

India's Energy Transition: The Way Forward





Message from Chairman Energy Committee AMCHAM India

India, one of the world's fastest-growing global economies, shall witness a significant rise in energy demand over the coming decades. Meeting this demand sustainably — while ensuring affordability, security, and resilience, places India as a leader in the global climate agenda.

The Government of India has laid out an ambitious vision-achieving net-zero emissions by 2070, ensuring sustainable and clean energy, achieving 500 GW of non-fossil fuel electricity capacity by 2030, and ensuring energy security for all citizens. The focus is on transitioning to a circular and green economy and strengthening energy efficiency across industries.

AMCHAM members, U.S. companies in India, have been actively partnering in India's energy growth, bringing-in globally proven technological capabilities and have been actively contributing to India's energy transformation.

AMCHAM's vision paper, *'India's Energy Transition: The Way Forward,'* prepared with inputs from AMCHAM's Energy Committee and knowledge partner, Dastur Energy, covers major areas where U.S. companies are actively working in India and have huge untapped potential for generating active partnerships. The document covers strategic interventions required to leverage the technical capabilities of U.S. companies in the areas of coal, natural gas, and renewables, advanced biofuels, coal gasification with carbon management and CCUS, energy efficiency and smart grids, storage, and AI-driven energy optimization as an integral enabler.

I am confident that with meaningful collaborations and investments, U.S. companies in India will continue to partner actively to support India to achieve its ambitious clean-energy goals and remain committed to long term association in this growth journey.

Anil Bhatia
Vice President & Managing Director – India
Emerson



Message from the Director General CEO AMCHAM India

India, the world's third-largest energy consumer, is poised for the highest energy demand growth. India is the 4th largest renewable energy producer and 3rd in solar power globally. The Government of India has focused on holistic and long-term structural improvements in the sector, with a focus on achieving 24x7 power for all.

Energy security is fundamental to economic growth, social well-being and inclusive growth. The United States of America and India have been long committed to partnership in this vital sector and have time and again reaffirmed the U.S.-India Energy Security Partnership and are keen to strengthen the partnership to ensure energy affordability, reliability, availability and stable energy markets.

AMCHAM's vision paper, 'India's Energy Transition: The Way Forward' sets forth a strategic framework for India's energy transformation. It emphasizes energy diversity, leveraging domestic endowments such as coal, natural gas, and renewables, combined with targeted deployment of clean coal technologies, coal gasification with carbon management, accelerating advanced bio-fuel adoption and natural gas expansion. Collaborative innovation with global partners, particularly the United States, across CCUS, smart grids, storage, SMRs, and AI-driven energy optimization, is identified as an integral enabler.

The document has also captured the capabilities of the best practices of U.S. industry in India. It highlights work undertaken in the global energy sector, future plans, contribution to the Indian economy by operating in the energy sector through technology sharing and indigenization, direct and indirect employment, talent and skilling and how they have bolstered the ecosystem through research and development. It provides reference information on the U.S.-India partnership in the energy sector and would help synergize forthcoming opportunities of collaboration.

Ranjana Khanna
Director General CEO
AMCHAM India



The American Chamber of Commerce in India

AMCHAM India is the leading apex chamber of U.S. industry in India. Established in 1992, AMCHAM has over 400 U.S. companies as members and plays a pivotal role in fostering strong ties between the U.S. and India. The incumbent U.S. Ambassador to India is the Honorary President of AMCHAM. The chamber enjoys a close relationship with the U.S. Embassy and complete support in fulfilling its objectives.

Country Heads of leading U.S. companies constitute the elected national executive board. The chamber's mission is to assist member companies to succeed in India through advocacy, information, networking and business support services. Headquartered in New Delhi, AMCHAM extends its influence through regional chapters in Bengaluru, Chennai, Hyderabad, Kolkata, Mumbai and Pune.

AMCHAM India is a member of the U.S. Chamber of Commerce in Washington DC and the AmCham's of Asia Pacific.



Our Partners



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Executive Summary

India stands at a pivotal moment in its development journey, where securing energy abundance, affordability, reliability, and sustainability is essential for long-term growth, industrialization, and global leadership. This whitepaper sets forth a strategic framework for India's energy transformation, rooted in evolutionary, pragmatic change. It emphasizes energy diversity, leveraging domestic endowments such as coal, natural gas, and renewables, combined with targeted deployment of clean coal technologies, coal gasification with carbon management, natural gas expansion, and the integration of small modular reactors (SMRs) as a scalable source of firm, zero-carbon baseload power. Collaborative innovation with global partners, particularly the United States, across SMRs, CCUS, smart grids, storage, and AI-driven energy optimization, is identified as an integral enabler. The overarching objective is to achieve minimum emissions while preserving affordability, reliability, and scalability. India's energy future must be Indian in ambition, global in technology, pragmatic in governance, collaborative in innovation, and resilient in design.

Energy as the Foundation of India's Growth Trajectory

India's economic growth and global leadership aspirations rest critically on the strength of its energy system. Energy is not merely a sectoral input; it forms the very foundation of industrialization, technological advancement, social development, and geopolitical influence. In this decisive decade, India must pursue a full-fledged energy transformation—not a superficial transition—that constructs an energy system capable of delivering abundance, affordability, reliability, and decarbonization simultaneously.

Strategic Use of Domestic Endowments and Technology Leadership

This transformation must be anchored in the intelligent and strategic use of India's domestic energy resources, while fostering leadership in diverse and critical technologies. No single fuel or technology pathway will suffice to meet India's complex and growing energy demands. Instead, the architecture must be broad-based and balanced, drawing upon the complementary strengths of clean coal, coal gasification, nuclear energy, natural gas, renewable generation, advanced energy storage, and carbon management systems. The approach must remain rooted in economic discipline, industrial competitiveness, and systemic resilience.

Coal Gasification and Clean Coal Technologies

Coal, being India's most abundant and secure energy resource, must be transformed through modern technological deployment. Rather than being phased out, coal must evolve. The aggressive adoption of clean coal technologies and coal gasification will allow high-ash Indian coal to be converted into cleaner syngas, hydrogen, methanol, and synthetic fuels. These products can form the basis of a new generation of cleaner power generation and low-carbon industrial feedstocks. High-efficiency, low-emissions (HELE) plants, when integrated with carbon capture, utilization, and storage (CCUS), can significantly reduce the carbon intensity of coal-based power. Regional gasification hubs, strategically located near coalfields, can serve as the nuclei for industrial ecosystems that are both cleaner and more economically integrated, reducing transport bottlenecks while generating employment and reducing emissions.

Nuclear Energy and the Strategic Role of SMRs

To provide firm, clean, and scalable baseload power, India must embrace nuclear energy with renewed urgency, particularly through the deployment of small modular reactors. SMRs offer a suite of advantages highly compatible with India's evolving energy landscape. Their smaller scale allows more rapid deployment and siting flexibility near urban centers, industrial clusters, or regions with limited transmission infrastructure. Their safety features, modular construction benefits, and lower upfront capital intensity make them ideally suited to India's infrastructure and financing constraints. Most importantly, SMRs provide zero-carbon electricity that can reliably complement intermittent renewables and displace more polluting baseload sources, reinforcing both decarbonization and grid reliability. Pragmatic integration of renewable energy renewables, especially solar and wind, will remain central to India's energy expansion. Yet, their integration must be shaped by system-wide pragmatism. Experience from jurisdictions such as Germany and California illustrates the risks of over-reliance on variable renewables without adequate firm backup. India must avoid replicating these vulnerabilities. Instead, a resilient grid must be anchored by firm generation from clean coal with CCUS, syngas-based plants, nuclear SMRs, and natural gas. These resources ensure grid stability, prevent price volatility, and safeguard economic performance. Storage solutions such as batteries and pumped hydro must be deployed where economically justified, as supplements to—not substitutes for—firm power. Storage deployment must be driven by system needs and cost-effectiveness, not by prescriptive planning.

Natural Gas as a Structural Transition Fuel

Natural gas must be recognized not as a temporary bridge but as a structural component of India's long-term energy strategy. With significantly lower carbon emissions than traditional coal combustion, high dispatchability, and reasonable costs, natural gas is uniquely positioned to support both firm power generation and cleaner industrial energy use. India must expand its LNG infrastructure, strengthen domestic pipeline networks, and develop hybrid syngas-natural gas clusters around industrial demand centers. Simultaneously, domestic production of natural gas, biogas, and biomethane must be accelerated to enhance energy security and reduce import dependence.

Biofuels Complementing Hydrocarbons

Biofuels can effectively supplement hydrocarbons as "drop-in" fuel and chemical feedstock due to their chemical similarity, allowing them to be used in existing infrastructure without significant modifications. Advancements in technology, scaling up production, and utilizing waste-derived feedstocks can help lower costs significantly with focus upon affordability by feedstock supply chain cost and availability.

Grid Modernization and Carbon Management Infrastructure

The reliability and resilience of the national grid must be treated as core pillars of infrastructure development. Integrating both firm and variable resources will require the development of flexible, intelligent, and digitally managed transmission and distribution networks.

Simultaneously, carbon management must be embedded into India's industrial and power planning frameworks. CCUS must move beyond demonstration to scale, with hubs

developed across major industrial corridors and coal-heavy regions. These hubs will be critical to decarbonizing India's existing industrial base while enabling new low-carbon industrial growth anchored in syngas, hydrogen, and clean power. Energy efficiency as a national mission reducing the energy intensity of India's economy must become a central national objective. Across sectors—from heavy industry to transportation and buildings—significant efficiency gains are possible. These not only lower emissions but also reduce operating costs, improve competitiveness, and moderate future energy demand growth. A coherent national mission on energy efficiency can drive behavioral change, technology deployment, and market-based incentives to accelerate adoption.

Affordable Battery and LDES

Affordable long-duration energy storage (LDES) is crucial for a reliable and decarbonized power grid, particularly as reliance on renewable energy sources increases, thus helping grid support and stabilization.

Minimum Emissions with Realism and Measurability

India's energy transformation must be guided by a clear focus on achieving minimum emissions in a manner that aligns with its developmental priorities and systemic realities. Rather than pursuing abstract or rigid net-zero targets, the emphasis should be on real, measurable progress in reducing emissions while ensuring affordability, reliability, and scale. Sector-specific pathways, grounded in available resources and technological feasibility, should define the pace and nature of decarbonization. This approach ensures that emissions reduction becomes a driver of long-term resilience and economic strength, not a constraint. By anchoring climate action in practical implementation, India can deliver sustained progress without compromising energy security or access.

U.S.-India Collaboration as a Strategic Enabler

Strategic technological partnerships with the United States will be essential to accelerate this transformation. Collaboration across domains such as small modular reactors, smart grid design, advanced CCUS systems, large-scale energy storage, and AI-based system optimization will allow India to leapfrog legacy technologies and rapidly scale solutions. Such collaboration should not be peripheral but integrated into India's core energy strategy, supporting both near-term deployment and long-term capability building.

The Need for an Integrated, Pragmatic Policy Framework

This energy transformation cannot occur spontaneously. It must be led by an integrated policy framework that coherently aligns India's energy, industrial, financial, innovation, and environmental objectives. Policies must support firm and flexible generation alongside renewables, enable economically sound CCUS and storage investments, facilitate technology transfer and capacity building, and preserve affordability for households and industries alike. Above all, policymaking must be grounded in practical implementation realities, with flexibility to evolve based on results and changing conditions.

Conclusion: An Indian path to energy transformation means India's energy strategy must be built not on disruption but on strategic evolution—rooted in Indian realities, powered by global innovation, and governed by pragmatic policy design. By expanding firm capacity through clean coal, coal gasification, CCUS, natural gas, and SMRs, and by integrating renewables and storage with economic discipline, India can construct a system that is abundant, affordable, reliable, and progressively lower in emissions. The objective is not theoretical perfection, but practical excellence—achieving minimum emissions while sustaining growth, resilience, and opportunity. The future must be Indian in ambition, global in technology, pragmatic in governance, collaborative in innovation, and resilient in design.



1. Coal Gasification and Clean Coal Technologies - CCUS

It is with a two-fold view of environmental concerns and simultaneously utilizing the most abundant domestic feedstock reserve, the Government of India has launched its National Gasification Mission, with a target of gasifying 100 million tons of Indian coal by the year 2030.

Hyper-Scale Modular Coal Gasification with Carbon Capture: India's coal can be utilized more effectively by converting it into synthetic fuels, industrial feedstocks, and low-carbon firm power using U.S. based modular gasifier designs along with integrated carbon capture for EOR. This accelerates energy expansion and security while reducing emissions intensity.

Syngas is primarily produced via gasification of fossil feedstocks such as coal. The economic rationale for this is that this is an inexpensive way to liberate the hydrogen in the feedstock given the ability to freely emit carbon. In this paradigm, syngas will come from reverse water gas shifting CO₂ to CO with green hydrogen being used as both the reducing agent and the source of thermal energy to drive this endothermic equilibrium reaction. This switch will elevate the importance of technologies that can make use of syngas. Coal gasification does produce less CO₂ in a more concentrated stream—enabling easier and more economic capture options than CO₂ from combustion.

Available Technologies

There exist opportunities to use commercially available technology to dehydrate ethanol to ethylene, a fundamental building block for modern chemistry and the backbone of the chemical industry – thereby achieving a three-way objective with a single solution: (1) utilization of abundant domestic reserves of fossil feedstock like coal in an (2) environmentally friendly/clean/zero-emission manner, thereby (3) provide the world with an economical and sustainable route to maintaining the existing value chain.



Policy Recommendations to Enable CCU Deployment in India

1. Establish a National CCU Incentive Framework

To accelerate the adoption of CCU technologies, India should introduce a dedicated incentive framework like the production linked incentive (PLI) schemes. This could include:

- Capital subsidies or viability gap funding for first-of-a-kind CCU projects.
- Tax incentives for companies investing in CCU infrastructure.
- Carbon utilization credits that reward industries for converting CO₂ into value-added products.

Such a framework would de-risk early investments and encourage private sector participation in scaling CCU technologies.

2. Integrate CCU into India's Carbon Market and ESG Mandates

India's evolving carbon market and ESG (environmental, social, and governance) reporting standards offer a strategic opportunity to embed CCU:

- Recognize CO₂ utilization as a valid offset mechanism within the Indian carbon credit system.
- Mandate reporting and disclosure of carbon utilization metrics under ESG frameworks.
- Allow tradable credits for verified CO₂-to-product conversions, especially in hard-to-abate sectors like steel, cement, and chemicals.

This would create a financial incentive for industries to adopt CCU technologies.

3. Prioritize CCU in the National Hydrogen Mission and Gasification Roadmap

India's National Coal Gasification Mission should explicitly prioritize CCU as a strategic enabler:

- Encourage co-location of green hydrogen and CCU facilities to produce renewable syngas.
- Provide policy clarity and funding for hybrid projects that combine coal gasification with green hydrogen and CCU.
- Promote public-private partnerships to demonstrate integrated CCU value chains, especially in industrial clusters.

This alignment would ensure that CCU is not treated as an afterthought but as a core pillar of India's clean energy transition.

4. Create a CCU Innovation and Commercialization Fund

To bridge the gap between R&D and commercialization, India could establish a CCU Innovation Fund under the Department of Science & Technology or NITI Aayog:

- Support pilot and demonstration projects for technologies like syngas-to-ethanol platform.

- Facilitate international collaborations and technology transfer.
- Provide low-interest financing or green bonds for scaling up proven CCU technologies.
- This would help Indian industries adopt globally competitive solutions while fostering domestic innovation.

5. Decarbonizing Existing Energy Infrastructure

It is important to employ innovative products and market-leading technologies to reduce energy usage, drive increased efficiency, extend equipment lifespans, and reduce operational costs.

- Advanced sealing and filtration technologies support reduced fugitive emissions, improved energy efficiency, extended equipment lifespans and lower operational costs. Reducing GHG fugitive emissions, especially methane, offers a cost-effective, viable approach to decarbonizing the oil and gas industry.
- Wet-to-dry gas seal retrofits and seal gas recovery solutions can significantly reduce emissions from plants and enable successful gas recycling and recovery.
- Digital and IoT integration of equipments including mechanical sealing solutions would help in predictive maintenance and hence will help to improve uptime and reduce emissions.
- Advanced filtration and mechanical sealing solutions.

2. Small Modular Nuclear Reactors (SMRs) - Accelerating Clean Energy Production, Transmission and Adoption

India announced an ambitious Nuclear Energy Mission in February 2025, with the goal of achieving 100 GW of installed nuclear power capacity by 2047. The United States has always focused on nuclear energy as a key part of its energy security strategy, launching the Advanced SMR R&D Program in 2019. This is a strategic segment for U.S.–India cooperation on nuclear energy, including private sector investment and technology licensing from U.S. companies to India.

SMRs offer a promising solution for clean, dispatchable energy suitable for industrial clusters and grid baseload. U.S. advancements in design and India's potential for engineering and deployment provide a strong basis for collaboration.



While solar and wind will remain central to India's decentralized energy production, nuclear projects will play an important role in meeting the country's growing energy demand—especially as India aspires to become a global hub for computing and AI. As nuclear technology is advanced through the use of 4th-generation and SMR reactors, expertise in handling diverse pressures, temperatures, fluids, and materials would become critical for enabling applications such as sealing solutions and power transmission couplings for circulation pumps in molten salt reactors.

Risk-Sharing Framework for Integration of SMRs: While SMRs offer potential for dispatchable low-carbon power, the absence of clear regulatory, financial, and community frameworks requires careful study.

Renewable Fuels of Non-Biological Origin (RFNBOs)

Opportunity exists in e-SAF and Power to Liquid (PTL) for monetizing the Co₂. EU and UK have already given sub mandates and attractive price for them as Renewable Fuels of Non-Biological Origin (RFNBOs). Going forward, opportunity exists for players to set up the projects in India for satiating domestic demand and even exporting it.

Recommendations:

- Public-private risk-sharing platforms.
- Community buy-in through education and participation in benefit-sharing models.
- Involve the insurance sector and global partners to model nuclear-specific risk coverage.
- U.S.-India bilateral ties on technology-sharing/technology transfer to enable a faster adoption.

3. Grid Optimization and Grid Modernization

Advanced Grid Engineering and Optimization

Grids must be reengineered to integrate, dispatch, and balance firm coal, gas, nuclear, and intermittent renewables to provide dependable and cost-effective power. U.S. and Indian expertise in grid modernization, digital systems, AI-based dispatch, grid economics and reliability engineering can play a key role in this transformation.

Technologies

Distributed Energy Resource Management-Value Add – (DERMS)

- ADMS – Gives visibility and control to the DSO for their network up to the consumer's meter.
- DERMS – Provides visibility and control for everything that's behind the customer's meter/at the grid edge.
- DERs: Renewable based generation (rooftop solar), storage (BESS), controllable load units
- Use-cases: Setpoints for solar PVs, BESS, load shedding.



Benefits of DERMS

- Enhanced visibility - real time insights such as location, performance, status
- Controllability - balancing supply and demand
- Network flow optimization/congestion management
- Manage network constraints (thermal limits, voltage excursions, fault levels)
- Grid flexibility service management
 - Provide valuable resources such as storage (pooled through a geographical area)
 - Integrate more renewables without having to build new lines (defer or avoid CAPEX)
- Secure endpoints to prevent cyber security threats and issue such as PII theft, power grid disruptions, equipment damage

Roadmap for Implementation and Success

DERMS an opportunity for a transition to sustainable future

- Enhanced situational awareness leveraging technology
- Power in the hands of the consumers
- Reduced capex, lower ROW issues

Collaboration is key

- Utilities and solution providers come together to augment products that meet the changing requirements
- Industry Advisory Groups

Implementation

- Identify specific goals
- Establish regulatory framework
 - Ex. FERC Order 2222 allows aggregated DERs to participate in wholesale electricity markets
 - Encourage VPPs to enhance commercial viability and create a thriving market
- DER registry for real-time monitoring and leveraging guidance systems such as forecasting for predictive analytics
- Adopt advanced cyber security standards (NERC CIP / IEEE 1547.3 / CERT-IN), leverage secure communication protocols and identity management techniques
- Capacity building and awareness

4. Growing Critical Energy Demand

India's natural gas consumption is likely to rise by close to 60% by 2030 and more than double by 2040, on the back of rise in usage of the fuel as CNG in automobiles and for cooking and industrial purposes, according to a study by oil regulator PNGRB. Consumption of natural gas, which is used to produce electricity, make fertilizer or turned into CNG for running automobiles and piped to household kitchens for cooking, is expected to rise from 187 million standard cubic metres per day to 297 mmscmd by 2030 under 'Good-to-Go' scenario, as per a study by Petroleum and Natural Gas Regulatory Board (PNGRB).

India's LNG imports are projected to more than double by 2030, reaching 64 billion cubic meters (bcm) annually. India is seeking to balance its trade with the U.S. by increasing imports of U.S. energy products. The U.S. has emerged as a key energy partner for India, with the U.S. being the 5th largest source of crude oil and the 2nd largest source of LNG imports.

The United States and India have a strategic opportunity to deepen their energy security partnership by aligning on shared interests in crude oil, LNG, and other critical energy commodities. Beyond trade, this partnership can play a pivotal role in co-developing a resilient and diversified supply chain for energy equipment manufacturing.



5. Advance Biofuels

India has a unique opportunity to lead in sustainable chemicals, potentially introducing mandates for blending these with fossil-based chemicals, mirroring the success seen in sustainable fuels. Crucially, innovative synthetic biology platforms are now enabling substantial value-addition in existing manufacturing assets. These platforms can monetize waste carbon from industrial gases, municipal solid waste (MSW), agricultural waste, and direct CO₂ emissions, transforming them into valuable outputs like sustainable fuels (ethanol, SAF) and everyday chemicals. There exists untapped potential of waste carbon based feedstock (industrial off gases, waste gases, MSW, Agri waste and even Co₂) to make advance biofuels, SAF which needs to be actively needs to be explored.

Biofuels industry has low barrier to adoption compared to many other energy pathways. All biofuels are produced as a drop-in replacement for corresponding fossil fuels within current vehicles design and fuel transport infrastructure. Refiners are trying to leverage existing infrastructure for processing/upgrading to the extent possible. Feedstock availability has always limited the growth but is expected to improve over time: (a) Usable biomass volume will grow with improving agricultural land productivity (b) Advancement of 2G processing technologies will even allow use of advanced/more woody feedstock generated from forestlands and non-arable wastelands and reduce competition for land use with food production. The technology development roadmap to process next generation feedstocks has high executability, based on deep process industries expertise in India, and (c) Feedstock aggregation can be improved through free-market incentives and institutional enablers. Any investment in early stages always carries high risk and therefore return on investments (ROI) should also be considered on the basis of cost to country against value generation for the country.



Sustainable Aviation Fuel (SAF) projects - a pricing model where the cost of SAF is determined by a "**cost-plus**" approach where producers can recover their expenses, including production, feedstock, and operational costs, plus a predetermined profit margin may be considered by the Government. Alternatively, the price gap between conventional jet fuel and SAF could be bridged through other mechanisms, such as financial support and tax credits.

Biofuel industry will go through a phase of development until it reaches maturity as supply chains are established and improved. Government incentives during this gestation period in terms of minimum price supports, blending mandates, tax incentives, etc. can help the industry in reaching self-sustainment. Scalability will always remain a challenge due to aggregation capabilities and hence multiple pathways will emerge capitalizing on the locally available feedstocks and seasonality. Currently, sugary crops (e.g. sugarcane), oil crops, used cooking oil (UCO), spoilt grains, and agri residues are the most used raw materials for biofuels production. As production technologies mature to use advanced generation feedstocks from wastes of forest produce, woody shrubs, etc. even the forestlands and non-arable wastelands in the country would become effective sources of these highly renewable feedstock types.

This aligns perfectly with India's vision for clean energy, enhancing energy security, and significantly reducing its import bill. Leveraging such innovative solutions through U.S.-India partnerships will be vital as India progresses toward its INDC targets for sustainability and energy transition.

It is also important to consider non-battery options of LDES such as mechanical (Compressed Air, Liquid Air, CO₂), thermal, electrochemical and chemical (Hydrogen) solutions.

6. Affordable Battery and LDES Helping Grid Support and Stabilization

In grid support and modernization, battery storage plays a crucial role by enhancing grid stability, integrating renewable energy sources, and improving overall grid resilience. Energy storage systems with advanced energy management software are keys to assure grid reliability. Technological advancements in battery and LDES offer compact, end-to-end modular battery energy storage systems and energy management tools that support improved energy density, while delivering a significant reduction of installation costs. Scalable modular architectures provide an optimized energy outcome, improve uptime, and allow electricity market participation to help increase use of renewable electricity to stakeholders. Globally benchmarked technologies help users to manage and optimize energy use by improving uptime, maximizing arbitrage potential from peak shaving and providing the ability to create a virtual power plant. The battery energy storage systems (BESS) within commercial real estate transcends conventional energy management paradigms, offering a multifaceted solution that extends beyond peak demand mitigation.



A comprehensive strategy, comprising regulations, incentives, and penalties, is essential to accelerate the adoption of affordable LDES technologies for grid integration and optimization.

7. Energy Efficiency

Commercial and residential buildings in urban areas use about 40% of global energy and global resources and emit approximately a third of greenhouse emissions. HVAC solutions consume 40% of a building's energy requirement, and thus account for 16% of global energy consumption. The increased demand for both residential and commercial buildings with increasing comfort level requirements call for energy efficient HVAC solutions in buildings.

At the same time, cooling is necessary to provide thermal comfort in residential and commercial buildings and is a crucial indicator to gauge the quality of life in any country. Space cooling in buildings is the dominant cooling sector and per India Cooling Action Plan (ICAP), it is projected to comprise 3/4th of cooling demand, 2/3rd of cooling electricity consumption, and 4/5th of the refrigerant demand by 2038. The environmental impact of rising cooling demand will lead to greater direct and indirect emissions from refrigerants and electricity, respectively. Thus, the promotion of integrated approaches combining passive building design and affordable energy efficient technologies will accelerate access to thermal comfort for all.

Government actions on the policy front, budget for catalytic investment, and ensuring effective implementation and compliance will enable thermal comfort to billions of people and protect them from extreme heat waves while ensuring that the electricity demand due to space cooling is controlled.



To achieve the above, there is need for:

- **Integration of passive design principles:** Implementation across India, with the involvement of states, with credible compliance checks can help reduce overall cooling load and improve energy efficiency.
- **Mandating buildings beyond a certain level power consumption** to ensure that their specific power consumption is well below a certain standard.
- **Promotion of district cooling systems** by creating provision of cooling at the neighborhood/community level in integrated planning of towns and cities.
- **For large buildings, the super-efficient chiller replacement program** can be reignited with a changed strategy of private sector ESCO involvement, where old and inefficient chillers are replaced with new super-efficient ones. The government schemes should be designed to promote independent third-party agencies to perform M&V using worldwide accepted industry-standards, such as IPMVP, to validate energy savings. Intelligent and smart controls systems for chillers can be implemented for demand flexibility.
- **For medium-sized office buildings, encourage the use of super-efficient systems such as Variable Refrigerant Flow (VRF) systems.** The Bureau of Energy Efficiency (BEE) can develop standards and labelling programs for VRFs.
- **Lifecycle assessment and end-of-life scrappage policy** for RAC systems to promote sustainability and energy efficiency during the lifecycle of the equipment.

8. Institutional and Industrial Capacity Building

1. **Joint R&D Platforms:** Establishing collaborative research and innovation programs, drawing on models such as ARPA-E, can support the development and adaptation of regionally relevant technologies.
2. **Energy Industrial Clusters:** The creation of energy manufacturing and deployment hubs focused on technologies like SMRs, gasifiers, and grid systems can strengthen domestic supply chains and open export opportunities.



9. Joint Innovation and Initiatives

1. **U.S.–India Energy Innovation Fund:** A dedicated fund can support pilot projects, demonstrations, and the initial scale-up of strategic technologies.
2. **Industrial Transition Demonstration Zones:** Select regions can serve as testbeds for advanced energy technologies, supporting industrial emissions reduction and modernization and systems integration.
3. **Strategic Energy Dialogue Taskforce:** A structured bilateral platform for policy coordination, implementation oversight, and resolution of cross-border issues.
4. **Innovation in Financing for Scaling the Transformation**
 - **Blended Finance and Risk Mitigation:** Combining public and private capital to de-risk early-stage projects can help attract commercial investment and accelerate deployment.
 - **Mobilizing U.S. Development Institutions:** Institutions such as the DFC and EXIM Bank can support financing, credit enhancement, and infrastructure investment for jointly developed energy projects.
 - **Market-Based Low Carbon Finance Corporation:** A specialized institutional vehicle in India could enable monetization of long-term revenue streams, such as market-based variant of 45Q type carbon incentives or capacity-based payments, to support investment in viable and affordable low-carbon technologies.

The Path Forward

The U.S.–India energy partnership offers an opportunity to pursue shared objectives: long-term energy affordability, system resilience, and economic growth. It must be rooted in mutual opportunities, shared investment, and practical implementation pathways that are responsive to U.S. and Indian contexts.

India's energy transformation can serve as a model of balanced development—addressing growth and sustainability in parallel. The United States and India, working together, can contribute to shaping an energy future that reflects both innovation and inclusion, while supporting regional and global stability.

The background features a light blue gradient with several concentric circles centered in the middle. Scattered around these circles are various geometric shapes, including triangles and polygons, some of which are outlined in a thin grey line. The overall aesthetic is clean and modern.

CAPABILITY DECK



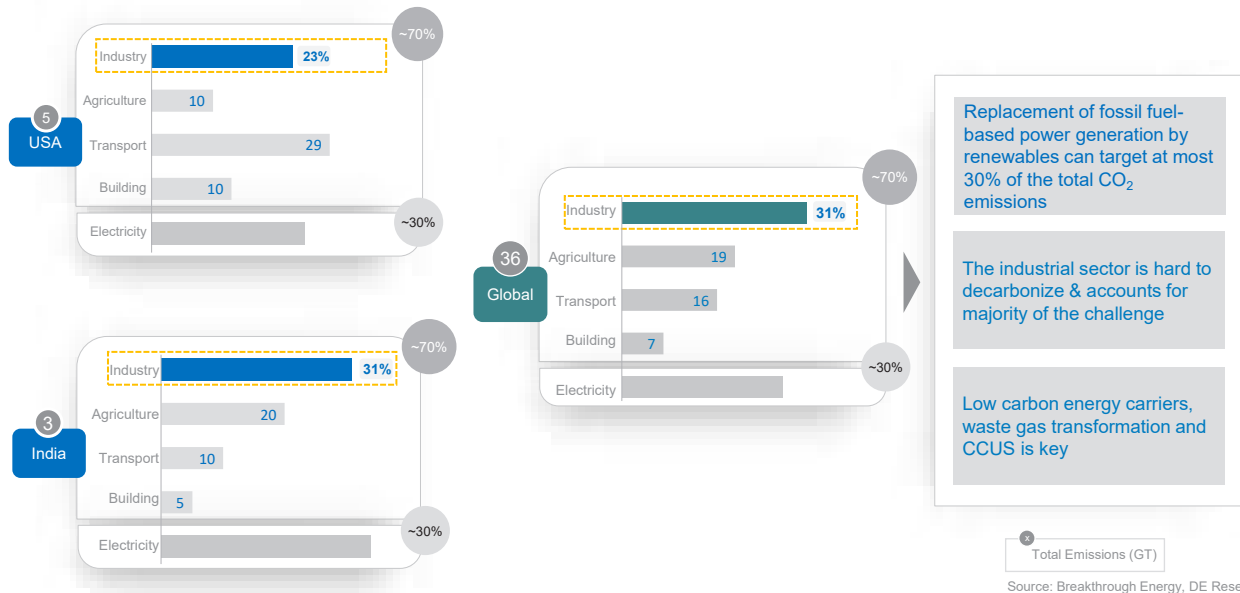


Leading Industrial Scale Clean Energy Transition

Austin, TX based Dastur Energy is the clean energy arm of the Dastur group of companies, that is leading the way in the field of clean energy with a strong track record of pioneering innovative projects in North America, the Middle East, and India



What Problem does Dastur Energy Address - The 70% Emissions Challenge

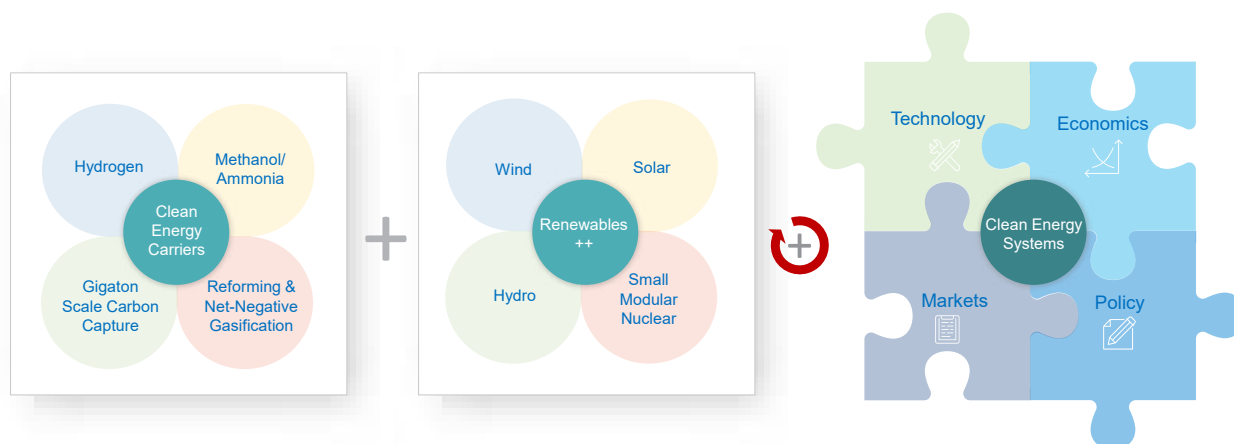


Dastur's Philosophy and Approach to Industrial Scale Clean Energy Transition

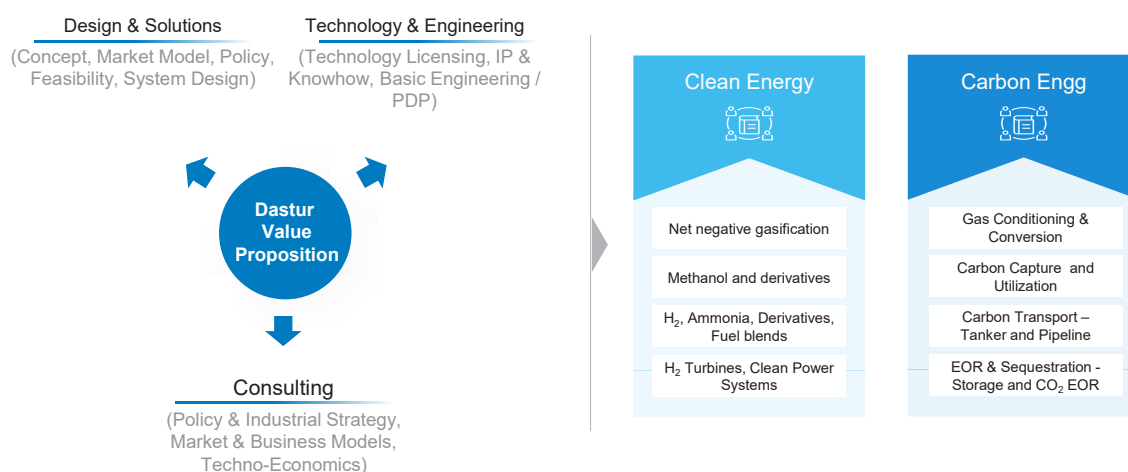


- 01 Recognizing that CO₂ is the Enemy, NOT Gas, Wind, Coal, Oil, Solar or Nuclear 
- 02 Decarbonizing Industrial Activity is Key to a Net Zero World 
- 03 Hydrogen and Other Low Carbon Carriers Key to Industrial Decarbonization 
- 04 Giga Ton (GT) Scale CO₂ Management Infrastructure Essential for Deep Decarbonization 
- 05 Without Economic Viability, Energy Transition cannot be Accelerated 

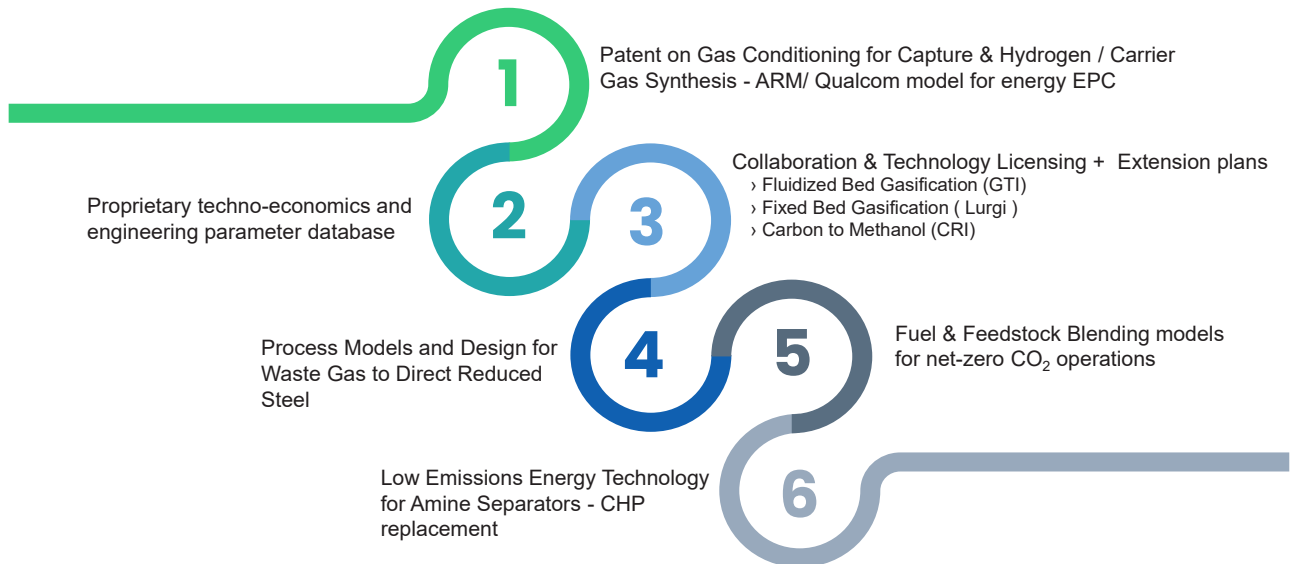
Our Vision - A Systems Approach to Deep Decarbonization with a Portfolio of Options



Dastur Energy Value Proposition



Dastur Energy IP and Knowhow



Broad Network of Partnerships across the Clean Energy Value Chain



Few Experiences



 FEED for 3.6 mtpa CO₂ capture using amine systems Decarbonization of 618 MW IGCC power plant Owner's Engineers and assistance in securing Govt. funding	 0.9 mtpa CO₂ capture from Merchant SMR FEED Engineering, Class 3 cost estimate, CO₂ Life Cycle Analysis Enabling production of 100 ktpa of clean hydrogen	 3 mtpa CO₂ capture from a steel plant with H₂ production optionality Pre-FEED Engineering, Class 4 cost estimate, CO₂ Life Cycle Analysis	Confidential Techno-economic assessment of 2 mtpa CO₂ capture H₂ based DRI making – optionality for switching from natural gas to H₂ DOE application for funding with tech. partners	 Techno-economic assessment of 1.9 mtpa CO₂ capture PSA + cryogenic capture – all electric operations to reduce Scope 2 emissions DOE application for funding with carbon capture licensor
 Replacement of natural gas with alternate low CO₂ footprint fuels - Green H₂ Fuel blending, sourcing, techno-economics and engineering viability, CO₂ footprint & mitigation	 CO₂ capture & blue H₂ from petcoke gasification 5 mtpa petcoke gasification and 10 mtpa CO₂ capture Gasification based market hedged product portfolio	 CCUS policy roadmap & technology gap assessment Strategy for scaling up CCUS to Giga-tonne scale Recommend policy and collaboration framework	 0.7 mtpa CO₂ capture from Refinery SMR CO₂ disposition through CO₂ EOR and Food Grade utilization Market, business case and techno-economic analysis	 1.24 MMTPA Petcoke Gasification Multi product port folio - Methanol, H₂, Acetic Acid, MEG and IGCC Power



111 Congress Ave
Suite 500, Austin, TX 78701
www.dasturenergy.com



Emerson At-A-Glance

COMPANY PROFILE

Emerson is a global leader in automation technology and software. We help customers in critical industries, like energy, chemical, power and renewables, life sciences and factory automation, operate more sustainably while improving productivity, energy security and reliability.

BUSINESS GROUPS



COMPANY IMPACT

20%
Global power generation automated using Emerson control systems and software

19,000+
Patents on employee inventions

~70%
Amount of world's LNG flowing through Emerson valves

25 of Top 25
Life sciences companies use Emerson technology

9 of Top 10
Semiconductor manufacturers use Emerson technology

Note: All data on this slide is for fiscal 2024 unless otherwise noted.

\$17.5 BILLION GLOBAL SALES

FOUNDED
1890

NYSE:
EMR

HEADQUARTERS
ST. LOUIS, MO USA

WORLDWIDE

~73,000 EMPLOYEES

130 MANUFACTURING LOCATIONS

2024 RECOGNITIONS

MOST INNOVATIVE COMPANIES
Fortune

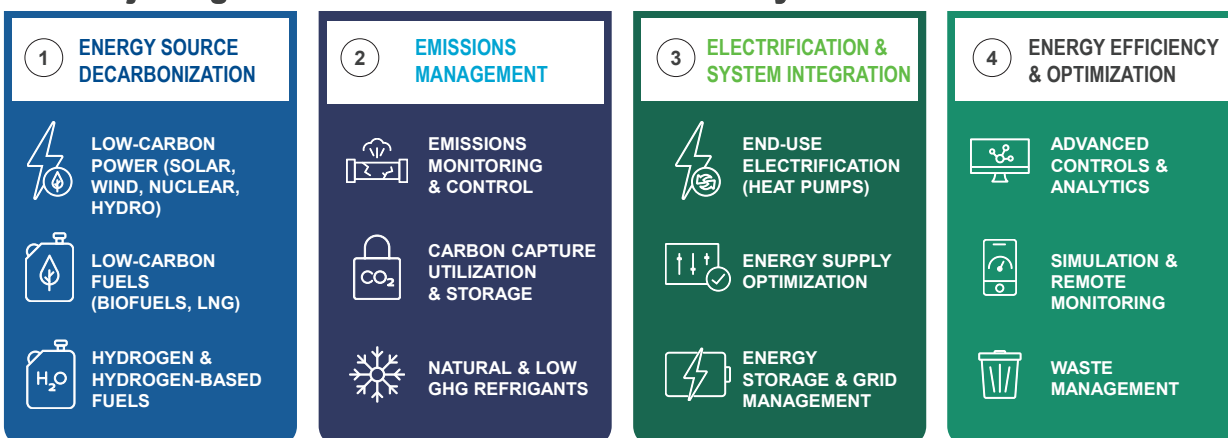
AMERICA'S MOST RESPONSIBLE COMPANIES
Newsweek Magazine

BEST LARGE EMPLOYERS
Forbes

DISABILITY INCLUSION SEAL OF ACCOMPLISHMENT
Center for Disability Inclusion award for 2024

Energy Transition Segments

Four major segments for environmental sustainability



Building our Franchises Through Innovation and Acquisitions Across All Technology Layers



Emerson For a Self-Reliant India

Emerson's vast footprint in India forms a complete ecosystem to support the Government of India's *Make in India* and *Aatmanirbhar Bharat* visions

 Emerson Innovates in and for India: <i>We are mindfully leveraging India's potential to position itself as one of the leading innovative nations of the world</i> Emerson's Industrial IoT offerings aid business performance improvements, while its innovative Commercial & Residential Solutions business ensures energy efficiency, infrastructure, food safety and human comfort	 Emerson Engineers in and for India: <i>Our focus in India is to develop a large-scale, efficient and cost-effective domestic technology & engineering ecosystem</i> A sizeable percentage of Emerson's workforce in India is made up of engineers who are poised to provide high quality engineering services in the field of process automation for local and global operations	 Emerson Manufactures in and for India: <i>There is consistent emphasis on leveraging India's manufacturing capabilities and local ingenuity to create global impact</i> Nearly 70% of Emerson products for India are made in India. Our vision for India as a manufacturing hub is to serve customers in India, Asia, the Middle East & Africa	 Emerson Builds Skills in and for India: <i>We recognise that India's biggest opportunity is to expand its labour force and talent pool through upskilling education</i> Emerson is galvanizing partnerships to help address the skills-gap issue in STEM through investments in upskilling promising talent for India and the world
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Best-in-class infrastructure, innovation, intellectual property and skill development

The ExxonMobil logo, with "Exxon" in red and "Mobil" in red, set against a background of a bright sun and geometric shapes.

ExxonMobil

Current business interests in India:

ExxonMobil has been powering India's growth for three decades.

The Company brought the first supplies of liquefied natural gas (LNG) to India in the early 2000s and is now a major LNG supplier to the country, helping to advance its transition to a gas-based economy.

ExxonMobil's cutting-edge product solutions such as Mobil lubricants are driving productivity and energy efficiency in India's automotive and industrial sectors, helping individual consumers and businesses achieve more with less. The Company's chemical products are enabling Indian manufacturers to make high-quality products and deliver sustainability benefits across sectors, including food processing, consumer durables, agriculture, water treatment, pharmaceuticals, and construction.

ExxonMobil's business and technology centres in Bengaluru provide critical support to the Company's global operations. The technology centres help develop strategies to reduce global emissions and collaborate with homegrown manufacturers to enhance global competitiveness of made-in-India products.

Striving to make a positive contribution to the communities where we operate, ExxonMobil supports a wide range of education, health, skill development and community-building initiatives in India.

The Company has offices in India in Bengaluru, Mumbai, and the National Capital Region.

Initiatives in India:



ExxonMobil's upcoming lubricant plant in Maharashtra

To meet growing domestic demand from industrial sectors such as manufacturing, steel, power, mining, and construction, as well as from passenger and commercial vehicle segments, **ExxonMobil is investing nearly INR 900 crore (USD \$110 million) to build a lubricant-manufacturing plant** at the Maharashtra Industrial Development Corporation's Isambe Industrial Area in Raigad. This new plant is expected to produce 159,000 kiloliters of finished lubricants per year to help meet demand growth in India. In a significant boost to the "Make in India" initiative, the plant will source a larger part of the base stocks, additives, and all packaging locally.

Apart from ExxonMobil's pioneering effort in developing India's LNG market in collaboration with value-chain players, its affiliates have also been developing solutions for India's agriculture, mobility, and packaging industries.

For example, Rishi FIBC, one of India's largest manufacturers of container liners and silo bags, has been using **ExxonMobil's high-performance chemical solutions to boost their storage technologies**, which includes mulch films and greenhouse films to improve crop quality and productivity. These films help minimize soil erosion, control soil temperature and suppress weeds, thereby enhancing the yield.

ExxonMobil's Bengaluru Research and Development Technology Centre helps Indian businesses to **redesign packaging, making it thinner, stronger, reducing weight by 20-40% and blending recycled materials with new ones**. For example, the company collaborated with Indian packaging manufacturer Shrinath Rotopack and packaging-machine maker Syntegon



ExxonMobil's R&D lab in Bangalore is working to improve plastic packaging and tyres



to develop recyclable packaging for dry foods that can replace hard-to-recycle multilayer plastic packaging.

While ExxonMobil is helping its customers ‘to do more with less’, the company itself is creating a benchmark for plastic packaging in India and lifting the levels of recycled plastics in lubricant pails. It recently launched a 20-liter lubricant pail in new plastic packaging, made of 50% post-consumer recycled (PCR) content. This includes discarded plastic pails, jars, and battery casings. Since launching in 2023, 115 metric tons of recycled plastic have been sourced to make these pails. This is roughly equal to recycling 2.3 million used plastic bottles, and these pails can be recycled again.

Exxon Mobil Corporation has numerous affiliates, many with names that include ExxonMobil, Exxon, Esso, and Mobil. For convenience and simplicity, those terms and terms like “corporation,” “company,” “our,” “we,” and “its” are sometimes used as abbreviated references to specific affiliates or affiliate groups.

Honeywell

**THE
FUTURE
IS WHAT
WE
MAKE
IT.**



Honeywell

Company's Operations in India: 90+ years

9
Decade
Legacy

13000
Employees

5500
Engineers

20
Facilities in Major
Cities
Pune
Bengaluru
Gurugram
Chennai
Dehradun
Mumbai
Kolkata
Madurai
Hyderabad
Jamshedpur
Vadodara

\$1B
Domestic Sales
and Exports

3000+
Products, Solutions,
Applications
Engineered in India

4
Technology
Development Centers
Bengaluru
Madurai
Hyderabad
Gurugram

3
Manufacturing
Centers
Gurugram
Dehradun
Pune



UOP technology used in almost all India refineries, improving yield and fuel quality.



Supporting the country's defense, space and civil aviation for more than 40 years through strategic partnerships.



Supporting STEM education and technology incubation in deep Science.



Atmanirbhar Bharat – commenced N95 face mask production in Pune.



Committed 150 crores towards environmental sustainability initiatives in India.



Strong partner to the government of India's Smart and Safe Cities Mission.

Honeywell is a committed partner to India. Investing in cutting-edge technology development and engineering centers, manufacturing facilities and our people across the country, we are creating solutions for challenges faced by the Indian industry. Made in India, by Indians, for India and the world.

Organization Overview



Our products and services are used on virtually every commercial, defense, and space aircraft. We build aircraft engines, cockpit and cabin electronics, wireless connectivity systems and mechanical components. Our hardware and software solutions create more fuel-efficient aircraft, more direct and on-time flights and safer skies.



Commercial building owners and operators depend on our operational technology hardware, software and analytics to help create safer and more efficient and productive facilities. Our solutions and services are used in more than 10 million buildings worldwide.



We help solve tough sustainability and energy transition challenges across our end markets that help reduce emissions and deliver innovative sustainable solutions while seizing new opportunities to deliver outstanding value to our clients and shareholders.



We provide solutions to support our customers to help deliver results with enhanced productivity and safety standards. Our innovation powers process solutions, asset performance management, cybersecurity, and warehouse and retail automation.

HONEYWELL CONNECTED ENTERPRISE

We empower those who make, move and operate critical resources to grow responsibly. Our flagship Honeywell Forge solutions help drive business outcomes around performance, efficiency, cybersecurity and safety by uniting data across assets, people and processes. We leverage the latest technologies and persona-focused design to help uncover hidden insights, increase productivity and enhance the user experience from the shopfloor to the top floor.

Honeywell Process Technology

Honeywell Process Technology enables energy evolution, provides solutions that reduce emissions, and delivers innovative sustainable materials to our customers across industries. We are solving the world's toughest energy transition challenges across our end markets while seizing new opportunities to deliver outstanding value to our clients and shareholders.

HONEYWELL PROCESS TECHNOLOGY

Honeywell UOP

Over the last century, Honeywell UOP's engineers and chemists have shaped the refining, petrochemical and low carbon energy by turning laboratory science into industrial reality. UOP processes produce the fuels that power our cars, trucks, jets and trains. They make the natural gas that heats our homes and serves as a source of power generation. Biodegradable detergents and the plastic resins, films and fibers we use in commercial goods, packaging and fabrics are made with technologies from UOP.

Gas & LNG

From pre-engineered modular units to highly integrated, multiple technology operations, Honeywell UOP gas processing technologies focus on contaminant removal, natural gas liquids recovery and liquefaction to help maximize the value of your gas streams.

Industrial Solutions

A global technology leader focused on providing innovative industrial solutions

Refining

Petro
chemicals

Low Carbon
Energy

Sundyne

LNG

HSP

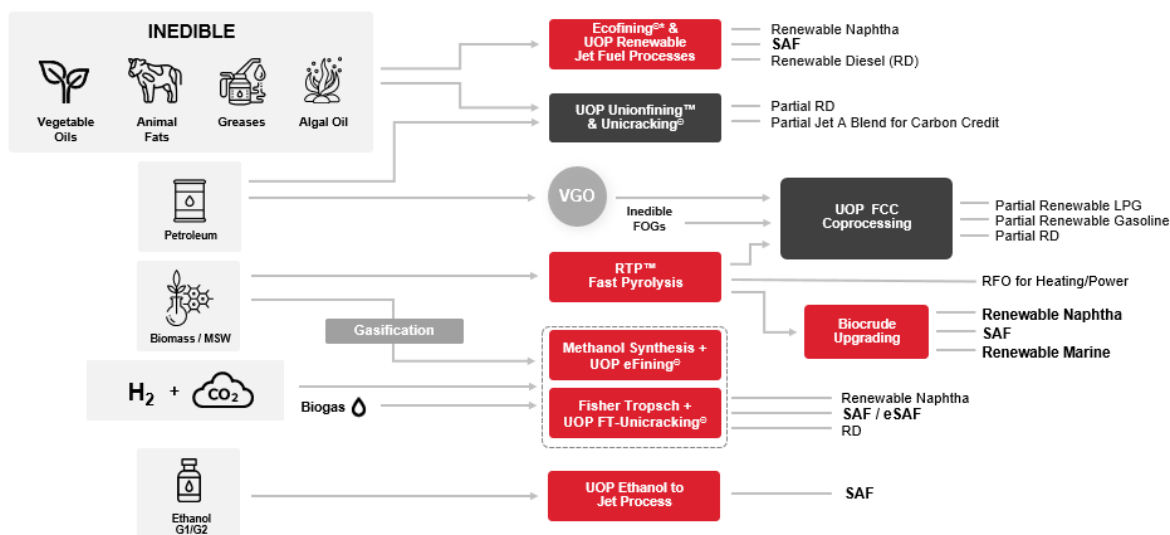
Company's role in the energy sector and the impact on Indian economy

India is now at the center of the energy transition, combining economic and energy demand growth with rapid decarbonization efforts. The country has set ambitious targets, including achieving 50 percent of its generation capacity from non-fossil fuel resources by 2030 and achieving net-zero emissions by 2070.

India's power sector currently accounts for 34% of the nation's total greenhouse gas (GHG) emissions, with fossil fuels making up 75% of the energy mix for electricity generation. Urgent action is required to decarbonize this sector, offering significant potential for reducing GHG emissions across residential, commercial, and industrial domains. Honeywell presents ready-now solutions leveraging renewable resources to aid India's transition. These include smart microgrids for load management, energy storage solutions, and dispatchable power generators ensuring grid reliability amid fluctuations in renewable output.

The transport sector contributes 10% of India's total GHG emissions, with more than 300 million vehicles on Indian roads. Decarbonizing road and rail transportation can be further accelerated by the adoption of green diesel. Honeywell's Ecofining technology enables the production of green diesel that can be a drop-in replacement, requiring no changes to fleet technology or the fuel storage and delivery infrastructure. Depending on the type of ethanol feedstock used, jet fuel produced from Honeywell's ethanol-to-jet fuel process can reduce greenhouse gas (GHG) emissions by 80% on a total lifecycle basis, compared to petroleum-based jet fuel.

HONEYWELL UOP PATHWAYS TO RENEWABLE FUELS



Industrial manufacturing constitutes 28% of India's GHG emissions, with key sectors like steel, cement, refining, iron, aluminum, and mining expected to grow, amplifying both investments and emissions. Honeywell's diverse range of process, environment, and industrial control systems can play a crucial role in transitioning these sectors to lower emissions.

To summarize, Honeywell's Low carbon energy Solutions are developed based on foundational pillars of Circular Economy, Energy Evolution, Environmental Transformation, Health Safety, Security, Resilience, and Accountability. Globally, 60% of Honeywell's research and development expenditure is focused on solving sustainability challenges for its customers, with much of the technology development work being undertaken in India, which is a matter of great pride for the company.

Skill development and training

Honeywell has driven technological collaboration and greater localization through partnerships for the last 4 decades. All of Honeywell's global businesses have a strong legacy in India, built over the last eight decades. Honeywell's India commitment is evident in 3 state-of-the-art manufacturing facilities and 4 global R&D centers of excellence for technology development and innovation. Most of these technologies breath life in these hubs which are run and managed by a diverse talent pool. Honeywell has been actively engaged with various skill development programs and research- oriented projects across premier institutes (IISc and IITs) and multiple engineering colleges to mentor, nurture and engage the institutions in building an in-country strong engineering talent pool for critical domains like Energy Transition. In addition, their teams have been closely interacting with various government and industry fora on knowledge sharing and trainings for safety critical product development, aviation safety and certification.

Results achieved/ partnerships/ future programs

Over the last century, Honeywell engineers and chemists have shaped the refining, petrochemical and gas processing industries by turning laboratory science into industrial reality. Honeywell UOP processes produce the fuels that power our cars, trucks, jets, and trains. They make the natural gas that heats our homes and serves as a source of power generation. Biodegradable detergents and the plastic resins, films and fibers we use in commercial goods, packaging and fabrics are made with technologies from Honeywell. Honeywell continues to innovate to create flexible, future forward and sustainable solutions that address the challenges in our ever-changing world. We're striving to create cleaner fuels by developing processes that reduce emissions and produce renewable fuel sources. Our process technologies, equipment and lifecycle solutions are helping customers generate the most value from every drop of oil, every cubic foot of natural gas and every ton of coal. And through connected software, Honeywell is helping customers become more efficient and profitable through digital tools that ensure plants are running at the peak of their capability. We are leading industry into the new world of energy.

Honeywell celebrated our 50th Renewable Fuels license in 2024. When functioning, the 50 sites have a combined capacity to produce more than 500,000 barrels per day of renewable fuel. Eight facilities are currently operational, and more than 40 licensed plants will be operational by 2030. From a catalyst perspective, Honeywell introduced 7 new catalyst offerings that have been commercialized and we are committed to R&D investment for future generation catalysts. These catalysts are seeing strong acceptance with customers, including multiple takeaways. Our sustainable technology solutions business is driving the clean energy movement forward.



ExxonMobil selected Honeywell's CO₂ Fractionation and Hydrogen Purification System - at its integrated complex in Baytown, Texas. This technology is expected to enable ExxonMobil to capture about 7 million tons of carbon dioxide (CO₂) per year, the equivalent of the emission of 1.5 million of automobiles for one year. Honeywell's digital transformation business is powering real time insights with our digital performance services that help unlock greater efficiencies, to benefit our customers' bottom line. We recently announced a strategic collaboration with ESS Tech, Inc to advance technology development and market adoption of iron flow battery (IFB) energy storage systems. The relationship builds upon each company's development of energy storage systems, and brings together ESS' market-leading, patented IFB design with Honeywell's advanced materials and energy systems expertise. And finally, Honeywell recently announced it will be acquiring Air Products' liquefied natural gas process technology and equipment business to expand on its LNG pretreatment business. Honeywell already pre-treats 50% of the world's LNG and this acquisition makes it a more robust partner for customers within this industry.

Global/Local best practices

Honeywell helps organizations solve the world's most complex challenges in automation, the future of aviation and energy transition. As a trusted partner, we provide actionable solutions and innovation through our Aerospace Technologies, Building Automation, Process Technology, and Process Automation business segments – powered by our Honeywell Forge software – that help make the world smarter, safer and more sustainable.

Honeywell exemplifies both global and local best practices through its commitment to innovation, sustainability, and community engagement. Globally, Honeywell sets industry standards by integrating advanced technologies, such as IoT and AI, into its products and services, ensuring operational excellence and efficiency across diverse sectors. The company's stringent adherence to international regulatory frameworks and quality certifications further underscores its dedication to best practices. Locally, Honeywell tailors its initiatives to meet specific community needs, fostering strong relationships through localized projects and investments. By prioritizing sustainable practices, reducing environmental impact, and promoting workforce diversity and inclusion, Honeywell demonstrates a holistic approach to best practices that benefits both global markets and local communities.



Powering Global Decarbonisation and the Energy Transition

John Crane is a world-leading provider of mechanical seals, industrial filtration, power transmission couplings and other mission-critical technologies for the energy industry. As the largest subsidiary of Smiths Group PLC, a multi-billion-pound industrial technology company listed on the FTSE 100 - John Crane has been at the forefront of innovation in rotating equipment for over a century. Founded in Chicago more than 100 years ago, the company pioneered the development of the first non-contacting dry gas seal and continues to support critical infrastructure worldwide with advanced engineering solutions.

In India, John Crane has been a trusted partner to the energy and industrial sectors for over 30 years. With more than 600 employees and manufacturing facilities in Bangalore and Pune, the company delivers end-to-end capabilities in large project execution, seal reliability, plant maintenance and asset management - contributing to the country's industrial resilience and energy security.



30+ years in India

India's Energy Transition

India's energy transition is a complex journey that demands reliable, scalable and efficient technologies. As the global shift towards clean energy gathers momentum, India must undergo a comprehensive transformation - one that ensures abundant, affordable and reliable energy while simultaneously decarbonising both production and consumption.

This transformation should be anchored in the strategic utilisation of domestic energy resources and a strong commitment to technological innovation. A balanced and diversified approach is essential - combining the continued use of fossil fuels with carbon abatement technologies and the expansion of carbon-free energy sources.

Decarbonising Existing Energy and Industrial Infrastructure

John Crane's advanced sealing and filtration technologies help reduce fugitive emissions, improve energy efficiency, extend equipment lifespans and lower operational costs. Reducing fugitive harmful emissions, especially methane, provides a cost-effective and scalable pathway to decarbonising the oil and gas industry.

Wet-to-dry gas seal retrofits and seal gas recovery systems can significantly reduce plant emissions, enabling effective gas recycling and capture.

John Crane also supports the deployment of carbon capture, utilisation and storage (CCUS) technologies, particularly for hard-to-decarbonise industrial sectors. We work alongside oil and gas leaders and OEM partners to accelerate the deployment of scalable CCUS initiatives while enabling some of the most innovative carbon capture projects around the world.

John Crane technologies are used in a majority of sites where CO₂ is injected underground and across each stage of the CCUS value chain - in liquid, gaseous and supercritical phases.

Since our first CCUS application three decades ago, we've established more than 1,100 references in CO₂ sealing and related applications - including supercritical fluid conditions - supporting our industry's critical decarbonisation goals.

Coal, as India's most abundant energy resource and a key contributor to rural employment, continues to play a role in the energy mix. The adoption of clean coal technologies, including coal gasification, is essential. John Crane's advanced filtration and mechanical sealing solutions will continue to support reliability and environmental performance in coal-based processes.

Natural gas is central to decarbonising the entire energy value chain - from production to end-use. Accelerating domestic production of natural gas and biogas, expanding pipeline infrastructure to connect demand centres with production hubs will be critical. Methane leakage from industrial infrastructure, landfills and mining operations must also be accurately measured and minimised - an area where John Crane brings deep expertise and proven technologies.

Accelerating Clean Energy Production, Transmission and Adoption

While solar and wind remain central to India's decentralised energy production, nuclear power is set to play an increasingly important role in meeting the country's rising energy demand - particularly as India aims to become a global hub for computing and AI. As nuclear technology evolves, including 4th-generation and small modular reactors (SMR), John Crane remains a trusted partner. Our expertise in handling extreme pressures, temperatures, fluids and materials has enabled us to develop sealing solutions and power transmission couplings for critical applications, including circulation pumps in molten salt reactors.

John Crane also supports renewable electricity generation across hydroelectric, geothermal and concentrated solar power (CSP) projects. In addition, we bring decades of experience across the full electric battery value chain - from critical mineral mining and processing to battery component production and recycling.



In the energy transition mining sector, including battery minerals, John Crane provides mechanical sealing, filtration and coupling solutions for chemical and metallurgical processes requiring high reliability and performance under fluctuating temperatures and rotary speeds. Beyond batteries, our products also enhance the performance of Long Duration Energy Storage (LDES) technologies such as thermal storage, compressed air and CO₂-based storage systems.

Hydrogen is a key enabler of the energy transition - serving as both an energy storage medium and a pathway to decarbonising sectors such as transport and heavy industry. John Crane offers hydrogen-ready sealing and filtration solutions, developed over 40+ years of working in hydrogen-rich environments, including refining and ammonia production. These innovations enhance safety, reliability and reduce total cost of ownership across hydrogen production, distribution and usage. Alongside John Crane Sense®-enabled dry gas seals and high-performance filters for cleaning electrolytes and product gases, we also provide specialised technologies for the production and handling of compressed

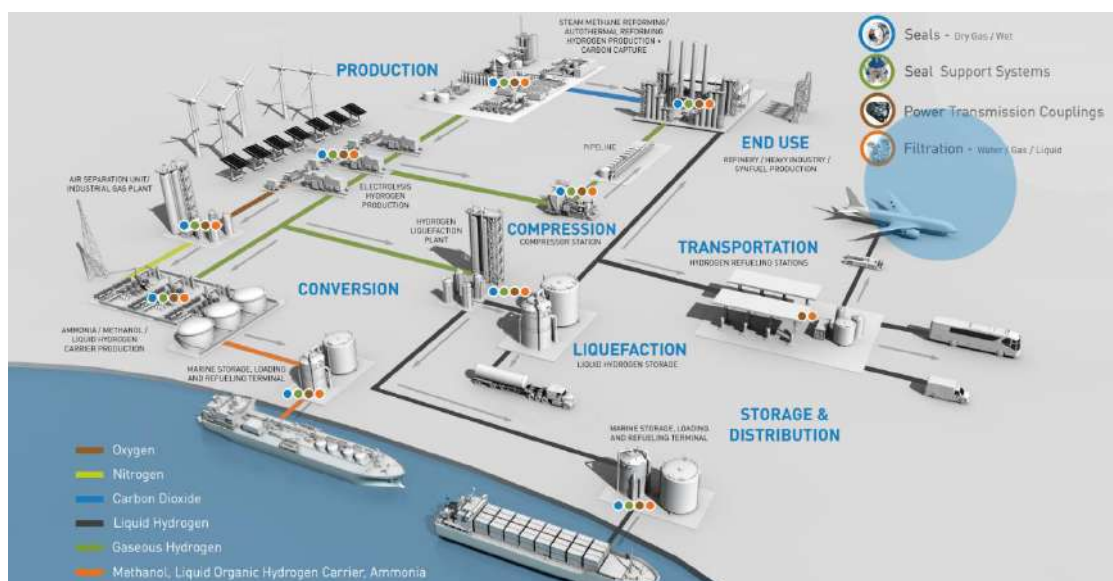
and liquid hydrogen, ammonia (NH₃) and other hydrogen carriers.

John Crane further contributes to sustainable fuel production through state-of-the-art agitator, vessel and pump sealing and filtration technologies. These products improve the efficiency and reliability of biofuel and e-fuel manufacturing by handling corrosive mixtures, slurries with high solids and enabling equipment to operate at higher vapour pressures and temperatures.

Innovation for a Sustainable Future

John Crane continues to invest in next-generation technologies that support India's evolving energy needs:

- **Advanced Materials:** Engineered for resistance to corrosion, contamination, wear and embrittlement.
- **Digital and IoT Integration:** Predictive maintenance tools designed to improve uptime and reduce costs.
- **High-Speed Dry Gas and Separation Seals and High-Efficiency Filtration:** Developed for demanding hydrogen, ammonia and CCUS applications.



In June 2025, John Crane launched the Type 93AX Coaxial Separation Seal - a next-generation innovation engineered to reduce nitrogen consumption by up to 80%, improve energy efficiency and support our customers' sustainability objectives. The Type 93AX addresses growing market demand and further reinforces John Crane's leadership in advanced sealing technologies.



Strategic Collaboration

Trade and technology partnerships between India and like-minded countries - especially the United States - will be essential to achieving India's energy transition in a progressive and future-focused way. Key areas for collaboration include:

- **Information Exchange:** Regular meetings and discussions to uncover mutual opportunities.
- **Joint Projects:** Frameworks for national and international energy transition initiatives.
- **Webinars and Knowledge Sharing:** Technical forums on market trends and technology development.
- **Facility Visits:** On-site tours and networking opportunities with key stakeholders.

Why John Crane?

- Proven experience and expertise in mission-critical rotating equipment for hydrogen, CCUS, biofuels, SAF and renewable power generation
- Strong local presence and manufacturing footprint in India, with a deep understanding of regional energy needs
- Trusted global partner with a century of engineering excellence and innovation
- Committed to supporting a just, inclusive and sustainable energy transition

At John Crane we're not just supporting the energy transition – we are engineering a better future.

www.johncrane.com/en/new-energy

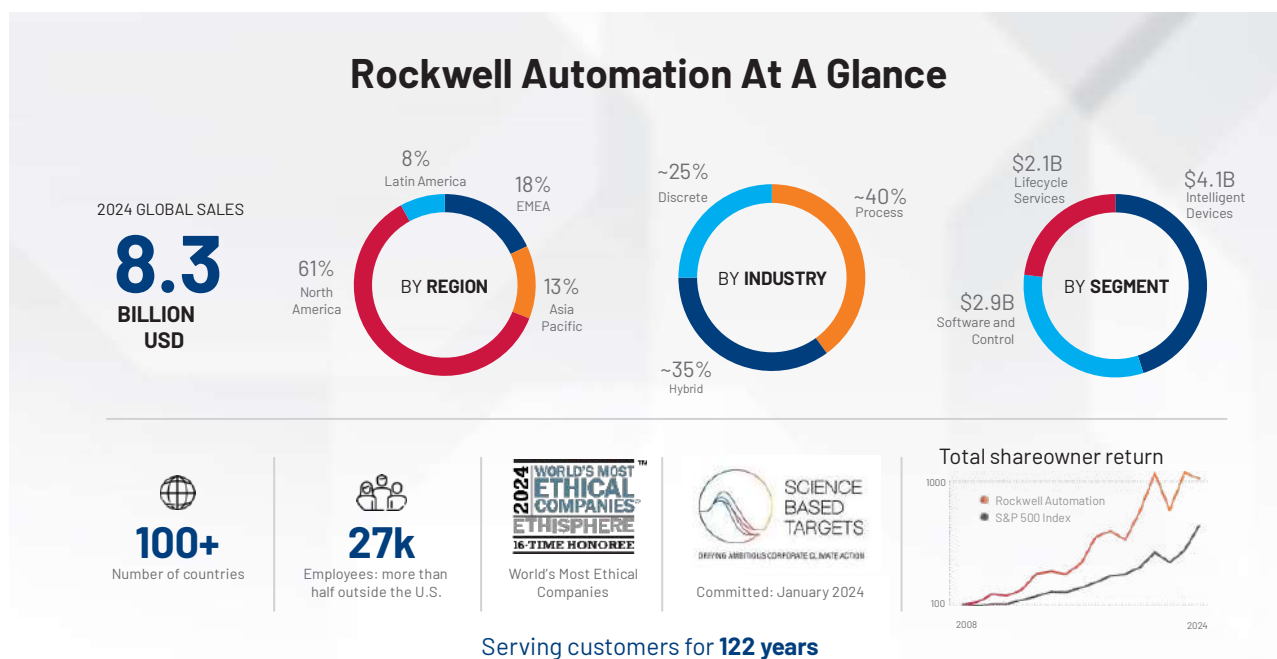
John Crane - New Energy Solutions





Rockwell Automation

expanding **human possibility**[®]



About Rockwell Automation:

Rockwell Automation is the world's largest pure-play industrial automation and digital transformation company, headquartered in Milwaukee, Wisconsin. Operating in over 100 countries with 27,000+ employees, its brands—Allen-Bradley®, FactoryTalk®, and LifecycleIQ™ Services—enable intelligent, connected operations across energy, manufacturing, and infrastructure.

Purpose & Vision

Rockwell's mission is to expand human possibility by marrying human imagination with digital technology. It fosters productivity, agility, and sustainability across traditional and emerging energy landscapes

Energy Sector Capabilities

Rockwell's integrated offerings empower both conventional and renewable energy operations through:

- Traditional Power Generation:
 - PlantPAX® Distributed Control Systems (DCS) for thermal and combined-cycle efficiency. SCADA systems with advanced SOE and redundancy support.
 - Intelligent MCCs (CENTERLINE®), PowerFlex® drives, vibration and turbine monitoring
- Renewables:
 - Solar: End-to-end automation for module manufacturing (stringing, lamination, QC) and solar farm control
 - Wind & Hydro: Predictive turbine analytics and grid management systems

- Green Hydrogen: Rockwell H2 Systems for electrolyzer controls, compression, storage, and dispatch
- Digital Transformation:
 - FactoryTalk® DataMosaix™ for energy benchmarking and optimization
 - Digital twin solutions and predictive control across assets
 - Robust OT cybersecurity frameworks aligned with ISA/IEC 62443 standards

Strategic Role in India's Energy Ecosystem:

Alignment with National Energy Goals

Rockwell enables India's Net-Zero ambitions and green economy vision by accelerating deployment of renewable assets, optimizing legacy systems, and enabling compliance through digital infrastructure:

- Support for **India's National Green Hydrogen Mission** with scalable, modular H2 platforms
- Contributions to **solar manufacturing capacity growth** through precision automation
- Integrated control and data systems for reducing LCOE and improving O&M transparency

Local Innovation & Manufacturing

- Manufacturing facility in Chennai supports assembly of systems for India's clean energy projects
- Collaborations with Tata, Mahindra, MRF to co-develop industry-specific digital solutions
- Energy system assembly for solar farms and electrolyzer skids under Make-in-India initiative.

Talent Development & Sustainability

- 4,000+ employees across Bengaluru, Pune, Delhi; localized engineering, support, and R&D
- OEM/SI capability development through training programs, cybersecurity readiness, digital twin simulations
- Initiatives promoting circular economy, water stewardship, and STEM education in rural communities

Ecosystem Engagement:

- Rockwell acts as a catalyst through key collaborations:
 - **Integration:** Accelerating project turnarounds with Indian EPCs and renewable OEMs.

- **Technology Alliances:** Partnering with inverter makers, hydrogen stack providers, and digital twin platforms.
- **Industry Leadership:** Actively participating in major energy transition task forces (ISA, REI, G20 ETWG).

Technology & Standards Leadership: Driving industry advancement:

- **Rapid Deployment:** Adopting NAMUR MTP, OPAF, and modular automation.
- **Real-time Energy Management:** Launching FactoryTalk® Edge Gateway.
- **Policy Influence:** Contributing to renewable energy and hydrogen safety regulations.

Impact & Results: Demonstrable improvements and efficiency gains:

- **Solar Module Automation:** 25% reduction in manufacturing downtime via integrated OT/IT.
- **Green Hydrogen Pilot:** 90% electrolyzer efficiency with remote diagnostics (Rockwell H2 System).
- **O&M Costs:** 20% reduction at a digitized thermal plant in Tamil Nadu.

Future-Ready Industry Enablement:

- Rockwell Automation continues to evolve its presence in India's industrial energy transition with a focus on:
 - Supporting **semiconductor fabs and data centers** through precision utility control systems
 - Accelerating **energy-as-a-service** models via data-driven insights and performance contracts
 - Scaling **AI-enhanced automation** for adaptive load balancing and carbon emission analytics

Commitment to India's Transformation:

Rockwell's India strategy is rooted in sustainable outcomes, operational resilience, and ecosystem empowerment. Its combination of domain expertise, digital platforms, and collaborative innovation makes it a trusted partner for India's trillion-dollar manufacturing and clean energy ambitions.

From plant floors to power grids, Rockwell Automation is building the digital backbone of India's energy future.

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AMERICAN CHAMBER OF COMMERCE IN INDIA

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New Delhi - 110016, India

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Email: amcham@amchamindia.com • **Web:** www.amchamindia.com