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New Deep-Sea Ports in Pakistan: Expert panel accelerates work on detailed feasibility study

Pakistan has formally initiated groundwork for the development of three to four new deep-sea ports along its extensive coastline, as a high-level, multi-agency committee begins preparing a comprehensive feasibility framework to guide the country's maritime expansion over the next century.

The move comes amid projections of rapid economic growth, rising regional transit trade, and mounting pressure on existing port infrastructure, prompting policymakers to rethink Pakistan's long-term maritime strategy.

Chaired by Federal Minister Junaid Chaudhry, the multi-agency committee has already commenced work on a detailed feasibility report incorporating technical assessments, hydrographic surveys, satellite imagery, environmental evaluations, and investment models, which will be submitted to the Ministry of Maritime Affairs.

Strategic Need for New Ports

Addressing the committee, the minister underscored that Pakistan's future economic trajectory will depend heavily on its maritime capacity. With industrial activity expanding, shipping volumes rising, and Pakistan increasingly positioned as a regional transit hub, existing ports are expected to reach saturation in the coming decades.

"Developing new deep-sea ports is no longer optional—it is essential," the minister said, stressing that Pakistan must prepare today for the maritime demands of the next hundred years. He highlighted the importance of complementing major ports with smaller, business-model ports to ease congestion, diversify cargo handling, and support regional economic clusters.

The approach reflects a broader shift toward distributed maritime infrastructure, rather than over-reliance on a limited number of mega ports.

Multi-Agency Technical Framework

The meeting brought together representatives from ten key organizations, including the Port Qasim Authority (PQA), Karachi Port Trust (KPT), Gwadar Port Authority (GPA), the Ministry of Maritime Affairs, the Special Investment Facilitation Council (SIFC), the Surveyor General of Pakistan, the Hydrographer of Pakistan, and the governments of Sindh and Balochistan.

Participants briefed the minister on the committee's methodology, performance milestones, and site identification criteria. A structured assessment framework has been developed for three potential sites—referred to as Port 1, Port 2, and Port 3—with evaluations focused primarily on technical feasibility.

Key technical parameters include natural depth, marine access, tidal patterns, sediment movement, and coastal stability, all of which determine operational efficiency and long-term viability. These factors are critical in minimizing dredging requirements and ensuring cost-effective port operations.

Environmental and Social Considerations

Beyond technical feasibility, the committee is giving equal weight to environmental sensitivity and social impact. Land availability and future expansion potential are being assessed alongside ecological considerations such as the presence of mangroves, protected coastal ecosystems, and fishing communities.

Officials emphasized that new ports must be developed in a responsible and sustainable manner, balancing economic growth with environmental protection and community livelihoods. Environmental risks, climate resilience, and regulatory compliance form a core component of the feasibility framework.

Connectivity and Economic Value

The committee is also examining hinterland connectivity, including road, rail, and logistics corridors, to ensure that new ports are integrated into national and regional supply chains. This includes assessing linkages to industrial zones, energy infrastructure, and trade routes

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Pakistan, ADB sign two major climate resilience initiatives one each for Sindh, Punjab

The Government of Pakistan and the Asian Development Bank (ADB) signed two major climate resilience initiatives in Pakistan.

One focuses on the Sindh and is called the Sindh Coastal Resilience Sector Project (SCRP), amounting to USD 180.5 million, and the other on Punjab, named the Punjab Climate Resilient and Low Carbon Agriculture Mechanization Project, amounting to USD 124 million.

Muhammad Humair Karim, Secretary, Ministry of Economic Affairs, expressed his sincere appreciation for ADB's role as a trusted development partner and its continued support to Pakistan in advancing climate resilience, sustainable agriculture, and inclusive growth, said an official communication to the media.

He highlighted that the Sindh Coastal Resilience Project will promote integrated water resources and flood risk management, restore nature-based coastal defenses, and strengthen institutional and community capacity for strategic action planning.

The project, financed through USD 140.5 million from ADB (including USD 140 Million Loan and USD 0.5 million technical assistance grant), USD 40 million from the Green Climate Fund, and USD 20 million as counterpart funding from the Government of Sindh, will directly benefit over 3.8 million people in Thatta, Sujawal, and Badin districts.

The Punjab Climate Resilient and Low Carbon Agriculture Mechanization Project will enhance agricultural productivity and climate resilience across 30 districts of Punjab.

The project amounting to USD 129 Million, financed through USD 120 million ADB Loan, USD 4 million ADB grant, and USD 5 million as counterpart funding from the Government of Punjab, will improve access of small farmers to climate-smart machinery, introduce circular agriculture practices to reduce residue burning, establish testing and training facilities, and empower 15,000 women through skills development and livelihood diversification.

Both the initiatives, as the secretary emphasized, are transformative in nature as the Sindh Coastal Resilience Project will safeguard livelihoods, food security, and biodiversity along Sindh's vulnerable coastal belt, whereas the Punjab Mechanization Project will drive sustainable, low-carbon agricultural growth and inclusive development.

Ms. Emma Fan, Country Director, ADB, expressed appreciation for the Government of Pakistan's strong commitment to these initiatives. She emphasized the significance of the Sindh Coastal Resilience Project in addressing climate-induced risks and protecting coastal communities, and highlighted the Punjab Mechanization Project as a critical step in modernizing agriculture and reducing emissions.

Both sides expressed their commitment to effectively utilize the financing for the successful and timely completion of the two initiatives. - ERMD

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GAED, MMG Engineering Partner to Advance Carbon Credit Recording, Climate Solutions

GAED (An affiliate company of Enercon Asia) and MMG Engineering have signed a strategic partnership agreement to collaborate on carbon credit recording and sustainability-driven initiatives in Pakistan, supporting the country's transition toward a low-carbon and climate-resilient future.

As part of this collaboration, GAED (GAED Keeper), through its energy intelligence platform, helps with carbon credit monetization, energy efficiency solutions, comprehensive energy audits, and data-driven energy advisories.

The combined strengths of Enercon Asia, MMG Engineering, and GAED will enable a holistic approach to sustainability—linking real-time Energy Intelligence, Engineering expertise, and structured carbon credit frameworks.

Joint teams will facilitate carbon credit identification, monitoring, reporting, and verification (MRV) aligned with international standards.

Pakistan offers substantial potential for carbon credit generation and energy optimization, particularly across:

* Clean and renewable energy generation
* Biomass and bio-waste power plants
* Energy efficiency and demand-side management
* Industrial decarbonization and optimization
* Waste-to-energy and sustainable infrastructure projects

The partnership will help Project owners and industrial clients reduce Energy consumption, lower emissions, improve operational efficiency, and unlock additional value through carbon markets.

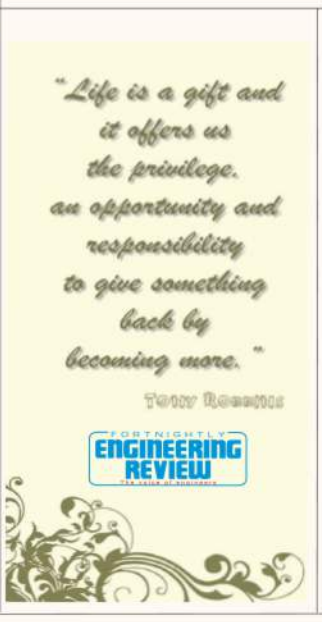
About GAED (GAED Keeper)

GAED - Energy intelligence and analytics platform, an affiliate company of Enercon group offering fast, data-driven energy efficiency solutions, comprehensive energy audits, and strategic energy advisories to help organizations optimize performance, reduce emissions, and achieve sustainability targets.

About MMG Engineering

MMG Engineering is a multidisciplinary engineering firm providing Energy consulting, project development, Energy Audit, and other technical services, supporting infrastructure, Energy, and industrial sectors with a focus on sustainable and innovative solutions.■

Bijli Ghar



Engineering Bazar

TEP Calls for Incubation Centers, Reforms in PEC to Support Young Engineers

A joint sitting of the Core Committee and the Executive Council of The Engineers Pakistan (TEP) was held in Lahore under the chairmanship of TEP Chairman Engr. Jawed Salim Qureshi.

The meeting focused on pressing issues faced by engineers, the engineering industry, and matters related to the Pakistan Engineering Council (PEC).

Following detailed deliberations, the forum decided to take up key challenges confronting engineers, particularly young professionals.

According to a statement issued on TEP's official Facebook account, the meeting called for the immediate establishment of incubation centers and startup facilities in all major cities of Pakistan at PEC buildings. The initiative aims to promote entrepreneurship among young engineers, with participants emphasizing that engineers should be job creators rather than job seekers.

Referring to the PEC Graduate Engineers Training (GET) program, the meeting demanded that any alleged manipulation of computer-based transparency in the program be stopped immediately. It further called for the formation of a dedicated committee at PEC, under the chairmanship of the Senior Vice Chairman (SVC), with representation from vice chairmen of all provinces, to oversee and address all matters related to the GET program.

The moot also demanded the immediate approval of reserved seats for young male and female engineers to ensure their representation in the Pakistan Engineering Council.

Other key demands included:

- Immediate approval of the Engineers Service Structure Bill, currently pending in the National Assembly, to strengthen Pakistan's engineering capacity.
- Approval of technical allowances for engineers across all departments to bring salary parity with non-technical cadres.
- Immediate implementation of the unanimous recommendations of the committee chaired by the Senior Vice Chairman concerning the Registrar of PEC.

The meeting underscored the need for concrete and timely measures to support the professional growth, career development, and representation of young engineers across the country.

– ER News Desk

Supernet Rebranded as "Supernet Global" to Expand Int'l Footprint

Supernet Limited has approved a strategic rebranding initiative under the name "Supernet Global", signalling its intention to selectively expand into high-growth international digital markets, the company informed the Pakistan Stock Exchange (PSX) on Tuesday.

In a disclosure made in accordance with Section 96 of the Securities Act, 2015 and Clause 5.6.1(a) of the PSX Rule Book, the company said the move aligns with its long-term strategy to participate in the international information and communication technology (ICT) and digital services arena.

Under the Supernet Global identity, the company plans to expand operations across the Middle East, Africa and Central Asia, exporting Pakistan-origin digital, ICT and managed services expertise to global customers while contributing to the country's IT and services exports.

The Board noted sustained growth in ICT spending across the Middle East and Africa, driven by government-led digitalisation initiatives, rising cybersecurity investments, increased cloud adoption and enterprise modernisation. It also highlighted strong medium- to long-term growth prospects in the global satellite communications sector, one of Supernet's core areas of expertise.

Founded in 1995, Supernet has nearly three decades of experience in delivering mission-critical ICT services, satellite connectivity and managed services to clients in the banking, energy, telecom, government and large enterprise segments.

As part of its international expansion strategy, Dubai will serve as the company's first regional hub, leveraging its UAE-based subsidiary, Phoenix Global FZE, which has been operational since 2018. While Supernet Global will cater to enterprise, carrier and institutional customers across multiple regions, its technical delivery, engineering and managed services functions will continue to be anchored in Pakistan.

The company's international service portfolio will include cybersecurity services, cloud and data solutions, managed ICT services, smart and Internet of Things (IoT) platforms, enterprise connectivity through local partnerships, and satellite-based connectivity solutions. Satellite services will remain a cornerstone of the company's global strategy, enabling scalable cross-border service delivery across multiple industry verticals.

– ER News Desk

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DG Khan Cement LC for Largest Ever Single Clinker Line

DG Khan Cement Company Limited (DGKC) has established a Letter of Credit (LC) for the installation of Pakistan's largest single clinker production line with a capacity of 11,000 tons per day, the company disclosed in a notice to the Pakistan Stock Exchange (PSX).

According to the disclosure of material information, the new clinker line will be set up on a brownfield basis at Mauza Khofi Sattai, Dera Ghazi Khan, marking a significant expansion in the company's production footprint. The project is aimed at enhancing operational efficiency and strengthening the company's long-term competitiveness in the cement sector.

DG Khan Cement stated that the disclosure has been made in compliance with the PSX Rule Book and the Securities Act, 2015, and that a detailed disclosure form has been submitted to the exchange.

Industry analysts view the move as a strategic step that reflects renewed confidence in Pakistan's cement demand outlook, particularly driven by infrastructure development and anticipated recovery in construction activity.

Company Profile: DG Khan Cement Company Limited

DG Khan Cement Company Limited is one of Pakistan's leading cement manufacturers, with a strong presence in both the north and south regions of the country. The company is part of the Nishat Group, one of Pakistan's largest and most diversified business conglomerates.

DGKC operates multiple cement plants equipped with modern dry-process technology and has consistently focused on efficiency, cost optimization, and sustainability. Over the years, the company has invested in waste heat recovery systems (WHRS), energy-efficient operations, and alternative fuels to reduce its carbon footprint and energy costs.

In addition to catering to domestic demand, DG Khan Cement also serves export markets, depending on regional demand dynamics and pricing conditions.

Performance Overview

DG Khan Cement's performance in recent years has been shaped by fluctuating construction activity, energy cost pressures, and macroeconomic challenges. However, the company has maintained operational resilience through prudent cost management and efficiency improvements.

Key performance highlights include:

Stable production base supported by geographically diversified plants

Focus on energy efficiency, including WHRS and optimized fuel mix

Improved margins during periods of lower coal prices

Strong balance sheet backing due to association with a leading business group

The establishment of the LC for a large-scale clinker line signals DGKC's long-term growth strategy, positioning the company to benefit from future demand recovery while leveraging economies of scale.

Market observers note that once commissioned, the new line is expected to enhance capacity utilization, reduce per-unit production costs, and strengthen the company's competitive standing in Pakistan's cement industry. ■

Four Brothers, Telenor Partner to Offer Free Crop R&D Services

Four Brothers Group Pakistan and Telenor Pakistan have signed a Memorandum of Understanding (MoU) to jointly provide free Crop Research and Development (R&D) services to farmers across Pakistan, marking a major step toward digital transformation of the agriculture sector as 2025 draws to a close.

Under the agreement, the two organizations will collaborate to strengthen digital connectivity and promote innovation in agriculture by leveraging Telenor Pakistan's digital platforms and outreach to over 16 million farmer customers nationwide, alongside Four Brothers Group's expertise in agricultural research, development, and advisory services.

The strategic partnership is aimed at empowering farmers through technology-driven solutions, enabling better crop management, improved productivity, and informed decision-making. By integrating digital tools with advanced agricultural R&D, the initiative seeks to support farmers in adopting modern, data-driven farming practices.

Officials said the collaboration would contribute to the development of a smart and sustainable agri-ecosystem, helping farmers respond more effectively to challenges such as climate variability, input optimization, and market access.

The initiative is expected to enhance agricultural productivity, promote sustainable farming methods, and improve livelihoods in rural communities. Both organizations reiterated their commitment to supporting Pakistan's agriculture sector by making innovation accessible to farmers at no cost, reinforcing the role of technology as a catalyst for inclusive growth.

About Four Brothers Group PakistanFour Brothers Group is one of Pakistan's leading agriculture-focused conglomerates, with operations spanning crop sciences, seeds, fertilizers, agri-services, and research and development. The group is widely recognized for its work in improving farm productivity through modern inputs, advisory services, and farmer outreach programs across Punjab, Sindh, and other agricultural regions of the country.About Telenor PakistanTelenor Pakistan is a leading telecommunications and digital services provider, serving millions of customers nationwide, including a large base of farmers through digital agriculture and connectivity platforms. The company plays a key role in expanding mobile connectivity, data services, and digital inclusion, supporting innovation in sectors such as agriculture, finance, and e-services. - **ER**

HVACR Trends 5.0: Smart Decarbonization as Pakistan's Built-Environment Imperative

HVACR Trends 5.0, held at the Marriott Hotel Karachi, marked a significant evolution in Pakistan's HVACR discourse — shifting the conversation from isolated energy efficiency measures toward Smart Decarbonization as a system-level transformation of the built environment.

With the theme "Smart Decarbonization: Integrating AI, Innovation and Sustainability in Pakistan", the two-day technical conference brought together engineers, policymakers, academics, and industry leaders to examine how artificial intelligence, operational intelligence, and sustainable design can collectively address Pakistan's climate and energy challenges.

From Climate Reality to Engineering Responsibility

The conference opened with a keynote address by Mr. Farooq Mehboob, Presidential Member of ASHRAE, who framed decarbonization not as a future aspiration but as an urgent professional responsibility. Drawing on global climate data, population trends, and built-environment growth projections, the keynote highlighted that nearly 90% of carbon emissions from buildings originate from operational energy use, underscoring the central role of HVACR systems in climate mitigation.

The keynote further emphasized that while technology is essential, governance, workforce development, building performance standards, and public awareness are equally critical if decarbonization efforts are to succeed in emerging economies such as Pakistan.

A Structured Technical Dialogue

Day 1 of the conference focused on strategic pathways and global perspectives. Technical papers explored decarbonization frameworks, bio-based materials for healthier indoor environments, AI-enabled collaboration across building portfolios, and the transition from net-zero concepts toward measurable carbon reduction outcomes.

International experts and ASHRAE Distinguished Lecturers shared insights into how human expertise combined with artificial intelligence can optimize building performance at scale, moving beyond theoretical net-zero targets toward operational carbon accountability.

Day 2 shifted attention to applied intelligence, manufacturing decarbonization, and institutional capacity building. Presentations examined AI-based energy management systems, efficiency improvements in air-conditioning technologies, and decarbonization pathways for Pakistan's manufacturing sector — a critical contributor to national emissions.

Academic contributions highlighted the role of research institutions in developing indigenous solutions, while policy-oriented sessions emphasized alignment with national SDG commitments and climate strategies.

Integrating Technology, Policy, and Practice

A dedicated panel discussion on "How AI and Innovation Can Enable Smart Decarbonization in Pakistan" brought together experts from engineering, academia, and industry to address implementation barriers. Panelists emphasized that data transparency, skill development, and enforceable building performance metrics are essential to translate innovation into real-world impact.

The conference also featured a Product Display Exhibition, where leading HVACR companies showcased technologies aligned with energy efficiency, intelligent controls, and low-carbon system design. This practical dimension reinforced the conference's focus on deployable solutions rather than conceptual discussions.

Reframing Sustainability for Pakistan

HVACR Trends 5.0 distinguished itself by grounding sustainability in Pakistan's climatic, economic, and institutional realities. Discussions repeatedly emphasized that while global decarbonization frameworks provide direction, local adaptation — informed by passive design principles, operational efficiency, and regional construction practices — is indispensable.

Speakers also highlighted historical examples of climate-responsive architecture in South Asia, reinforcing that sustainability is not a new concept, but one that must now be re-enabled through modern engineering tools and digital intelligence.

A Platform, Not Just an Event

More than a technical conference, HVACR Trends 5.0 positioned itself as a continuing knowledge platform — linking professional engineering practice, policy dialogue, academic research, and industrial innovation. By integrating AI, sustainability, and decarbonization into a single narrative, the event reflected a growing recognition that HVACR professionals will play a decisive role in shaping Pakistan's low-carbon future.

As Pakistan confronts rising cooling demand, water stress, and climate vulnerability, forums such as HVACR Trends 5.0 serve as critical spaces for informed, evidence-based dialogue — turning global climate objectives into actionable engineering solutions. - PR

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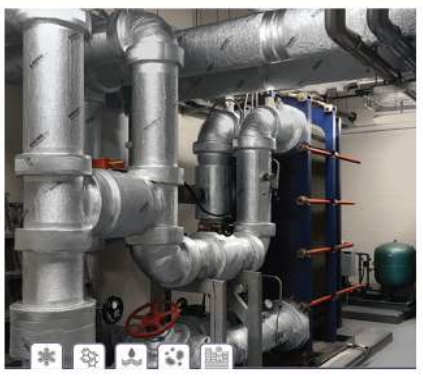

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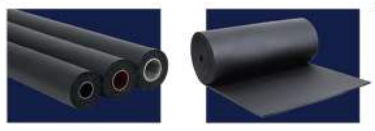

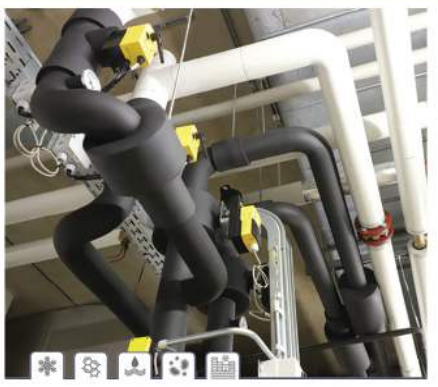

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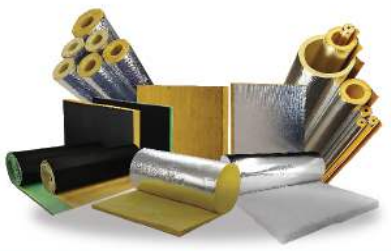

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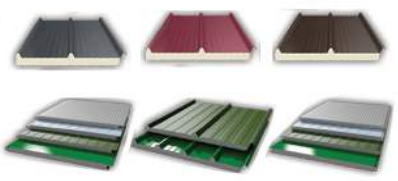

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Agriculture Review

Punjab and Balochistan Turn to Hydroponics for Year-Round Vegetable Supply and Water-Smart Farming

In a major shift towards modern and climate-resilient agriculture, the governments of Punjab and Balochistan have initiated plans to introduce and promote hydroponics technology, ensuring year-round vegetable production, improving food security, and addressing water scarcity challenges.

In Punjab, the reports said, the provincial government has intensified efforts to promote modern farming technologies to ensure an uninterrupted supply of vegetables, particularly tomatoes, throughout the year. The Punjab Agriculture Department has reportedly sought expert recommendations to introduce hydroponic farming as a viable solution for extending the tomato production season, especially during off-season periods.

Relevant formations of the department have been tasked with identifying suitable locations across the province for off-season tomato cultivation. The government also plans to organise training workshops in various districts to encourage farmers to adopt hydroponic methods. In addition, technical support will be provided for installing small-scale hydroponic systems on household rooftops, promoting urban agriculture.

The agriculture department officials said, the program was finalized during a special strategy meeting attended by Parliamentary Secretary for Agriculture Osama Khan Laghari, Secretary Agriculture Punjab Iftikhar Ali Sahoo, senior officials, and agricultural experts. The moot focused on expanding vegetable production through modern technology to stabilize prices and improve availability.

The experts have been asked to submit proposals for rooftop hydroponic systems to promote urban farming. The increasing off-season vegetable production would help ensure affordability for consumers while strengthening market stability and food security.

Moreover, Secretary Agriculture, Punjab, Iftikhar Ali Sahoo has reportedly directed experts from Barani Agricultural University, Rawalpindi, to present practical and cost-effective proposals for small-scale hydroponic structures. He also sought recommendations for low-cost models that could be easily adopted by farmers and households. The initiative is expected to modernise vegetable production, enhance farmers' incomes, and ensure a steady supply of tomatoes throughout the year.

Meanwhile, the Balochistan government has approved the introduction of hydroponics technology across the province to modernize agriculture and tackle acute water shortages. The decision was taken during a meeting of the Parliamentary Committee on the Public Sector Development Program (PSDP), chaired by Chief Minister Mir Sarfraz Bugti at the Chief Minister's Secretariat.

The committee approved a flagship project to establish hydroponic facilities and promote high-value horticulture, recognizing hydroponics as an ideal farming system for Balochistan's arid climate due to its low water consumption and high productivity. The pilot phase will be launched in ten districts, with plans for province-wide expansion upon successful implementation.

Chief Minister Sarfraz Bugti emphasized that "high yield with less water is the fundamental requirement of modern agriculture," adding that hydroponics would play a key role in achieving food security, employment generation, and sustainable economic growth in the province.

A report said the initiative aligns with global findings highlighted in a report presented by the Ellen MacArthur Foundation at the World Economic Forum (WEF) Annual Meeting in Davos. The report warns that while industrial farming has increased food availability, it has also intensified environmental stress and resource depletion. With cities projected to consume nearly 80 percent of global food by 2050, technologies such as hydroponics and vertical farming are increasingly viewed as critical solutions.

What Is Hydroponics Technology?

Hydroponics is a modern method of agriculture in which plants are grown without soil. Instead, plant roots are placed in inert media such as rockwool, vermiculite, or clay pellets and supplied with nutrient-rich water. This allows precise control over water usage, nutrients, temperature, and pests, resulting in faster plant growth and higher yields.

Hydroponics can use up to 70–90 percent less water than traditional farming, making it especially suitable for water-stressed regions like Balochistan. It also reduces the need for pesticides and chemical fertilizers, lowers waste, and improves overall resource efficiency.

Hydroponics vs Traditional Farming

Unlike traditional farming, which relies heavily on soil quality, weather, and large land areas, hydroponics can be practiced indoors, on rooftops, or through vertical structures. Crops grow faster, yields are more consistent, and production is less affected by climate variability. Traditional farming, by contrast, is highly seasonal and dependent on rainfall and soil conditions.

Cost of Hydroponics Systems

While hydroponics offers long-term benefits, its initial capital cost is higher than conventional farming. Small-scale rooftop or household hydroponic systems in Pakistan can cost between Rs 150,000 to Rs 500,000, depending on size, automation level, and materials used. Medium-scale commercial units may require an investment ranging from Rs 1 million to Rs 5 million, while fully automated greenhouse-based systems can cost significantly more.

However, experts note that operating costs are lower due to reduced water use, minimal pesticide requirements, and higher productivity. With faster crop cycles and premium-quality produce, farmers can recover their investment within a few years, particularly for high-value crops like tomatoes, lettuce, herbs, and strawberries.

By promoting hydroponics, both Punjab and Balochistan are positioning themselves toward sustainable, technology-driven agriculture—one that conserves water, stabilises food supply, enhances farmer incomes, and aligns Pakistan with global best practices in climate-smart farming. – ER News Desk

The Spatio Marks 13 Years of Excellence, Honors Top Performers

The Spatio, Engineering & GeoSpatial Consultants, celebrated its 13th anniversary with a memorable annual lunch, bringing together the entire organization for a day of reflection and appreciation.

The event was attended by office and field teams, distinguished guests, and employees' families, making it a truly inclusive celebration of the company's journey and achievements.

A key highlight of the occasion was the presentation of the Yearly Performance Awards, recognizing exceptional dedication and leadership across the organization. Awards presented included Emerging Professionals of the Year, Best Project Manager, Best Team Lead, and Employee of the Year, honoring individuals whose commitment and performance have contributed significantly to the company's continued success.

The management expressed gratitude to all team members for their hard work and loyalty, reaffirming its commitment to fostering a culture of excellence, collaboration, and professional growth. The celebration concluded on a positive note, looking ahead to new milestones and sustained progress.

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In addition, the company provides customized solutions tailored to the specific requirements of its clients, ensuring accuracy, efficiency, and value-driven outcomes in every project. – ER

Thatta Cement Approves 7.5MW Wind Power Project

Thatta Cement Company Limited has approved the development of an additional 7.5 megawatt (MW) wind power project, following the successful completion and commissioning of its 4.8MW wind energy facility, the company informed the Pakistan Stock Exchange (PSX) on Tuesday.

In its disclosure made under Clause 5.6.1 of the PSX Regulations, the company said that the decision was approved by its Board of Directors as part of its ongoing strategy to expand the use of renewable energy.

Upon completion of the new project, Thatta Cement's total installed renewable energy capacity will rise to 17.3MW, comprising two wind power projects of 4.8MW and 7.5MW, along with an existing 5MW solar power installation.

The company stated that the expansion would significantly increase the share of renewable energy in its overall energy mix, reinforcing its commitment to sustainable and environmentally responsible operations.

ER Report

New Deep-Sea Ports

Contd from page 1

Asia, the Gulf, and East Africa.

Economic and strategic value assessments cover trade facilitation potential, regional development impact, and redundancy within Pakistan's port network. Risks and constraints—spanning environmental, technical, security, and regulatory domains—are being identified early to guide informed decision-making.

Preparing for Capacity Constraints

Pakistan's coastline stretches over 1,000 kilometers, from Sir Creek in Sindh to Jiwani in Balochistan, encompassing an Exclusive Economic Zone (EEZ) of approximately 240,000 square kilometers and a continental shelf of nearly 50,000 square kilometers. Despite this vast maritime geography, the country currently relies on just three major ports: Karachi Port, Port Qasim, and Gwadar.

According to ministry officials, Pakistan's GDP is projected to reach $1 trillion between 2030 and 2035, a milestone that will significantly increase maritime trade volumes. Projections suggest that all three existing ports could reach full operational capacity between 2035 and 2045, driven by expanding CPEC-linked transit trade, cargo flows from Afghanistan and Central Asia, and potential trans-shipment traffic from the Gulf and East Africa.

Compounding the challenge is rapid coastal urbanisation, tourism development, and the expansion of private housing societies along the seafront, particularly near Karachi Port and Port Qasim, which is shrinking the availability of suitable land for future port infrastructure.

Hundred Years Vision

To address these constraints, the Ministry of Maritime Affairs has articulated a "Hundred Years Vision (2047–2147)", aimed at establishing three to four new deep-sea ports equipped with modern cargo-handling facilities, green energy integration, and digital port management systems.

The committee's mandate includes collecting and reviewing empirical studies, hydrographic surveys, and satellite data to shortlist viable locations—not only for ports, but also for port cities, shipyards, and energy hubs. It will propose indicative layouts, phased development roadmaps, and investment structures, while also developing a national framework to prioritise future port projects.

Officials caution, however, that close coordination with provincial governments and federal agencies will be essential to ensure a unified national approach to maritime expansion and coastal management.

As Pakistan looks seaward for its next phase of economic transformation, the work of this committee could define the country's maritime landscape for generations to come. -

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Engineering Review

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Sustainability as a Competitive Advantage in Technology Startups

Engr. Dr. Muhammad Nawaz Iqbal

Sustainability has moved from the periphery of corporate responsibility to the mainstream of technology startups, and it no longer serves solely as an ethical position but as a powerful competitive force.

For young ventures, sustainability can constitute the core business logic, affecting product design, resource consumption, and market positioning from the outset. In contrast to more established companies that need to retrofit sustainability practices, startups can embed environmental and social practices into their DNA, allowing them to be nimble, authentic, and strategically focused on the long term.

Sustainable technology startups tend to be more easily trusted and accepted at early stages in mass markets. Stakeholders are increasingly becoming more critical of the values behind digital products and platforms in an era of heightened consumer awareness. By starting with a high level of transparency in responsible sourcing, energy efficiency, and data ethics, startups can distinguish themselves beyond functionality and form emotional, value-based relationships that even long-established competitors find difficult to replicate.

Sustainability also acts as an innovation driver in technology startups. Constraints related to energy consumption, waste minimization, or social inclusion often compel founders to rethink traditional technological solutions. This creativity under constraint can lead to breakthrough solutions such as energy-efficient algorithms, low-bandwidth applications for underserved areas, or circular hardware architectures that reduce electronic waste while creating new revenue streams.

In the eyes of investors, sustainability has emerged as an indicator of resilience and viability. Venture capitalists and impact investors are increasingly evaluating startups through environmental, social, and governance (ESG) lenses, having realized that sustainable operations minimize regulatory, operational, and reputational risks. Companies that can present a credible sustainability narrative supported by sound financial modeling are more likely to attract patient capital and acquisition interest.

Another area where sustainability translates directly into competitive advantage is operational efficiency. Technology startups can significantly reduce operating costs through optimized energy consumption, reduced resource waste, cloud optimization, and green computing solutions. Such efficiencies are particularly valuable during early stages, when budgets are tight and margins for error are small, enabling sustainable startups to scale faster than less conscious counterparts.

Sustainability also enhances talent acquisition and retention. Increasingly, skilled technology professionals seek meaningful work environments aligned with their personal values. By embedding sustainability into their mission and workplace culture, startups are better positioned to attract motivated, innovative, and loyal talent, boosting productivity and reducing turnover in an industry where human capital is a critical asset.

Startups driven by sustainability are also better prepared for regulatory and policy changes. As governments worldwide strengthen environmental and data protection laws, startups that operate responsibly and sustainably face fewer compliance shocks. This preparedness allows them to focus on innovation and growth rather than reactive adjustments, giving them a time-to-market advantage.

Perceived responsibility and transparency are becoming central to customer loyalty in the digital economy. Technology startups that integrate sustainability into user experiences—such as carbon tracking, ethical AI, or privacy-by-design features—build long-term customer trust. These trust-based relationships are difficult to replicate and can lower customer acquisition costs while increasing lifetime value.

Sustainability also supports scalability in global markets. Companies with inclusive and environmentally sensitive business models are better equipped to enter diverse cultural and regulatory environments. By engineering technologies that respect local ecosystems and social norms, sustainable startups can achieve smoother international expansion and avoid backlash often associated with disruptive technologies.

Sustainability plays a particularly important role during brand formation, especially for technology startups. A strong sustainability-focused brand serves as an intangible asset in digital markets where products are easily replicated. Such brands signal responsibility, future readiness, and credibility, enabling startups to command premium positioning even when competing with larger, better-capitalized players.

Data ethics and responsible artificial intelligence are increasingly integral to technological sustainability. Startups that prioritize fairness, transparency, and accountability in algorithm design gain credibility in low-trust industries. This ethical differentiation not only mitigates legal and social risks but also attracts enterprise clients and government institutions seeking responsible technology partners.

Sustainability also strengthens partnership ecosystems. Corporations, governments, and non-profit organizations pursuing shared-value initiatives are more inclined to collaborate with startups that demonstrate strong sustainability credentials. These partnerships can facilitate faster market entry, enhance legitimacy, and provide access to pilot projects otherwise unavailable to early-stage firms.

Moreover, sustainability-driven startups are better equipped to withstand uncertainty and systemic shocks. Organizations grounded in sustainable practices demonstrate greater resilience to supply chain disruptions, energy crises, and societal pushback against technology. Strong stakeholder relationships and efficient resource use help cushion volatility.

Ultimately, sustainability enables startups to shift from

short-term opportunism to long-term value creation in technology-driven markets. When innovation aligns with societal and environmental needs, startups move beyond transactional growth to build enduring solutions and ecosystems. This strategic alignment enhances both competitiveness and relevance in a rapidly evolving technological landscape.

Sustainability positions technology startups not merely as disruptors but as responsible architects of the future. As digital technologies increasingly shape economies and societies, startups that treat sustainability as a strategic asset rather than an afterthought will set new competitive benchmarks. In doing so, they demonstrate that technological advancement and sustainable development are not opposing forces but complementary drivers of competitive advantage.■

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Punjab, Sindh Report Satisfactory Wheat Sowing

Punjab and Sindh have reported satisfactory progress in wheat sowing for the Rabi 2025–26 season, with Punjab completing sowing on schedule and Sindh surpassing its assigned targets, officials said during the second meeting of the National Wheat Oversight Committee chaired by Federal Minister for National Food Security and Research Rana Tanveer Hussain.

Reviewing province-wise progress, the committee was informed that wheat sowing in Punjab had been completed in a timely manner, with around 90 percent of the crop sown early. Officials noted a marked increase in the use of certified wheat seed and higher application of urea fertilizer, attributed to improved availability and comparatively lower prices. These developments are expected to translate into improved yields and raise prospects of a bumper wheat crop in the province.

In Sindh, wheat sowing was described as satisfactory and ahead of set targets, reflecting effective planning and implementation at the provincial level. The positive progress in both provinces is seen as a key factor in ensuring overall national wheat output for the coming season.

During the meeting, provinces were advised to establish Provincial Implementation Units to ensure coordinated and effective implementation of the Integrated National Wheat Policy (INWP).

The committee also reviewed the wheat sowing situation in other regions. In Balochistan, sowing remains below target due to insufficient rainfall, though officials expressed optimism that the shortfall would be covered following expected rains. In Khyber Pakhtunkhwa, a substantial portion of sowing has been completed, while planting in snow-bound areas is naturally delayed. Overall, wheat sowing targets across the country are expected to be achieved. **-ER**

Sales Blog for Young Engineers and Entrepreneurs

An Ancient Story from Damascus

Muhammad Tariq Haq | www.eslpk.com

Long ago, when Damascus was a crossroads of caravans and kings, two great trading houses stood opposite each other near the eastern gate of the city.

Both dealt in grain, oil, and bread for the people of the city.

The House of Hakam the Swift

Hakam ibn Rashid, known as the Swift, ruled his house with sharp calculation.

He pressed farmers hard at harvest time, paying the lowest coin when their barns were empty and their children hungry.

He shortened weights, lengthened prices, and charged extra whenever scarcity appeared.

He paid his workers only what was required and dismissed them the moment the market slowed.

Hakam often said, "The market has no memory. Only the clever survive."

His coffers filled quickly, and he took pride in his cleverness.

The House of Samira the Steadfast

Across the street stood the house of Samira bint Khalid, called the Steadfast.

She paid farmers fairly, even when grain was plentiful and cheap.

When porters worked late unloading caravans, she fed them warm bread and paid them fully.

When a traveler arrived weary, she added a little extra oil or grain and said, "May your road be easy."

Some merchants mocked her, saying she gave away profit. Samira answered, "I give away fear."

The Test of the Famine

One year, the rains failed. The Barada River ran thin, and grain became scarce.

Hakam hurried to the countryside and bought what little grain remained at desperate prices. He stored it behind locked doors, waiting for hunger to raise its value.

Samira also went out, but she paid a just price and promised continued trade when the rains returned. Farmers remembered her words.

The Turning of Fortune

When the rains finally came, caravans returned to Damascus.

Farmers brought their best grain first to Samira's house. Other traders followed, trusting her scales and her word. Her storehouses stayed full, and her name spread through the markets.

Hakam found himself alone. Farmers avoided him, workers left when they could, and customers crossed the street to Samira's door.

Only then did Hakam understand: wealth gained without trust melts faster than snow in the sun.

Samira's house endured because she planted loyalty where others planted fear.

The Same Story in Pakistan's Diesel Generator Market:

The same pattern plays out in Pakistan's diesel generator market, ranging from 20 kVA standby units to 3,000 kVA industrial powerhouses, supplied by a mix of local assemblers and international brands.

This market is crowded, price-sensitive, and driven by outages, infrastructure gaps, and industrial demand. Many suppliers compete aggressively. Most behave like Hakam. Only few operate like Samira.

The Many Hakams of the Generator Market

Most suppliers pursue rapid sales and margin extraction.

They under-spec engines and alternators while marketing higher nameplate ratings.

They quote aggressively low prices, then cut corners on control panels, wiring, and acoustic treatment.

They oversell fuel efficiency and ignore site conditions, duty cycles, and load profiles.

They treat commissioning, warranty, and after-sales support as cost centers to be minimized.

Projects are won on price alone. Warehouses move quickly.

But over time, reality intrudes. Generators overheat. Fuel consumption exceeds promises. Spare parts are delayed. Clients face downtime, disputes, and unplanned costs.

These suppliers often say, "We delivered what was in the quotation."

The Samira of the Generator Market

Few suppliers stand apart.

They size generators honestly, whether the requirement is 20 kVA for a clinic or 3,000 kVA for an industrial plant. They specify engines, alternators, and control systems based on real operating conditions, not brochure numbers. They price transparently, including installation, testing, training, and lifecycle support. Invest in technicians, spare parts availability, and long-term service contracts.

Their bids are rarely the cheapest. Their growth is slower. But machines run when others fail, and clients return.

These suppliers say, "If it cannot run reliably for years, it is not sold correctly."

The outcome mirrors the old Damascus market.

Many Hakams vs The Few Samira

Sales Strategy: Win on lowest price vs Win on correct solution

Technical Integrity: Overstated ratings vs Honest sizing and specs

After-Sales Support: Minimal and reactive vs Proactive and continuous

Client Relationship: Transactional vs Long-term partnership

Long-Term Outcome

Disputes and replacements vs Loyalty and repeat business

The Hakams grow like sparks: brief, bright, and quickly extinguished.

Samiras grow like a foundation: unseen at first, but carrying the load for decades.

The Enduring Principle:

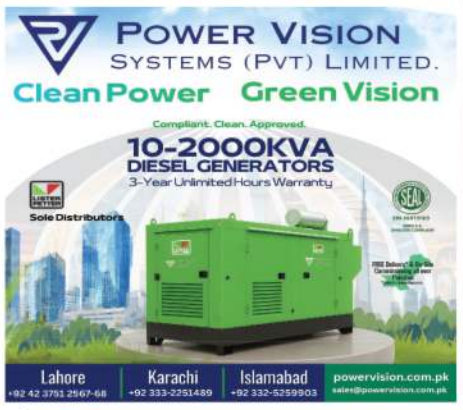
Buyers remember who stood by their equipment.

Operators remember who answered the phone at midnight.

Markets remember which machines kept running.

Profit taken by cutting corners fades quickly. Profit earned through reliability compounds.

The markets of Damascus taught this lesson long ago.■



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2025 کا اختتام، کراچی میں کوئی میگا منصوبہ مکمل نہیں کیا جا سکا

ان میں ایسے پراجیکٹ بھی شامل ہیں جو 8 سال قبل شروع کیے گئے، کچھ منصوبے آدھے مکمل اور کچھ پر ترقیاتی کام جاری

شہر میں پانی کے بحران پر قابو پانے کے لیے 2 میگا منصوبے 2016 میں شروع کیے گئے جو ابھی تک مکمل نہیں کیے جا سکے

سال 2025 کا بھی اختتام ہو گیا لیکن کراچی میں گزشتہ کئی سالوں کی طرح وفاقی و صوبائی حکومت کی زیر نگرانی تعمیر ہونے والا کوئی میگا منصوبہ ابھی تک مکمل نہیں کیا جا سکا، ان میں ایسے بھی منصوبے شامل ہیں جو 8 سال قبل شروع کیے گئے اور ادھورے ہیں، کچھ منصوبے آدھے مکمل کیے گئے، کچھ منصوبوں پر جزوی تعمیراتی کام ہوا لیکن پھر انھیں بند کر دیا گیا اور کچھ منصوبوں پر ترقیاتی کام جاری ہیں لیکن ان کے دیگر کمپونٹ پر کوئی کام شروع نہ ہونے کے سبب ان کی افادیت عوام تک نہ پہنچنے کا خدشہ ہے۔

تفصیلات کے مطابق کراچی میں پانی کا بحران کئی سالوں سے جاری ہے، 3 کروڑ آبادی والے شہر میں دو سو رسز دریائے سندھ اور حب ڈیم سے 650 ملین گیلن پانی فراہم کیا جاتا ہے جبکہ ضرورت 1200 ملین گیلن ڈیلی ہے، شارٹ فال 550 ملین گیلن ڈیلی ہے، پانی کے اس بحران پر قابو پانے کیلیے 2 میگا منصوبے 2016 میں شروع کیے گئے جو ابھی تک مکمل نہیں کیے جا سکے اور ایک میگا منصوبہ 2024 میں شروع کیا گیا جو اگرچہ مکمل کر لیا گیا لیکن ناقص منصوبہ بندی کی وجہ سے عوام تک اس کی افادیت نہیں پہنچ سکی۔

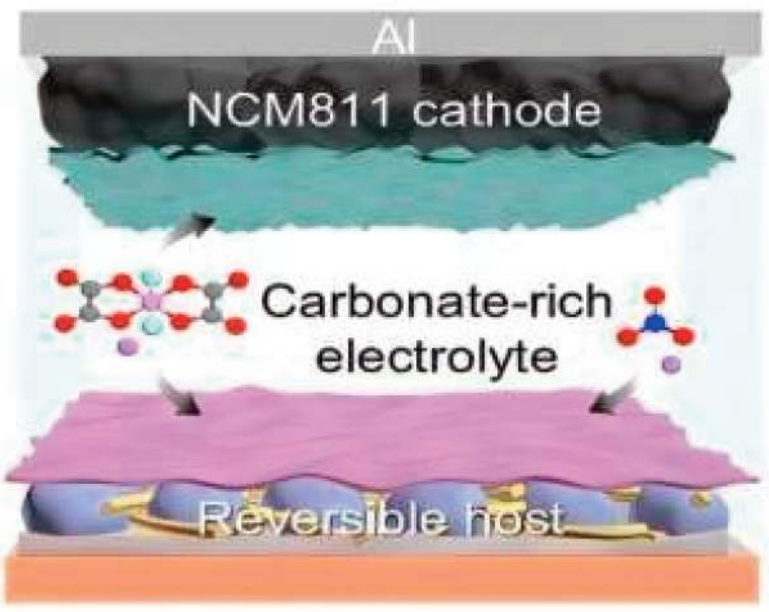
260 ملین گیلن ڈیلی پانی کی فراہمی کا اضافی منصوبہ کے فور 2016 میں سندھ حکومت اور کراچی واٹر اینڈ سیوریج کارپوریشن کی زیر نگرانی شروع ہوا، اسے دو سال میں مکمل ہونا تھا لیکن ناقص پلاننگ کی وجہ سے 2018 میں ترقیاتی کام بند کر دیا گیا، بعد ازاں وفاقی حکومت نے یہ منصوبہ واپڈا کو سونپ دیا، واپڈا نے 2022 میں KIV کی ری ڈیزائننگ کر کے دوبارہ ترقیاتی کام شروع کیا اور اسے دسمبر 2025 میں مکمل کیا جاتا ہے تاہم فنڈز کی کمی کی وجہ سے ابھی اس کا 65 فیصد کام ہو سکا ہے، کے فور پروجیکٹ کے تین مزید کمپونٹ ہیں جنہیں سندھ حکومت نے تعمیر کرنا ہے۔ ان میں دو پر کام شروع ہو گیا اور ایک کمپونٹ پر ابھی تک کام شروع نہیں ہوا ہے۔ ان تینوں کمپونٹ کی تکمیل کی مدت 2027 رکھی گئی ہے۔

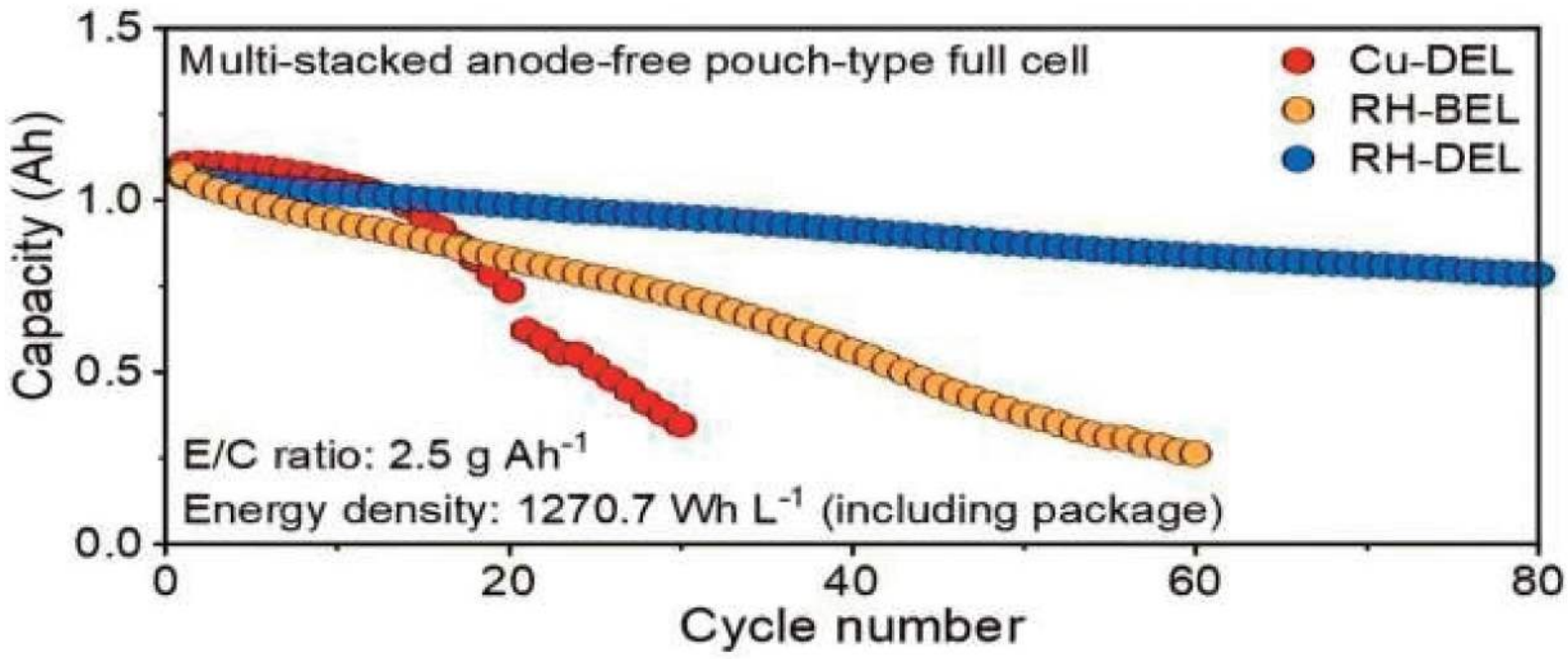
فراہمی آب کا دوسرا منصوبہ 65 ملین گیلن ڈیلی کا ہے جو سندھ حکومت کی عدم دلچسپی کی وجہ سے 7 سال سے بند پڑا ہے، اس پر صرف 15 فیصد کام کیا جا سکا ہے، واٹر کارپوریشن کے ایک افیسر نے نام ظاہر نہ کرنے کی شرط پر بتایا کہ اصل ایشو یہ نہیں کہ ترقیاتی کام مکمل کیے بغیر منصوبے کا افتتاح کر دیا گیا بلکہ اصل معاملہ یہ ہے کہ حب ڈیم سے ملنے والا 100 ملین گیلن ڈیلی پورا نہیں پہنچ پا رہا ہے اور صرف 70 ملین گیلن ڈیلی مل رہا ہے، متعلقہ افیسر کے مطابق واٹر کارپوریشن نے اپنے حدود کی 22 کلومیٹر نئی کینال کی تعمیر کا کام تقریباً مکمل کر دیا ہے لیکن واپڈا کی حدود میں آنیوالی 8 کلومیٹر کینال خستہ حالی کا شکار ہے۔ اب یہ 30 ملین گیلن پانی واپڈا کی کینال میں رساؤ میں ضائع ہو رہا ہے یا واٹر کارپوریشن کی نئی کینال کی کسی خرابی کا نتیجہ ہے۔

وفاقی حکومت کا منصوبہ گرین لائن فیز ٹو مختلف وجوہ کے باعث 3 سال سے تاخیر کا شکار تھا تاہم اب 2 ماہ قبل یہاں تعمیراتی کام شروع ہو گیا ہے، گرین لائن فیز ٹو تاج میڈیکل کمپلیکس تا میونسپل پارک پر تین کلومیٹر محیط ہے۔ یہ ترقیاتی کام ایک سال میں مکمل کر لیا جائے گا، اورنج لائن منصوبہ جو اورنگی ٹاؤن آفس سے میٹرک بورڈ آفس تک 3.9 کلومیٹر طویل ہے، اس کو مکمل ہوئے چار سال گذر چکے ہیں تاہم ابھی تک مسافروں کی توجہ حاصل نہیں کر سکا ہے، متعلقہ افسران کا کہنا ہے کہ پہلے یہ منصوبہ 2025 میں مکمل کیا جانا تھا، تاہم اب یہ منصوبہ 2027 میں مکمل ہوگا۔ ابھی اس پر صرف 45 فیصد کام مکمل ہو چکا ہے۔ یلو لائن منصوبہ کئی سالوں سے تاخیر کا شکار رہا ہے تاہم سندھ حکومت نے 2024 میں اس پر تعمیراتی کام شروع کیا۔ اسوقت یہ منصوبہ مناسب رفتار سے کیا جا رہا ہے اور 13 فیصد کام مکمل کیا جا چکا ہے، توقع ہے کہ یہ شیڈول کے مطابق 2028 میں مکمل کر لیا جائے گا۔

یلو لائن منصوبہ ورلڈ بینک کے مالی تعاون سے داؤد چورنگی تا نمائش چورنگی 26 کلومیٹر تعمیر کیا جائے رہا ہے، سندھ حکومت کی زیر نگرانی سیوریج کے دو میگا منصوبے دو عشروں سے تاخیر کا شکار ہیں، کمبائنڈ ایفلوینٹ ٹریٹمنٹ پلانٹ، یہ صنعتی فضلے کی ٹریٹمنٹ کا منصوبہ 2018 میں شروع کیا جانا تھا لیکن باوجود نہ ہو سکا، سندھ حکومت نے اب اس منصوبے کو پبلک پرائیوٹ پارٹنرشپ پر تعمیر کرنے کا فیصلہ کیا ہے۔ ■

Anode-free battery can double electric vehicle driving range





Could an electric vehicle travel from Seoul to Busan and back on a single charge? Could drivers stop worrying about battery performance even in winter? A Korean research team has taken a major step toward answering these questions by developing an anode-free lithium metal battery that can deliver nearly double driving range using the same battery volume.

Breakthrough in battery energy density

A joint research team led by Professor Soojin Park and Dr. Dong-Yeob Han of the Department of Chemistry at POSTECH, together with Professor Nam-Soon Choi and Dr. Saehun Kim of KAIST, and Professor Tae Kyung Lee and researcher Junsu Son of Gyeongsang National University, has successfully achieved a volumetric energy density of 1,270 Wh/L in an anode-free lithium metal battery. This value is nearly twice that of current lithium-ion batteries used in electric vehicles, which typically deliver around 650 Wh/L. The article is published in Advanced Materials.

An anode-free lithium metal battery eliminates the conventional anode altogether. Instead, lithium ions stored in the cathode move during charging and deposit directly onto a copper current collector. By removing unnecessary components, more internal space can be devoted to energy storage, much like fitting more fuel into the same-sized tank.

Overcoming technical challenges and safety risks

However, this design comes with serious challenges. If lithium deposits unevenly, sharp needle-like structures known as dendrites can form, increasing the risk of short circuits and potential safety hazards. Repeated charging and discharging can also damage the lithium surface, rapidly shortening battery life.

To address these issues, the research team adopted a dual strategy combining a Reversible Host (RH) and a Designed Electrolyte (DEL). The reversible host consists of a polymer framework embedded with uniformly distributed silver (Ag) nanoparticles, guiding lithium to deposit in designated locations rather than randomly. In simple terms, it acts like a dedicated parking lot for lithium, ensuring ordered and uniform deposition.

The designed electrolyte further enhances stability by forming a thin but robust protective layer composed of Li_2O and Li_3N on the lithium surface. This layer functions like a bandage on skin, preventing harmful dendrite growth while maintaining open pathways for lithium ions transport.

Performance results and commercial potential

When combined, the RH–DEL system delivered outstanding performance. Under high areal capacity (4.6 mAh cm^{-2}) and current density (2.3 mA cm^{-2}), the battery retained 81.9% of its initial capacity after 100 cycles and achieved an average Coulombic efficiency of 99.6%. These results enabled the team to reach the record-breaking 1,270 Wh/L volumetric energy density in anode-free lithium metal batteries.

Importantly, this performance was validated not only in small laboratory cells but also in pouch-type batteries, which are closer to real-world electric vehicle applications. Even with a minimal amount of electrolyte (E/C = 2.5 g Ah^{-1}) and under low stack pressure (20 kPa), the batteries operated stably. This demonstrates strong potential for reducing battery weight and volume while lowering manufacturing burdens, significantly improving commercial viability.

Professor Park commented, "This work represents a meaningful breakthrough by simultaneously addressing efficiency and lifetime issues in anode-free lithium metal batteries."

Professor Lee added, "Our study demonstrates that electrolyte design based on commercially available solvents can achieve both high lithium-ion mobility and interfacial stability." - TX

New generator uses carbon fiber to turn raindrops into rooftop electricity

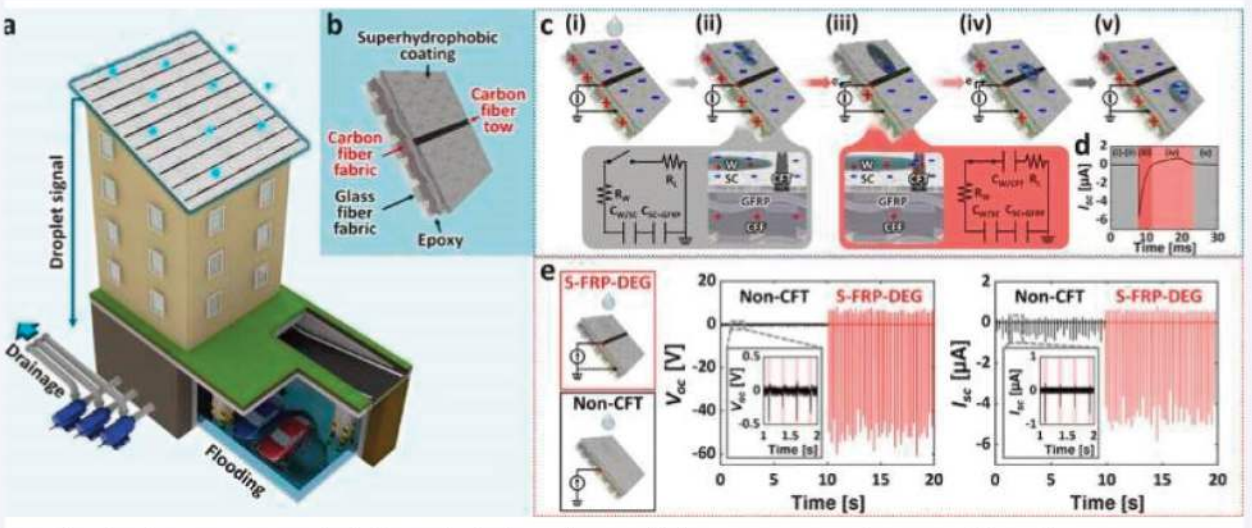
A research team affiliated with UNIST has introduced a technology that generates electricity from raindrops striking rooftops, offering a self-powered approach to automated drainage control and flood warning during heavy rainfall.

Led by Professor Young-Bin Park of the Department of Mechanical Engineering at UNIST, the team developed a droplet-based electricity generator (DEG) using carbon fiber-reinforced polymer (CFRP). This device, called the superhydrophobic fiber-reinforced polymer (S-FRP-DEG), converts the impact of falling rain into electrical signals capable of operating storm water management systems without an external power source. The findings are published in Advanced Functional Materials.

CFRP composites are lightweight, yet durable, and are used in a variety of applications, such as aerospace and construction because of their strength and resistance to corrosion. Such characteristics make it well suited for long-term outdoor installation on rooftops and other exposed urban structures.

The generator produces electricity through a process similar to static charge generation. When a positively charged raindrop contacts the device's negatively charged superhydrophobic surface, electric charge is transferred as the droplet rapidly detaches and rolls away. This motion drives an electric current through embedded carbon fibers, generating power almost instantly.

Unlike conventional metal-based droplet generators, which are prone to corrosion from moisture and urban pollutants, the CFRP-based design maintains stable performance under harsh environmental conditions. The research team further improved efficiency by introducing a textured surface and lotus-leaf-inspired coating that enhances water repellency while preventing the buildup of dirt and soot.



In laboratory tests, a single raindrop with a volume of approximately 92 microliters generated up to 60 volts and a few micro amps of current. When four units were connected in series, the system briefly powered 144 LED lights, demonstrating its scalability.

The team also validated the technology in real-world settings by installing the device on building rooftops and drainage pipes. As rainfall intensity increased, the electrical signals became stronger and more frequent, allowing the system to distinguish between light, moderate, and heavy rain and automatically activate drainage pumps when necessary.

"This technology enables urban infrastructure to monitor rainfall and respond to flood risks using only the energy of rain itself," said Professor Park. "Looking ahead, it could be further integrated into mobility systems, including vehicles or aircraft, where carbon fiber composites are already widely used." - TX

World's Smallest Programmable, Autonomous Robots Measuring 200 × 300 × 50 Micrometers Become a Reality

Researchers at the University of Pennsylvania and University of Michigan have created the world's smallest fully programmable, autonomous robots: microscopic swimming machines that can independently sense and respond to their surroundings, operate for months and cost just a penny each.

Barely visible to the naked eye, each robot measures about 200 by 300 by 50 micrometers, smaller than a grain of salt. Operating at the scale of many biological microorganisms, the robots could advance medicine by monitoring the health of individual cells and manufacturing by helping construct microscale devices.

Powered by light, the robots carry microscopic computers and can be programmed to move in complex patterns, sense local temperatures and adjust their paths accordingly.

Described in Science Robotics and Proceedings of the National Academy of Sciences, the robots operate without tethers, magnetic fields or joystick-like control from the outside, making them the first truly autonomous, programmable robots at this scale.

"We've made autonomous robots 10,000 times smaller," says Marc Miskin, Assistant Professor in Electrical and Systems Engineering at Penn Engineering and the papers' senior author. "That opens up an entirely new scale for programmable robots."

Breaking the sub-millimeter barrier

For decades, electronics have gotten smaller and smaller, but robots have struggled to keep pace. "Building robots that operate independently at sizes below one millimeter is incredibly difficult," says Miskin. "The field has essentially been stuck on this problem for 40 years."

The forces that dominate the human world, like gravity and inertia, depend on volume. Shrink down to the size of a cell, however, and forces tied to surface area, like drag and viscosity, take over. "If you're small enough, pushing on water is like pushing through tar," says Miskin.

In other words, at the microscale, strategies that move larger robots, like limbs, rarely succeed. "Very tiny legs and arms are easy to break," says Miskin. "They're also very hard to build."

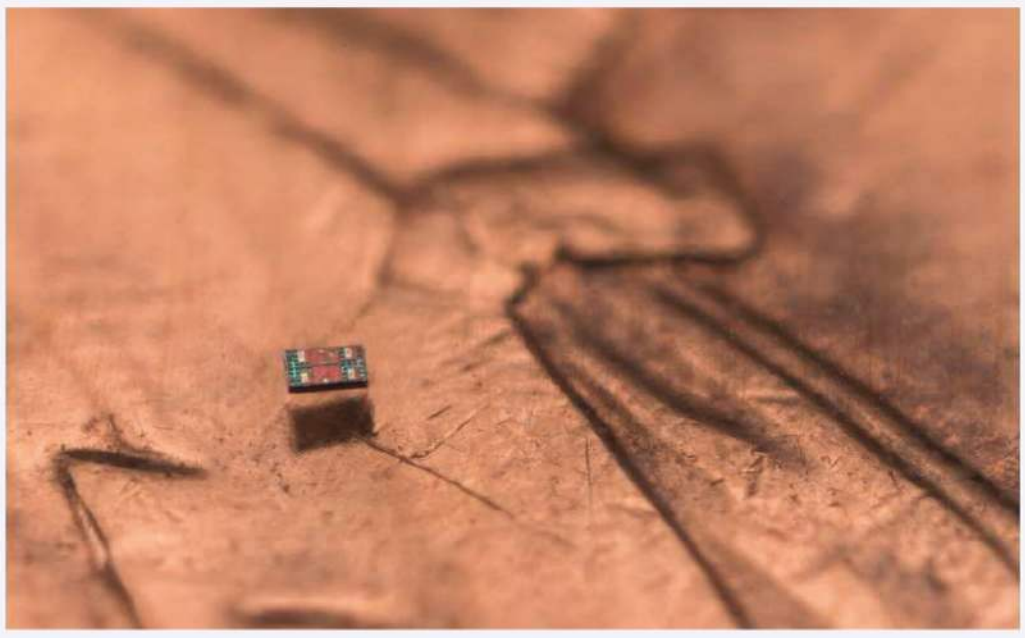
So the team had to design an entirely new propulsion system, one that worked with—rather than against—the unique physics of locomotion in the microscopic realm.

Making the robots swim

Large aquatic creatures, like fish, move by pushing the water behind them. Thanks to Newton's Third Law, the water exerts an equal and opposite force on the fish, propelling it forward.

The new robots, by contrast, don't flex their bodies at all. Rather, they generate an electrical field that nudges ions in the surrounding solution. Those ions, in turn, push on nearby water molecules, animating the water around the robot's body.

"It's as if the robot is in a moving river," says Miskin, "but the robot is also causing the river to move."



The robots can adjust the electrical field that causes the effect, allowing them to move in complex patterns and even travel in coordinated groups, much like a school of fish, at speeds of up to one body length per second.

And because the electrodes that generate the field have no moving parts, the robots are extremely durable. "You can repeatedly transfer these robots from one sample to another using a micropipette without damaging them," says Miskin. Charged by the glow of an LED, the robots can keep swimming for months on end.

Giving the robots brains

To be truly autonomous, a robot needs a computer to make decisions, electronics to sense its surroundings and control its propulsion, and tiny solar panels to power everything, and all that needs to fit on a chip that is a fraction of a millimeter in size. This is where David Blaauw's team at the University of Michigan came into action.

Blaauw's lab holds the record for the world's smallest computer. When Miskin and Blaauw first met at a presentation hosted by the Defense Advanced Research Projects Agency (DARPA) five years ago, the pair immediately realized that their technologies were a perfect match.

"We saw that Penn Engineering's propulsion system and our tiny electronic computers were just made for each other," says Blaauw. Still, it took five years of hard work on both sides to deliver their first working robot.

"The key challenge for the electronics," says Blaauw, "is that the solar panels are tiny and produce only 75 nanowatts of power. That is over 100,000 times less power than what a smart watch consumes."

To run the robot's computer on such little power, the Michigan team developed special circuits that operate at extremely low voltages and bring down the computer's power consumption by more than 1000 times.

Still, the solar panels occupy the majority of the space on the robot. Therefore, the second challenge was to cram the processor and memory to store a program in the little space that remained.

"We had to totally rethink the computer program instructions," says Blaauw, "condensing what conventionally would require many instructions for propulsion control into a single, special instruction to shrink the program's length to fit in the robot's tiny memory space."

Robots that sense, remember and react

What these innovations made possible is the first sub-millimeter robot that can actually think. To the researchers' knowledge, no one has previously put a true computer—processor, memory and sensors—into a robot this small. That breakthrough makes these devices the first microscopic robots that can sense and act for themselves.

The robots have electronic sensors that can detect the temperature to within a third of a degree Celsius. This lets robots move towards areas of increasing temperature, or report the temperature—a proxy for cellular activity—allowing them to monitor the health of individual cells.

"To report their temperature measurements, we designed a special computer instruction that encodes a value, such as the measured temperature, in the wiggles of a little dance the robot performs," says Blaauw. "We then look at this dance through a microscope with a camera and decode from the wiggles what the robots are saying to us. It's very similar to how honey bees communicate with each other."

The robots are programmed by pulses of light that also power them. Each robot has a unique address that allows the researchers to load different programs on each robot. "This opens up a host of possibilities," adds Blaauw, "with each robot potentially performing a different role in a larger, joint task."

Only the beginning

Future versions of the robots could store more complex programs, move faster, integrate new sensors or operate in more challenging environments. In essence, the current design is a general platform: its propulsion system works seamlessly with electronics, its circuits can be fabricated cheaply at scale and its design allows for adding new capabilities.

"This is really just the first chapter," says Miskin. "We've shown that you can put a brain, a sensor and a motor into something almost too small to see, and have it survive and work for months. Once you have that foundation, you can layer on all kinds of intelligence and functionality. It opens the door to a whole new future for robotics at the microscale." - TX