September 2025

International Integrated **Energy** Industry Magazine

Oil Gas & Power

www.jasubhaimedia.com

Power:
Thermal & Nuclear

Oil Gas & Power
World Expo 2027
3-5 March 2027, Mumbai, India

Jasubhai MEDIA

seal.tech

sealmatic®

MECHANICAL SEALS

Oil & Gas
Refinery
Petrochemical
Chemical
Power
Fertiliser
Pharmaceutical
Paper
Aerospace
Marine

Sealmatic India Ltd.
Bldg A, Indiplex IV, Survey No-12, Hissa No-9A,
Village Ghodbunder, Shanti Vidya Nagri Road,
Mira Road (E). Thane - 401104. India.

T : +91 22 50502700
E : info@sealmaticindia.com

TÜVRheinland®
European Directive 97/23/EC
QS-System (Module H)

TÜV INDIA
CE Ex II 3 G/D c T2
ATEX - 2014/34/EU

UKAS MANAGEMENT SYSTEMS
ISO 9001:2008
ISO 14001:2004
BS-OHSAS 18001:2007

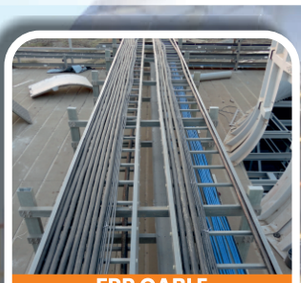
Q1 API Spec Q1 Registered

sealmaticindia.com

More than
800+
Satisfied
Clients

CORROSION FREE
COMPOSITE SOLUTIONS

Save Project Costs
Without Compromising Strength



FRP CABLE MANAGEMENT SYSTEMS

FRP GRATINGS

FRP HANDRAIL

FRP REBAR

FRP TANK

FRP CUSTOM SOLUTIONS

FRP TRENCH COVER

Approved with all major consultants and EPC Contractors for Oil, Gas and Process Plants

- Corrosion/Chemical Resistance
- High Strength
- Light Weight
- Electrical Non Conductivity
- Thermal Non Conductivity
- Ease of Fabrication
- Low Life Cycle Cost
- Sustainable
- Flame Retardant

MANUFACTURER OF FIBERGLASS / FRP / GRP

Cable Trays I Gratings I Structural Profiles I Ladders I Pitt Cover I Crossovers I Fencing
Handrails I Staircases & Platforms I Safety Marker Line I Cable Cleats I FRP Rebar I FRP Tank

Aéron©
THE COMPOSITE EXPERT...
www.aeroncomposite.com

AERON COMPOSITE LIMITED

Survey No. 170 to 174, Jornang - Akhaj Road, Via Ambaliyasan,
Jornang, Dist. - Mehsana, Gujarat - 382732 (INDIA)
T : +91-99099 88266, +91-90331 58500 | F : +91-79-26561238
E : info@aeroncomposite.com | W : www.aeroncomposite.com

Dealers & Distributors Inquiry Solicited

International Integrated ENERGY Special Issue

Oil Gas & Power

CHAIRMAN
Maulik Jasubhai Shah

PUBLISHER & CEO
Hemant K. Shetty

DEPUTY EDITOR
Reshmi Menon

CREATIVES
Arun Parab

GENERAL MANAGER SALES
Prashant Koshti
Amit Bhalerao

BRAND MANAGER
Sudhanshu Nagar

SALES
Godfrey Lobo
Chandrahas M Amin
Yonack Pradeep

JASUBHAI MEDIA PVT. LTD.
Registered Office: 26, Maker Chambers VI, 2nd Floor, Nariman Point, Mumbai 400 021, INDIA.
Tel.: 022-4037 3737 Fax: 022-2287 0502
E-mail: sales@jasubhai.com

PUBLISHED BY:

Jasubhai MEDIA

AD INDEX

Roto pumps since 1968

WE COMPETE WITH ONLY ONE PUMP

Introducing New

'P' RANGE PUMPS

Compact & Robust Design

Flow Rate - Up to 360 m^3/hr
Pressure - Up to 24 Bar

Engineered with Unique Thrust Bush Joint Design

Compact Design
One of the Shortest Footprint Pump

Top Hat Design
Easy Conversion to Bare shaft / Close Coupled Configurations

Improved Pump Housing
with 2 Large Inspection Ports

Strong presence in
55+
Countries

Association with more than
12,000
Customers

More than
3,25,000
Pumps Installed, sets us apart from the league

ROTO PUMPS LTD.
contact@rotopumps.com | www.rotopumps.com
Australia | Germany | India | Malaysia | South Africa | UK | USA | UAE

CONTENTS

GUEST COLUMN

FEATURES

NEWS FEATURE

India's renewable rise: Non-fossil sources now power half the nation's grid

New Delhi: India has achieved a landmark in its energy transition journey by reaching 50 per cent of its installed electricity capacity from non-fossil fuel sources—five years ahead of the target set under its Nationally Determined Contributions (NDCs) to the Paris Agreement. This significant milestone underscores the country's steadfast commitment to climate action and sustainable development, and signals that India's clean energy transition is not only real but also accelerating under the leadership of Prime Minister Narendra Modi.

Union Minister of New and Renewable Energy Pralhad Joshi, said, "In a world seeking climate solutions, India is showing the way. Achieving 50 per cent non-fossil fuel capacity five years ahead of the 2030 target is a proud moment for every Indian."

Flagship programmes such as *Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM), PM Surya Ghar: Muft Bijli Yojana,* solar park development, and the National Wind-Solar Hybrid Policy have laid a strong foundation for this transformation. The bioenergy sector, which was once on the margins, has now become an important contributor to both rural livelihoods and clean energy generation.

By achieving the 50 per cent non-fossil milestone well ahead of schedule, India further reinforces its leadership as a clean energy frontrunner, demonstrating that economic growth and environmental stewardship can go hand in hand.

REC Limited becomes first Indian Public Sector NBFC to achieve ISO 31000:2018 certification

New Delhi: REC Limited, a Maharatna Central Public Sector Enterprise under the Ministry of Power and a leading NBFC, has been certified with ISO 31000:2018 (Risk management — Guidelines) for its enterprise-wide risk management framework. This significant achievement marks REC as the first Indian Public Sector Non-Banking Financial Company (NBFC) to receive this certification from the British Standards Institution (BSI).

The ISO 31000:2018 is an internationally recognized standard that provides principles and guidelines for effective risk management. "This ISO 31000:2018 certification is a testament to REC's unwavering commitment to excellence in Enterprise Risk Management," said Mr. Subrata Aich, Chief Risk Officer of REC. "It signifies that REC has a structured, comprehensive, and internationally

Bhupender Gupta takes over as Chairman and Managing Director, NHPC

Bhupender Gupta has taken over as Chairman & Managing Director of NHPC Limited. Before joining NHPC, he was Director (Technical), THDC India Limited. Gupta is also holding the additional charge of the post of Chairman & Managing Director, SJVN Limited. Gupta holds a bachelor's degree in electrical engineering and an MBA in Operations Management.

With an illustrious career spanning more than 34 years including 31 years in Power CPSUs, Gupta has contributed significantly to the Indian power sector across hydro, thermal, renewable energy, transmission, and distribution domains. His contribution encompassed planning, design, execution, contract and project management, and O&M of large hydro projects as well as transmission and distribution projects.

aligned approach to risk management, which will further enhance the confidence of all our stakeholders, including investors and lenders."

The official certificate was formally handed over to Shri Subrata Aich by Shri Shripad Yesso Naik, Minister of State for Power and New & Renewable Energy and Shri Prateek Rai, India Head – Training (Sales and Operations), BSI, during 56th Foundation Day of REC.

Eastman brings solar energy solutions to Amazon India

New Delhi: Eastman Auto & Power Limited (EAPL), a leading name in innovative and sustainable energy solutions, has entered into a strategic partnership with Amazon India to make its cutting-edge solar products available online. This move marks a significant step in Eastman's digital transformation journey, aiming to bring high-quality, clean energy solutions directly to customers' doorsteps across the country.

Under this collaboration, customers can now conveniently purchase Eastman's flagship solar and power backup products on Amazon.

The range includes Solar PCUs – PWM and MPPT based solar off grid inverters; Solar Panels – Mono-Perc, Bifacial and TopCon technology; Home UPS – Sine wave and square wave inverters and Lead Acid Batteries – Solar and residential backup.

Speaking on the partnership, Mr. Shekhar Singal, Managing Director, Eastman Auto and Power Ltd said, "By making our solar panels, inverters, batteries and home UPS systems available online, we are eliminating barriers to accessibility and ensuring that quality solar products are just a click away for millions of customers across India."

DNV validates Electric Hydrogen's 'HYPRPLANT' turnkey electrolyzer solution

Katy, Texas: DNV, the independent energy expert and assurance provider, has completed a comprehensive technical review of Electric Hydrogen's HYPRPlant, validating its alignment with current industry standards for process design, safety, and manufacturing process.

The pre-engineered electrolyzer system – a device that uses electricity to split water into hydrogen and oxygen – features high-current-density stacks in a turnkey product which reduces front-end engineering and field installation burdens, offering a scalable solution for electrolytic hydrogen production.

Sipan Kumar Garg assumes additional charge of Director (Finance), NHPC Limited

Sipan Kumar Garg has taken over the additional charge of the post of Director (Finance) of NHPC Limited, India's premier hydropower company and a Navratna Enterprise of Government of India on 1st September 2025. A distinguished finance professional, he holds a degree in Bachelor of Commerce (Hons.) and is a member of the Institute of Chartered Accountants of India (CA), the Institute of Cost Accountants of India (CMA), and the Institute of Company Secretaries of India (CS). Additionally, he has done LL.B. and was a rank holder in the Company Secretary examination.

With over 24 years of extensive experience in Finance, Accounts, Taxation and Commercial aspects within the power sector, he brings deep expertise to his role at NHPC Limited.

DNV's review assessed Electric Hydrogen's proprietary proton-exchange membrane technology, power electronics, plant design, monitoring and controls, and standard product warranty with commercial assurances on their core technology. The analysis focused on the second-generation HYPRPlant, which incorporates fluid optimization and enhanced stack isolation. Available in 75 MW, 100 MW, and 120 MW configurations, the system achieves industry-leading power density, thus reducing stack count per unit of capacity within a standardized balance of plant.

To verify performance, DNV audited lab and pilot testing data from 2022–2025 and observed live operation at Electric Hydrogen's Pioneer Plant in San Jose — a 1/10th-scale facility running a commercial-grade stack. The review confirmed the system's ability to maintain rated efficiency, pressure, and purity while collecting critical lifetime degradation data. DNV also inspected the Devens, Mass. manufacturing facility, noting advanced quality controls, 5S lean management, and value-stream mapping aligned with established electrolyzer OEM standards.

JSW Neo Energy signs agreement to acquire 100% equity shares of Tidong Power Generation

Mumbai, Maharashtra: JSW Neo Energy Limited (JSWNEL), a wholly-owned subsidiary of JSW Energy Limited, has signed a definitive agreement with Statkraft IH Holding AS to acquire 100 per cent equity shares of Tidong Power Generation Private Limited (TPGPL), having a 150 MW under construction hydro power project. The transaction is subject to receipt of the necessary regulatory approvals and other customary conditions under the definitive agreement. Upon consummation of the transaction, TPGPL will become a subsidiary of JSWNEL and step-down subsidiary of JSW Energy Limited.

JSW Energy Limited has set a target to reach 30 GW generation capacity and 40 GWh of storage capacity by FY 2030, with the share of renewable energy generation increasing to 70 per cent by FY 2030. The hydro asset under this transaction will be acquired by JSW Neo Energy Limited. Approval from the Government of Himachal Pradesh for change in the controlling shareholding and approvals from lenders is required for the acquisition. The proposed acquisition is expected to be completed on or before 15th January, 2026, subject to fulfilment of the conditions under the definitive agreements. ■

Nayara Energy appoints Teymur Abasguliyev as Chief Executive Officer

Nayara Energy has appointed Teymur Abasguliyev as its new Chief Executive Officer (CEO). Teymur brings over two decades of diverse international leadership experience in the energy sector, renowned for his expertise in driving organizational transformation and delivering sustainable growth. Teymur holds both bachelor's and master's degrees from the Department of International Relations and Law at Baku State University. Recognized for his strategic vision and results-driven approach, Teymur has a proven track record across the energy value chain, encompassing refining, petrochemicals, gas distribution, trading, and infrastructure. He has led multibillion-dollar investments, transformative transactions, and has consistently built resilient, multicultural high-performing teams. Teymur is also a respected board member and mentor.

PM Shri Narendra Modi inaugurates first unit of SJVN's 1320 MW Buxar thermal power project in Bihar

Shimla, Himachal Pradesh: In a major push for sustainable development, industrial growth and infrastructure enhancement, Prime Minister of India Shri Narendra Modi laid the foundation stone of projects in Bihar worth over ₹13 thousand crore from Bodh Gaya. In this historic moment, Prime Minister Shri Narendra Modi virtually inaugurated first unit (1x660 MW) of 1,320 MW Buxar thermal power project of SJVN, a Navratna Central Public Sector Enterprise (CPSE), under the Ministry of Power.

Employees of SJVN and its subsidiaries across all projects and units in India and Nepal witnessed this historic occasion through live streaming. The 1,320 MW (2x660 MW) Buxar thermal power project located at Chausa in district Buxar, Bihar is being implemented by SJVN Thermal Private Limited, a wholly-owned subsidiary of SJVN. The foundation stone of the project was laid by Prime Minister Shri Narendra Modi on 9th March 2019. Equipped with state-of-the-art supercritical technology, the project ensures higher efficiency and reduced environmental impact.

With the total investment of ₹13,756.56 crore, the project will generate 9,828.72 million units of electricity annually, out of which 85 per cent power has been allocated to Bihar under a long-term power purchase agreement. The project will substantially enhance power availability in Bihar and the Eastern Region, reducing peak-hour shortages and strengthening energy security. Its construction involved the use of around 2,54,932 MT of steel and 2,80,362 tonnes of cement, providing a significant boost to the vision of *Atmanirbhar Bhara*t by promoting domestic industries.

During construction phase, the project engaged nearly 5,000 workers annually, with local residents being the primary beneficiaries. It has created both direct and indirect employment opportunities, which will continue during its operational phase as well. Local markets, small businesses, hotels, and transport services have also experienced growth, contributing to the region's economic development.

TEMA India unveils India's first private test facility for depleted heavy water upgradation

Senior members during the inauguration of India's first private test facility for depleted heavy water upgradation

Achhad, Mumbai: TEMA India Limited has inaugurated India's first-of-its-kind, state-of-the-art private test facility dedicated to the upgradation of depleted heavy water, marking a new chapter in the nation's journey toward nuclear self-reliance. The ribbon-cutting and facility unveiling ceremony was graced by eminent dignitaries from India's nuclear industry, including Rajesh V, Director - Technical, Nuclear Power Corporation of India Limited (NPCIL); K. T. Shenoy, Director, Chemical Engineering Group, BARC; Haresh K. Sippy, Founder & CMD, TEMA India; Chetan Doshi, Founder Director & CEO – Nuclear Division and Narendra Rao, Director & COO – Nuclear Division.

The event included the unveiling of the test facility, a briefing and walkthrough of the testing process, and the symbolic flag-off of the first validated consignment of 8 distillation columns sections with activated phosphor bronze modules and validated by performance test-key components used in distillation columns of Pressurized Heavy Water Reactors (PHWRs). The modules are slated for delivery to critical nuclear power plant projects such as RAPP 8, GHAVP Units 1–4, and KAIGA Units 5 and 6.

This pioneering facility is a testament to the TEMA India's 40+ years of engineering excellence. The inauguration of this facility represents a significant step forward in strengthening domestic capabilities for nuclear component validation. By establishing this test infrastructure, TEMA India has contributed meaningfully to the broader goals of self-reliance and quality assurance in the nuclear sector.

Rajesh V, Director - Technical, NPCIL and K. T. Shenoy, Director, Chemical Engineering Group, BARC, both lauded TEMA India's technical capabilities, commitment to quality, and its role as a trusted partner in India's nuclear supply chain. The dignitaries also joined a tree plantation and traditional pooja, followed by a ceremonial flag-off - marking the movement of India's private sector into advanced nuclear component manufacturing.

Haresh K. Sippy, Founder Director and CMD of TEMA said that TEMA is always willing to take up new challenges and has contributed in the past also successfully in Atma-Nirbhar Bharat initiative. This is another success story and TEMA is committed to participate in such initiatives in future also.

Chetan Doshi, Founder Director and CEO-Nuclear explained the vision of TEMA Nuclear vertical to become a major player in Indian nuclear industry by executing Class I critical heat exchangers, tanks and vessels and nuclear components and EPC packages. He mentioned that Narendra Rao, Director and COO – Nuclear, TEMA and Sunil Kubal, Executive Director – Nuclear, TEMA are well equipped with their experience, skillset and leadership to make it happen soon.

REnergy Dynamics enters into a strategic alliance with GMM Pfaudler to manufacture paddle agitators

New Delhi: REnergy Dynamics (RED), a company dedicated to advancing the bioenergy sector in India, has entered into a strategic alliance with GMM Pfaudler, a global leader in technologies, systems, and services, to become one of the first companies in India to manufacture paddle agitators under the Government's 'Make in India' initiative.

Under this alliance, commercial production of paddle agitators has commenced at a state-of-the-art facility in Gujarat, positioning RED-GMM among the first movers to locally manufacture and supply this critical equipment for CBG plants in India. These agitators are already operational at marquee projects, including Reliance Industries' CBG plant executed by RED, which serves as a flagship reference.

With nearly 1,000 CBG plants expected to become operational over the next three years, the paddle agitator market within the CBG sector alone is projected to reach ₹7,500 crore.

GMM Pfaudler agitators have also been used on mixing application of hydrolysis of bamboo based 2G Ethanol facility at the Assam Bio Refinery (Numaligarh Refinery Limited).

With this alliance, RED once again reaffirms its commitment to bringing technology, quality, and affordability to the CBG industry.

UltraTech operationalizes India's first-of-its-kind on-site hybrid RTC renewable energy project

Hybrid RTC renewable energy project installation at UltraTech's Unit Sewagram Cement Works

Mumbai, Maharashtra: UltraTech Cement Limited, India's largest cement and ready-mix concrete company, has operationalised a 7.5 MW round-the-clock (RTC) hybrid renewable energy project at its integrated cement manufacturing unit, Sewagram Cement Works, located in Gujarat. This innovative solution integrates solar using bifacial modules with trackers and wind energy alongside battery storage, co-located on-site, to provide uninterrupted energy during the cement manufacturing process without any reliance on grid power. The project was executed in collaboration with clean energy solutions company Gentari.

Installed as a behind-the-meter system, the project marks the country's first in industrial power consumption and showcases what advanced system integration can achieve in terms of emissions reduction and energy cost optimisation at scale. The project, which has been executed with the objective of providing uninterrupted clean energy, represents a new benchmark in India's clean energy transition, demonstrating the power of customer-led design and integrated system engineering.

UltraTech aims to increase the share of green energy in its total power mix to 65 per cent by 2027 and 85 per cent by 2030. As part of its RE100 commitment, UltraTech aims to meet 100 per cent of its electricity requirement through renewables sources by 2050.

Premier Energies secures landmark solar electrification orders in Benin, West Africa

Hyderabad, Telangana: Premier Energies Limited has won contracts worth USD 19.95 million for supply and installation of solar power systems in the Republic of Benin, West Africa. The scope of the contracts covers installation of 750 rooftop solar systems at key socio-community facilities including district police stations, educational institutions, health centres and special border surveillance units, plus installation of over 4,400 high-efficiency solar streetlights and 650 solar water heaters. These projects are part of a national initiative by the Government of Benin to expand access to reliable, sustainable clean energy. Implementation will be carried out by Premier Energies in collaboration with the General Directorate of Energy Planning and Rural Electrification, under the Ministry of Energy, Water and Mines, Republic of Benin. Financing for the project is secured through a Line of Credit from the Export-Import Bank of India (EXIM Bank) and the ECOWAS Bank for Investment and Development (EBID).

L&T Renewables Business secures order for BESS-Integrated solar plant

Mumbai, Maharashtra: The Renewables business vertical of Larsen & Toubro has secured a significant order to develop a grid-connected 116 MWac Solar Photovoltaic (PV) plant integrated with a 241 MWh Battery Energy Storage System (BESS) at Kajra, Lakhisarai district in Bihar. The Engineering, Procurement and Construction (EPC) order marks an extension of the earlier phase, taking the total co-located storage capacity of the renewable generation site at Lakhisarai to 495 MWh — the largest such project awarded by a state utility in India.

The deployment of a 4-hour BESS alongside intermittent solar generation will enable energy time-shifting, allowing surplus clean energy to be stored and despatched during peak demand periods. The advanced BESS solution will feature liquid cooling technology, ensuring higher power density, improved safety, and extended operational life.

The initiative aligns with Government of India's policy push for co-located renewable energy storage systems and supports the *Jal-Jeevan-Hariyali Abhiyan* (water, life, and greenery mission) in Bihar, while contributing to employment generation and long-term energy security. The Renewables business vertical had earlier secured an EPC order for a 275 MW Solar PV project in Gujarat, strengthening its portfolio of flexible, efficient and cost-effective clean energy systems.

In another major development, the Hydrocarbon Offshore business vertical (L&T Energy Hydrocarbon Offshore) of L&T has secured an ultra-mega order from a prestigious client in the Middle East. The order encompasses multiple offshore packages, and the scope includes EPC and installation of offshore structures, along with the upgradation of existing facilities.

WABAG secures order to deliver pure water, ETP & ZLD Solutions for RenewSys Solar Cell manufacturing unit

Chennai, Tamil Nadu: VA TECH WABAG, a leading pure-play water technology Indian Multinational Group, has secured a prestigious order from RenewSys India Private Limited to deliver comprehensive water management solutions for its 2 GW solar cell manufacturing facility in Hyderabad, Telangana. The scope of work includes the design, engineering, manufacturing, supply, installation and commissioning of an Ultrapure Water system, Effluent Treatment Plant (ETP), and a Zero Liquid Discharge (ZLD) system, to be executed within a period of 11 months.

The order, worth ₹46.50 crore is strategically significant for WABAG as it marks a strong foothold in the solar manufacturing sector, reinforcing its capabilities across UPW, ETP, and ZLD segments. It also positions WABAG to capitalize on future opportunities in solar, green hydrogen, semi-conductor and other high-growth industrial applications. Commenting on this order win, V. Sivakumar, General Manager - Sales & Marketing,

India Cluster said, "This order marks WABAG's foray into delivering comprehensive water management solutions for solar cell facilities, one of the high growth segments for the future. WABAG's technological expertise, proven track record and competitive pricing enabled us to offer lowest life-cycle cost."

JSW Neo Energy signs first FDRE PPA with SECI

Mumbai, Maharashtra: JSW Neo Energy Limited, a wholly owned subsidiary of JSW Energy Limited, has signed a Power Purchase Agreement (PPA) with the Solar Energy Corporation of India (SECI) for the supply of 230 MW ISTS connected Firm and Dispatchable Renewable Energy (FDRE) under the SECI–FDRE Tranche IV scheme. This marks the company's first PPA for a FDRE project. The agreement has been signed for a tenure of 25 years at a tariff of ₹4.98 per kWh.

With this, the company's total under-construction capacity stands at 12.9 GW, and its total locked-in generation capacity now stands at 30.2 GW. JSW Energy remains well-positioned to achieve its strategic target of 30 GW installed generation capacity and 40 GWh of energy storage by 2030.

Sharad Mahendra, Joint Managing Director and CEO of JSW Energy, said, "We are proud to announce the signing of our first Power Purchase Agreement for a load-following Firm and Dispatchable Renewable Energy project. With this project, we are strengthening our energy products and services offering while supporting the country's energy transition goals."

L&T Energy GreenTech to establish India's first largest green hydrogen plant

Mumbai, Maharashtra: L&T Energy GreenTech Ltd (LTEG), a wholly-owned subsidiary of Larsen & Toubro (L&T), will set up India's first largest green hydrogen plant at Indian Oil Corporation Ltd's (IOCL) Panipat refinery in Haryana. The plant, to be developed on a Build-Own-Operate (BOO) basis, will supply 10,000 tonnes of green hydrogen annually to IOCL for 25 years, supporting Government of India's National Green Hydrogen Mission. The plant will operate round the clock using renewable energy, aligning with IOCL's broader strategy to decarbonise its refining operations and contribute to India's net-zero ambitions. It will produce the green hydrogen using high-pressure alkaline electrolysers manufactured at L&T Electrolysers Ltd's state-of-the-art facility in Hazira, Gujarat.

Subramanian Sarma, Deputy Managing Director & President, L&T, said, "The decision to set up India's maiden green hydrogen plant validates our strategy to lead the nation's energy transition. This long-term project not only deepens our partnership with IOCL but also reinforces our capability to deliver large-scale clean energy solutions. As a first mover in India's green hydrogen space, we are proud to lay the foundation for cleaner industrial processes at scale."

JSW Energy commissions 261 MW RE capacity, taking installed capacity to 12.8 GW

Mumbai, Maharashtra: JSW Energy Limited has successfully commissioned 261 MW of renewable energy capacity with solar capacity of 189 MW and wind capacity of 72 MW, taking the installed capacity to 12,760 MW. With this the cumulative capacity addition during Q1 FY26 stands at 1.9 GW constituting both organic and inorganic capacities.

Share of renewables in the overall capacity increases to 56 per cent constituting of wind capacity at 3,554 MW, solar capacity at 2,157 MW and hydro capacity at 1,391 MW. This capacity addition is timely in nature and will enable the company to benefit from the peak renewable generation season during the year and will contribute meaningfully to overall renewable output. JSW Energy has total locked-in generation capacity of 29.9 GW comprising of 12.8 GW operational, 12.5 GW under-construction across thermal, wind, solar and hydro and pipeline of 4.6 GW.

The company also has 29.3 GWh of locked-in energy storage capacity through hydro pumped storage projects of 26.4 GWh and battery energy storage system of 2.9 GWh. The company aims to reach 30 GW generation capacity and 40 GWh of energy storage capacity by FY 2030. JSW Energy has set an ambitious target of achieving carbon neutrality by 2050.

L&T secures thermal power contract from Adani Power

Mumbai, Maharashtra: Larsen & Toubro (L&T) has secured an ultra-mega contract from Adani Power Ltd to set up eight state-of-the-art thermal power units, each with a capacity of 800 MW, totaling 6,400 MW of new generation capacity. The order will be executed by L&T Energy – CarbonLite Solutions (LTECLS), the company's specialized business vertical for advanced power and low-carbon technologies. The scope of work encompasses the complete design, engineering, manufacturing, supply, and commissioning of Boiler-Turbine-Generator (BTG) packages, along with auxiliaries and associated mechanical, electrical and control & instrumentation (C&I) systems. Subramanian Sarma, Deputy Managing Director & President, L&T, said, "In today's dynamic energy landscape, where India's demand for reliable and affordable power continues to grow, this order from the Adani Group reinforces our role as a leading partner in building the country's critical energy infrastructure." Adani Power Ltd, India's largest private sector thermal power producer with an installed capacity of over 18,000 MW, plays a pivotal role in meeting the nation's baseload electricity requirements.

Thermax, HydrogenPro ASA partner to indigenise alkaline water electrolysis solution for GH2 projects

Pune, India and Porsgrunn, Norway: Thermax, a leading energy and environment solutions provider and a trusted partner in energy transition, has entered into a strategic partnership with HydrogenPro, a leader within green hydrogen technology and systems, for alkaline electrolysers. As part of the technology licensing and agreement for supply of stacks, including any future upgrades and technical support from HydrogenPro, Thermax will have exclusive rights in India for the supply, installation, commissioning, and after-sales services of alkaline electrolyser systems based on HydrogenPro's technology, which will be effective immediately and available for deployment in ongoing Indian green hydrogen projects.

HydrogenPro brings world-class, proven electrolyser technology that fully complies with international standards and certifications. HydrogenPro's in-house expertise in advanced electrode development and coating serves as a key enabler for delivering high-efficiency systems. Through a comprehensive technology transfer, Thermax will engineer and manufacture key systems and balance-of-plant components of the electrolyser for integration with stacks. Additionally, Thermax and HydrogenPro will collaborate on the joint development of advanced solutions to meet evolving market needs. As a significant first step, a state-of-the-art test station for short stacks will be established at Thermax's facility in Pune.

JSW Energy commissions 240 MW Kutehr hydro plant

Mumbai, Maharashtra: JSW Energy Limited has successfully commissioned the third and final 80 MW Unit of Kutehr Hydroelectric Power Plant, marking the full commissioning of the 240 MW greenfield hydro project. The Kutehr plant is situated in Chamba district of Himachal Pradesh and is amongst one of the fastest built greenfield hydro projects in India.

The project is backed by a long-term Power Purchase Agreement with Haryana Power Purchase Centre (HPPC) for the entire 240 MW at a levelized ceiling tariff of ₹4.50/kWh, valid for 35 years with provisions for extension. Power generated will supply Haryana's state distribution utilities — Uttar Haryana Bijli Vitran Nigam and Dakshin Haryana Bijli Vitran Nigam. The commissioning of Kutehr HEP, coupled with recent organic wind capacity additions, has taken the company's installed capacity to 13,020 MW, up from 10,875 MW at the end of FY25, reflecting a robust 2,145 MW increase since March 2025. ■

"The article "Engineering the Future: Tackling Skilled Workforce Shortage" (published in June 2025 edition) resonates with everyone in the industry. It can be solved by industry participation and the industry coming forward to doing lectures giving practical advice to the students. I do my little bit in terms of taking guest lectures."

Gautam Watve
Managing Director
Suyash Composite Industries Pvt Ltd
Mumbai

Why India Prefers Energy Diversity Over Transition

PRAVEEN NAKKELLA
Director Pre-Sales
Hexagon Asset Lifecycle Intelligence

Faced with rapid economic and population growth, India is investing tremendously in renewable and nuclear energy, as well as in the development of its oil fields and refining capacity. While the country has set a 'Net Zero' goal for 2070, energy security and the ability to provide affordable power to its 1.5 billion inhabitants remain the main priority, opines ***Praveen Nakkella, Director Pre-Sales, Hexagon Asset Lifecycle Intelligence.***

How to supply reliable, affordable energy to 1.5 billion people while keeping emissions under control? This question is at the heart of India's energy policy. While many Western countries focus primarily on energy transition, the country must pursue energy expansion to meet demand sustainability.

This need has led to a dual track: building new renewable and nuclear capacity, and developing domestic oil and refining infrastructure, alongside stricter environmental regulation. Technology plays a central role to ensure that this strategy succeeds. Improved project delivery, greater plant reliability and accurate emissions tracking are key to ensuring this strategy achieves both economical and environmental gains and positions India as an energy superpower.

The Rapid Rise of India's Energy Demand

India's energy consumption has increased by 20 per cent since 2019, reaching 36.2 quadrillion BTU. That makes it the world's third-largest energy consumer, behind the United States and China. Government projections expect another 35 per cent rise over the next decade.

The country's share of global greenhouse gas emissions has also grown — from 6.7 per cent in 2019 to 7.8 per cent in 2023. India has set a net zero target for 2070 and aims for half of installed electricity capacity to come from non-fossil sources by 2030. This objective requires major investment in renewables. Solar capacity has recently surpassed 100 gigawatts, on par with Germany. Hydroelectric power is expected to rise by 50 per cent by 2032, from 42 to 67 gigawatts. Nuclear capacity, currently 8 gigawatts, is also expanding, with six new reactors under construction.

Betting on Oil and Gas Expansion

At the same time as it boosts green energy, the country is also placing a major bet on oil production and refining. Part of the reason is the growth of domestic demand: India will account for one-third of the global increase in oil consumption between now and 2030, according to the IEA. In addition, India imports more than 80 per cent of the oil it consumes, making domestic production a strategic concern.

But India's ambitions go beyond meeting domestic demand. The country has positioned itself as a major exporter of refined products, supplying Europe, Asia and the Middle East with over $80 billion of petroleum fuels, lubricants and petrochemicals annually. This meeting of domestic needs, strategic concerns and economic ambitions has led to expand domestic oil production, with the country opening more than one million square kilometers to exploration in October 2024, with a tender for 16 blocks launched in February. The government is reforming its regulations to attract international players, largely absent from exploration and production. The Oilfield (Regulatory and Development) Amendment Bill, for example, simplifies environmental and land-use authorizations, frequent causes of delays in oil and gas projects.

A Matter of R&D

India is also seeking to make oil production cleaner, using advances in technology and applied research to limit environmental impact. One example of this approach is Hexagon R&D India. Based in Hyderabad, the site is home to 2,100 engineers working across sensors, software and autonomous systems for energy and industry. It is

the largest global research centre of Hexagon, whose technologies support more than half of all oil and gas processed worldwide.

This local presence has allowed Hexagon to support Indian clients in connecting their engineering, construction and maintenance systems. When data is centralised, changes in design or execution can be reflected accurately in digital models and documentation — reducing errors and delays. Tools such as HxGN EAM also help operators track emissions, optimise maintenance and reduce waste across the lifecycle of a plant.

In this domain, one of the areas producers are increasingly zeroing in on is the reduction of methane emissions. Methane, a gas with 28 times the warming potential of carbon dioxide, is a byproduct of oil and gas production that often escapes through leaks, venting or flaring, and has become a key target for emissions monitoring and control. Indian operators including ONGC have announced targets to reduce flaring and curb methane leaks, and monitoring tools are playing a growing role in supporting these goals.

The Crucial Role of Refineries

A crucial theater for India's ambitions to grow energy supply without growing its emissions will be the country's 23 refineries, which are crucial nodes in its energy system. As the backbone of India's energy system, refineries are critical to ensuring energy availability. Any disruption can quickly lead to shortages. Maintenance must be scheduled carefully to avoid holiday periods, when demand peaks. In October 2024, which included the Diwali festival, diesel consumption rose by 20 per cent compared to September. To keep pace with demand, India is investing heavily in refining capacity, ranking second globally behind China. But increasing output is only part of the strategy.

The country is also investing in digital tools to improve reliability and maintenance planning. Numaligarh Refinery Limited, the leading public facility in eastern India, is digitalising its operations, aiming to establish a digital twin as the definitive source of operational data.

The Making of a Global Energy Superpower

This focus on better data also supports tighter regulation. Refineries have undergone major upgrades to produce fuel compliant with Bharat Stage VI standards, which cut sulphur content to 10 parts per million — on par with the Euro 6 norm. As India takes on a larger role in global energy markets, this shift serves two goals.

For policymakers, it signals the country's readiness to meet global expectations on environmental and operational standards. For energy companies, particularly multinationals expanding their footprint in India, it offers a model of how fossil fuel operations can evolve alongside renewables. With a large and growing population, vast geography and limited electrification in key sectors—electric vehicles still represent just 2.5 per cent of new car sales — India's energy needs will remain high. The government is not seeking to replace fossil fuels outright but to manage them more efficiently while scaling up alternatives. If it succeeds, India will become a leading light for energy diversity, where fossil and renewable sources operate side by side to meet demand, reduce emissions and serve as a powerful foundation to the country's economic growth.

Can India meet the challenges of providing net-zero electricity to one-fifth of the world's population? The country has set the ambitious objective of achieving carbon neutrality by 2070 and, by 2030, bringing the share of non-fossil energy to 50 per cent of installed electrical capacity. This goal involves the development of renewable and low-carbon energy sources. India has recently passed the threshold of 100 gigawatts of solar capacity, equaling Germany.

Hydroelectric power is also expected to experience rapid growth, with the goal of increasing its installed capacity by half, from 42 gigawatts today to 67 by 2031-2032. Finally, nuclear energy, which currently represents 8 gigawatts or barely 2 per cent of installed capacity, should also see this figure increase by half, thanks to six reactors under construction.

The Energy Transition Tested by Strategic Independence

At the same time, to meet the needs of its population, India is also accelerating its offshore oil exploration. In the recent period, energy demand has risen sharply, driven by population and economic growth, urbanization, industrial expansion and the development of a more energy-intensive middle class. Its total primary energy consumption has increased by 20 per cent since 2019, reaching 36.2 quadrillion Btu. This already places the country third in the world, behind the United States and China, and it is expected to grow by another 35 per cent over the next 10 years, according to government forecasts.

The result: in a world where consumption is expected to increase by 1.2 million barrels of oil per day by 2030, India alone accounts for a third of that increase, according to the IEA. Yet the country imports more than 80 per cent of its oil, mainly from OPEC+ countries, the rest being supplied by the one million barrels per day of domestic production. The increase in domestic field developments, described by Minister of Petroleum and Natural Gas, Shri Hardeep Singh Puri as a 'hundred-billion-dollar opportunity,' is therefore as much a matter of strategic independence as it is of trade balance.

The objective of increasing domestic production has led to opening more than one million square kilometers to exploration in October 2024, with a tender for 16 blocks launched in February. The government is reforming its regulations to attract international players, largely absent from exploration and production. The Oilfield (Regulatory and Development) Amendment Bill, for example, simplifies environmental and land-use authorizations, frequent causes of delays in oil and gas projects. India also hopes to chart a path toward a more environmentally respectful oil extraction, notably through stricter environmental standards for fuels and refined products — for example, the Bharat Stage (BS) VI emission standards, aligned with European Euro 6/VI norms.

The Hope for High-Tech, Greener Oil Extraction

On the production side, India faces a dual imperative. On the one hand, the country wants to move quickly to accelerate the exploration of its oil resources while global demand is at its peak. The country is already the third-largest exporter of refined products, with Europe among its main clients. At the same time, it wants to avoid increasing its carbon footprint, as India's share of global greenhouse gas emissions has already risen from 6.7 per cent in 2019 to 7.8 per cent in 2023.

Energy players are counting on technological solutions to resolve this equation. For example, new exploitation projects now typically include digital twins from the design stage, intended to centralize information and measure greenhouse gas emissions throughout the lifecycle of future facilities. A key target is methane emissions, a greenhouse gas responsible for a third of emissions in the energy sector, whose warming potential is considered 28 times greater than that of carbon dioxide. Several major players in the sector, including state-owned giant ONGC, have expressed their intent to tackle their methane emissions and to reduce harmful practices such as gas flaring.

Refinery Reliability Under Scrutiny

Another key focus of government attention: the country's 23 refineries. Unlike Western countries, the growth in hydrocarbon demand comes from consumers rather than businesses. The country's development and the rise of the middle class have led to a surge in two main uses: transport (cars, motorcycles) and domestic consumption (especially for cooking).

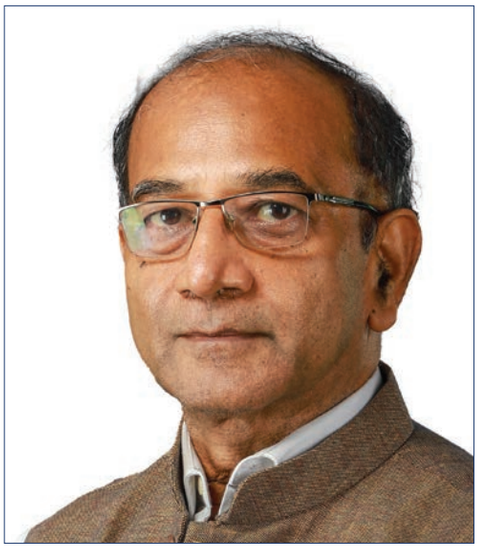
Increasing Environmental Regulations

This greater traceability of information also aims to meet regulations that are developing to align with Western standards: oil distributors have massively invested in modernizing refineries to produce BS6-compliant fuel, with reduced sulfur content (10 ppm compared to 50 ppm under the BS4 standard), aligned with the Euro 6 norm.

As India plays an increasingly important role in the global energy industry, this alignment serves a dual purpose. For public authorities, it is about proving that India is a major energy player, capable of aligning with the best environmental and operational practices and serving the entire world. For major industry players — and particularly global giants who are increasingly present in India —the aim is to show that an alternative path exists to the decline of fossil fuels and their replacement by renewables.

With its growing population and economy, vast geography, and energy uses that are hard to replace with electricity — electric vehicles, for example, account for only 2.5 per cent of new car sales — India faces significant energy challenges. To meet them, it intends to embody the perfect laboratory of 'energy diversity,' where fossil and renewable energies coexist sustainably as an alternative to the energy transition. ■

The Fusion Frontier: Is the Ultimate Clean Energy Source Finally Within Reach?



DR. PRABHAT RANJAN
Distinguished Nuclear Fusion Scientist and Co-founder, ASPL Fusion,
Chairman (Research, Innovation and International Relations) Dr D Y Patil Pratishthan

For decades, it has been the holy grail of the energy sector—a source of power that mirrors the sun, promising limitless, carbon-free electricity from the most abundant elements in the universe. Nuclear fusion, the process that powers the stars, has long been touted as the ultimate solution to humanity's energy and climate crises. For just as long, it has remained tantalizingly "30 years away." But the paradigm is shifting. A convergence of groundbreaking technological advancements, a surge in private investment, and a dramatic pivot in government policy are transforming fusion from a distant dream into a tangible prospect. The question is no longer if fusion energy will happen, but when—and who will lead the charge into this new era.

At its core, nuclear fusion is the process of forcing light atomic nuclei, typically isotopes of hydrogen called deuterium and tritium, to combine, releasing immense amounts of energy. The challenge lies in recreating the sun's conditions on Earth: heating the fuel to over 100 million degrees celsius t o create a plasma and confining it long enough for fusion to occur. For years, one approach dominated this pursuit.

The Stalwart: Tokamaks

The most well-known method for containing this superheated plasma is the 'tokamak', a donut-shaped device that uses powerful magnetic fields to suspend the plasma away from the chamber walls. The world's largest fusion experiment, the ITER (International Thermonuclear Experimental Reactor) project in France, is a monumental tokamak built by a consortium of 35 nations, including India. Its goal is to be the first fusion device to produce a net energy gain, generating 500 megawatts of thermal power from a 50-megawatt input. While ITER represents a critical step in fusion science, its immense scale, cost, and long timeline have opened the door for alternative, and potentially faster, paths to commercialization.

The Rise of Alternative Concepts

The last decade has seen a Cambrian explosion of

The world's largest fusion experiment, the ITER (International Thermonuclear Experimental Reactor) project in France, is a monumental tokamak built by a consortium of 35 nations, including India. Its goal is to be the first fusion device to produce a net energy gain, generating 500 megawatts of thermal power from a 50-megawatt input.

innovative designs, driven largely by agile private companies.

- **Stellarators:** A cousin to the tokamak, the stellarator uses a more complex, twisted set of magnets to confine plasma. While harder to design, it offers the potential for continuous, steady-state operation, a key requirement for a power plant. Germany's Wendelstein 7-X is the world's most advanced stellarator, proving the stability of this approach. It achieved highest 'triple product (calculated by multiplying together fuel density, fuel temperature and confinement time)' among long duration plasma in May 2025, while this record is held by tokamak for shorter duration plasma.

- **Magnetic Mirrors:** These linear devices confine plasma between two powerful magnetic fields that act as 'mirrors.' Their simpler geometry could make them easier and cheaper to build and maintain than toroidal machines. A key innovation in this area is the Gas Dynamic Trap (GDT), which enhances stability and confinement.

- **Inertial Confinement Fusion (ICF):** In a radical departure from magnetic fields, ICF uses incredibly powerful lasers to rapidly heat and compress a tiny fuel pellet, triggering fusion in a manner akin to a microscopic star. In 2022, the National Ignition Facility (NIF) in the United States made history by achieving 'ignition' — the first time a fusion experiment produced more energy than was delivered to the target, a landmark scientific achievement.

Key Technological Leaps Powering the Race

This diversification of approaches is being fueled by two game-changing technological advancements that are lowering barriers and accelerating progress.

1. High-Temperature Superconducting (HTS) Magnets

Perhaps the single most important breakthrough has been the development of HTS magnets. These new magnets can generate vastly stronger magnetic fields than their low-temperature predecessors in a much smaller package. Stronger fields mean better plasma confinement, which allows for the construction of smaller, more powerful, and potentially much cheaper fusion devices. This technology is the cornerstone of projects like Commonwealth Fusion Systems' (CFS) SPARC, which, in partnership with MIT, aims to build a compact, net-energy-gain tokamak on a dramatically faster and cheaper scale than ITER.

2. AI and Computational Modeling

Fusion research is no longer just about physical experiments. Today, the world's most powerful supercomputers, coupled with artificial intelligence and machine learning, can model and predict the chaotic behavior of plasma with unprecedented accuracy. Companies are now able to design, simulate, and optimize entire fusion reactors in the virtual world before ever cutting a piece of metal, slashing development times and costs.

The Policy Pivot: Nations Race for Fusion Leadership

Recognizing that fusion is entering a new era of commercial possibility, governments worldwide are shifting their policies from funding pure science to fostering a competitive private industry.

India, a long-standing partner in ITER and home to the Institute for Plasma Research (IPR), has a deep pool of scientific talent and a strategic imperative for clean energy, creating a fertile ground for domestic fusion ventures, however policy changes are needed to separate out nuclear fission and fusion based systems like USA and other countries.

ASPL Fusion's plan is spearheaded by visionaries including Prof. Prabhat Ranjan. Prof. Ranjan has been a pivotal figure in India's fusion program, having played a key role in the design and development of the country's first superconducting tokamak, SST-1, at the Institute for Plasma Research. His extensive experience in plasma physics and fusion technology provides the deep technical expertise necessary to guide such an ambitious venture.

- The United States has launched a 'Bold Decadal Vision for Commercial Fusion Energy' and a landmark Milestone-Based Fusion Development Program, modeled on NASA's successful partnership with SpaceX. This program directly funds private companies to solve specific technical and commercial challenges on the path to a pilot power plant.
- The United Kingdom has established a proactive regulatory framework for fusion energy, separate from nuclear fission, to provide clarity and encourage investment. Its STEP (Spherical Tokamak for Energy Production) program aims to have a prototype power plant connected to the grid in the early 2040s.
- Germany and Japan continue to make significant public investments in their flagship stellarator and tokamak programs, respectively, providing a deep scientific foundation for the industry.
- India, a long-standing partner in ITER and home to the Institute for Plasma Research (IPR), has a deep pool of scientific talent and a strategic imperative for clean energy, creating a fertile ground for domestic fusion ventures, however policy changes are needed to separate out nuclear fission and fusion based systems like USA and other countries.

The Indian Vision: ASPL Fusion's Pragmatic Roadmap

Embodying this new global trend is ASPL Fusion, an Indian startup with a pragmatic, phased approach to commercializing fusion technology. The company's strategy is designed to build on technical successes while generating revenue at each stage, directly addressing India's unique energy and healthcare needs.

ASPL Fusion's plan unfolds in three stages:

1. **Phase 1: Rapid Profitability:** The company will first deploy a high-intensity accelerator-based neutron source, capable of producing 10^{12} to 10^{13} neutrons per second. This will be used to manufacture medical isotopes like Molybdenum-99, capturing the domestic market and achieving profitability in under two years.
2. **Phase 2: Market Leadership & Early Energy:** In its second phase, ASPL will commission an advanced magnetic mirror based system. This powerful facility will pursue multiple revenue streams simultaneously: capturing 10 per cent of the global isotope market, producing tritium (a crucial fusion fuel), and using its neutrons to drive an innovative fusion-fission hybrid system (50-100 MW) for early grid-scale power generation.
3. **Phase 3: The Ultimate Goal:** The final phase will leverage the expertise and revenue from the preceding stages to build a full-scale, commercially viable 400 MW pure fusion power plant.

The Road Ahead

Despite the palpable excitement, significant challenges remain on the path to a fusion-powered world. Developing materials that can withstand the intense neutron bombardment from a fusion reactor, perfecting the tritium fuel cycle, and, most importantly, driving down the cost to make fusion economically competitive with other energy sources are all formidable engineering hurdles.

However, for the first time in history, there is a clear and credible roadmap to overcoming these challenges. The convergence of new technology, massive private investment, and supportive government policy has ignited a global race. The fusion industry is no longer a monolithic, decades-long science experiment. It is a dynamic, diverse, and competitive ecosystem. As the world looks beyond oil, gas, and even traditional renewables for a lasting energy solution, ventures like ASPL Fusion are positioning themselves to deliver on the 70-year-old promise of harnessing the power of a star. ■

Beyond the Megawatts: Building Resilient Energy Systems for a Net-Zero Future

CHANDRA KISHORE THAKUR
Global CEO
Sterling and Wilson Renewable Energy Group

As India races toward its 2070 net-zero goal, clean power is just the beginning. Grid modernization, policy reform, and sustainable design are reshaping the nation's energy backbone for a low-carbon, high-growth future, opines ***Chandra Kishore Thakur, Global CEO, Sterling and Wilson Renewable Energy Group.***

India stands at the threshold of a transformative energy era — one defined not just by scale or capacity, but by a fundamental shift in system architecture and purpose. Achieving net-zero carbon emissions by 2070 is no longer aspirational; it is a binding national commitment. This goal requires more than adding megawatts; it demands the creation of resilient, adaptable, and sustainable energy systems that align with developmental priorities and address the urgent realities of climate change.

A Dynamic Energy Landscape

India's changing energy trajectory is clearly depicted in the Energy Statistics India 2025 report. FY 2023-2024 saw a 7.8 per cent increase in Total Primary Energy Supply (TPES), reaching 9,03,158 Kilotonnes of Oil Equivalent (KTOE). Fossil fuels still account for 48 per cent of the energy mix, followed by oil (28 per cent), and natural gas. However, a quiet transformation is underway. Nuclear energy now accounts for 4 per cent of the mix, while renewables have grown to 12 per cent. In FY 2024–25 alone, India added 30 GW of renewable capacity — enough to electrify 18 million homes. The shift is no longer tentative — it is irreversible and accelerating.

This transformation is no accident. It reflects sustained, deliberate action by key stakeholders in energy and climate policy. The government's integrated approach, one which blends fiscal incentives, regulatory reforms,

India's changing energy trajectory is clearly depicted in the Energy Statistics India 2025 report. FY 2023-2024 saw a 7.8 per cent increase in Total Primary Energy Supply (TPES), reaching 9,03,158 Kilotonnes of Oil Equivalent (KTOE). Fossil fuels still account for 48 per cent of the energy mix, followed by oil (28 per cent), and natural gas. However, a quiet transformation is underway. Nuclear energy now accounts for 4 per cent of the mix, while renewables have grown to 12 per cent. In FY 2024-25 alone, India added 30 GW of renewable capacity — enough to electrify 18 million homes. The shift is no longer tentative — it is irreversible and accelerating.

and domestic manufacturing competitiveness, has begun to deliver results. Initiatives such as the Production Linked Incentive (PLI) schemes for solar cells and advanced battery chemistry have catalyzed domestic capacity. However, adding clean energy is only part of the task. It is essential to enable its effective integration through carbon markets, green open access, and extensive grid upgrades which will need strategic transmission, corridor development and decentralization of renewables. India's path is not an incidental energy transition; it is a structural overhaul of its energy economy.

Strategic Policy Interventions: Budget 2025 and Beyond

An ambitious plan to establish a foundation for clean energy has been outlined in India's Union Budget 2025. A strategic wager on baseload, non-intermittent clean power is reflected in the goal of 100 GW for nuclear energy capacity by 2047. At the same time, the government is developing a strong domestic manufacturing base for battery storage, wind turbines, and solar modules. To expedite this transition, production-linked incentives and reduced customs duties are being implemented. Policy mechanisms are being improved to increase institutional capacity through the embedding of innovative ecosystems, public-private partnerships, and the streamlining of approvals. Driving economic growth, creating green jobs, and securing long-term decarbonization are the clear objectives.

The Built Environment: From Passive to Net-Zero

The built environment, which consumes over 30 per cent of total electricity, is central to the energy transition. The transformation of the Energy Conservation Building Code (ECBC) into the Energy Conservation and Sustainable Building Code (ECSBC) marks a new paradigm — one that integrates energy, water, waste, and site sustainability.

Net-Zero Energy Buildings (NZEBs) are gaining ground across India. Intelligent building management systems, rooftop solar, LED retrofits, and passive design are becoming standard. Growing interest in green-certified assets and the rise of ESG-linked disclosures are pushing real estate developers to embed sustainability from the design stage.

To accelerate this transformation, regulatory frameworks and fiscal instruments are now converging to make green construction non-negotiable. Several state governments have instituted policy levers such as additional Floor Space Index (FSI), fast-track approvals, and statutory incentives for projects adhering to green building certifications. Simultaneously, leading financial institutions are recalibrating risk assessments to favour green-rated infrastructure, offering lower interest rates and longer repayment tenures. As India advances toward its net-zero targets, sustainable design is no longer an architectural preference — it is a compliance imperative, financial strategy, and climate commitment rolled into one.

Renewable Energy: Progress and Structural Headwinds

With a Compound Annual Growth Rate (CAGR) of more than 10 per cent, India's renewable energy capacity increased from 81,593 MW in 2014 to 198,213 MW by

Green hydrogen is another game-changer, particularly for hard-to-abate sectors like steel, cement, and heavy transportation. Pilot projects are scaling across industrial clusters, and India is investing in global critical mineral partnerships particularly with resource-rich Australia — for lithium, cobalt, and rare earths. These supply chains are vital for battery manufacturing and EV development, and they underscore the geopolitical dimensions of India's clean energy security.

March 2024. Although the pace is admirable, there are still structural issues. Even with these advancements, only 24 per cent of electricity is still produced by renewable sources. Scalability is still limited by intermittent solar and wind power, antiquated grid infrastructure, and insufficient energy storage.

However, states and industry players are responding. Andhra Pradesh aims to deploy 3,00,000 rooftop solar systems by mid-2025. A leading automobile manufacturer in India is investing ₹925 crore to scale up its solar capacity to 319 MWp by FY 2031. For such efforts to succeed, they must be complemented by scalable storage solutions, predictive analytics, and digital grid upgrades.

New Energy Frontiers: Biofuels, Hydrogen, and Critical Minerals

India's diversified energy portfolio is expanding into next-generation fuels. The ethanol blending ratio has reached 18.4 per cent, closing in on the 20 per cent target well ahead of schedule. Green hydrogen is another game-changer, particularly for hard-to-abate sectors like steel, cement, and heavy transportation. Pilot projects are scaling across industrial clusters, and India is investing in global critical mineral partnerships particularly with resource-rich Australia — for lithium, cobalt, and rare earths. These supply chains are vital for battery manufacturing and EV development, and they underscore the geopolitical dimensions of India's clean energy security. Simultaneously, skilling programs and R&D linkages are being developed to future-proof the workforce and accelerate innovation.

Meeting Future Demand: From Addition to Integration

Electricity demand in India is expected to grow at 6-6.5 per cent annually through FY 2030, driven by urbanization, data center growth, and electric vehicle adoption. Meeting this demand sustainably requires shifting focus from capacity addition to system integration.

The first step is grid modernization. Smart AI-enabled grids, real-time monitoring, and cybersecurity protocols will be critical to managing demand-supply variability. Second, sustainability must be embedded into urban governance via net-zero mandates, zoning laws, and green building codes. Third, financial incentives and time-of-day pricing must empower consumers to adopt energy efficiency and self-generation practices.

Most importantly, siloed strategies must give way to integrated, multi-sectoral collaboration. Technology firms, urban planners, investors, and policymakers must work in tandem. Only a systems-level, adaptive approach can unlock the full potential of India's energy transition.

The Way Forward

India's clean energy transformation is not optional, but essential. It is driven by planetary limits, national ambitions, and global expectations. But it is not merely a technological shift. It is institutional, economic, and geopolitical.

India has already taken decisive steps through policy reforms, ambitious targets, and international leadership. Yet, this is only the beginning. The journey ahead calls for continuous innovation, not just in energy generation, but in building a modern, equitable, low-carbon economy. ■

Ethanol Blending in India's Gasoline: A Success Story That Can Accelerate with "Daam Kam, Dum Zyada" Approach

SANDEEP GUPTA
Director-Business Development
Alchemie Finechem Private Limited

AASHAY GOGRI
Executive Director
Alchemie Finechem Private Limited

On Independence Day, 15 August 2025, Prime Minister Shri Narendra Modi ji reiterated India's resolve for Aatmanirbhar Bharat through greater energy self-reliance. The call of "Daam Kam, Dum Zyada" (low cost, high impact) made by him is particularly relevant for India's ongoing energy transition, where every rupee saved translates into reduced foreign exchange outgo and stronger national resilience. Among the most visible successes of this effort has been the Ethanol Blending Program (EBP). ***Sandeep Gupta, Director-Business Development and Aashay Gogri, Executive Director, Alchemie Finechem Private Limited****, throw more light on this topic.*

From a modest 1.5 per cent ethanol blending in petrol in 2014, India has achieved nearly 20 per cent blending by July 2025[1]. This has:

- Substituted nearly 245 lakh metric tons of crude oil.
- Saved ₹1.44 lakh crore in foreign exchange.
- Reduced 736 lakh metric tons of CO_2 emissions: equivalent to planting 30 crore trees.
- Generated steady demand for ethanol feedstocks, improving farmers' incomes.

As petrol demand growth plateaus over the next decade, ethanol blending ensures that India stays on track for its energy security, climate, and agricultural goals. But for the Ethanol Blending Program (EBP) to succeed at scale, one crucial factor requires closer attention: the choice of denaturants. As we publish this article, the unnecessary murmur around loss of efficiency in vehicles with E20 is headed for Supreme Court hearing though ARAI (Pune) and other elite vehicle manufacturers have dismissed the concerns as per studies done by them.

The Critical Role of Denaturants

Ethanol intended for industrial and fuel use must be denatured which means treatment to render it unsuitable for human consumption. This prevents diversion into the potable sector and ensures regulatory compliance. Two Bureau of Indian Standards (BIS) frameworks guide this process:

- **IS 4117:** Lists permitted denaturants and prescribed dosages.
- **IS 2796:** Specifies petrol quality parameters, including limits on oxygen content, vapour pressure, aromatics, sulphur, and other sensitive properties. The IS 2796 must be met for all gasoline sold including E20 blended version.

The interaction of these standards is critical. While IS 4117 allows a range of denaturants, any choice must also comply with IS 2796 once ethanol is blended with petrol. Thus, not every technically permitted denaturant is practically suitable when ethanol blending is scaled up to 20 per cent.

Technical Reality Check

At 20 per cent ethanol blending (E20), the risks of non-compliance can grow if any Denaturant is used without checking the ultimate effect on blended gasoline having 20 per cent Ethanol (which has denaturants blended in it) vs compliance of final gasoline to IS 2796. Our team examined the main categories of denaturants and their possible interaction with Gasoline with E20 as new norm and keeping in view IS 2796 applicability for blended Gasoline:

- **Oxygenates** (e.g., methanol, isopropanol, acetone, ethyl acetate, tertiary butyl alcohol): Adding these raises the total oxygen content in fuel. The standard IS 2796 caps oxygen at 3.7 per cent by weight. Thus adding 'other oxygenates' beyond ethanol itself can easily breach IS 2796 cap on Oxygen. Using oxygenates as specified denaturants at 20 per cent Ethanol blending risks breaching this cap thus violating the standard.
- **Very volatile compounds:** These can raise the blend's vapour pressure above the IS 2796 limit of 67 kPa, leading to drivability and safety concerns.
- **Aromatic denaturants (e.g., benzene, toluene):** These increase benzene and total aromatic content. IS 2796 limits benzene to 1 per cent v/v and aromatics to 35 per cent v/v; high possibility exists that these levels can be exceeded if aromatics are used as denaturants.
- **Sulphur-bearing denaturants:** These add sulphur to the blend, risking breach of the strict 10 mg/kg sulphur limit. In fact, this was the most significant change as India transitioned from BS-IV to BS-VI wherein sulphur content from 50 ppm in BS-IV fuel was changed to 10 ppm in BS-VI gasoline. This reduction directly decreases the formation of harmful sulphur dioxide emissions and particulate matter. which has been the hallmark of smooth transition for India.
- **Halogenated solvents and inorganics** (e.g., chloroform, caustic, ammonia): These create emissions and compatibility issues and are atypical for fuel use.

By contrast, reactive aldehydes such as crotonaldehyde used in small doses can possibly comply to IS 2796. Our calculations show: Using Crotonaldehyde 85 per cent at 0.2 litres per 100 Litres of Ethanol as per IS 4117, translates to 0.4 mL of Crotonaldehyde 85 per cent per litre of gasoline. When compared with IS 2796 limits, the 'aldehyde limit' (expressed as acetaldehyde): max 0.05 per cent v/v (≈500 mg/L) in final gasoline is allowed. While Crotonaldehyde density ~ 0.846 g/mL, it means 0.4 mL/L of gasoline translates to 0.34 g/L (= 340 mg/L) which means the aldehyde content is well below 500 mg/L. Even with existence of other aldehydes in gasoline, the upper limit is expected to be not breached thereby complying to IS 2796 aldehyde requirement at

Ethanol intended for industrial and fuel use must be denatured which means treatment to render it unsuitable for human consumption. This prevents diversion into the potable sector and ensures regulatory compliance. Two Bureau of Indian Standards (BIS) frameworks guide this process:

The Ethanol Blending Program has delivered immense value to India; saving foreign exchange, reducing emissions, and creating rural prosperity. But its continued success depends on ensuring that every part of the value chain is optimized for compliance, cost, and sustainability.

Ethanol blending of 20 per cent with Crotonaldehyde 85 per cent as denaturant.

In short, most oxygenates, and aromatics used as denaturants, there is high-risk in an E20 regime, while crotonaldehyde is uniquely positioned to deliver compliance at minimal dosage. The same has been recommended by National Sugar Institute[2] in the presentation with it being the most economical and frugal denaturant for EBP program.

Why Crotonaldehyde Works Best

Crotonaldehyde offers a compelling combination of technical suitability, cost-effectiveness, and policy alignment.

1. **Low dosage, high effectiveness:** At just 0.2 litres per 100 litres of ethanol, crotonaldehyde achieves denaturing objectives.

2. **Standards compliance:** Unlike oxygenates and aromatics, crotonaldehyde does not push fuel properties beyond IS 2796 limits, ensuring smoother adoption at higher ethanol blends.

3. **Cost advantage:** Public data comparisons show that Crotonaldehyde delivers the lowest cost per litre[2] of denatured ethanol. Alternatives such as MEK not only require far higher dosage but are also largely import-dependent, undermining foreign exchange savings.

4. **Transportation Costs Advantage:** When ethanol blended with denaturant is transported, the costs per litre per kilometer is lowest with Crotonaldehyde 85 per cent as denaturant as it is mixed in lowest quantity wrt other specified approved denaturants.

5. **Ease of enforcement:** Higher dosage solvents are easier to separate or 'renature', making them weaker deterrents against diversion to potable use. Crotonaldehyde, with its sharp odor, chemical properties and higher boiling point, is far more effective.

6. **Endorsement by experts:** The National Sugar Institute (NSI)[2], Kanpur, has recommended crotonaldehyde as the most frugal and effective denaturant for biofuel production.

7. **Make in India solution:** Crotonaldehyde is manufactured domestically, strengthening the value chain from sugarcane and maize to ethanol to denatured ethanol — without reliance on costly imports like MEK.

In every dimension, as per our analysis, be it technical, economic, and strategic; Crotonaldehyde emerges as the "Daam Kam, Dum Zyada" denaturant option for EBP program.

Policy Concerns: State-Level Bans

A recent development wherein Supreme Court judgment of 2025 shifted regulatory control of the 'industry of intoxicating liquor' (including industrial alcohol) to state governments; is impacting the national EBP vision. This has led to inconsistencies in denaturant policy as Ethanol has become a 'State' subject wherein each Excise of State is looking to optimize the State's revenues. For example, in February 2025, the Maharashtra Excise Department[3] issued a circular prohibiting Crotonaldehyde and mandating instead the use of higher per cent dosing of Acetone, MEK (pretty much imported into India) and Ethyl acetate wrt Crotonaldehyde 85 per cent dosage. However, upon representation by Sugar Mills Associations & Ethanol Association, in mere 3 days this circular was amended[4] allowing usage of Crotonaldehyde 85 per cent. Such an approach must be avoided as industry faces various headwinds, the more the clearer the policy and the support; the better our manufacturing prowess will be impacting positively the GDP per cent of India!

Our team wishes to state that the economic inefficiency @ cited per cent dosage, as per circular of Maharashtra Excise would require far higher volumes adding to significant costs (be it denaturant or logistics) which will only diminish the oil marketing companies margins adversely impacting national savings. The enforcement risks around ethyl acetate (BP ~ 77 Deg C), Acetone (BP ~ 56 Deg C) and MEK (~ 80 Deg C) are higher as all of them have a fairly below BP wrt Crotonaldehyde 85 per cent (~range of 95-105°C under atmospheric pressure). This means all three cited denaturants will have to be blended at higher per cent in Ethanol wrt Crotonaldehyde 85 per cent and that too with a technical threat where process of 'renaturing' of denatured ethanol after using higher per cent denaturants loom large undermining the very purpose of denaturing. In other words, such state-level tweaking / recommendations must be well thought and re-looked as these can derail the competitive momentum of Indian Ethanol Blending which has proved to be not only frugal but game changing for a section of farmers wellbeing. A lower denaturing per cent via Crotonaldehyde 85 per cent backed by lower expenses towards denaturing can Distilleries push more ethanol thereby lowering logistics cost (₹/Km of Net Ethanol Transported) for oil marketing companies, helping them to foot lower procurement bills supporting their balance sheets bottom line!

The Way Forward

For ethanol blending to continue as a national success story, harmonization of policy between center and states is critical. Denaturant choices must be guided by:

- Scientific evaluation of compliance with IS 4117 and IS 2796.
- Cost-benefit analysis to ensure the lowest burden on Refineries / OMCs / Distilleries.
- Alignment with *Aatmanirbhar Bharat* through preference for domestically produced denaturants.
- Enforcement robustness to prevent diversion while maintaining supply chain efficiency.

Crotonaldehyde at 0.2 per cent emerges as a strong candidate meeting various objectives set out by EBP program and hence this denaturant (with co-additive as Bitterant, again available in India) meets all these criteria. A unified, evidence-based policy framework at States level would prevent fragmented regulations and ensure that India's ethanol blending journey continues smoothly with all god luck to unveil E27!

Conclusion

The Ethanol Blending Program has delivered immense value to India; saving foreign exchange, reducing emissions, and creating rural prosperity. But its continued success depends on ensuring that every part of the value chain is optimized for compliance, cost, and sustainability. Denaturants may appear to be a small detail, but they carry outsized implications for fuel quality, refinery economics, and national savings. Replacing crotonaldehyde with high-cost, high-dosage solvents (few being imported like MEK, partially acetone, etc.) risks undermining the very premise on which 'successful Ethanol Blending Program' has been devised! As the Prime Minister has said, the goal must be "Daam Kam, Dum Zyada"; it aligns with India's Ethanol Blending Program when Crotonaldehyde 85 per cent is used as a denaturant; proudly 'Made in India'! ■

References

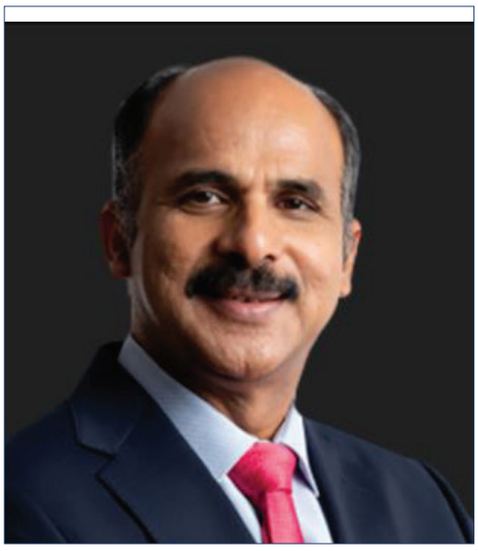
1 *Newspaper The Economic Times, Mumbai Edition, Aug 15, 2025; Page 14*

2 *https://www.chinimandi.com/wp-content/uploads/2025/02/SEIC_PPT_NSI.pdf*

3 *https://stateexcise.maharashtra.gov.in/Site/Upload/Pdf/परपित्रक.PDF*

4 *https://stateexcise.maharashtra.gov.in/Site/Upload/Pdf/pdf.PDF*

Geothermal Turbines: Harnessing Earth's Heat for Sustainable Energy



S. NARAYANA PRASAD
Chief Executive Officer
Triveni Turbines

In the pursuit of a sustainable energy future, geothermal turbines serve as a vital source of reliable and eco-friendly power generation. Despite its potential, geothermal power has not yet achieved mainstream adoption. High upfront investment costs for drilling and infrastructure pose major challenges. ***S. Narayana Prasad, Chief Executive Officer, Triveni Turbines, emphasizes*** *on the immense potential of geothermal turbines.*

Geothermal energy originates from the natural heat stored beneath the earth's crust. This immense thermal resource can be tapped for a range of applications, including power generation, heating systems and cooling solutions. In electricity generation, geothermal power plants utilize this underground heat, with turbines serving as the critical link in transforming thermal energy into mechanical motion, which is then converted into electrical power.

Unlike conventional steam turbines fuelled by coal, oil or gas, geothermal turbines operate on naturally occurring steam sourced from geothermal reservoirs deep underground. These reservoirs, accessed via drilled wells, provide high-temperature steam — often exceeding 150°C (300°F) — which is directed onto turbine blades. The resulting motion powers a generator, ultimately producing clean, reliable electricity.

Types of Geothermal Power Plants

The design of a turbine depends on the type of geothermal power plant, with three primary categories in use:

1. **Dry Steam Plants –** Utilize steam drawn directly from geothermal sources to rotate the turbine.
2. **Flash Steam Plants –** Pump hot water from reservoirs, rapidly depressurizing it to convert into steam for turbine operation.

3. **Binary Cycle Plants –** Transfer heat from geothermal water to a secondary fluid with a lower boiling point, which then vaporizes to spin the turbine.

Key Advantages of Geothermal Turbines

1. **Renewable & Sustainable:** Geothermal energy is virtually inexhaustible as Earth's heat is constantly replenished.
2. **Minimal Emissions:** It produces significantly fewer greenhouse gas emissions than traditional fossil fuel-based energy.
3. **Continuous Power Supply:** Geothermal plants can deliver stable, around-the-clock electricity, unlike intermittent sources such as wind or solar.
4. **Compact Land Use:** These plants require less land area compared to other renewable power installations like wind farms.

Challenges Facing the Industry

Despite its potential, geothermal power has not yet achieved mainstream adoption. High upfront investment costs for drilling and infrastructure pose major challenges. Moreover, its deployment is geographically limited, as only certain regions offer the right underground conditions for harnessing geothermal energy effectively.

In the pursuit of a sustainable energy future, geothermal turbines serve as a vital source of reliable and eco-friendly power generation. Companies like Triveni Turbines play a crucial role in sustaining and enhancing the efficiency of these power plants.

Triveni Turbines specializes in supplying new geothermal steam turbines with power ratings from 1 MW to 60 MW, including Organic Rankine Cycle (ORC) turbines, which are especially advantageous for low-temperature geothermal resources. With expertise in turbine design, maintenance and supply of critical spare parts, Triveni Turbines have enabled power plants worldwide to reduce downtime and extend their operational lifespan. Through ongoing support and technological innovation, the company continues to be a key player in the geothermal energy sector, supporting both new installations and the efficient operation of existing geothermal power plants.

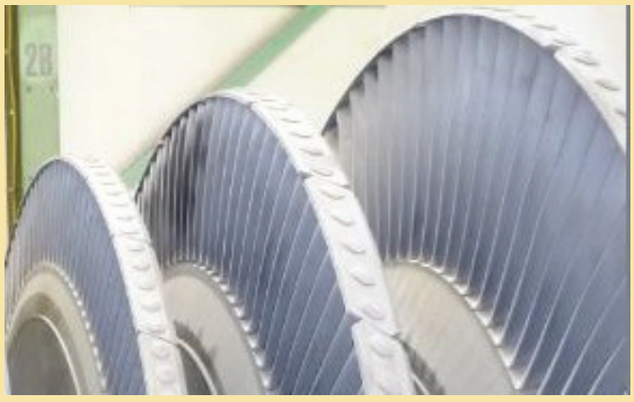
CASE STUDY

Triveni Turbines won a prestigious order from a leading geothermal energy operator in New Zealand to revamp a 16 MW turbine of American origin. The project aimed to address critical issues of erosion and corrosion that were impacting rotor life and overall turbine performance. With Triveni's expertise, the upgrade significantly improved the turbine's operational efficiency and longevity.

Challenges

The client faced a triad of formidable issues such as:

- Frequent erosion in blade tenons
- Cavity formation in high-pressure gland areas
- Rotor material enhancement
- Engaging Triveni Turbines



Old rotor design

New rotor design

After carefully evaluating potential solutions and partners to overcome these challenges, the client strategically chose to collaborate with Triveni Turbines. This decision was influenced by Triveni Turbines' extensive expertise in rotor remanufacturing and its strong capabilities as an Original Equipment Manufacturer (OEM).

Solutions

- Integral shroud design
- Enhanced rotor material
- Coating application
- Precision shot peening

Benefits

- Prolonged turbine lifespan
- Augmented reliability
- Heightened plant efficiency
- Enhanced availability

Triveni Turbines leveraged its extensive expertise in rotor remanufacturing and innovative design enhancements to successfully overcome erosion, corrosion and material challenges encountered by a valued client in the geothermal energy sector. This collaborative effort not only prolonged the turbine's operational lifespan but also greatly improved the efficiency and reliability of the geothermal power plant, contributing significantly to the advancement of a sustainable energy future. ■

Selective Hydrotreating of Kerosene for ATF & PCK Production

Aviation Turbine Fuel (ATF), derived from crude oil, is a critical component of the global aviation sector, supporting the international movement of passengers and cargo. The growing global population, accelerating urbanization, and expansion of the air cargo industry are contributing to a steady rise in ATF demand. Forecasts indicate that global aviation fuel consumption will increase from the current level of ~7 million barrels per day to approximately 10–11 million barrels per day by 2050. Recognizing the strategic importance and high growth potential of ATF, IndianOil has developed the indigenous technology - indJet® - utilizing cost effective inhouse catalyst system and low severe process to produce ATF compliant with emerging and future specifications.

indJet® is an indigenous hydrotreating technology developed by IndianOil for the selective removal of mercaptan sulfur from kerosene, with minimal conversion of other sulfur species using selective hydrogenation catalyst system. It operates under mild-severity conditions, enabling the production of Aviation Turbine Fuel (ATF) that meets all regulatory and commercial specifications. Unlike conventional kerosene treating technologies that rely on hazardous chemicals such as caustic, the developed process is inherently eco-friendly, eliminating the need of hazardous chemicals and thereby reducing environmental impact. In addition to ATF production, the process is also capable of generating Pipeline Compatible Kerosene (PCK) with total sulfur content ≤10 ppmw. PCK is used as an interface plug in a multi-product pipeline having ≤10 ppmw sulfur content. PCK is also suitable as a blending component in diesel pool of refineries.

Crude petroleum inherently contains a range of organo-sulfur - compounds, which are partially distributed into various fractions during primary distillation based on their boiling ranges. These sulfur species, along with other contaminants, are further targeted during secondary refining operations to meet product quality specifications. The kerosene fraction, derived from fossil-based crude oil, typically contains impurities such as mercaptans, other organo-sulfur compounds, nitrogen species, naphthenic acids, and chlorides. Among these, the removal of mercaptans is of prime focus in jet fuel treatment processes, as their presence can lead to corrosive degradation of aircraft fuel system components, posing serious safety risks to aviation operations.

The reactivity of sulfur compounds varies significantly depending on their molecular structure. In general, their reactivity toward hydrotreatment follows the order: Mercaptans > Sulfides > Disulfides > Thiophenes. The kerosene stream predominantly contains C_7–C_9 mercaptans, which are particularly corrosive to metal surfaces. Notably, this corrosivity is not directly correlated with total sulfur content; rather, it is strongly influenced by the specific chemical nature of sulfur species, especially mercaptans. Accordingly, secondary treatment processes for kerosene upgrading to ATF are primarily designed to either selectively remove mercaptans or convert them into non-corrosive derivatives.

One of the widely employed conventional technologies is the caustic-based process. This process is used for the treatment of virgin or cracked hydrocarbon streams through either extraction of mercaptans using caustic solutions or their oxidation to disulfides using a proprietary catalyst. However, caustic extraction presents operational limitations, particularly when treating heavier hydrocarbons such as pentanes and above. The higher molecular weight and branched mercaptans associated with such streams exhibit limited solubility in aqueous caustic, making them difficult to extract effectively. As a result, caustic extraction is generally more suitable

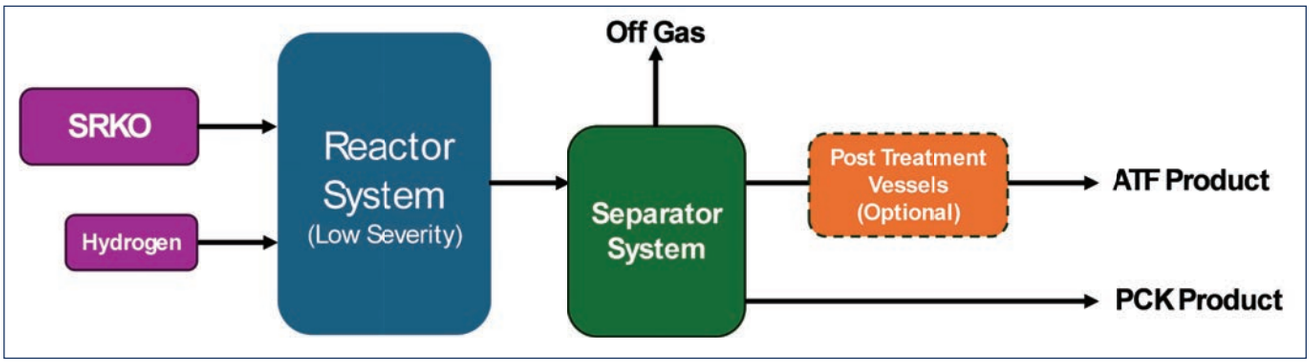


Figure 1: Block diagram of indJet® process

for lighter hydrocarbon fractions (e.g., fuel gases, LPG, and light naphtha), which predominantly contain C_1–C_4 mercaptans that are more soluble and reactive in alkaline media. Moreover, the aqueous nature of this treatment necessitates multiple contact stages to achieve sufficient mercaptan removal.

The C_{5+} mercaptans are converted to disulfides, which are non-corrosive, via catalytic oxidation using fixed bed catalyst in a caustic environment. This process is typically applied to heavier streams such as heavy naphtha, kerosene, jet fuel, and diesel. However, a major drawback of this approach is that it only alters the chemical structure of sulfur species without reducing the total sulfur content of the product. Furthermore, the process faces significant operational challenges when treating high TAN feedstocks, which may cause foaming, increased pressure drop, and a decline in overall process efficiency. The handling and disposal of spent caustic, coupled with associated environmental concerns, adds to the complexity and cost of operation.

In light of these technological and environmental limitations, IndianOil has developed indJet® process, an advanced hydrotreating-based technology engineered to address these challenges. The process offers greater operational flexibility, enabling the treatment of high TAN, high sulfur and nitrogen feedstocks with metal contaminants, and post-treatment removal of impurities such as residual H_2S, nitrogenous compounds, and moisture. These are often responsible for non-compliance with critical ATF specifications. indJet® process is specifically tailored to mitigate these issues while ensuring production of on-spec jet fuel with improved reliability and environmental performance.

Process Description

The process primarily facilitates hydrodesulfurization (HDS) and hydrodenitrogenation (HDN) reactions, with limited extent of aromatic saturation. The unit is capable of operating in either PCK or ATF mode, selected based on specific refinery requirements. Process parameters are tailored and optimized according to the selected operational mode. Under PCK mode, the process operates at elevated severity to achieve a product total sulfur content of ≤10 ppmw. In ATF mode, the conditions are optimized to specifically reduce mercaptan sulfur content to ≤18 ppmw. The hydrotreated ATF product undergoes post-treatment facilities on case-to-case basis to comply with additional product specifications beyond sulfur content, such as colour, silver strip corrosion, etc. The final product thus conforms to all requisite fuel specifications without necessitating further treatment. A simplified block flow diagram of the process is illustrated in Figure 1.

Commercial Deployment

A 400 kTA grassroot unit (Figure 2) was successfully commissioned at one of the IndianOil refineries in July 2022. Since its commissioning, the unit has been operating in a blocked-out mode, switching between PCK and ATF production based on refinery requirements. The unit has consistently demonstrated robust performance, achieving total sulfur levels of 3–5 ppmw in PCK mode and mercaptan sulfur levels below 1 ppmw in ATF mode. The operational performance data of the Unit is presented in Figure 3.

Figure 2: First commercial indJet® unit at one of the IndianOil refinery.

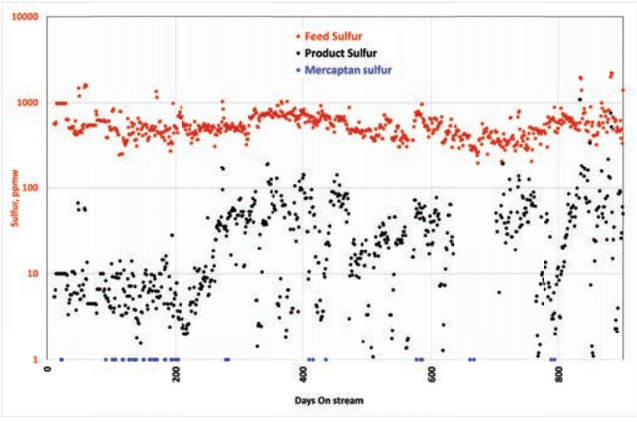


Figure 3: Performance of indJet® unit operating in blocked out mode operation.

Subsequently, another 300 kTA grassroot unit (Figure 4) was commissioned at IndianOil owned refinery in June 2024. This unit is dedicated to the production of Pipeline Compatible Kerosene (PCK). Since startup, the unit is consistently producing kerosene with total sulfur content in the range of 2-3 ppmw, processing feedstocks with sulfur from 2000 to 3000 ppmw. The performance of the unit is illustrated in Figure 5.

Salient Technology Features

- Low severity hydrotreating operation with minimal hydrogen consumption
- Selectively removes mercaptan sulphur to <18 ppmw
- Capable of handling wide range TAN feedstock
- Can process high sulfur feedstocks derived from various crude sources
- Significant Colour improvement meeting Saybolt specification
- Inhouse developed customized proprietary catalyst and efficient reactor internals developed by IndianOil
- Flexibility to use reformer off-gas instead of pure hydrogen
- Possible to revamp existing caustic-based units by keeping the same post treatment vessels for salt dryer and clay treatment
- Process can be extended for production of PCK (Pipeline Compatible Kerosene) with sulfur < 8 ppm

Figure 4: Second commercial indJet® unit at IndianOil refinery.

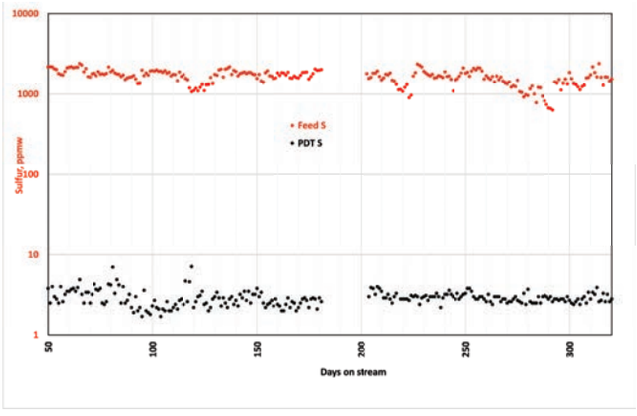


Figure 5: Performance of indJet® unit operating in Pipeline Compatible Kerosene (PCK) mode.

Conclusion

The process for selective hydrotreating of kerosene is a novel indigenously developed technology by IndianOil R&D, utilizing a proprietary in-house catalyst system for the production of Aviation Turbine Fuel (ATF). In addition to ATF, the technology is also suitable for the production of Pipeline Compatible Kerosene (PCK), which serves as an interface fluid in multiproduct pipeline operations. The process offers operational flexibility and can be operated in blocked-out mode, depending on the specific requirements of the refinery.

The process parameters are optimized based on the selected operating mode, achieving total sulfur content

≤10 ppmw in PCK mode and mercaptan sulfur ≤18 ppmw in ATF mode. Developed as a low severity hydrotreating process, indJet® enables the selective removal of mercaptan sulfur from kerosene, while ensuring full compliance with regulatory and commercial ATF specifications. A key advantage of indJet® process is its environmentally benign operation, as it avoids the use of hazardous chemicals typically required in conventional kerosene treating technologies. Moreover, the process is capable of handling high sulfur and high total acid number (TAN) feedstocks, addressing critical limitations faced by conventional caustic treatment routes.

The technology has been successfully commercialized at two IndianOil refineries, where it is operating reliably and consistently producing on-spec products. This demonstrates the technical viability, scalability, and commercial readiness of indJet® technology as a strategic solution for clean and sustainable jet fuel production. ■

Authors

Ms. Pragati Ghumade
SRO, Indian Oil Corporation Limited R&D Centre

Mr. A. Arun
SRM, Indian Oil Corporation Limited R&D Centre

Mr. Kamal Kumar
CRM, Indian Oil Corporation Limited R&D Centre

Mr. Ganesh V. Butley
DGM, Indian Oil Corporation Limited R&D Centre

Mr. K. O. Xavier
DGM, Indian Oil Corporation Limited R&D Centre

Mr. Ramesh Karumanchi
GM, Indian Oil Corporation Limited R&D Centre

Mr. Sarvesh Kumar
CGM (HD, CAT&TS), Indian Oil Corporation Limited R&D Centre

Dr. Alex C. Pulikottil
ED (PC & CAT), Indian Oil Corporation Limited R&D Centre

Dr. Alok Sharma
Dir (R&D), Indian Oil Corporation Limited R&D Centre

CHEMICAL ENGINEERING WORLD

Dynamic Platform

to

Connect with Chemical Industry

Ecosystem

Direct Reach

to

>200,000 Readers

across

>50 countries

in Print and

Digital Version

Contact: +91-22-4037 3636,
Email: sales@jasubhai.com
Website: www.jasubhaimedia.com

Jasubhai MEDIA

PharmaBio World

INSIGHT INTO THE PHARMACEUTICAL AND BIOTECH INDUSTRIES

www.jasubhaimedia.com

Quantum Leap your Business

via

Dynamic 'PharmaBio network'

platform

Directly Reach the Inboxes of

40,000+

Affluent Leaders & Business Influencers' from the

Pharma Industry each month with the

PharmaBio World

in Print and

Digital Version

Contact: +91-22-4037 3636
Email: sales@jasubhai.com
Website: www.jasubhaimedia.com

Jasubhai MEDIA

Syensqo Material Solutions for 800 Volt BEV Powertrain to Increase Range, Enhance Efficiency, and Enable Light weighting

One of the main reasons consumers hesitate to adopt battery electric vehicles (BEVs) is concern over driving range. To address this, global OEMs are optimizing BEV powertrains — including the battery, electric motor, power electronics, and electric drive — to increase range and enable fast charging. Engineers are focusing on boosting battery power density, improving electric motor efficiency, and increasing inverter switching speeds, which are central to power electronics performance. **Brian Baleno, Director Global Business Development & Program Management, Syensqo,** explains about Syensqo Material Solutions for 800 Volt BEV Powertrain.

Battery design is typically the starting point in Battery Electric Vehicles (BEV) development. The typical battery chemistries considered are Nickel Manganese Cobalt (NMC) and Lithium Ion Phosphate (LFP). Both are compatible with Syensqo's Solef® PVDF, a critical component for cathode binders and separators.

NMC batteries offer higher energy density compared to LFP, resulting in increased energy storage, reduced packaging space, and potential weight reduction. Additionally, NMC batteries can operate at higher voltages, further enabling fast charging. Figure 1 illustrates Syensqo's comprehensive portfolio of Solef® PVDF grades for NMC battery binders.

	SOLEF® 6020	SOLEF® 5130	SOLEF® 5140	New SOLEF® ZA830
APPLICATION				
	Mid Ni LFP LCO	**Mid/High Ni** LFP LCO	**Mid/High Ni**	**Mid/High Ni**
POLYMER PROPERTY				
Polymer type	Homopolymer	Modified homopolymer	Modified homopolymer	New Gen modified homopolymer
Intrinsic viscosity (l/g)	0.20	0.30	0.40	0.30
MW (ratio to Solef 5130)	0.7	1.0	1.3	1.0
Melting temperature (°C)	170	164	164	169
KEY FEATURES				
Adhesion	+	+++	++++	+++
TSC (Total solid content)	++++	+++	++	++++

*SSA: Specific Surface Area
** All data indicated here are typical values for comparison, not for specifications

Figure 1: Solef® PVDF NMC battery binder grades

The slurry viscosity of cathode binder materials is a key selection criterion. Stable slurry viscosity provides battery cell manufacturers with a broader processing window and improves particle dispersion and conductivity additive distribution during cell manufacturing. Figure 2 compares the slurry stability of various PVDF materials in the formulation NMC811/MWCNT/PVDF/97.6/0.9/1.5.

Beyond viscosity, other important binder properties include adhesion, resistance, and flexibility. Lower

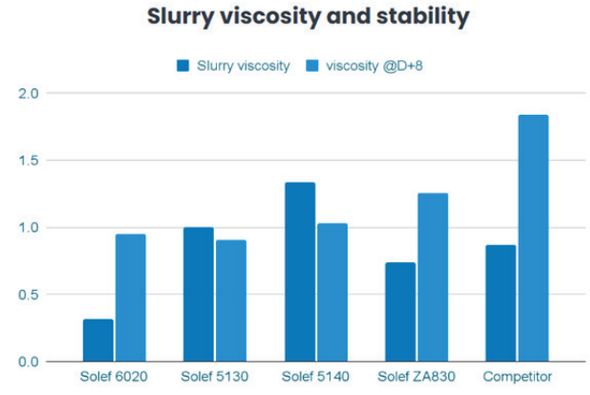


Figure 2: Solef® PVDF NMC battery grades viscosity & slurry stability

Figure 3: Solef® PVDF NMC adhesion

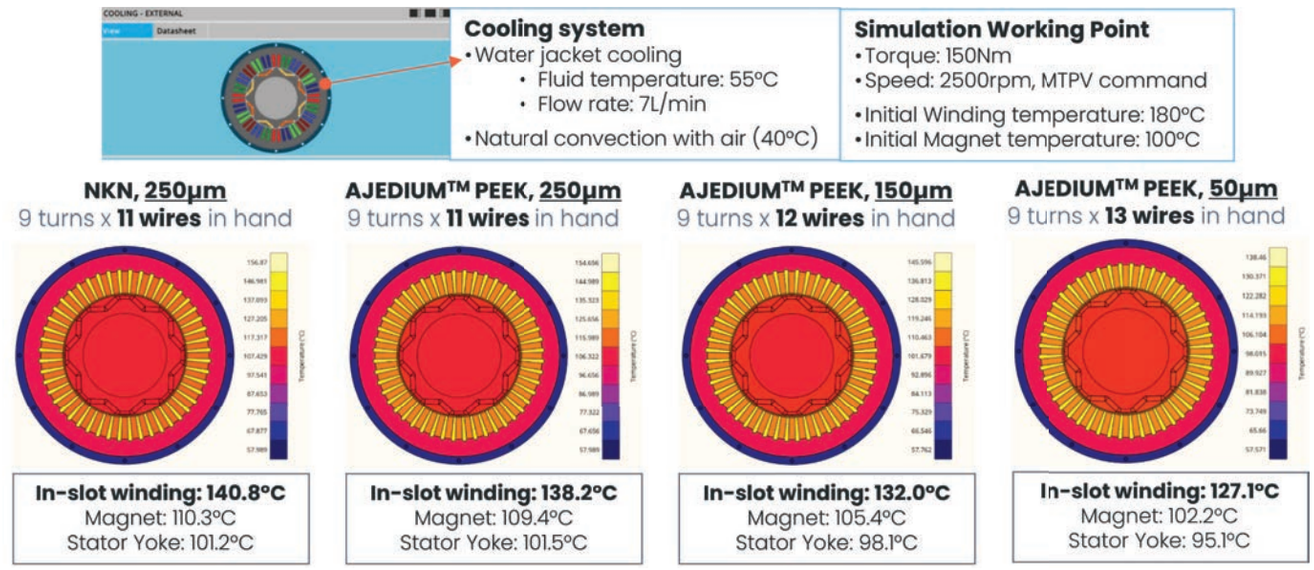


Figure 4: Thermal Improvement PEEK vs. NKN

resistance generally translates to better battery performance. Figure 3 summarizes the comparison of adhesion, resistance, and flexibility among PVDF cathode binder materials.

Electric motor design and materials

Electric motor design significantly impacts BEV powertrain efficiency. The automotive and heavy-duty truck industries are moving toward higher voltages, often exceeding 800 volts, with most 800V e-motor designs based on Permanent Magnet Synchronous Motor (PMSM) technology. Design engineers are seeking ways to increase e-motor efficiency, such as maximizing copper slot fill. Higher voltage systems impose more stringent electrical, thermal, and chemical requirements on materials.

Syensqo's KetaSpire® PEEK magnet wire, combined with Ajedium™ PEEK and PPSU slot liners, enables thinner insulation systems, allowing for increased copper content in stator slots. These insulation systems also offer better thermal conductivity than traditional aramid paper and paper laminate (NKN) solutions, improving heat dissipation and reducing e-motor temperature. This results in a proven overall efficiency gain of 1–2 per cent.

A cooler-running e-motor can be downsized without sacrificing performance, and the battery can also be reduced in size while maintaining range.

These downsizing opportunities decrease the amount of raw material used, making the system more cost-effective, lighter, and more sustainable.

Another significant advantage of PEEK slot liners over traditional materials like paper aramide or NKN is their superior durability in harsh conditions. One effective way to assess this durability is by measuring and comparing corona discharge resistance. A slot liner's ability to withstand corona discharge is a strong indicator of its overall durability and can be directly correlated to the electric motor's lifespan. As shown in Figure 5, Ajedium™ PEEK and PPSU not only deliver higher partial discharge inception voltage (PDIV) per thickness, but also exhibit much greater resistance to corona discharge compared to incumbent materials.

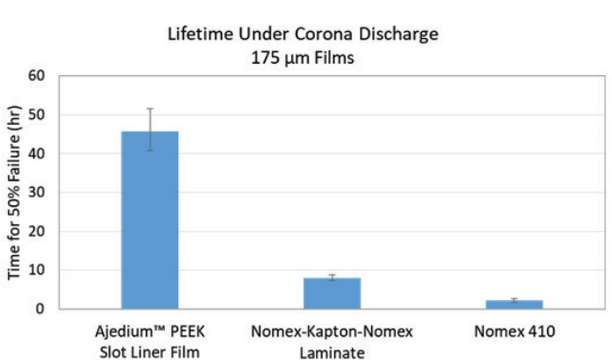


Figure 5: Ajedium™ PEEK film slot liners Corona Discharge Lifetime

Power electronics design and materials

Inverters are critical to BEV power electronics. While first-generation 400V inverters used Insulated Gate Bipolar Transistor (IGBT) technology, 800V systems have shifted to Silicon Carbide (SiC) technology. SiC MOSFETs enable faster switching, essential for DC fast charging, and allow for more compact, lightweight inverters, freeing up space and increasing BEV range.

	R4-200BL	R4-230BL	R7-120BL	R4-270BL	Ryton Supreme R7-600BL HV	Amodel Bios R1-133 HFFR	Amodel Bios AE R1-133
Material Type	PPS	PPS	PPS	PPS	PPS	PPA	PPA
Tg, °C	85	85	85	85	85	135	135
Density, g/cm3	1.67	1.68	1.99	1.68	1.9	1.5	1.46
Elongation at Break, %	1.7	1.3	0.9	1.8	0.6	2.1	2.3
Charpy Unnotched, kJ/m²	53		19	57		49	48
HDT @ 1.8 MPa, °C	265	265	265	265	270	275	300
Flame Rating, 0.8 mm	V-0	V-0	V-0	V-0	V-0	V-0	V-0
CTI, V	175	175	175	250	600	>600	>600
Moisture Absorption, %	0.02	0.02	0.018	0.02		0.18	0.23
Design for low GWP	+	+	+	+	+	+++	++

Figure 6: PPA vs. PPS for Power Modules

Similar to e-motors, SiC based inverters require materials with better performance to address higher temperatures and electrical requirements. Inverter components like power modules, AC and DC busbars, and capacitors need to retain electrical properties beyond 150. There's also a safety requirement so many of these components specify that the materials have a UL V0 flammability rating. Design engineers typically select between materials like Syensqo's Amodel® PPA Bios or Ryton® PPS for power modules. Figure 6 compares the two different chemistries and the tradeoffs in mechanical performance.

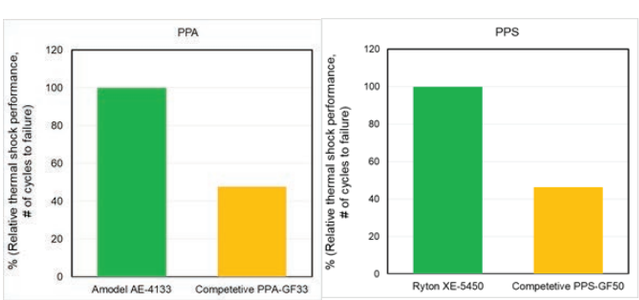


Figure 7: Thermal Shock Cycle Testing: 150 cycles (-40 °C for 1 hour followed by 150 °C for 1 hour)

Busbars, used throughout the BEV powertrain, must withstand thermal shock, especially in SiC 800V inverters where temperatures range from -40°C to 180°C. Depending on the specific design requirements, PPA or PPS are typically considered for overmolded AC/DC busbar insulation. Figure 7 presents thermal shock performance comparisons.

Electric drive and gearbox materials

Another system that is critical to overall efficiency of the battery electric power system is the electric drive. Next-generation BEV designs often integrate the electric motor, inverter, and e-drive (gearbox) into a single "3-in-1" system. Efficiency improvements can be achieved by using a planetary gearbox and increasing the rotational speed of the electric motor.

Planetary gearboxes introduce thrust forces that require robust thrust bearing components. Polymeric thrust bearings require the adoption of wear resistant materials

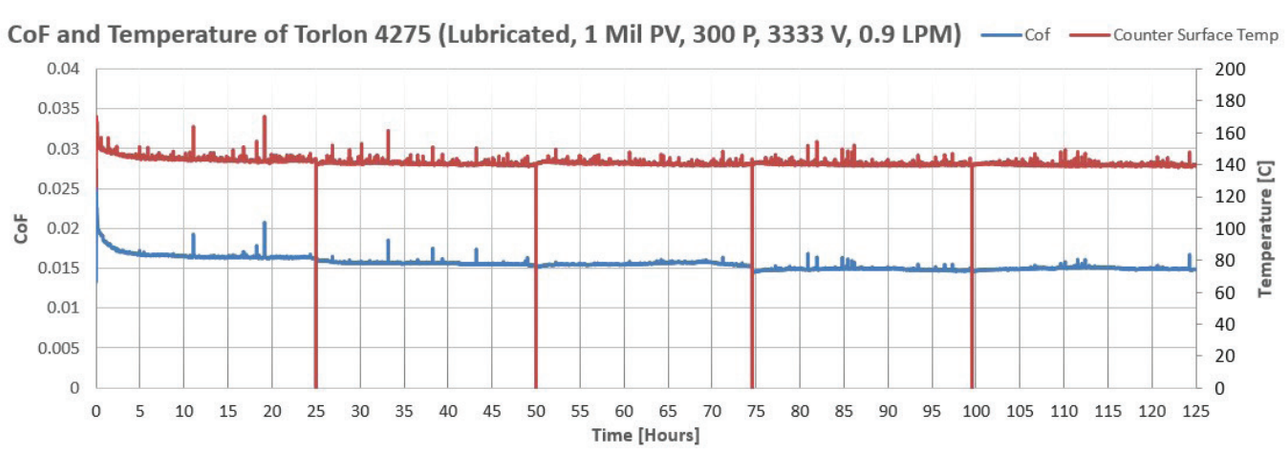


Figure 8: Wear data as function of temperature and time according ASTM D3702

Figure 9A: eDrive System Component Design Freedom - Oil Flow Channels Built into the part geometry (courtesy: Allegheny Performance Plastics)

Figure 9B: eDrive System Component Design Freedom- locking tabs molded onto the part geometry (courtesy: Allegheny Performance Plastics)

like Torlon® PAI or KetaSpire® PEEK, which provide sufficiently low friction coefficient to allow the rotation of components with minimal frictional losses. Polymeric thrust bearings made from wear-resistant materials such as Torlon® PAI or KetaSpire® PEEK offer low friction coefficients, enabling efficient rotation with minimal losses. These polymers also allow for thinner, injection-molded bearings, saving space. Material selection is guided by wear resistance data under application-relevant conditions (see Figure 8).

In addition to the space savings achieved by replacing metallic needle bearings, injection-molded polymeric thrust bearings offer several other advantages. Notably, they allow for the integration of features such as cooling channels for oil flow and locking tabs directly into the part during the molding process. These design options enable easier and more efficient assembly, eliminating the need for any machining operations. Figures 9A and 9B demonstrate both the multiple cooling channels and the four locking tabs incorporated into the component.

Conclusion

The development of 800V BEV powertrains directly addresses consumer range concerns. Higher voltage systems across the battery, electric motor, inverter, and eDrive demand advanced materials: PVDF for battery cathode binders; PEEK and PPSU for motor magnet wire insulation and slot liners; PPA and PPS for inverter power modules and busbars; and PAI and PEEK for electric drive systems. These materials must retain mechanical and electrical properties above 150°C and exhibit high wear resistance, especially in planetary gearsets.

Optimal material selection is best achieved through close collaboration between system designers and material suppliers, ensuring that electrical, mechanical, thermal, and chemical requirements are matched to the most suitable materials for each application environment. ■

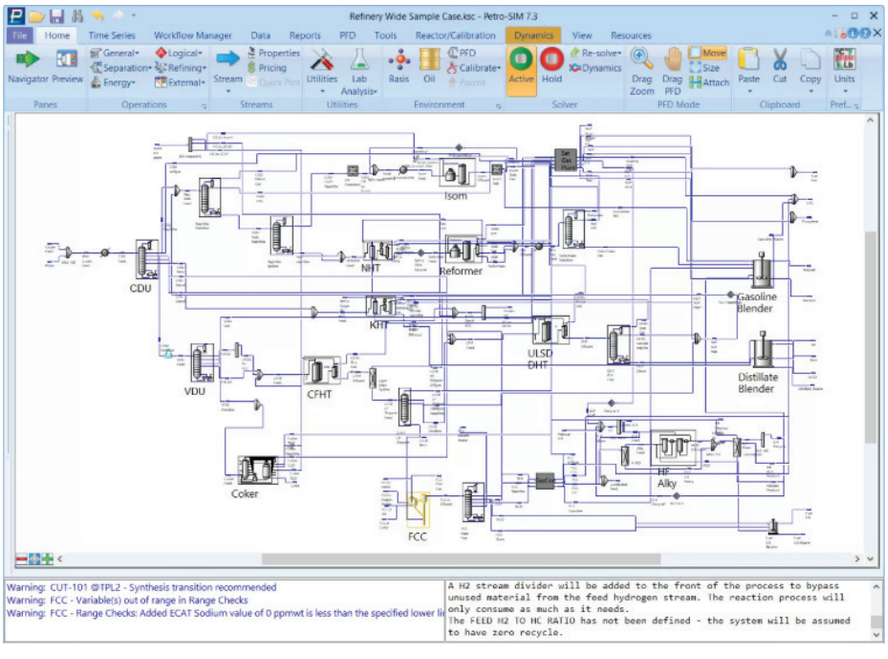
Author

Brian Baleno
Director Global Business Development & Program Management
Syensqo

Samsung E&A launch new hydrogen solution - CompassH2

Samsung E&A has launched CompassH2, a green hydrogen production plant solution developed in collaboration with Nel. CompassH2 is designed to achieve best performance and cost-competitiveness. It acts as a pathfinder to the optimal Levelized Cost of Hydrogen (LCOH). It is designed with scalability in mind, starting with a base capacity of 100 megawatts, allowing for flexible expansion based on project needs. The solution guarantees an exceptional hydrogen purity level. Electrolyser-based green hydrogen production is considered a gateway technology for synthesizing green ammonia, green methanol, and e-fuels. ■

KBC launches Petro-SIM 7.6 Simulation Software



KBC (A Yokogawa Company) has launched Petro-SIM® v7.6, the latest release of its flagship digital twin process simulation platform for the upstream and downstream oil and gas sectors, including the refining, petrochemical, polymer, and sustainable aviation fuel (SAF) industries. Building on its digital twin foundation, Petro-SIM v7.6 delivers enhancements across both first-principles and hybrid modeling to deliver advanced optimization with the integration of artificial intelligence and machine learning (AI/ML). It empowers engineers, operators, and business leaders to accelerate digitalization, energy transition, and decarbonization. This momentum drives faster progress toward profitability, operational performance, and sustainability goals. ■

Supported by

CHEMTECH FOUNDATION 1974-2024
Inspiring Intelligence...
..Igniting Innovation

World Meet of the CHEMICALS, PETROCHEMICALS, BIOPHARMA & PROCESS Industry in India

Supported by

सत्यमेव जयते

DEPARTMENT OF PHARMACEUTICALS
MINISTRY OF CHEMICALS & FERTILIZERS
GOVERNMENT OF INDIA

DEPARTMENT OF BIOTECHNOLOGY
MINISTRY OF SCIENCE & TECHNOLOGY
GOVERNMENT OF INDIA

जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
भारत सरकार
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES,
RIVER DEVELOPMENT & GANGA REJUVENATION
GOVERNMENT OF INDIA

VDMA Process Plant and Equipment
DECHEMA Society for Chemical Engineering and Biotechnology e.V.

ChemTECH WORLD EXPO 2026

International Exhibition & Conferences

3-6 February 2026

Venue: Bombay Exhibition Center, Goregaon (East), Mumbai, India

Concurrent Events

EPC 2026 Engineering Procurement Construction
Specialty Chemical World Expo 2026
BIO-India World Expo & Conferences 2026
Refining & Petro Chemicals 2026
Health Safety & Environment World Expo 2026
Industry Automation & Control 2026
PVF Pumps, Valves & Fittings World Expo 2026
Global Meet Agrochemicals & Fertilizers Innovations and R&D World Expo & Conferences 2026
WaterEX World Expo 2026
BOILER World Expo 2026
Surface Engineering Coating & Corrosion World Expo 2026
SCALE@ CHEMTECH World Expo 2026
Student Outreach Program 2026 Develop Future Leaders

Scope for ChemTECH World Expo 2026

- Plant Machinery & Industrial Consumables
- Engineering Consultants
- OEMs for Chemicals & Pharmaceutical Processing Equipment
- Metals & Metallurgy
- Bioprocessing Equipment
- Construction Services Providers
- Plant Maintenance Services Providers
- Logistics & Supply Chain Solutions Providers
- Instrumentation & Process Control
- Industry Automation (Process & Factory)
- Systems Integration & ERP Solutions Providers
- Water & Waste Water Treatment Consultants
- Environment Solutions Providers
- Waste Management Consultants
- Financial Institutions
- Fire & Safety Solutions Providers
- Material Handling Solutions
- Certification Bodies
- Welding Solutions
- Quality Health & Environment Solutions
- Analytical & Laboratory
- Packaging Materials, Machinery & Systems
- Business Consultants

Scope for Specialty Chemicals World Expo 2026

- Agrochemicals Intermediates
- Adhesives & Sealants
- Agrochemicals & Crop Protection
- Bulk Drugs & Intermediates
- Enzymes
- Colorants, Dyes & Pigments
- Cosmetics & Personal Care Ingredients
- Hygiene & Cleaning Chemicals
- Laboratory Chemicals
- Surfactants
- Water Treatment Chemicals
- Catalysts
- Electronic Chemicals
- Flavours & Fragrances
- Contract Manufacturers

Scope for Biopharma World Expo 2026

- Materials Processing
- Pharma Machinery
- Pharma Ingredients
- Plant Engineering, Process Plants & Equipment
- Laboratory & Analytical Solutions
- Process Measurement & Inspection
- Sterilization & Clean Room Solutions
- Biopharma R&D And Manufacturing
- IT Solutions
- Water & Waste Treatment Solutions

FACT & FIGURES 2024

- **750** EXHIBITORS FROM 15+ COUNTRIES
- **25871** VISITORS FROM 53 COUNTRIES
- **8** TECHNICAL CONFERENCES
- **1500+** BUSINESS DELEGATES
- **250+** GLOBAL SPEAKERS
- **2500+** ENGINEERING PHARMA & SCIENCE STUDENTS AT STUDENT OUTREACH PROGRAM FROM 28 STATES & UNION TERRITORIES
- SCALE@ CHEMTECH World Expo 2024: 60+ GLOBAL CLIMATE TECH STARTUPS FROM 20 COUNTRIES; 40 TECHNICAL PRESENTATIONS
- BRICS WORKING GROUP BRAIN STORMING SESSION

Organised by:

Jasubhai MEDIA

Jasubhai Media Pvt Ltd

Taj Building, 3rd Floor, 210, Dr. D N Road, Fort, Mumbai – 400 001, INDIA.
Tel: +91-22-4037 3636, **Email:** sales@jasubhai.com

Ahmedabad - 09833104834 | Bangalore - 09892644177 | Chennai - 09176963737
Delhi - 09891469629 | Hyderabad / Pune - 09822209183 | Vadodara - 09820544904

sales@jasubhai.com

www.chemtech-online.com

CHEMTECH FOUNDATION
1974-2024
Inspiring Intelligence...
..Igniting Innovation

International Integrated **ENERGY** Exhibition & Conferences

Oil Gas & Power

World Expo 2027

ANNOUNCING 2027

3-5, March 2027

Venue: Bombay Exhibition Center, Goregaon (East), Mumbai, India

Oil&GAS World Expo 2027 | POWER + COAL World Expo 2027 | Nuclear ENERGY World Expo 2027

GREEN ENERGY & HYDROGEN World Expo 2027 | GAS WORLDTECH Expo 2027 | Refining & Petro CHEMICALS 2027 | SMP Shipping, Marine & Ports WORLD EXPO 2027 | Surface Engineering Coating & Corrosion World Expo 2027

EXHIBITOR GROUPS

OIL & GAS
- Exploration & Production
- Oil Field Services
- Geographical and Seismic Surveys
- Drilling
- Sub Sea
- Transportation Storage & Infrastructure

NATURAL GAS & LNG
- Natural Gas Marketing
- City Gas Distribution
- Transportation & Storage Infrastructure

REFINING
- Oil Refining
- Marketing
- Petrochemicals Manufacturing
- Technology Licensors

POWER
- Power Generation
- Technology Licensors
- Power Transmission & Distribution
- Infrastructure

CLEAN ENERGY
- Renewables – Solar Wind & Hydro
- Hydrogen
- Biofuels
- Methanol
- Nuclear

ENGINEERING SERVICES
- EPC services
- Project Management Consultants
- Engineering Services
- Construction

SHIPPING MARINE & PORTS
- Shipping Services
- Ports
- Inland water ways
- Transportation Warehousing
- Supply Chain Management
- Material Handling & Supply Chain Management
- Logistics Services

CORROSION CONTROL
- Surface Engineering
- New metallurgies
- Industrial Coatings
- Corrosion Control Technologies & Services

PROCESS PLANTS & PLANT EQUIPMENT
- Distillation Columns
- Reactors
- Heat Exchangers, Cooling Towers & Boilers
- Storage Tanks
- Compressors , Pumps & Valves
- Plant instrumentation & automation
- IT Infrastructure & Digital Technologies

Jasubhai MEDIA

Organised by: **Jasubhai Media Pvt Ltd**

Taj Building, 3rd Floor, 210, Dr. D N Road, Fort, Mumbai – 400 001, INDIA.
Tel: +91-22-4037 3636, **Email:** sales@jasubhai.com

Ahmedabad - 09833104834 | Bangalore - 09892644177 | Chennai - 09176963737
Delhi - 09891469629 | Hyderabad / Pune - 09822209183 | Vadodara - 09820544904

sales@jasubhai.com **www.chemtech-online.com**