up to 52 tonnes of green hydrogen per year, and Spirare fuel cells to convert green hydrogen to electricity for NTPC NETRA's microgrid.

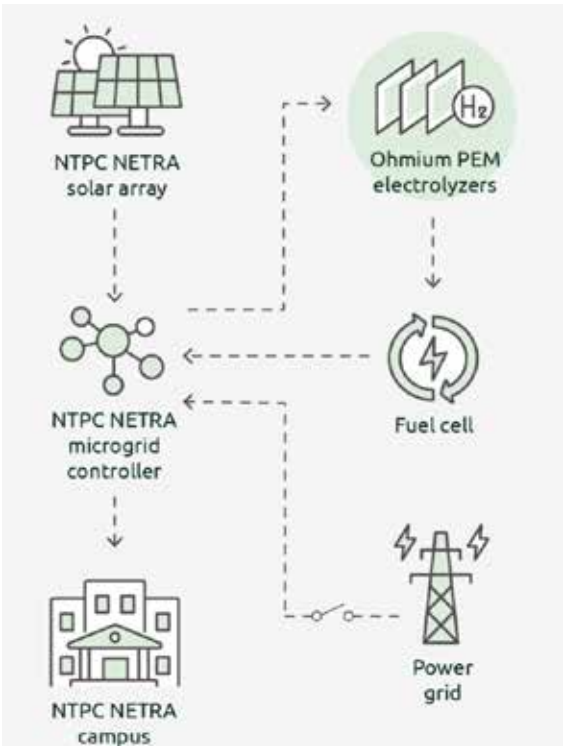
During peak sunlight hours, the excess electricity from the NTPC NETRA microgrid is used to power high-efficiency Ohmium PEM electrolyzers. Water is sourced from a nearby sewage treatment facility. The hydrogen produced by the Ohmium electrolyzers is stored for use during peak demand periods or during unavailability of solar power. When the campus electricity demand exceeds solar supply, the stored hydrogen powers a fuel cell which feeds electricity back into the NTPC NETRA microgrid.

The project avoids up to 130–520 tonnes of CO_2 emissions annually, equivalent to planting 6,000 to 23,000 trees.

Reliable Power for any Industry

As global industries and communities strive to achieve their sustainability goals, green microgrids offer a cost-effective option for reliable green power supply. The Ohmium high-efficiency, cutting-edge PEM electrolyzers can provide an ideal solution for green microgrids that can benefit hard-to-abate industries and communities with unreliable electricity, even in extreme climates.

Whether for industrial applications or large-scale utility projects, microgrids that include green hydrogen can provide robust energy storage and reliable power generation that can adapt to a wide range of environments.



Process flow diagram for green hydrogen-based power generation for the NTPC NETRA campus

To know more about this project, please visit: https://www.ohmium.com/project/spirare-and-ntpc-netra

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Out of Thin Air: A New Way Forward

Amid concerns regarding water depletion at an all-time high, a silent revolution is brewing. A start-up in Bengaluru has ambitious plans to extract water out of air, pass multiple hurdles and make that water a reality in daily usage globally. **Swapnil Shrivastav** details how Uravu's solution—FromAir® is a completely renewable, scalable, and sustainable method to produce water from air.

It is rightly said, *"Necessity is the Mother of Invention"*. In 2016, a severe drought-hit Kozhikode, Kerala, leaving the NIT Calicut campus nearly dry. For a group of students studying there, it was a wake-up call. The taps were dry with hostels having little to no water. That's when the idea first took root—what if we extract water from air for a reliable, sustainable supply? That idea gave birth to Uravu Labs.

Uravu's solution—FromAir® is a completely renewable, scalable, and sustainable method to produce water from air—without drawing a single drop from the ground or any other source. It started as a personal mission, but it now addresses a global challenge. According to NITI Aayog, 600 million Indians already face high to extreme water stress, and by 2030, India's water demand is projected to be double the available supply.

Flagship FromAir Hub in Bangalore

That's the daily reality for millions, and it is what sparked a revolution at NIT Calicut. Swapnil Shrivastav, Venkatesh RY and Balaji GB were inspired to leverage this technology for a water positive future. Uravu is re-imagining water infrastructure for the 21st century by tapping into inexhaustible atmospheric moisture, we aim to provide a zero-carbon, zero-waste, and high-quality solution for consumer, commercial, and industrial applications.

Water Woes: Indiscriminate, Water-Intensive Practices

Groundwater remains India's largest source of fresh water. Unfortunately, it is also the most exploited with industries, households, and agriculture drawing unsustainable volumes on a daily basis, leading to rapidly falling water tables. Reverse osmosis

(RO)—a popular method for purifying water—wastes approximately 3 to 4 litres for every litre of clean water it produces. In urban India, where RO and groundwater dominate, this leads to vast inefficiencies, carbon emissions, and a mounting plastic waste problem.

The water crisis is no longer a future concern; it is already looming. Traditional technologies are not built for long-term sustainability and that's where atmospheric water generation offers a compelling solution—albeit with its own set of challenges.

Air to Water: The Promise and The Pitfalls

The concept of extracting water from air is not new. But most conventional atmospheric water generator (AWG) technologies come with serious limitations. They are energy-intensive, perform poorly in dry climates, and often require frequent maintenance. These systems can be expensive to operate and scale, making them unviable for consistent, high-volume use, especially in regions that need it the most.

The challenges go beyond the hardware—the cost per litre of water remains high. The technologies are largely inaccessible due to their niche market presence. Public awareness about such solutions is still minimal and most importantly, these systems haven't been built with a large scale in mind—the very thing required to make a dent in the water crisis.

Uravu saw an opportunity in these gaps. Instead of relying on energy-hungry cooling systems, Uravu developed a desiccant-based technology that uses hygroscopic materials to absorb moisture from the air, even at lower humidity levels. This process is then powered using renewable energy sources like solar thermal, solar PV, biomass, or even waste heat—making it significantly more energy-efficient and climate-resilient.

Uravu's solution can produce water at ₹1–2 per litre — a fraction of the cost of traditional AWG systems. It is modular and scalable, capable of producing up to 50,000 litres per day, and designed to operate in a variety of geographies including arid regions. With the ability to integrate into existing infrastructure, it opens up pathways for decentralized water access—right where it is needed the most.

Uravu's innovation bridges the gaps between promise and practicality—making water from air a truly viable, scalable, and sustainable solution for the future.

The Journey from Prototype to Scale

Uravu's breakthrough moment came in 2018, when its technology was recognized as one of the top five global finalists in the Water Abundance XPrize, among 98 teams worldwide—the only Asian team to make it that far. This validation proved the concept had real merit, not just technical novelty.

In 2019, Uravu Labs was incorporated. The next few years were spent in R&D, building and testing prototypes, learning from each failure. With support from organizations like DST and UNIDO, and investment from leading deep tech and global VCs, the team eventually built a production-ready solution.

By 2023, Uravu scaled to producing 4,000 litres per day from air—right at their Bengaluru facility. Today, it works with over 130+ premium hospitality venues across the city, delivering fresh, mineralized water FromAir® in glass bottles.

The Environmental Impact: Saving What we can't Replace

Traditional bottled water leaves behind a massive footprint—from groundwater extraction to plastic waste and transport emissions. Uravu's model changes that entirely.

4000 LPD | The world's first-of-its-kind Water FromAir® plant that runs 24x7

Project for TAQA, Abu Dhabi

At the Bengaluru hub alone:

- Over 2 million litres of groundwater has been saved
- 1.5 million+ plastic bottles have been eliminated
- Every bottle is collected back, sanitized, and reused—forming a closed-loop system with zero waste

The B2B Edge: Water for Industries that Need it the Most

Some of the most water-intensive industries—pharma, specialty chemicals, hospitality—rely heavily on high-purity water and typically extract it from borewells or use RO systems, adding to the water stress.

Uravu's water from air technology is now being deployed in industrial setups to meet process water demands without putting pressure on groundwater sources. A prominent example is the TAQA project, where Uravu's system is integrated into their infrastructure to sustainably produce high-quality water for operational usage.

A 10,000 LPD system installed by a client can save up to 7.1 million litres of groundwater annually and prevent 18.1 tonnes of carbon emissions. And unlike groundwater, which takes thousands of years to recharge, atmospheric moisture replenishes every 8–9 days.

Founders of Uravu | L–R: Balaji GB, Swapnil Shrivastav, Venkatesh RY

From 4,000 Litres to 1 Million Litres

Uravu's vision is to scale FromAir® production to 1 million litres per day in the next five years. This will mean:

- Over 700+ million litres of groundwater saved annually
- Replacing millions of single-use plastic bottles
- Empowering communities, buildings, and businesses with local, decentralized water access

One key milestone in this direction has been the shift from bottles to on-site installations. Uravu is now enabling buildings, hotels, and industries to generate their own water right where it's needed—removing the need for tankers, jars, and dependence on municipal supply. This is the water infrastructure for the 21st century—decentralized, resilient, and renewable.

The Bigger Picture: Water, Redefined

At its core, Uravu isn't just a water company. It is an idea—that technology and sustainability can go hand in hand. By creating affordable water from air, Uravu Labs offers not just a technical breakthrough, but a mindset shift. It asks us to rethink what we consume, how we consume it, and where it comes from.

And in doing so, it shows us that perhaps the answers to our greatest crises have been floating above us, all along.

Swapnil Shrivastav
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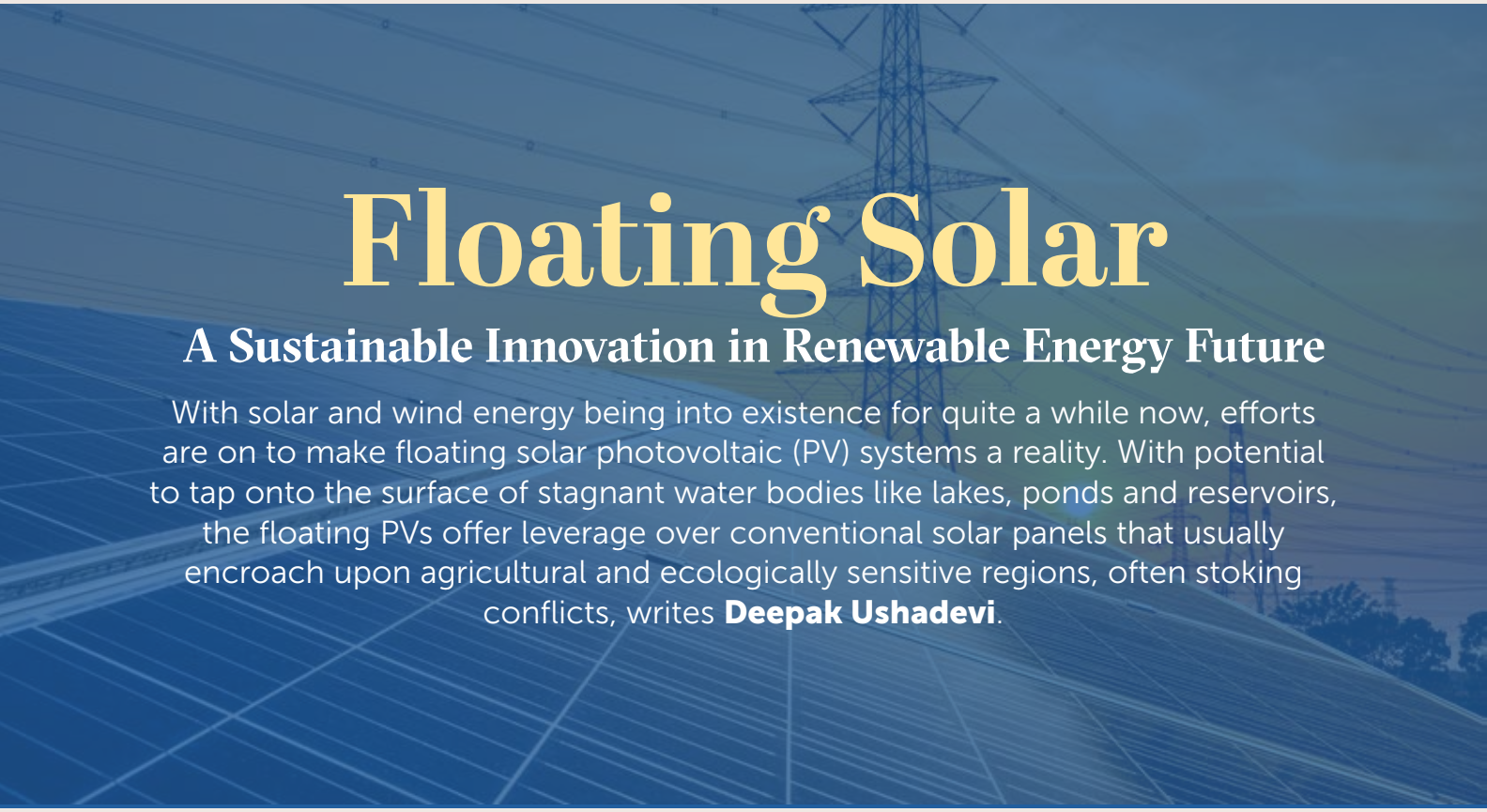

Floating Solar

A Sustainable Innovation in Renewable Energy Future

With solar and wind energy being into existence for quite a while now, efforts are on to make floating solar photovoltaic (PV) systems a reality. With potential to tap onto the surface of stagnant water bodies like lakes, ponds and reservoirs, the floating PVs offer leverage over conventional solar panels that usually encroach upon agricultural and ecologically sensitive regions, often stoking conflicts, writes **Deepak Ushadevi**.

An inventive breakthrough in the field of renewable energy is floating solar photovoltaic (FPV) technology, which addresses land-use restrictions while providing a sustainable response to the rising need for clean electricity. As the world's energy revolution picks up speed, floating solar becomes a strategic advantage, especially for nations like India where land scarcity and population density make large-scale ground-mounted solar deployment extremely difficult. Floating solar systems, which are mounted on the surface of still water bodies like lakes, ponds, and reservoirs, offer a practical solution that makes use of unused aquatic areas to generate electricity. The worldwide movement for floating solar is accelerating, with India in a strong position to benefit from its extensive reservoir network and benevolent regulatory climate.

Advantages of Floating Solar

Natural cooling system

The energy yield of floating solar power systems is significantly higher. The effectiveness of the solar panels is increased because of the water body's natural cooling effect, which keeps the panels' working temperature lower. Up to 5–7% more electricity can be produced by floating PV systems than by traditional ground-mounted ones. In comparable climates, the energy production of floating solar arrays is around 6% higher. Particularly in areas with high temperatures, the improved performance results in a higher return on investment and more possibilities for power generation.

Reduced water evaporation

Water saving is another important advantage of floating solar. Solar panels lower the amount of direct sunlight that water is exposed to by covering the surface of lakes, ponds, and reservoirs, which significantly decreases evaporation rates. Up to 60–75% of water evaporation can be reduced with floating solar panels. This is especially helpful in places that are prone to drought and water scarcity. Installing a standard 1 MW floating solar plant on a 1-hectare body of water can save around 37 million litres of water annually, making a significant contribution to the preservation of water resources.

Saving of Land

Floating solar technology effectively tackles the increasing issue of land scarcity. Traditional ground-mounted solar systems require extensive land areas, frequently encroaching upon agricultural or ecologically sensitive regions. In contrast, floating solar systems offer a viable solution by making use of underutilized water bodies. In countries with limited land resources, such as India, reaching the floating solar goal of 10 GW could preserve more than 22,000 acres of land. This approach not only promotes sustainable development but also reduces conflicts related to land acquisition and mitigates environmental harm.

Reduced carbon emission

From an ecological perspective, floating solar installations provide numerous environmental advantages. By providing shade to the water, these systems inhibit algae proliferation and contribute to improved water quality. Additionally, when implemented with care, they present a negligible threat to aquatic biodiversity. Regarding climate initiatives, a 1 MW floating solar project can mitigate approximately 800–1500 tonnes of CO_2 emissions each year—an environmental effect comparable to the annual planting of about 38,750 to 57,500 trees.

Hybrid system

Floating solar technology holds significant strategic importance in enhancing grid and operational efficiency. Numerous floating solar installations are situated on reservoirs linked to hydroelectric dams, facilitating the use of shared transmission infrastructure and the advantages of hybrid systems. This co-location can assist in balancing grid loads, minimizing curtailment, and enhancing overall energy availability.

The economic benefits of floating solar technology are highly encouraging. These systems can be situated close to industrial facilities or urban areas, which minimizes transmission losses and enhances energy accessibility.

The levelized cost of electricity (LCOE) for floating solar can be lower than that of ground-mounted systems, considering the greater energy output, water conservation, and decreased land expenses, which provide significant long-term advantages. As innovation progresses and economies of scale are realized, floating solar is swiftly emerging as a viable and sustainable option for the deployment of clean energy.

Secondary Benefits of Floating Solar

Floating solar + fish farming

Floating solar initiatives are being combined with aquaculture in certain areas, resulting in what is referred to as 'floatovoltaics-aquaculture hybrid' systems. This innovative use of water surfaces enables local communities to produce energy while simultaneously benefitting from fish farming, thereby, uplifting their socio-economic circumstances.

Self-power consumption

Floating solar technology can be implemented on industrial water

bodies. Facilities such as mines, thermal power plants, and refineries that have substantial water storage or wastewater ponds can leverage this technology to reduce their internal energy consumption. This approach enables industries to realize cost savings on energy and meet sustainability objectives without modifying current operations or requiring extra land, while also minimizing water evaporation from storage.

Green hydrogen + FPV

The FPV and hydrogen system meets 99.43% of the electricity requirements. The water bodies can support a floating PV system, which is sufficient to produce green hydrogen.

Lower soiling and maintenance requirements

Floating panels are less susceptible to dust and debris accumulation than ground-mounted systems, particularly in arid or desert regions. This results in a reduced need for cleaning, thereby conserving water for maintenance and decreasing operational expenses.

Customized solution

The flexibility and expandability of floating solar systems enhance their appeal. The technology can be tailored to different dimensions and setups, enabling developers to modify installations according to the available water surface area, depth, and environmental factors. Consequently, floating solar is ideal for a wide range of applications, from small community initiatives to large-scale installations that are integrated with current infrastructure.

The Global Floating PV (FPV) Market is Forecasted to Install 13.7 GW by 2026

The leading eight nations with the most FPV installations during 2020–2021 are Mainland China, India, Japan, and South Korea, with a notable rise in India's share. Additionally, 70 markets are engaged in 51 GW of FPV projects, majority of which are still in preliminary phases such as 'potential' and 'preplanning'. From 2022 to 2026, the foremost three FPV markets are anticipated to be India (23%), Indonesia (18%), and South Korea (15%) with a 11 GW market projection.

Around 2GW of floating is at various tendered stages in India, many of the water bodies are part of hydro reservoirs. Studies have indicated the potential for about 600–725 GW of floating solar in India, with grid connected projects on still water considered alone.

Conclusion

Floating solar is a revolution in renewable energy. In recent years, floating solar (Floatovoltaics) has emerged as a promising innovation in the renewable energy field. Having several benefits such as optimal land use, increased power generation efficiency, low water evaporation, employment generation and local economic boost, environmental benefits, relaxed energy goals with temporary solar support, contribute to India's ambitious renewable energy goals (500 GW non-fossil capacity) without additional land pressure. These advances mark an important step towards diversifying solar deployment and maximizing the utility of water surfaces. Floating continues to receive traction as an important component of solar global renewable energy mixture, bridges the gap between nature and technology, proving that progress and preservation can sail together. As the world moves towards decarbonization, floating solar stands as a testament to innovation, proving that the vast expanse of water bodies holds the key to a brighter, greener future.

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Hydrogen-fuelled Buses and Trucks Introduced

Under the National Green Hydrogen Mission

Dr Sujit Pillai highlights a milestone in sustainable transportation as India advances with the rollout of hydrogen-powered buses and trucks under the National Green Hydrogen Mission (NGHM). This ambitious initiative underscores the country's increasing dedication to addressing climate change and building a future centred on clean, renewable energy. As global efforts to cut carbon emissions accelerate, India is positioning itself as a leader in leveraging Green Hydrogen to revolutionize transportation and drive industrial decarbonization.

In a landmark development towards sustainable transportation, India has taken a significant step forward with the introduction of hydrogen-fuelled buses and trucks under the National Green Hydrogen Mission (NGHM). This bold move reflects India's growing commitment to combat climate change while laying the groundwork for a future driven by clean and sustainable energy sources. As nations across the globe intensify efforts to reduce their carbon footprint, India is steadily emerging as a frontrunner in adopting Green Hydrogen as a transformative fuel for mobility and industrial decarbonization.

The Vision for Sustainable Transportation

The transportation sector has long been a significant contributor to India's carbon footprint, accounting for a substantial portion of greenhouse gas emissions. Recognizing this challenge, the Indian government has set ambitious goals to transform the sector through the adoption of Green Hydrogen as a viable fuel source. During a flag-off ceremony on March 4, 2025, Union Ministers Shri Nitin Gadkari and Shri Pralhad Joshi emphasized the importance of hydrogen in achieving a sustainable and low-carbon future.

Minister Gadkari articulated that hydrogen holds immense potential to revolutionize India's transportation sector. He stated, "Such initiatives will accelerate the transition to sustainable mobility in heavy-duty trucking, moving us closer to an efficient, low-carbon future." This vision aligns with India's broader goals of achieving net-zero emissions by 2070, as outlined in various national policies and commitments.

Minister Joshi echoed this sentiment, highlighting the role of hydrogen in India's transition to a sustainable and zero-carbon future. He remarked, "The beginning of this trial is a significant step forward in showcasing the potential of green hydrogen in decarbonizing India's transportation sector." The introduction of hydrogen as a fuel source is not merely an environmental imperative; it is a strategic move that aligns with global efforts to combat climate change.

National Green Hydrogen Mission

The NGHM was launched with the aim of creating a robust ecosystem for green hydrogen in India. With an initial outlay of ₹19,744 crore, the mission is designed to catalyse the development of the green hydrogen ecosystem, create demand, support production, and lay down the necessary infrastructure for growth. By 2030, the target is to achieve a minimum of 5-million metric tonnes (MMT) of annual capacity for green hydrogen production.

The mission's goals are ambitious yet achievable, positioning India as a global leader in the green hydrogen space. To ensure the success of this mission, the government is heavily investing in research and development, fostering innovation, and encouraging collaboration between public and private sectors.

Pilot Projects and Infrastructure Development

As part of the NGHM, the Automotive Research Association of India (ARAI) has awarded five pilot projects worth ₹208 crore, which comprise of a total of 37 hydrogen-powered buses and trucks, along with 9 hydrogen refuelling stations across 10 different routes. An advance amount of ₹41.58 crore has already been released to kickstart these initiatives. The details of these 5 projects are as follows:

A. NTPC Ashok Leyland Consortium:

Under the National Green Hydrogen Mission, NTPC has collaborated with Ashok Leyland (AL) to deploy six 12-metre hydrogen fuel cell (FC) buses. These buses will operate along two key routes: Greater Noida–Delhi–Agra and Bhubaneswar–Konark–Puri. Hydrogen Refuelling Stations (HRS) to support these operations will be set up at the NTPC campus in Greater Noida and in Bhubaneswar. The project has received ₹39.05 crore as sanctioned viability gap funding.

B. Tata Motors – IOCL Consortium:

Tata Motors and Indian Oil Corporation Limited (IOCL) are jointly implementing the largest pilot in terms of vehicle diversity. Their fleet will include two 12-metre FC buses, eight 55-tonne hydrogen internal combustion engine (ICE) trucks, four 28-tonne ICE trucks, and two 55-tonne FC trucks. These vehicles will be tested across major industrial corridors such as Ahmedabad–Vadodara–Surat, Sahibabad–Faridabad–Delhi, Pune–Mumbai, and Jamshedpur–Kalinga Nagar. HRS infrastructure is planned along the Balasore and Mumbai Highway routes. The consortium has been allotted ₹70.02 crore under the mission.

C. ANERT – BPCL Consortium:

The Agency for Non-conventional Energy and Rural Technology (ANERT) has partnered with Bharat Petroleum Corporation Limited (BPCL) to test hydrogen-powered heavy-duty trucks in Kerala. This project includes two 28-tonne FC trucks and two 28-tonne ICE trucks, operating on routes between Thiruvananthapuram–Kochi and Kochi–Edappally. To facilitate this, HRS stations will be developed in Trivandrum and Kochi. With ₹34.84 crore in funding, this pilot aims to explore the integration of hydrogen mobility in South India.

D. Reliance Industries – Ashok Leyland Consortium:

Reliance Industries Limited (RIL) and Ashok Leyland are collaborating to pilot a mix of hydrogen vehicle technologies, including one 11-metre hydrogen ICE bus, one 13.5-metre fuel cell electric vehicle (FCEV) bus, and multiple hydrogen-powered trucks: three 19-tonne ICE trucks, three 28-tonne ICE trucks, and two 35-tonne FCEV trucks. These vehicles will operate between Jamnagar and Ahmedabad, with refuelling stations planned near Rajkot and near Vadodara. The project has been granted ₹46.87 crore under the NGHM.

E. HPCL – Volvo Consortium:

Hindustan Petroleum Corporation Limited (HPCL) has teamed up with Volvo to operate a single 40-tonne hydrogen ICE truck along National Highway 16, covering the route between Visakhapatnam and Bayyavaram. A dedicated HRS will be established at Bayyavaram, Anakapalli, to support the operation. This pilot, backed by ₹17.13 crore, will help evaluate the long-haul performance of hydrogen-powered heavy-duty trucks on freight corridors.

These pilot projects are likely to be commissioned in the next 18–24 months. The trials will not only demonstrate the safe and secure operations of hydrogen-based vehicles but will also assess their effectiveness, validate technical feasibility, and evaluate their economic viability under real-world operational conditions.

Economic and Environmental Impact

The introduction of hydrogen-fuelled buses and trucks is expected to have a profound impact on both the economy and the environment. By reducing reliance on fossil fuels, hydrogen can help lower greenhouse gas emissions, contributing to cleaner air and a healthier environment. This transition is particularly crucial in urban areas, where air pollution from traditional diesel vehicles poses significant health risks.

Moreover, the development of a hydrogen economy can create new job opportunities in manufacturing, infrastructure development, and maintenance of hydrogen-powered vehicles. As the demand for green hydrogen grows, it will stimulate investments in research and development, fostering innovation and technological advancements.

The economic benefits extend beyond the transportation sector. By investing in hydrogen infrastructure, India can enhance its energy security and reduce its dependence on imported fossil fuels. This shift towards domestic energy sources aligns with the government's vision of achieving energy independence and promoting sustainable development.

Challenges and Path Forward

While the potential of hydrogen as a clean fuel is immense, several challenges must be addressed to realize its full potential. One of the primary challenges is the establishment of a comprehensive hydrogen infrastructure, including production, storage, and distribution facilities. Additionally, public awareness and acceptance of hydrogen-powered vehicles will play a crucial role in their adoption.

Collaboration between government bodies, industry leaders, and research institutions will be essential in overcoming these challenges. By fostering partnerships and sharing knowledge, stakeholders can work together to develop innovative solutions that drive the hydrogen economy forward.

As the nation moves forward with these pilot projects, the collaboration between government bodies, industry leaders, and stakeholders will be vital in ensuring the success of this mission. Together, they will strive for a greener tomorrow, powered by innovation and collective action.

The introduction of hydrogen-fuelled buses and trucks under the NGHM marks a significant milestone in India's journey towards a cleaner and more sustainable future. This initiative not only aligns with global efforts to combat climate change but also positions India as a potential leader in the green hydrogen space.

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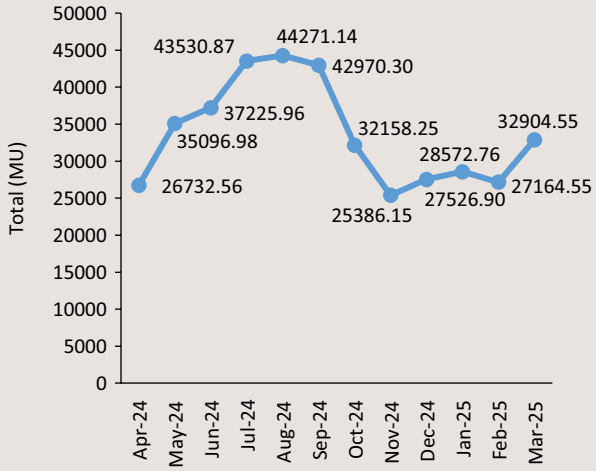
All India Total Renewable Energy Generation in March 2025



Source: CEA

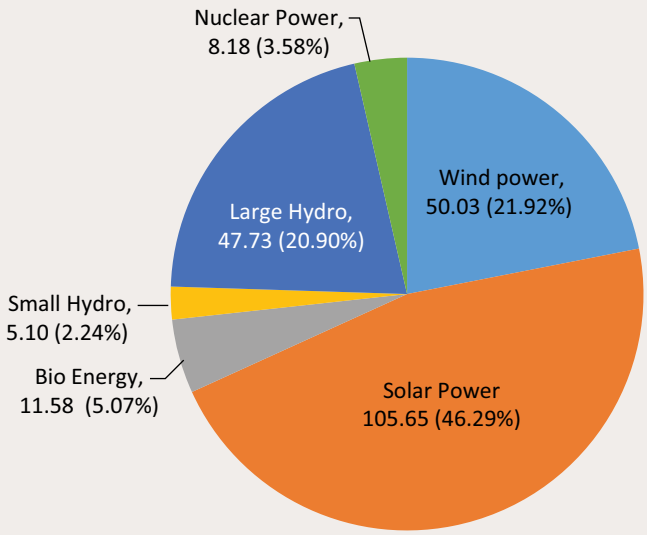
Month	Wind	Solar	Biomass	Bagasse	"Small Hydro"	"Large Hydro"	Others	"Total (MU)"
Mar-24	4578.06	12225.83	305.15	1455.71	468.22	7015.7	251.42	26300.10
Apr-24	4729.26	12021.05	278.73	781.11	581.9	8109.14	231.36	26732.56
May-24	8257.63	12645.99	295.16	317.07	734.16	12595.42	251.56	35096.98
Jun-24	10134.92	11445.66	273.43	188.61	776.37	14173.69	233.29	37225.96
Jul-24	13627.00	10356.35	284.12	132.36	1323.02	17562.91	245.11	43530.87
Aug-24	10268.88	10157.52	297.05	132.17	1600.37	21565.90	249.24	44271.14
Sep-24	8870.62	11302.62	258.15	118.58	1612.83	20574.25	233.26	42970.30
Oct-24	3238.28	12256.61	337.9	166	1457.59	14455.88	245.98	32158.25
Nov-24	3109.33	11246.52	321.47	980.79	860.92	8630.89	236.23	25386.15
Dec-24	5747.49	10707.21	350.76	1935.01	807.35	7753.43	225.65	27526.90
Jan-25	5637.69	12285.74	356.41	2041.06	624.57	7388.05	239.24	28572.76
Feb-25	4592.48	12913.58	339.16	1556.29	561.87	6970.88	230.79	27164.55
Mar-25	5133.63	16811.38	346.33	986.25	615.16	8763.28	248.51	32904.55

Source: CEA

State wise RE Generation (MU)		
Name of State/UT	**Mar-25**	**Mar-24**
NORTHERN REGION		
Chandigarh	0.40	0.63
Delhi	60.58	64.57
Haryana	194.75	156.70
Himachal Pradesh	1701.02	1737.41
Jammu & Kashmir	991.89	1128.93
Ladakh	15.02	15.00
Punjab	541.62	537.14
Rajasthan	6232.37	4824.80
Uttar Pradesh	1060.68	953.55
Uttarakhand	854.01	785.78
SUB TOTAL (NR)	11652.35	10204.51
WESTERN REGION		
Chhattisgarh	353.85	265.77
Gujarat	5792.46	3571.39
Madhya Pradesh	1769.86	1382.09
Maharashtra	2373.75	2071.41
Dadra and Nagar Haveli and Daman and Diu	2.68	2.98
Goa	5.44	5.44
Sub Total (WR)	10298.04	7299.07
SOUTHERN REGION		
Andhra Pradesh	1532.47	1353.86
Telangana	974.71	774.15
Karnataka	4045.61	2909.50
Kerala	702.27	641.57
Tamil Nadu	2370.31	1864.00
Lakshadweep	0.01	0.01
Puducherry	1.02	1.02
SUB TOTAL (SR)	9626.40	7544.11
EASTERN REGION		
Andaman Nicobar	3.36	4.49
Bihar	50.20	41.97
Jharkhand	10.34	9.91
Odisha	532.84	488.63
Sikkim	49.10	41.70
West Bengal	339.46	306.42
SUB TOTAL (ER)	985.30	893.05
NORTH-EASTERN REGION		
Arunachal Pradesh	184.22	226.88
Assam	89.12	66.79
Manipur	19.71	14.02
Meghalaya	34.63	27.32
Mizoram	10.01	17.10
Nagaland	4.15	4.76
Tripura	0.61	2.50
SUB TOTAL (NER)	342.46	359.37
ALL INDIA TOTAL	**32904.55**	**26300.11**

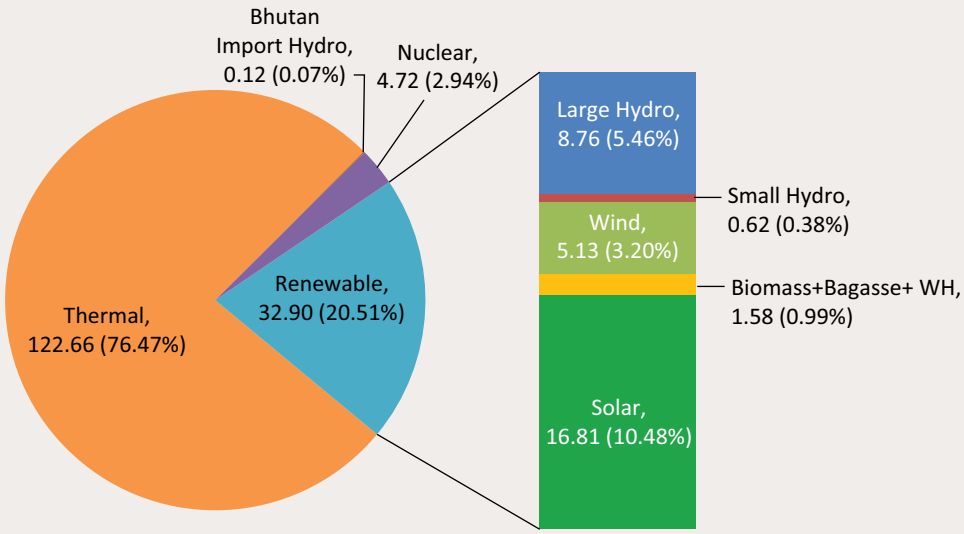
Source: CEA

Installed RE Capacity as on March 31, 2025: 228.27 GW

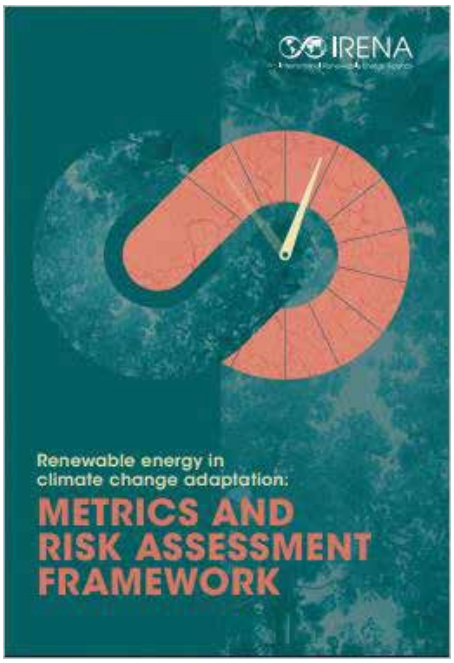


Source: MNRE

All India Monthly Energy Generation in India, 160.40 BU and Share of RE, 32.90 BU (20.51%) March 2025



Source: CEA

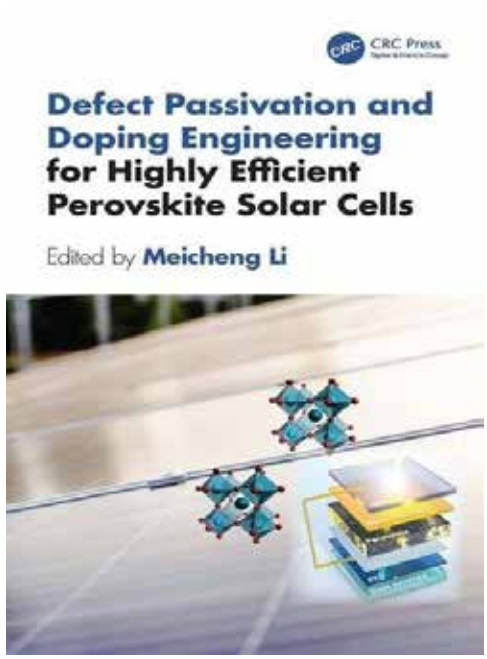


Renewable energy in climate change adaptation: Metrics and risk assessment framework

Author- IRENA (International Renewable Energy Agency)
Year- 2025
ISBN: 978-92-9260-655-8

Analysing the convergence of renewable energy and climate adaption strategies offers a vital opportunity to confront dual issues of mitigating climate consequences and promoting sustainable development. Advocating for renewable energy as an adaptation method necessitates informed policymaking and increased understanding of its advantages, such as diminished greenhouse gas emissions, bolstered energy security, improved socio-economic results, and heightened resistance to climate effects. The document emphasizes the identification and quantification of adaptation needs, offering a methodology for prospective indicators and metrics to effectively evaluate the advantages of renewable energy as a risk mitigator in adaption efforts.

Risk assessment constitutes the initial phases of climate adaptation, facilitating the evaluation of potential impacts and vulnerabilities to formulate appropriate responses. It includes a case study of the Canary Islands to evaluate the risks associated with heightened energy demand, GHG emissions, as well as the role of renewables in mitigating this risk.



Defect Passivation and Doping Engineering for Highly Efficient Perovskite Solar Cells

Editor: Meicheng Li
Year: 2025
Publisher: CRC Press
ISBN: 9781032614168

Perovskite solar cells (PSCs) have garnered heightened interest from academics owing to their exceptional power conversion efficiency. Intrinsic trap defects, inevitably generated during the fabrication process, can lead to non-radiative recombination, ion migration, I-V hysteresis, and instability in perovskite solar cells (PSCs). Nonetheless, trap faults are not invariably detrimental. A comprehensive understanding of trap faults, together with passivation and doping techniques, is beneficial for enhancing device efficiency and stability. This book elucidates the methodologies and tactics for defect passivation and material doping, with the objective of clearly delineating the fundamental principles that contribute to high-efficiency and stable perovskite solar cells (PSCs). It presents the essential attributes of flaws in perovskite materials and examines the primary methodologies, principles, and applications of defect passivation. It also elucidates the ramifications of defect passivation and the methodologies for characterization. Explores the principles, methodologies, and applications of doping engineering in perovskites and investigates the structural design, benefits, attributes, fabrication techniques, and prospective advancements of perovskite homojunctions.


NATIONAL
Solar & Storage Expo 2025 Rajasthan
June 20, 2025 | Jaipur, Rajasthan, India
Mercom India Renewables Summit
July 24-25, 2025 | New Delhi, India
4th Green Hydrogen India
August 6-8, 2025 | New Delhi, India
Energy Transition Summit India
September 16-17, 2025 | New Delhi, India
Renewable Energy India Expo 2025
October 30, 2025 - November 1, 2025 | New Delhi, India


INTERNATIONAL
British Renewable Energy Awards 2025
June 12 , 2025 | Piccadilly, London, UK
ASEAN Sustainable Energy Week
July 2–4, 2025 | Bangkok, Thailand
UK Solar Summit
July 1–2, 2025 | London, United Kingdom
2nd World Summit and Expo on Renewable and Non-Renewable Energy
September 22–24, 2025 | Frankfurt, Germany

RNI No DELENG/2007/22701

Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan **(PM-KUSUM)** Scheme was launched in March 2019 by the Government of India, aiming to boost farmers' income by decreasing reliance on diesel and promoting the use of solar energy in agricultural activities. Under the Scheme, central government subsidy up to 30% or 50% of the total cost is given for the installation of standalone solar pumps and also for the solarization of existing grid-connected agricultural pumps. Further, farmers can also install grid-connected solar power plants up to 2 MW under the Scheme on their barren/fallow land and sell electricity to local DISCOM at a tariff determined by state regulator. This scheme is being implemented by the designated departments of the State Government.

For more information: https://pmkusum.mnre.gov.in/