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Can Pakistan Benefit from Iranian Oil? The Real Opportunity Lies in Refining, Not Just Importing

As discussions over a possible easing of sanctions on Iran gather momentum, the question is once again being asked: Can Pakistan benefit from importing Iranian crude oil?

The answer is yes—but not simply because Iranian oil could be cheaper or geographically closer. The real economic opportunity lies in refining crude oil into high-value petroleum products, a process known as value addition.

Many people assume crude oil enters a refinery and simply emerges as petrol. In reality, a modern refinery is one of the world's most sophisticated industrial facilities, converting one barrel of crude oil into a range of products that power transport, industry, agriculture and manufacturing.

From crude oil to dozens of products
 Crude oil is the unprocessed petroleum



extracted from underground reservoirs. It cannot be used directly in vehicles or industries.

Inside a refinery, crude oil is heated to around 350–370°C in a distillation unit,

where different hydrocarbons separate according to their boiling points.

The refining process produces: LPG, Petrol (gasoline), Naphtha, Jet fuel, Diesel, Lubricating oils, Bitumen, Paraffin wax, Petrochemical feedstock.

These products serve dozens of industries, from transportation and aviation to plastics, pharmaceuticals, fertilizers, textiles and packaging.

This is where the real value is created. A barrel of crude oil worth around US\$70 can eventually generate petroleum products worth significantly more after refining.

Pakistan's refining capacity

Pakistan currently has five major oil refineries with a combined installed capacity of around 470,000 to 500,000 barrels per day (bpd).

The country's refining industry comprises:

- Cnergyico Refinery – approximate-

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OGDCL Starts Production from Bobi Deep-1, Reinforcing Sindh's Position as Pakistan's Energy Hub

Pakistan's largest exploration and production company, Oil & Gas Development Company Limited (OGDCL), has commenced commercial oil production from the Bobi Deep-1 well in Sindh, marking another milestone in its efforts to boost indigenous hydrocarbon production and strengthen the country's energy security.

In a notice to the Pakistan Stock Exchange (PSX), the state-owned company said the development follows its June 3, 2026 announcement regarding the successful oil discovery at Bobi Deep-1 from the Massive Sand reservoir of the Lower Goru Formation.

Located in the Bobi and Dhamraki Mining Lease in Sanghar district, the well is currently producing approximately 2,000 barrels of crude oil per day (BOPD).

To accelerate the commercialization of the discovery, OGDCL completed the installation of a 4-inch, 1.5-kilometre flowline connecting the well to the nearby Bobi Processing Plant within a short period, enabling early production from the newly discovered reservoir.

OGDCL, which holds a 100 percent working interest in the Bobi and Dhamraki Mining Lease, said the project demonstrates the company's ability to rapidly monetize hydrocarbon discoveries through indigenous technical expertise and operational capabilities.

"The commencement of production from Bobi Deep-1 will contribute to strengthening Pakistan's domestic energy supplies, reducing reliance on imported crude oil and supporting the country's long-term energy security," the company said.

The latest development further reinforces Sindh's status as Pakistan's principal

hydrocarbon-producing province, where oil and gas are currently produced from around 15 districts. The province contributes more than half of Pakistan's indigenous crude oil production and nearly 70 percent of the

overall hydrocarbon output.

OGDCL remains Pakistan's largest exploration and production company, currently producing around 38,000 barrels of crude oil per day and more than 700 million

overall hydrocarbon output.

Energy experts say the rapid monetization of discoveries such as Bobi Deep-1 is vital for improving Pakistan's energy security at a time when the country continues to spend billions of dollars annually on importing crude oil, petroleum products and liquefied natural gas (LNG). Although domestic production cannot fully meet national demand, every increase in indigenous output helps reduce the import bill, conserve precious foreign exchange reserves and improve the country's balance of payments.

Established in 1961, OGDCL is Pakistan's flagship exploration and production company with one of the country's largest portfolios of exploration licences and producing fields. The company plays a central role in meeting Pakistan's energy requirements through the exploration, development and production of oil and natural gas while investing in advanced technologies to maximize recovery from existing reservoirs and accelerate the commercialization of new discoveries. — ER Report



country's natural gas output, making it the backbone of Pakistan's energy sector.

Besides the newly producing Bobi Deep-1 well in Sanghar, OGDCL operates several strategic oil and gas assets across Sindh, including the Qadirpur Gas Field in Ghotki—one of Pakistan's largest gas fields—as well as the Tando Alam, Dars West, Chakrun, Sahito, and Bobi-Dhamraki fields. In recent years, the company has also made a series of successful discoveries in Sindh, reflecting the province's continuing exploration potential.

The province hosts several of Pakistan's largest hydrocarbon fields operated by OGDCL and other exploration and production companies, including the Mari (Daharki) Gas Field, Qadirpur, Kandhkot, Bobi-Dhamraki, Tando Alam, Adam, Shahdadpur, and Shah Bandar fields. Major producing districts include Sanghar, Ghotki, Khairpur, Badin, Sujawal, Tando Allahyar, Tando Muhammad Khan, Hyderabad, Matiari, Jamshoro, Dadu, Thatta, Kashmore, Jacoba-

standard cubic feet of natural gas (MMSCFD) daily from its producing assets across the country, with Sindh accounting for a significant share of the company's

Inside Islamabad Chamber of Commerce



Sardar Tahir Mehmood, President Islamabad Chamber of Commerce and Industry presents Chamber's souvenir to Shawn Young, General Manager APAC, Alibaba.com. Ms. Summer Gao, Country Manager for Pakistan and Bangladesh, ICCI Vice President Irfan Chaudhry, Executive Member Waseem Chaudhry, Executive Director (CHAP), Abrar-ul-Haq, Convener ICCI IT, Telecom and Computer Hardware Committee Aizaz Muhammad, Convener ICCI Software Development Committee Dr. Muhammad Usman are also present.

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Can Pakistan Benefit from Iranian Oil? The Real Opportunity Lies in Refining, Not Just Importing

Contd from page 1

ly 156,000 bpd

- PARCO Mid Country Refinery – approximately 100,000 bpd
- National Refinery Limited (NRL) – around 66,000 bpd
- Attock Refinery Limited (ARL) – around 53,000 bpd
- Pakistan Refinery Limited (PRL) – around 50,000 bpd

Although Pakistan has the capacity to refine nearly half a million barrels of crude oil daily, the refineries often operate below capacity because of market conditions, maintenance shutdowns and limited availability of suitable crude supplies.

The engineering challenge

While Pakistan possesses adequate refining capacity, most of its refineries were built decades ago and still operate largely as hydroskimming refineries.

Hydroskimming technology performs only basic refining. It produces limited quantities of premium fuels while generating relatively large volumes of furnace oil, a heavy residual fuel.

Twenty years ago, furnace oil was widely used in Pakistan's power generation sector. Today, however, electricity production has shifted toward LNG, hydropower, coal, renewables and nuclear energy, causing domestic

demand for furnace oil to decline sharply.

As a result, refineries are left with surplus furnace oil, which commands much lower prices than diesel or petrol, reducing refinery profitability.

What modernization is needed?

To maximize the value of crude oil—including potential Iranian crude—Pakistan's refineries require substantial modernization.

Engineering upgrades include installation of:

- Hydrocrackers
- Fluid Catalytic Crackers (FCC)
- Delayed Cokers
- Diesel Hydrotreaters
- Residue Upgradation Units
- Sulphur Recovery Units
- Euro-V fuel production facilities

These sophisticated processing units convert heavy residual fuel into premium products such as diesel, petrol, aviation fuel and petrochemical feedstocks.

For example, a Delayed Coker breaks heavy furnace oil into lighter, more valuable fuels, while a Hydrocracker uses hydrogen under high pressure to convert heavy hydrocarbons into clean diesel and jet fuel.

Modern refineries can increase yields of premium fuels by 15–25 percent, significantly improving prof-

itability.

How much would modernization cost?

Pakistan's Refining Policy encourages refineries to upgrade their facilities to produce Euro-V standard fuels, which contain lower sulphur and meet international environmental standards.

Industry estimates suggest that modernizing Pakistan's refining sector would require investments of approximately US\$5–6 billion.

Such investments would enable local refineries to:

- Reduce furnace oil production
- Increase diesel and petrol output
- Produce cleaner fuels
- Expand jet fuel production
- Supply feedstock to Pakistan's petrochemical industry

Experts believe these upgrades could save Pakistan

billions of dollars annually by increasing domestic value addition and reducing imports of refined petroleum products.

Why Iranian crude fits Pakistan

From an engineering perspective, Iranian Light Crude is considered highly compatible with Pakistan's existing refineries.

Its physical and chemical characteristics are broadly similar to crude oils imported from Saudi Arabia, Iraq and the UAE, which Pakistani refineries have processed for decades.

Therefore, no major modifications would be required simply to refine Iranian Light crude.

The real engineering challenge lies not in processing Iranian oil itself, but in upgrading refineries to maximize the production of high-value fuels.

A strategic geographic advantage

Iran also offers significant logistical advantages.

Unlike crude imports from the Gulf, Africa or other distant suppliers, Iranian oil could eventually reach Pakistan through: Road transport, Railway links, Future oil pipelines, Existing maritime routes over shorter distances

Shorter transport distances could reduce freight costs, improve supply security and lower overall import expenses.

Beyond fuel

The greatest economic impact may not come from petrol alone.

Refined products such as naphtha serve as feedstock for plastics, synthetic fibres, fertilizers, chemicals, pharmaceuticals, detergents and hundreds of industrial products.

A stronger refining industry could therefore stimulate Pakistan's petrochemical sector, create skilled employment, increase exports and

strengthen industrial growth.

Politics remains the biggest obstacle

Despite the technical feasibility, Pakistan has yet to import Iranian crude because of international sanctions, financial restrictions, payment mechanisms and geopolitical considerations.

From an engineering standpoint, Pakistan is capable of refining Iranian crude.

Whether it can actually do so will depend less on technology than on diplomacy, sanctions policy and regional geopolitics.

If these barriers are eventually removed and refinery modernization proceeds as planned, Iranian crude could become more than just another source of oil—it could provide Pakistan with an opportunity to transform its downstream petroleum industry and generate far greater economic value through domestic refining and petrochemical production. — ER Report

Mujtaba Shaikh, now CEO at AI Engineers Pakistan

AI Engineers Pakistan (AIE-PK) is pleased to announce the promotion of Mujtaba Shaikh, PE, PMP to Chief Executive Officer of AIE-PK.

With more than 25 years of experience spanning infrastructure, buildings, transportation, ports, healthcare, and tourism sectors across the United States, Pakistan, and Middle East, Mujtaba brings a combination of technical depth and executive leadership to this role. He holds a BE from NED University and an MS from UC Berkeley, and is a licensed professional engineer in both Pakistan and US-California. Since joining AIE-PK,

Mujtaba has been instrumental in establishing the firm's first international office in

an active project portfolio not only in Pakistan but also in the US, Canada, Middle East,

AEC industry projects for several public, donor, and private sector clients. His experience has been defined by a commitment to leadership, business acumen, rigorous project controls, technology-driven delivery, and a high-performance culture - qualities that have positioned AIE-PK as a trusted partner in the regional AEC landscape.

A recognized voice in the profession, Mujtaba has also contributed widely through speaking engagements and publications on engineering, project management, contracts, disputes, and technology solutions. As CEO, he will lead AIE-PK's next chapter of strategic growth and regional impact. Please join us in congratulating Mujtaba on this well-deserved promotion. ■



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Pakistan's Four Brothers Group Signs MoU with Iran's Kimia Exir to Expand Agricultural Technology Cooperation

Pakistan's Four Brothers Group (FBG) has signed a Memorandum of Understanding (MoU) with Iran's Kimia Exir Company to establish

range of agricultural initiatives, including manufacturing, research and development (R&D), commercialization of high-performing crop varieties, and the transfer of advanced agricultural technologies.

A key component of

sides will also explore the formation of a joint venture to own and operate the facility.

The agreement further provides for cooperation in the research, development and commercialization of improved cotton, canola, wheat and other

native pesticides, crop protection technologies and product development expertise, while Kimia Exir will facilitate product registration, market development, distribution, sales and customer support within Iran.

The two companies also

According to the MoU, the partnership seeks to facilitate technology transfer between Pakistan and Iran, develop local manufacturing capabilities, promote advanced seed technologies, expand access to modern crop protection products and support sus-

taining between the two companies.

The MoU will remain valid for five years from the date of signing unless extended by mutual written consent.

The agreement marks another step in expanding Pakistan-Iran economic



a strategic partnership aimed at enhancing agricultural productivity, technology transfer, seed development, and crop protection in Iran.

Under the agreement, the two companies will collaborate on a wide

the MoU is the establishment of a Sulphur DF manufacturing facility in Iran. Four Brothers Group will provide technical know-how, manufacturing technology, quality control systems, installation and commissioning support, as well as operational expertise. The two

strategic crop varieties suited to Iranian conditions. Four Brothers Group will contribute breeding expertise, agronomic support and technical assistance to strengthen Iran's seed sector.

In the area of crop protection, the Pakistani company will supply inno-

agreed to jointly undertake agricultural research focusing on increasing crop yields, improving climate resilience, strengthening pest and disease resistance, enhancing crop genetics, promoting sustainable farming practices and boosting overall agricultural productivity.

tainable agricultural growth and food security.

The agreement serves as a framework for future commercial cooperation. Detailed arrangements relating to investment, manufacturing, licensing and distribution will be finalized through separate definitive agreements

cooperation, particularly in the agriculture sector, and is expected to promote the exchange of technology, strengthen agricultural research, and create opportunities for investment and industrial collaboration between the two neighboring countries. — ER News Desk

Saudi Aramco Resumes Oil Loadings at Ras Tanura After Four-Month Suspension

Saudi Aramco resumed crude oil loadings at its Ras Tanura export terminal on Friday, ending a nearly four-month suspension, according to LSEG shipping data, in a sign that

Bahri loading crude at Ras Tanura, while a third vessel waited offshore. Each VLCC can carry up to two million barrels of oil.

Ras Tanura, the world's largest oil export terminal, had not loaded a cargo since March 8, when exports were diverted to the Red Sea port of Yanbu following disruption

attack near the coast of Oman while transiting the Strait of Hormuz on Thursday. The incident prompted the UK Maritime Trade Operations (UKMTO) agency to suspend escort operations through the strategic waterway.

Meanwhile, regional producers including Iraq,



Middle Eastern producers are moving ahead with plans to increase exports despite renewed security concerns in the Strait of Hormuz.

The data showed two Very Large Crude Carriers (VLCCs) operated by Saudi shipping company

tions caused by the conflict involving Iran, the United States and Israel. Saudi crude exports fell to around 4 million barrels per day over the past three months from more than 7 million bpd in February.

The resumption comes despite fresh security concerns after a cargo vessel reported a suspected

Kuwait, the United Arab Emirates and Qatar are increasing crude exports, while Iran is also accelerating shipments following a temporary easing of U.S. sanctions.

Oil prices fell more than \$1 a barrel on Friday as improving regional supply outweighed concerns over the latest security incident.—ERMD

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THE Global Sustainability Rankings

QUEST Tops Sindh's Engineering Universities for Quality Education

Quaid-e-Awam University of Engineering, Science and Technology (QUEST), Nawabshah has emerged as Sindh's top engineering university for quality education in the Times Higher Education (THE) Impact Rankings 2026, securing second position among all universities in the province and fifth nationwide.

The rankings, which assess universities worldwide on their contributions to the United Nations Sustainable Development Goals (SDGs), recognize institutions demonstrating excellence in education, research, innovation, environmental sustainability, social responsibility, and global partnerships. QUEST achieved

The achievement reflects QUEST's commitment to providing inclusive, high-quality education while promoting research, innovation, community engagement, and sustainable development.

The university attributed its progress to the leadership of Vice Chancellor Prof. Dr. Saleem Raza Samo, who has focused on strengthening academic quality, enhancing research productivity, promoting innovation, expanding indus-

Speaking on the achievement, Prof. Dr. Samo congratulated the faculty, students, researchers, officers, staff, alumni, and stakeholders, saying the global ranking reflects the university's collective commitment to academic excellence, quality education, and societal impact. He reaffirmed QUEST's resolve to further improve its international standing while producing engineers, scientists, and professionals capable of addressing national and global challenges.

The Vice Chancellor also acknowledged the efforts of Prof. Dr. Abdul Sattar Saand, Prof. Dr. Abdul Hanan Shaikh, Engr. Agha Sheraz, and Dr. A.R. Kattri, whose leadership and technical contributions were instrumental in preparing the university's submission for the THE Impact Rankings 2026.



an impressive world ranking band of 101-200 in SDG 4 (Quality Education), placing it first among engineering and technology universities in Sindh, second among all universities in the province, and among Pakistan's top five institutions in this category.

The university also earned global recognition in several other SDGs, ranking in the 601-800 band for SDG 10 (Reduced Inequalities), 1001+ for SDG 5 (Gender Equality), and 1001-1500 for SDG 17 (Partnerships for the Goals).

try-academia collaboration, improving governance, and aligning the university's strategic priorities with international standards and the UN Sustainable Development Goals.

Under his leadership, QUEST has accelerated institutional reforms, strengthened quality assurance mechanisms, expanded international collaborations, and encouraged departments to contribute actively to sustainable development through teaching, research, and community outreach.

The latest recognition marks another significant milestone in QUEST's journey toward becoming a globally recognized centre of excellence in engineering, science, technology, research, innovation, and sustainable development. The university said it would continue strengthening its role in delivering quality education, generating impactful research, and contributing to Pakistan's sustainable development agenda through continuous improvement and international collaboration. — ER

CDWP Clears 24 Development Projects

The Central Development Working Party (CDWP) approved 24 development projects worth Rs465.762 billion, including 15 projects valued at Rs34.740 billion, while referring

and Innovation Hub, a Robotics Centre of Excellence, the installation of smart electricity meters for LESCO, CT scan and MRI facilities in hospitals across Azad Jammu and Kashmir, and several road, security and border infrastructure schemes.

The forum also granted in-principle approval to sev-



nine major projects costing Rs431.022 billion to the Executive Committee of the National Economic Council (ECNEC) for final approval.

The meeting, chaired by Federal Minister for Planning, Development and Special Initiatives Ahsan Iqbal, reviewed projects spanning information technology, transport, power, health, science and technology, housing, and infrastructure under the government's URAAN Pakistan development agenda.

Among the projects approved by the CDWP were the establishment of Prime Minister's E-Sports Arenas and Training Centres, a Geospatial AI Development

eral high-value projects for ECNEC consideration, including the Rs278.6 billion upgradation of the ML-3 railway track, the Rs37.2 billion Pakistan Communication Satellite-2 (PakSat-2), the Rs13 billion National Artificial Intelligence Ecosystem Development Programme, the Rs7.93 billion Emerging Technologies Data Centre, the Rs20.35 billion Lalamusa Bypass project, and a Rs10 billion electricity network improvement scheme for Azad Jammu and Kashmir.

Addressing the meeting, Ahsan Iqbal said the projects support the government's vision of digital transformation, modern infrastructure, improved connectivity and sustainable economic growth under the URAAN Pakistan initiative.—ERMD

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Engineering Entrepreneurship for Sustainable Technological Development

Engr. Dr. Muhammad Nawaz Iqbal

Engineering entrepreneurship provides a vital link in the chain of sustainable technological development by transforming innovative ideas into practical solutions that address societal, environmental, and economic challenges.

The combination of engineering expertise and entrepreneurial skills is essential for creating and commercializing cutting-edge technologies. When engineering knowledge is integrated with entrepreneurial capability, it creates opportunities for sustainable growth by ensuring that technological innovations are not confined to laboratories but are translated into products and services that improve quality of life and drive economic development.

As the demand for sustainable solutions continues to grow, the role of engineering entrepreneurs has become increasingly important in addressing challenges such as climate change, energy scarcity, resource depletion, and environmental pollution. Entrepreneurial engineers develop innovative technologies that promote efficient resource utilization, reduce waste, and minimize environmental impacts. They actively contribute to renewable energy systems, smart infrastructure, green manufacturing, and environmentally friendly products, supporting long-term sustainability while creating economic value.

Engineering entrepreneurship also fosters the development of innovative business models that facilitate the widespread adoption of sustainable technologies. Many promising technologies fail to achieve commercial success because of economic, technical, or market constraints. Entrepreneurial engineers bridge this gap by designing business strategies that make sustainable technologies economically viable and accessible. Through innovative financing models, subscription-based services, circular economy solutions, and collaborative partnerships, they accelerate the adoption of technologies that support sustainable development goals.

The integration of digital technologies into engineering entrepreneurship has significantly accelerated sustainable technological development. Artificial Intelligence (AI), the Internet of Things (IoT), blockchain, and big data analytics enable entrepreneurs to develop intelligent systems that improve efficiency and sustainability. Smart energy management systems, predictive maintenance platforms, and resource optimization tools help reduce operating costs while minimizing environmental impacts. These innovations demonstrate that digital transformation not only enhances economic performance but also contributes substantially to environmental sustainability.

Engineering entrepreneurs are playing a pivotal role in driving sustainable industrial transformation. Traditional industries often struggle with high energy consumption, excessive emissions, and inefficient production processes. Entrepreneurial engineers introduce advanced manufacturing technologies, automation systems, and sustainable produc-



tion methods that improve productivity while reducing environmental impacts. Their innovations facilitate the transition toward cleaner industries and help businesses remain competitive in an increasingly sustainability-conscious global marketplace.

Interdisciplinary collaboration is essential for achieving sustainable technological development, and engineering entrepreneurship naturally encourages such cooperation. Successful ventures often bring together expertise from engineering, business, environmental science, social sciences, and public policy. This collaborative approach enables the development of comprehensive solutions that address technical, commercial, regulatory, and societal challenges simultaneously. Such integration enhances the effectiveness, scalability, and long-term success of sustainable innovations across multiple sectors.

The emerging concept of social engineering entrepreneurship has expanded the impact of technological innovation beyond purely economic outcomes. Today, many engineering entrepreneurs pursue social and environmental objectives alongside financial success. They develop technologies that improve access to healthcare, clean water, affordable housing, quality education, and other essential services. By addressing societal challenges through innovative technologies, these entrepreneurs contribute directly to sustainable development and community empowerment.

Engineering entrepreneurship has also become a driving force behind the advancement of renewable energy technologies, which are essential for achieving global sustainability goals. Entrepreneurs have played a significant role in commercializing solar power, wind energy, energy storage systems, and smart grid technologies. These innovations have reduced costs, improved effi-

ciency, and expanded access to clean energy. As renewable energy continues to become more affordable and competitive, engineering entrepreneurs will remain central to the global transition toward a low-carbon economy.

The principles of the circular economy have become increasingly important within engineering entrepreneurship. Rather than following

traditional linear production models based on extraction, consumption, and disposal, entrepreneurial engineers design products and systems that emphasize reuse, remanufacturing, recycling, and resource recovery. This approach reduces waste generation, improves resource efficiency, and creates new business opportunities. Circular economy innovations make significant contributions to sustainable technological development by extending product life cycles and minimizing environmental impacts.

Educational institutions play a crucial role in promoting engineering entrepreneurship for sustainable development. Universities are increasingly incorporating entrepreneurship, innovation management, and sustainability into engineering curricula. Through business incubators, innovation laboratories, startup accelerators, and industry collaborations, students gain practical experience in transforming technological ideas into commercially viable businesses. This educational approach equips future engineers with the skills needed to become innovators, entrepreneurs, and leaders capable of addressing complex sustainability challenges.

Government policies and supportive innovation ecosystems significantly enhance the success of engineering entrepreneurship. Public investment in research and development, innovation grants, startup incentives, and sustainability-focused regulations creates an environment that encourages entrepreneurial activity. By supporting innovation, governments enable engineering entrepreneurs to develop technologies that contribute to sustainable economic growth, environmental protection, and social well-being. Effective policy frameworks strengthen national innovation systems and improve international

competitiveness.

Rapid urbanization presents both challenges and opportunities for engineering entrepreneurship. Entrepreneurial engineers are developing smart city technologies that improve transportation, waste management, energy efficiency, water management, and public services. Intelligent urban infrastructure uses real-time

data and advanced analytics to optimize city operations while reducing environmental impacts. These innovations contribute to the development of sustainable, resilient, and livable cities capable of supporting growing populations and adapting to evolving societal needs.

Innovation and calculat-

ed risk-taking are fundamental characteristics of engineering entrepreneurship and essential drivers of sustainable technological advancement. Entrepreneurs are willing to invest time, effort, and resources in developing new technologies despite uncertain outcomes. Their openness to experimentation and creative thinking often leads to breakthrough innovations capable of transforming industries and addressing critical sustainability challenges. This entrepreneurial mindset promotes continuous improvement and ensures that technological development keeps pace with evolving economic, environmental, and societal needs.

Global collaboration has become an increasingly important component of engineering entrepreneurship in the pursuit of sustainable development. Engineering entrepreneurs actively participate in international innovation networks, research collaborations, and cross-border partnerships. These collaborations facilitate knowledge exchange, technology transfer, and joint problem-solving. By leveraging global expertise and resources, entrepreneurial engineers can accelerate the development and deployment of sustainable technologies that benefit communities around the



world.

Ultimately, the future of sustainable technological development depends on the ability of engineering entrepreneurs to anticipate emerging challenges and create innovative solutions. As technological transformation continues to reshape industries and societies, entrepreneurial engineers will play an increasingly important role in ensuring that innovation is not only technically and economically viable but also socially inclusive and environmentally sustainable. Their unique ability to integrate technical expertise, business acumen, and social responsibility positions them as key drivers of sustainable economic growth, environmental stewardship, and inclusive development in the decades ahead. ■

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Agriculture Review



Pakistan Moves to Unlock Agricultural Biotechnology but Success Hinges on Implementation

Pakistan has taken a significant step towards modernising its agriculture sector with the approval of the National Agricultural Biotechnology Policy (NABP) 2025, a comprehensive framework that aims to promote biotechnology-driven farming, improve crop productivity, strengthen food security, and attract investment in agricultural research and innovation.

The policy, recently approved by the Federal Cabinet, marks the country's first comprehensive national roadmap for regulating and commercializing modern agricultural biotechnology. Officials believe it could transform Pakistan's agriculture by facilitating the safe development and adoption of genetically improved crops, advanced seed technologies,

livestock vaccines, and genomic research.

The Ministry of National Food Security and Research said the policy was developed following directives of the Special Investment Facilitation Council (SIFC) and after extensive consultations with provincial governments, research institutions, academia, regulatory authorities, and private-sector stakeholders.

The NABP establishes a national framework covering the development, regulation, commercialization, import and export of biotechnology products.

The policy regulates genetically modified organisms (GMOs), gene-editing technologies, recombinant livestock vaccines, and cross-border movement of genetically modified agricultural products. It also promotes research in plant tissue culture, genomics, molecular breeding, and biotechnology-based crop improvement.

Officials said the policy seeks to remove regulatory uncertainty that has long dis-

couraged investment in Pakistan's biotechnology sector while ensuring that biosafety and environmental standards remain aligned with international practices.

The approval comes at a time when Pakistan's agri-

agricultural commodities.

Agriculture contributes nearly one-fourth of Pakistan's Gross Domestic Product (GDP), employs around 37 percent of the national labour force, and provides livelihoods to millions of

other commodities due to declining domestic production.

Experts believe modern biotechnology could help address many of these structural challenges by developing crop varieties that are more resistant to drought, heat, salinity, insects and diseases while producing higher yields.

Cotton sector among major beneficiaries

Agricultural experts say one of the immediate beneficiaries of the policy could be Pakistan's struggling cotton sector.

Once among the world's leading cotton producers and exporters, Pakistan has witnessed a sharp decline in cotton production over the past several years owing to climate change, pest infestations, poor-quality seed, water shortages and changing cropping patterns.

Industry analysts believe biotechnology-enabled seed development and advanced breeding techniques could play a key role in reviving cotton productivity and reducing the country's

dependence on imported cotton for its textile industry.

The government believes the policy will also encourage greater collaboration between universities, research institutions and the private sector.

Officials expect the new framework to attract domestic and foreign investment in agricultural biotechnology by providing greater regulatory clarity for companies interested in developing improved crop varieties, modern seed technologies and biological products.

Pakistan's research institutions, including the Pakistan Agricultural Research Council (PARC), provincial agricultural research organisations and universities, are also expected to benefit from increased collaboration with international biotechnology companies and research centres.

The policy is designed to facilitate technology transfer while encouraging innovation in seed development, molecular breeding and precision agriculture.

Contd on page 9



culture sector is confronting multiple challenges, including declining crop yields, climate change, water scarcity, pest attacks, deteriorating soil fertility, and rising dependence on imported

rural households. Yet productivity of several major crops has stagnated over the past decade.

The country has increasingly relied on imports of cotton, edible oil, pulses and



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GCIL wins five-year gas processing contract from OGDCL for Sindh field

Ghani Chemical Industries Limited (GCIL), one of Pakistan's leading producers of medical and industrial gases, has secured a five-year contract from Oil & Gas Development Company Limited (OGDCL) for the development and processing of natural gas from the Sono Lashari Field in Sindh.

In a notice submitted to the Pakistan Stock Exchange (PSX), GCIL said OGDCL will allocate a designated quota of raw natural gas from the field to the company, which will process it into value-added hydrocarbon products including Compressed Natural Gas (CNG), Liquefied Petroleum Gas (LPG), and associated hydrocarbon condensates.

The project marks a strategic collaboration between two major Pakistani companies: Oil & Gas Development Company Limited and Ghani Chemical Industries Limited. Under the arrangement, OGDCL will provide the raw gas resource from its producing field, while GCIL will develop and operate the processing infrastructure needed to convert the gas into commercially marketable products.

OGDCL, Pakistan's largest exploration and production company, is responsible for a substantial share of the country's indigenous oil and gas output and operates numerous fields across Sindh, Punjab, Khyber Pakhtunkhwa and Balochistan. The company plays a central role in Pakistan's energy security by exploring, developing and producing hydrocarbon resources.

GCIL, incorporated in 2015 and converted into a public limited company in 2017, has

rapidly emerged as a leading manufacturer in Pakistan's industrial and medical gases sector. The company operates five state-of-the-art Air Separation Unit (ASU) plants and supplies gases to healthcare, manufacturing, engineering and industrial customers across the country.

GCIL said project implementation will begin after completing the required engineering, procurement, regulatory approvals and site mobilisation activities. Commercial operations are currently expected to commence during the first quarter of 2027.

Based on the current technical configuration and prevailing market conditions, the company estimates the project could generate annual revenues of approximately Rs1.5 billion to Rs2 billion once commercial operations begin.



The company described the contract as an important milestone in its strategy to diversify into the energy processing sector and create an additional recurring revenue stream over the five-year contract period.

Analysts say the collaboration highlights a growing trend of partnerships between Pakistan's upstream energy companies and private-sector industrial players to maximise value from domestic gas resources. By converting raw natural gas into higher-value products such as LPG, CNG and condensates, the project is expected to improve resource utilisation while supporting local energy supply chains.

The financial impact of the project, GCIL said, will begin once commercial production starts, with the venture expected to strengthen the company's long-term revenue base and expand its footprint beyond its traditional industrial gases business. — ER News Desk

SML Tires expands truck, bus radial tyre production capacity by 25%

SML Tires Limited has successfully expanded its production capacity for truck and bus radial (TBR) tyres by 25 percent, increasing annual output from 1.6 million tyres to 2.0 million tyres, the company informed the Pakistan Stock Exchange (PSX).

In its notice to the bourse, the company said the expansion reflects its continued commitment to operational growth and long-term value creation.

The enhanced capacity

is expected to help meet rising demand in both domestic and international markets while strengthening the company's competitive position in the tyre industry.

SML Tires said the increased production capa-



bility would enable it to better serve customers, capitalize on growing market opportunities, and support its export ambitions.

The company expects the expansion to contribute

positively to future revenues and profitability by improving economies of scale and enhancing its ability to meet higher order volumes.

The latest capacity enhancement comes as Pakistan's tyre industry continues to focus on import substitution, export growth, and increased localization amid rising demand from the transport and logistics sectors.

SML Tires stated that it remains committed to expanding its manufacturing capabilities and creating sustainable value for shareholders through strategic investments and operational excellence. —ER News Desk

Pakistan Oilfields reappoints Shuaib A. Malik as CEO, elects him Chairman

Pakistan Oilfields Limited (POL), one of the country's leading oil and gas exploration and production companies, has elected Shuaib A. Malik as Chairman of its Board of Directors and reappointed him as the company's Chief Executive Officer for another three-year term.

In a notice submitted to the Pakistan Stock Exchange (PSX), the company said its Board of Directors elected Malik as Chairman and

approved his reappointment as Chief Executive with effect from June 27, 2026, for a term of three years.

The dual appointment reflects the board's confidence in Malik's leadership as the company continues to pursue its exploration, production and growth objectives in Pakistan's upstream energy sector.

Pakistan Oilfields Limited is one of Pakistan's oldest and largest exploration and production (E&P) companies. Established in 1950, it is part of the Attock Oil Group and is engaged in the exploration, drilling and production of crude oil and natural gas.

The company operates several producing fields across the country and plays a significant role in meeting Pakistan's domestic energy requirements. POL is also recognized for its strong financial performance, consistent profitability and regular dividend payouts, making it one of the blue-chip companies listed on the Pakistan Stock Exchange.

The latest board decision ensures continuity in the company's leadership as it focuses on expanding hydrocarbon production, enhancing operational efficiency and creating long-term value for shareholders. —ER News Desk

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مطالبات تسلیم نہ ہونے تو عدالت اور پبلک اکاؤنٹس کمیٹی (PAC) سے رجوع کیا جائیگا

پاکستان کنٹریکٹرز ایسوسی ایشن (PCA) سندھ کا ایک اہم اور بنگالی اجلاس صدر حاجی میر زمان مندوخیل کی صدارت میں منعقد ہوا۔ اجلاس میں سندھ پبلک پروکیورمنٹ ریگولیٹری اتھارٹی (SPPRA) کے حالیہ متنازع نوٹیفکیشن نمبر 673/26-2025/SPPRA/(M&CB) (مورخہ 18 مارچ 2026) کا تفصیلی جائزہ لیا گیا اور اسے متفقہ طور پر مسترد کر دیا گیا۔

اجلاس سے خطاب کرتے ہوئے ایسوسی ایشن کے صدر حاجی میر زمان مندوخیل اور دیگر رہنماؤں نے کہا کہ سپرا کا یہ نیا قانون چھوٹے ٹھیکیداروں کا معاشی قتل اور مخصوص بڑے ٹھیکیداروں کی من پسند جاہد داری قائم کرنے کی بدترین کوشش ہے۔ یہ پالیسی نئے اور چھوٹے ٹھیکیداروں (C5 اور C6 کیٹیگری) کے کاروبار کو چھیننے کے لیے بنائی گئی ہے۔ اجلاس کے اعلائیے میں سپرا کے نوٹیفکیشن پر درج ذیل سنگین اعتراضات اٹھائے گئے: 1. *مائی بڈز (Bids Tie) کی آڑ میں نا انصافی: *برابر ریش آنے کی صورت میں پچھلے 5 سال کا تجربہ اور ورک آرڈر مانگنے کی شرط عائد کی گئی ہے۔ رہنماؤں نے سوال اٹھایا کہ اگر نئے ٹھیکیدار کو کام ہی نہیں ملے گا تو وہ تجربہ کہاں سے لائے گا؟ یہ شرط نئے انجینئرز اور کمپنیوں کو کام سے روکنے کے مترادف ہے۔ 2. *پاکستان انجینئرنگ کونسل (PEC) کی خاموشی: *اجلاس میں بی بی سی کے کردار پر شدید تنقید کرتے ہوئے کہا گیا کہ کونسل صرف فینسیں جمع کرنے اور لائسنس بانٹنے تک محدود ہو چکی ہے۔ اگر پی ای سی بقیہ صفحہ 11 پر

داسو ہائیڈرو پاور پروجیکٹ نے ایک اور اہم تعمیراتی ہدف حاصل کر لیا

داسو ہائیڈرو پاور پروجیکٹ کے 23 مختلف ورک فرمنس پر تعمیراتی سرگرمیاں بیک وقت جاری ہیں، داسو ہائیڈرو پاور پروجیکٹ کی مجموعی پیداواری صلاحیت 4 ہزار 320 میگا واٹ ہے۔ داسو ہائیڈرو پاور پروجیکٹ دو مراحل میں مکمل ہوگا، ہر مرحلے کی پیداواری صلاحیت 2 ہزار 160 میگا واٹ ہے۔ پروجیکٹ کے پہلے مرحلے پر تعمیراتی کام جاری ہے، پہلا مرحلہ مکمل ہونے پر قومی گروتھ کو ہر سال 12 ارب روپے کم لاگت اور ماحول دوست پین بجلی مہیا کی جاسکے گی۔

پروجیکٹ پر آرسی سی ورکس کا آغاز گئی ایریا سے درکار میٹریل پوزولان کی دستیابی کے تمام تکنیکی پہلوؤں کا تفصیلی جائزہ لیں گی۔

انجینئر زاور تکنیکی ماہرین کی ٹیمیں ٹرائل کے تمام تکنیکی پہلوؤں کا تفصیلی جائزہ لیں گی۔

قومی اہمیت کے حامل داسو ہائیڈرو پاور پروجیکٹ نے ایک اور اہم تعمیراتی ہدف حاصل کر لیا



ہے۔ پروجیکٹ پر فل اسکیل رولر کمپیکٹڈ کنکریٹ (AI سی) ٹرائل کا آغاز کر دیا گیا۔ فل اسکیل ٹرائل مین ڈیم پر آرسی سی تعمیراتی کام شروع کرنے سے قبل ایک لازمی مرحلہ ہے۔

کے قریب قائم ٹرائل سیکشن میں فل اسکیل کنکریٹنگ کی مشقیں جاری ہیں، پروجیکٹ پر فل اسکیل آرسی سی ٹرائل چار ماہ تک جاری رہے گا۔

پرمختصر ہے، گزشتہ 10 سال پر محیط کوششوں کے باوجود گئی ایریا کی تحویل واپڈا کو نہیں مل پائی ہے۔

ٹرائل کی کامیاب تکمیل کے بعد مین ڈیم پر آرسی سی ورکس کا باقاعدہ آغاز رواں سال کے آخر میں شیڈول ہے۔

ٹرائل چار ماہ تک جاری رہے گا۔

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Underwater robots that are always on call pave the way for pipeline and cable security

Growing economic activity in the ocean space is increasing the need for more regular monitoring and inspection of underwater infrastructure and its surroundings.

Autonomous underwater vehicles capable of monitoring and inspecting pipelines, cables and underwater installations are becoming increasingly important in an uncertain global security situation. In addition, we need more knowledge about the seabed and the ocean space.

Currently, monitoring and inspections are carried out by large ships using sonar for broad surface-based scans, or by underwater vehicles that are accompanied by vessels and operated from control rooms on the mother ship or onshore.

Both systems require large, expensive surface-based vessels and many people. Chartering a ship with a crew is very expensive, and the CO₂ emissions are significant.

'Hearth and home' at a depth of 90 meters

One alternative currently under development is autonomous underwater robots that can operate on the seabed for many months or years at a time, without being brought to the surface or ashore.

Professor Martin Ludvigsen at the Norwegian University of Science and Technology (NTNU)'s Department of Marine Technology says that underwater robots capable of operating from fixed bases on the seabed, independent of costly surface vessels, will play a key role in monitoring, inspecting and protecting the increasing amount of infrastructure on the seabed—all over the world.

Researchers from NTNU have now successfully conducted trials involving an autonomous underwater vehicle (AUV) and a docking station at a depth of 90 meters (295 feet).

Without human intervention, the robot conducted inspections of infrastructure and found its way back to the docking station, where it connected to recharge its batteries and upload the collected data.

"These tests represent important steps toward fully autonomous operations over extended periods of time," said Leonard Florian Tom Günzel, a Ph.D. research fellow at NTNU's Department of Marine

Technology.

He explains that the motivation behind developing resident underwater vehicles is to reduce costs and thereby make the technology accessible to a wider range of users. Another important reason is the safety of seafarers and protection of the environment.

Simpler and more affordable

For years, there has been talk of deploying AUVs to ensure a more or less constant presence around oil and gas installations. There are already a few large, advanced systems in place. The recent spate of sabotage incidents targeting infrastructure, communication fibers, power lines and pipelines will increase the demand for more and simpler solutions.

More research and development are still

specially equipped for the specific tests.

Among other things, the robot was kitted out with a camera, sonar, sensors, communication equipment, an induction charger and a magnetic "mooring" system.

Ludvigsen and Günzel highlight that this test robot provides NTNU with a platform that can be used by students, Ph.D. research fellows and companies alike.

"We have developed a tool for the further development, testing and refinement of technology that can eventually be commercialized," said Günzel.

Tested in the Trondheim Fjord

The tests were conducted using NTNU's existing infrastructure in the Trondheim Fjord. A specially designed docking station was installed at a depth of 90 meters (295 feet).

way.

So far, the AUV has been deployed on two occasions, with a total of four weeks of operational service. The system completed its inspection missions and achieved an autonomous docking success rate of 90%. However, it has to reach a 100% success rate, so new deployments are planned this spring.

"Docking is absolutely critical. Without an operator, the consequences of errors are much greater. If the AUV is unable to find its way back to the docking station, it cannot be recovered," Ludvigsen said.

Tethered testing

Navigating on land or on the surface of the sea is relatively easy: GPS and other satellite systems provide access to location data. However, that is not possible underwa-

ter. Therefore, combinations of several techniques are used to calculate position and course, including gyroscopes and accelerometers (INS – Inertial Navigation System) as well as an acoustic-based system (DVL – Doppler Velocity Log). The navigation systems require a lot of processing power and therefore consume a significant amount of electricity.

The tests involving Blueye X3 were conducted using a tether to secure it. Future research trials will also be carried out using recovery tethers until a robust autonomous solution is in place. The process may still take some time, even though artificial intelligence (AI) helps the researchers find effective solutions more quickly.

One of the biggest remaining

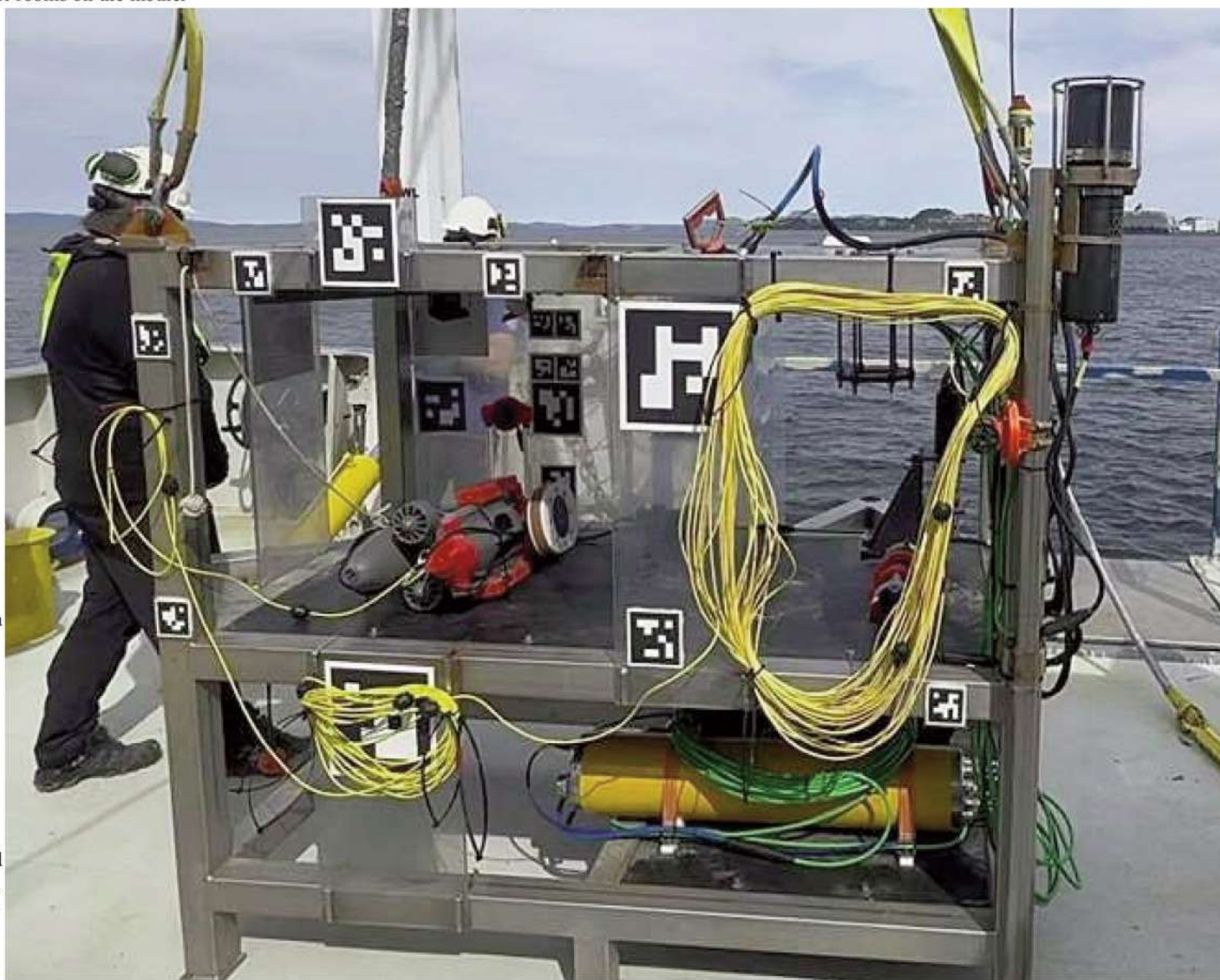
challenges is making the robot fully autonomous, meaning it is able to "understand" and "think" in such a way that it can make its own decisions based on observations of its surroundings. The trials revealed that fish swimming past the camera caused problems for the software that interprets the images.

"We are working on that issue," said Günzel.

Still some way to go

Ludvigsen believes there is still some way to go before a commercial solution is in place, but he is optimistic.

"The tests showed that this solution works and that the operations are repeatable. Resident underwater vehicles are a scalable and cost-effective solution for underwater monitoring," Ludvigsen said. - TX



needed to achieve the goal of robust and reasonably priced solutions.

"The groundwork has been laid, and the first steps have been taken toward the development and deployment of full-scale autonomous underwater robots equipped with a docking station for charging and data transmission," said Ludvigsen.

The most important tasks are related to developing docking systems that are robust and durable. In addition, there are challenges that need to be addressed regarding autonomy, navigation, docking, communication, and maintaining position, heading and course underwater.

Blueye robot

The NTNU tests were conducted using a Blueye X3 underwater robot weighing approximately 10 kg (22 pounds) that was

To enable the robot to locate the docking station and position itself correctly, a combination of low-data-rate acoustic communication and navigation technologies was used, including Ultra Short Baseline (USBL) positioning and visual markers that were read and interpreted using cameras and machine vision to guide the AUV into the station.

Over short distances, it can also be controlled remotely and exchange data via an optical modem. The docking station is connected to land-based facilities via a cable for power and communication.

As soon as the AUV is docked, data can be transferred via high-frequency broadband communication, and the vehicle can be charged inductively. This type of equipment has already been developed in Nor-

Real-time 256-antenna network could pave way for future 6G systems

Researchers at the Faculty of Engineering (LTH) at Lund University in Sweden have developed one of the world's most advanced test environments for the wireless communications of the future.

Using the new test system, researchers have demonstrated for the first time that a distributed wireless network with 256 digitally beam-steered antennas can operate in real time. The breakthrough opens new opportunities to develop the technologies expected to be central to future 6G networks.

"We have demonstrated that the technology works using 256 antennas sited at different locations, where signals and data are managed in a coordinated manner in real time," says Dumitra Iancu, a doctoral student in integrated electronic systems at LTH.

The demand for new communication technology is growing rapidly. The number of internet users continues to

grow, while industrial digitalization, autonomous vehicles and new critical societal services are placing ever-greater demands on capacity, reliability and security. At the same time, the radio frequencies used to transmit wireless sig-

more efficient use of the existing spectrum for transmitting radio signals, which will enable more users and greater network capacity," says Ove Edfors, professor of radio systems at LTH.

16 programmable panels

has a modular design, which makes it possible both to add components and to deploy them in different settings.

"The setup is controlled by software, which makes it flexible and means that changes to the way data is

various technologies in practice is that it enables us to identify challenges and practical problems that might not be identified in theoretical studies. We have identified and resolved issues relating to signal synchronization and

to demonstrate that massive MIMO—the use of a very large number of antennas for wireless communication—could work in practice. This technology is now a fundamental part of 5G networks.

"Unlike other massive MIMO test beds, LuLIS distributes both antennas and computations across a number of panels, with data processed in real time, reflecting real-world requirements," says Vilgot Snygg, a doctoral student in integrated electronic systems.

Ten years after its launch, LuLIS' predecessor, LuMaMi (Lund University Massive MIMO test bed), still holds the world record for spectral efficiency, achieved in collaboration with the University of Bristol. LuMaMi enabled researchers to distinguish among 22 simultaneous users within the same frequency band.

"With the new setup, we'll be able to accommodate 32 users in the near future. Our aim is to beat the 2016 record tenfold by upscaling the test bed in the future," says Edfors. ■



nals are a limited resource that must be used more efficiently. Resolving that issue is an important step toward the wireless networks of the future.

"We can use the test bed to investigate how to make

The Lund University Large Intelligent Surface (LuLIS) consists of 16 programmable panels, each with 16 antennas, and is based on specialized hardware from AMD. In terms of size, it is in a class of its own. The system

transmitted, for example, can be made more easily than if we had to replace the hardware," says Lina Tinnerberg, a doctoral student in integrated electronic systems.

"An important aspect of building and demonstrating

the distribution of computations," says Liang Liu, professor of integrated electronic systems.

Still holds the world record

The research team at LTH was also the first in the world

Team uses 3D printing to develop zinc-ion hybrid battery with seven times more energy

Storing solar and wind energy to meet the increasing power needs of the electrical grid calls for devices that can deliver power quickly, recharge quickly and last for decades at low cost.

A new study led by UCLA has uncovered a technology that could meet all these criteria: a zinc-ion hybrid battery with a 3D-printed electrode that stores more than seven times the charge of similar hybrids.

Energy storage based on zinc instead of lithium would be cheaper and more sustainable because zinc is 100 times more abundant, easier to mine and easier to recycle.

"The future of energy storage won't be defined by a single technology," said co-corresponding author Maher El-Kady, an assistant researcher in UCLA College's chemistry and biochemistry department. "At some point, we will need to look for something to complement the current options for grid-scale energy storage. What we've done in this study essentially gives us zinc-ion hybrid devices that can store nearly one order of magnitude higher capacity."

The study, published in the journal *Small*, includes a second advance enabled by 3D printing. The researchers designed a test cell for energy storage that improves on the most common setup used in labs like theirs to quantify the performance of experimental

devices.

A lot of charge out of a little terminal

The device in the study is a hybrid technology. One terminal works like the energy-storing part of a traditional lithium-ion battery. The other terminal uses a carbon electrode similar to those in the supercapacitor, a mode of

density in two ways: increasing the surface area of their carbon electrode and packing it with vanadium oxide, a material that stores a lot of energy.

The electrode was designed to look like a honeycomb or sponge, with tiny cavities throughout. It was built using a 3D printing tech-

area expanded so much that if you took a single gram and flattened it out like a piece of paper, it would cover about 10 tennis courts.

"The method we used lets us build any 3D scaffold, layer by layer, and control its microstructure," said co-corresponding author Ric Kaner, a UCLA distinguished professor

That means we can store a lot of charge."

In addition to storing more than seven times the charge of other capacitors, the team's device retained 82% of that capacity after 1,500 cycles of discharging and recharging.

A contribution to the battery research community

sticking with the beaker setup.

Unfortunately, there are two major drawbacks to that setup. The electrolyte solution will evaporate over time, causing experimental batteries to stop working before their natural lifespan. In addition, variations in electrode position can affect the measurements. This makes it harder to accurately quantify performance and reproduce results.

In the study, the researchers introduced a design for a 3D-printed test cell with a sealed top to prevent chemical evaporation. Their setup also included slots for holding electrodes a fixed distance apart.

"It's a concept that we hope can be useful to other researchers in the field by helping them obtain more consistent measurements and reliable data for their devices," said first author Sophia Uemura, who recently earned her Ph.D. from UCLA. "One of the exciting things about 3D printing is how accessible it has become. In this case, anyone with access to a 3D printer will be able to make a test cell like ours and adapt it for their own work."

Compared with an open beaker setup, the researchers showed that their printed cell resulted in more consistent measurements of capacitance and resistance. After 1,500 cycles with the test cell, standardized carbon electrodes retained 98% of their charge, whereas those tested in a conventional open-cell setup failed in fewer than 100 cycles. - TX



energy storage that holds far less energy but discharges quickly, charges quickly and is expected to last for decades.

Supercapacitors face storage limitations because energy can only be held on the surface of their electrodes. The UCLA-led team achieved a dramatic increase in energy

nique involving a liquid resin that solidifies instantly when exposed to UV laser light. The investigators put the electrode through a heating and gassing process that left only conductive carbon with open holes. They then used a chemical process to load that structure with vanadium oxide.

The component's surface

of chemistry and biochemistry and of materials science and engineering, holder of the Dr. Myung Ki Hong Endowed Chair in Materials Innovation, and a member of the California NanoSystems Institute at UCLA. "We can actually have billions and billions of these tiny holes, producing an enormous internal surface area.

The current method for testing energy storage technologies in research labs is fairly rudimentary, with an electrolyte solution and two electrodes in an open beaker. While there are premade glass test cells, they cost \$1,000 and up, motivating research teams to make the most of scant funding by