

FORTNIGHTLY ENGINEERING REVIEW

The voice of engineers

Founded by **Najam ul Hassan (Marhoom)**
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A River Divided: The Story of CCI's Halt on the Indus Canal Project

On the banks of the Indus, where history, livelihood, and politics converge, a decision was taken that could shape the future of Pakistan's most vital waterway.

In a long-awaited move aimed at easing inter-provincial tensions, the Council of Common Interests (CCI) met on Monday and unanimously decided to halt the proposed construction of six strategic canals until a mutual understanding among all provinces was reached.

The decision followed weeks of controversy and unrest, particularly in Sindh, where nationalist parties and political leaders, including those from the Pakistan Peoples Party (PPP), raised alarms about the possible impacts of the canal project

on lower riparian rights. Tensions had escalated to the point of highway blockades, a vivid reminder of how deeply water politics run in

growing unease. The gathering, attended by the Prime Minister and all four provincial chief ministers, issued a statement that the federal

eration and each province. "To allay the concerns of all provinces and to ensure Pakistan's food and ecological security," the council

with the Water Apportionment Accord of 1991 and the National Water Policy of 2018—two landmark documents that, on paper, bind the

Economic Council (Ecneec) on February 7, and set aside the Irsa water availability certificate issued on January 17. Both decisions had drawn sharp criticism for being rushed and unilateral.

Yet amid the political choreography, one glaring reality remains: if professional engineers and technical planners had been employed from the start—backed by credible hydrological data—this crisis could have been avoided.

In a nation as dependent on a single river system as Pakistan, the absence of scientific, transparent planning borders on negligence. Water resource management must begin with facts, not politics. Planning for large-scale infrastructure like canals demands detailed studies, basin-wide modeling, and engagement with communities who depend on the river



Pakistan's federation.

Initially scheduled for May 2, the CCI meeting was brought forward to April 28 at the request of the PPP—an urgent gesture reflecting the

government would not proceed with the project without complete consensus. A technical committee would now take the lead, composed of representatives from the fed-

declared, "no new canals will be constructed until a shared vision emerges through the committee."

This committee is tasked with aligning future projects

federation to an equitable distribution of water resources.

The CCI also rolled back the preliminary approval granted by the Executive Committee of the National

Contd on page 4

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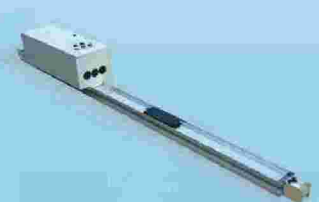
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Pakistan's Digital Leap: DFDI Forum 2025 Signals New Era for IT Investment

In a defining moment for Pakistan's digital future, the government inaugurated the first-ever Digital Foreign Direct Investment (DFDI) Forum 2025, a landmark event aimed at transforming the country into a regional hub for digital innovation and investment.

Held under the patronage of Prime Minister Muhammad Shehbaz Sharif in Islamabad, the Forum marked a clear departure from traditional development models, signaling Pakistan's bold shift toward the digital economy. Hosted by the Ministry of Information Technology and Telecommunication in collaboration with the Digital Cooperation Organization (DCO), the

event brought together an impressive coalition of global and domestic players: over 30 ministers from DCO member states, 75 international investors, and representatives from more than 100 leading Pakistani IT companies.

The Forum's opening day delivered immediate impact. Investment announcements worth \$700 million underscored the strong international confidence in Pakistan's digital sector—an area that has seen impressive growth in recent years despite broader economic headwinds.

Speaking at the event, Federal Minister for IT and Telecommunication, Ms. Shaza Fatima Khawaja, highlighted Pakistan's recent digital achievements. "Pakistan's ICT exports have grown by over 25% in the past nine months," she noted. "This is a direct reflection of

our expanding digital economy and the capabilities of our young tech workforce." Another milestone shared



during the event was Pakistan's 14-place improvement in the UN E-Government Development Index between

2022 and 2024, a tangible outcome of ongoing efforts to modernize government services and expand digital access.

Guest of Honor Ms. Deemah AlYahya, Secretary-General of the DCO, praised Pakistan's strategic focus on

digital transformation. In her remarks, she emphasized the role of partnerships and regional cooperation in driving inclusive innovation across the Global South. Her presence added international weight to the Forum's outcomes, reinforcing Pakistan's growing credibility in the global tech arena.

Beyond investment figures and speeches, the Forum created space for real engagement. Minister Khawaja and Secretary-General AlYahya held in-depth discussions with more than 40 Pakistani startups and technology leaders, many of whom showcased solutions in fintech, e-commerce, healthtech, and artificial intelligence. Their presentations demonstrated not only technical innovation but also investor readiness, as many seek to scale beyond local markets.

At the close of its first

day, the DFDI Forum carried a renewed sense of momentum, with attendees and organizers alike referring to Islamabad as the emerging "Davos of Digital Investment." The phrase captures both ambition and the need for sustained policy support, infrastructure upgrades, and investor confidence to maintain Pakistan's upward trajectory.

Pakistan's youth-driven IT sector now stands at the crossroads of promise and global opportunity. The groundwork laid by the DFDI Forum provides a strong foundation—what remains is the continued alignment of regulation, education, and international collaboration to unlock the sector's full potential.

In the words of one participant, "We're not just exporting software—we're exporting possibility." — ERMD

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A River Divided: The Story of CCI's Halt on the Indus Canal Project

Contd from page 1
for survival.

Ironically, institutions like the Pakistan Engineering Council and other engineering bodies remained silent throughout the controversy. No public warnings were issued. No independent reviews were conducted. These institutions, mandated

to uphold professional standards and guide national development, failed to perform their duty of informing the public and scrutinizing the flawed planning behind the canal initiative.

This silence allowed the issue to become yet another political football in a country already strained by water scarcity, provincial mistrust,



and ecological vulnerability. Had engineers spoken up—had planners presented alternative strategies rooted in data and environmental reality—perhaps the provinces wouldn't be so divided, and the roads of Sindh would never have needed to be blocked.

As the CCI prepares for its next meeting, and

as the technical committee begins its work, there is hope that Pakistan can now shift toward a rational, inclusive approach to water management. The canals project may be paused, but the greater task of rebuilding trust and integrating science into policy is only just beginning.

— Engineering Review Report

Bijli Ghar

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Industry Feedback from Textile Asia 2025: Cautious Optimism Amid Global Challenges



At Textile Asia 2025, industry leaders and participants expressed overall satisfaction with the event, praising the turnout, business prospects, and growing interest in local and international partnerships. While the ongoing global tariff tensions, especially involving the U.S., have raised some concerns, most participants remain optimistic about Pakistan's resilience and potential to tap into new markets.

The shift toward localization, technological adoption, and government reforms were seen as key drivers for future growth in the power and manufacturing sectors.

Here's what various industry stakeholders had to say:

Mohammad Tariq Haq | Energy Solutions (Pvt) Ltd



"This is a good event—we are satisfied. Business is improving in Pakistan, and this trend should continue. There is uncertainty due to the implications of U.S. tariffs, but I believe this is a conflict between major global powers and won't affect Pakistan much, as we operate with relatively low volumes. Some even see this as an opportunity for Pakistan."

Henrik Meyer | Cummins



"It's a fantastic event so far. We've received a warm welcome, and we're exploring how we can contribute to the industry's power needs. Given the current circumstances, gas engines are the best solution we're offering. They provide both steam and power to meet the textile industry's energy demands."

Malik Umair Akram | Rack n Racks



"We've received a good response at the exhibition. We provide solutions for various industries, and it's encouraging to engage

directly with customers."

Muhammad Nadeem Sadiq | Energy Solutions (Pvt) Ltd



"The response has exceeded our expectations and is enhancing our image nationally and internationally. We specialize in power generation. While the global tariff war continues, we remain hopeful. Our textile sector is strong enough to face these challenges."

Farid Ahmed Vawda | FAV Group



"We've introduced new technologies and are focused on staying connected with the latest innovations. Regarding tariff wars, Pakistan is not facing this alone. It's essential that we explore markets beyond just the U.S."

Tanzeel Alam | Alam Engineering



"We're receiving positive feedback and have generated many inquiries. Tariff issues are pushing us toward localization. We aim to develop more local products, especially in the manufacturing sector. Fortunately, the industry is supporting us, as our HVACR solutions meet the required standards."

Qazi Muhammad Salman | R.A. Engineering



"We've been part of this expo for the past ten years. With a broad product line and by the grace of God, we are doing well. We've had very positive feedback from this event."

M. Waleed Jawaid | INTEXCO



"We are an ICT distribution company working in security, surveillance, and networking for the past 25 years. The tariff war isn't significantly affecting Pakistan. InshaAllah, we will navigate through it successfully."

Muhammad Umair | Envo Xpert



"We're hopeful that the situation will improve with government reforms, such as reducing power tariffs. The U.S. tariff issue might affect us, and sales in the U.S. may dip slightly."

Muhammad Arsalan Omer | Allied Engineering & Services



"We've seen a good turnout at the event and hope to see further improvements. I believe the U.S. tariffs may actually prompt us to explore markets with lower tariffs. With the government's power tariff reforms, Pakistan's textile industry has the potential to grow even further."

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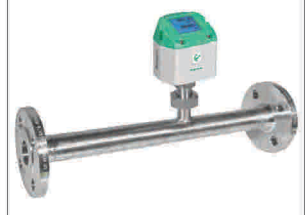


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Pakistani Engineer Raghieb Hussain Appointed CEO of Intel's Altera Division

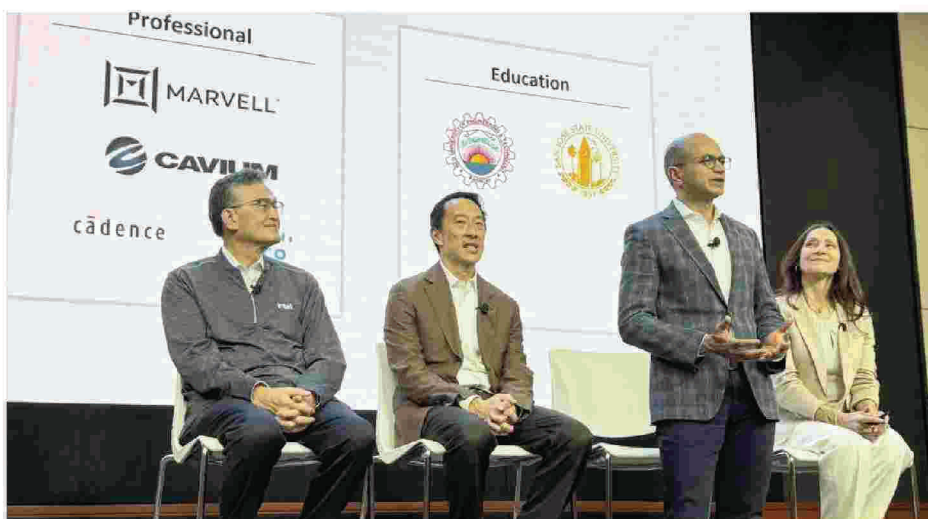
In a proud moment for Pakistan, engineer Raghieb Hussain has been appointed by Intel as the next Chief Executive Officer of Altera, effective May 5, 2025.

inspiration for engineers from Pakistan who continue to excel in cutting-edge technology fields worldwide. It puts Pakistan on the map alongside neighboring countries whose engineers have long held key roles in major tech firms.

Currently the President of

Systems, and he also co-founded VPNet, a company specializing in enterprise security.

Hussain earned his Bachelor's degree in Computer Systems Engineering from NED University in Karachi, Pakistan, and later completed his Master's in Computer



His appointment marks a significant milestone, showcasing the recognition of Pakistani-origin engineers for their exceptional contributions to the global tech industry—particularly in Silicon Valley, the heart of innovation.

This achievement not only reflects Hussain's outstanding professional journey but also serves as a source of

Products and Technologies at Marvell Technology Inc., Raghieb Hussain leads the company's business strategies, product development, and innovation initiatives. Before Marvell acquired Cavium in 2018, he co-founded the company and served as its Chief Operating Officer. His earlier career includes engineering roles at Cisco and Cadence Design

Engineering from San Jose State University, USA.

As we celebrate this achievement, it's a powerful reminder to support and encourage Pakistani engineers making remarkable strides in high-tech sectors globally. Their accomplishments are paving the way for a stronger presence in global innovation and leadership.

Doomsday for Engineering Education in Pakistan

By Ahsan Ahmad Ursani

In line with the increasing centralization of power under the notion of a "hard state", the Pakistan Engineering Council (PEC), through a letter dated April 10, 2025, issued by its Additional Registrar (Curriculum & Development), Engr. Osaf Mehmood Malik has announced its decision to introduce three new mandatory courses for undergraduate engineering programs: "Constitution of Pakistan", "Fahm-e-Quran I", and "Fahm-e-Quran II".

These are in addition to the already existing compulsory courses of "Pakistan Studies" and "Islamic Studies".

The letter specifies that the Fahm-e-Quran courses are mandatory for Muslim students only, but it fails to suggest any alternative coursework for non-Muslim students. In practice, institutions in Punjab have been offering these courses for over two years without any provisions for non-Muslim students, effectively making them compulsory for all. Similarly, "Pakistan Studies" and "Constitution of Pakistan" remain mandatory even for foreign students enrolled in Pakistani institutions.

This directive undermines academic autonomy by compelling higher education institutions to include these courses in the non-engineering domain of their engineering curricula. PEC, whose primary mandate is to regulate engineering practices and reform engineering education, has now ventured into academic micromanagement, stripping universities of the freedom to design curricula based on the best interests of their students. A close reading of the referenced PEC letter reveals that out of the 42 cred-

it hours allocated for non-engineering domain courses, only one 2-credit-hour course is left to the discretion of the universities.

This decision blatantly contradicts PEC's stated mission to uphold "realistic and internationally relevant standards of professional competence and ethics for engineers". I challenge PEC to cite any international engineering regulatory body that mandates the teaching of religion or scripture as part of engineering education to justify this move under the umbrella of "internationally relevant standards".

Under the PEC Act and its regulations, the Council is authorized only to determine the minimum standards of study and practical training for inclusion in the First and Second Schedules — the former relating to programs offered within Pakistan and the latter to internationally recognized programs. As per PEC's own notification dated January 13, 2025, Second Schedule programs include those accredited by the Engineering Council UK, the European Federation of National Engineering Associations, and Chinese institutions. It is evident that none of these Second Schedule programs mandate courses like "Pakistan Studies", "Constitution of Pakistan", "Islamic Studies", or "Fahm-e-Quran" as part of their engineering curricula. Therefore, imposing these courses domestically contradicts PEC's own standardization benchmarks and overreaches its regulatory authority, which is confined to establishing minimum standards only.

Non-engineering domain courses in engineering programs globally include mathematics, natural sciences, management, and a diverse range of humanities subjects—such as visual arts, media and communication studies, popular culture, gender studies, ethics, law, human geography, anthro-



pology, and archaeology. These courses are designed to instill soft skills in future engineers and help them understand and navigate the broader world in which they operate. Unfortunately, Pakistani higher education institutions have either ignored this crucial component or been actively restricted from doing so, leading to a narrow, insular educational experience.

This top-down imposition erodes core academic values such as adaptability, creativity, and independent thinking, isolating Pakistani graduates from globally accepted professional norms and practices.

The new mandatory courses on "Ideology of Pakistan" and Fahm-e-Quran are a brainchild of the government of Punjab. By using PEC as a vehicle to implement them nationally, the federal government has overstepped its constitutional bounds, transgressed into the realm that is completely a provincial subject after the 18th amendment to the constitution of Pakistan, and imposed the rigorous religious policies of the Punjab government over other provinces of Pakistan. It is high time for the PEC to refrain from meddling in the provincial subject, in the affairs of academia, and respect the autonomy of higher education bodies.

The author is a professor in the Department of Biomedical Engineering at Mehran University of Engineering and Technology, Jamshoro, Sindh. (aursani@gmail.com)

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Attock Petroleum Partners with HUBCO Green to Launch Nationwide EV Charging Network

In a significant step toward sustainable mobility in Pakistan, Attock Petroleum Limited (APL) has entered into a strategic collaboration with HUBCO Green (Private) Limited (HGL), a wholly owned subsidiary of Hub Power Holding Limited.

According to the information that the company shared with the Pakistan Stock Exchange, the agreement, signed on April 24, 2025, outlines joint efforts to develop and market electric vehicle (EV) charging infrastructure across selected APL outlets nationwide.

The partnership is aimed at accelerating the adoption of EV technology in Pakistan by enhancing public charging accessibility and supporting the country's green energy transition.

About the Companies:

Attock Petroleum Limited (APL) is one of Pakistan's leading oil marketing compa-

nies, known for its extensive retail network and commitment to delivering high-quality petroleum products. APL is part of the Attock Group, which has diverse interests in oil refining, exploration, and marketing.

HUBCO Green (Private) Limited (HGL) is a clean energy-focused subsidiary of Hub Power Holding Limited, Pakistan's largest

Independent Power Producer (IPP). HGL is tasked with leading HUBCO's transition into sustainable and renewable energy

solutions, including EV infrastructure, solar energy, and green technology innovations.

This collaboration marks a new milestone in the public-private effort to foster environmental sustainability, economic modernization, and energy diversification. By combining APL's nationwide retail presence with HGL's green energy expertise, the partnership is poised to create a robust EV charging ecosystem across Pakistan. — Engineering Review



Strengthening Global Ties

Prof. B.S. Chowdhry Visits UPV, Spain Under Erasmus+ International Credit Mobility

Universitat Politècnica de València invited Prof BS Chowdhry, Advisor for international collaborative projects MUET

He was hosted by Prof Dr. Jorge Martínez-Bauset, from the PELICAN research group (Performance Evaluation and Economic Analysis of Communication Networks) at the Department of Communications. He met

tion were explored, as the exchange of Master's and Ph.D. students. He also spoke at the ETSIT on the "Importance and Need for Standardization of Telecommunication Engineering Education in Pakistan." It was previously presented at the "Joint ITU-GISFI-DS-CTIF Standards Education Workshop (Aalborg-Denmark)". He also provided a presentation on Various EU-funded ICM and Erasmus+ CBHE programs being coordinated by him at MUET, such as CENNTAL (Digital Technologies for Business Transformation), o ACTIVE (ICT-

based climate action), CATCH_VR (Capacity Building in Teaching AR/VR).

He visited the laboratory of the research group where a meeting was held on different ways to gain insight into the latest advancements in Dynamic Medium Access in Clustered NOMA IoT Networks based on Reinforcement Learning.

A conclusion meeting was held on the opportunities to share ongoing and prospective research activities among research groups of the Mehran and UPV uni-

Contd on page 8



Jamshoro, through Erasmus+ International Credit Mobility (ICM) to strengthen Academic Collaboration.

with Prof. Dr. Felipe L. Peñaranda-Foix, Deputy Director of International Relations at the Telecommunications School. Different aspects of future collabora-



Technology Transfer Vital for Pakistan's Growth: Local Integration Key, Says Adnan Sheriff

The IEEE Symposium continues to improve each year with the addition of topics relating to emerging technologies, said Adnan Sheriff, of Jubilee Corporation. Speaking to Engineering

zation. "Our elders, including my father, prioritized community service when launching this business, even though commercial interests naturally existed. Industry-academia liaison and supporting students have been part of our blood — we cannot leave it, and InshaAllah, we shall continue it," he said. Sheriff also emphasized



Review, Sheriff praised the organizers, stating, "The management must be appreciated and they should also keep on improving the symposium in the coming years." He highlighted that discussions on new technologies are vital for keeping the event relevant and beneficial to the industry.

Explaining Jubilee Corporation's support for events like the IEEE Symposium, Sheriff said knowledge sharing and community service are core values of the organi-

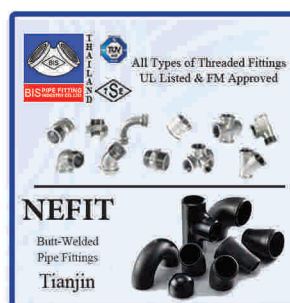
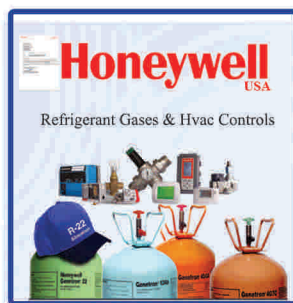
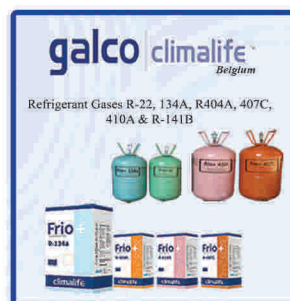
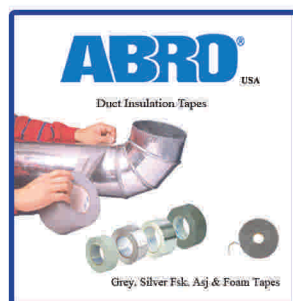
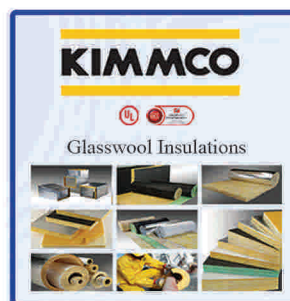
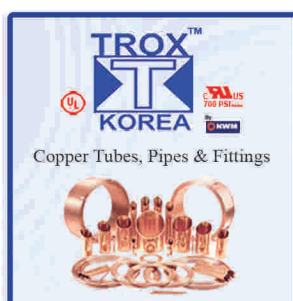
the role of technology transfer in national development. "Our footprint in technologies is increasing because Pakistan urgently needs technology transfer. This is only possible if companies like ours introduce new technologies and gradually integrate them into the local environment," he added.

The IEEE Symposium is recognized as a key platform for promoting technological advancement and collaboration between academia and industry in Pakistan. ■

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Agriculture Vision 2030-III

By: Ishrat Husain

Poor Governance and corruption have made distribution system highly inequitable. One third of the total flow in some areas is diverted by large and influential farmers from 'direct outlets' bypassing the varabandi system of sharing.

Small farmers and tailenders get 40-50 percent less than those at the head-end. Head Enders usually apply 4 to 5 irrigations per field while the tail-ender may apply as few as one or two. As water is not available on time and in required quantities, small farmers and tailenders are unable to use

other complementary inputs such as fertilizers. Consequently, water stress damages a crop's growth cycle. The productivity gap in the same ecological zones between the progressive and large farmers and other farmers can be bridged by redistribution of water currently used in excess by head-enders. The latest Agriculture census shows that about 70 percent of the total private owned land belongs to farmers with less than 20 hectares. The yield differences between the average national yields and those of the progressive farmers vary between 30 to 70 percent.

Agriculture extension services of the Provincial Governments have been weak as they are infested with people with poor tech-

nical skills and subject matter knowledge, little accountability for results, and outdated practices of dissemination and communication. Whatever limited resources are available with the Agriculture departments are mainly deployed to serve the interests of large and politically connected farmers. Small farmers who need extension services badly get hardly served.

The above analysis shows that to meet the needs of food production and food security in an adverse climatic conditions, agriculture sector reforms would have to be implemented in a number of key areas. These reforms are briefly sketched in the following paragraphs:

Reforms in agricultural

sector

1) Develop flexible rural factor markets – Land, Labour, Water, and Finance – and allow them to operate in a competitive market structure.

i) Establish clear land titles and land right security, computerized land records, web-based information on ownership and tenancy arrangements. Simplified alienation, transfer and mutation procedures are needed for efficient land markets to function. These land markets will lead to consolidation of holdings and avoid increasing fragmentation. Land can then be pledged as collateral for bank borrowing and investment. Leasing land by paying rentals can become a source of livelihood for landless and poor households neutralizing the detrimental effects of land purchase and consolidation by efficient commercially-oriented farmers.

ii) Water markets with alienable water rights along with alternative systems to conserve and save water such as Drip irrigation, Sprinkler Irrigation and appropriate water pricing can bring about some improvement in the efficient utilization of the scarce resource. Water charges from the users should be based on actual volumetric draw down and the total annual collection must at least equal the maintenance cost i.e. 1% of the value of irrigation infrastructure.

iii) Labour market in agriculture would face shortages as educated young men and women migrate to live in urban centres or overseas. Skill intensity and capital intensity would have to be raised to substitute for declining unskilled agriculture labor force. Sector-spe-

cific technical and vocational training would have to be promoted and delivered.

2) Remove the restrictions imposed on whole sale transaction for agriculture commodities under the Agriculture Produce Markets Act 1939; discontinue government procurement of Wheat and issuing of Wheat at subsidized prices to the flour mills from government stocks and limit the roles of Foods Departments, PASSCO and TCP in the purchase and trading of agri-commodities.

3) Agri-business sector should be facilitated to modernize the whole value chain from the farm to retail outlets. Input supplies, transport, storage and warehousing, Cold Chains and refrigerated vans, processing and wholesale and retail marketing of agriculture commodities should be in the hands of the private sector. Government's role should be limited to quality control, enforcement of standards, grading, consumer and farmer protection, and food security.

4) Access to agriculture credit for production, distribution and exchange is limited to a small proportion of farmers. Innovative schemes such as warehouse receipt system linked to a bank which can pledge stocks and advance loans should be introduced.

5) Intensify efforts on Research and Development and its linkages to extension with focus on system-based approach in place of commodity specific research. Finding new strains that can survive and produce high yields in water stressed conditions should get priority. Allocations for Agriculture Research and development by



the provincial governments in partnership with universities and the private sector should be stepped up. Transfer and dissemination of technology and research findings can take place through strong partnership with private sector and NGOs.

6) Institutions such as WAPDA, IRSA, Irrigation Departments, PIDAs, Area Water Boards and Users Association have to be restructured and reorganized. Their technical and organizational capacity should be geared to manage the integrated water resources system equitably and efficiently. Performance evaluation and annual increments should be linked to key indicators of delivery of services and maintenance of the system. Their budgets should be based on the assessment and collection of water user charges. The responsibility for bulk water supply from rivers and canals should remain with Irrigation Departments or Authorities but the distribution from minors and water courses should be assigned to Farmers organizations and private service providers.

– Concluded

Prof. B.S. Chowdhry Visits UPV, Spain Under Erasmus+ International Credit Mobility

Contd from page 7

versities; possibilities for applying to ICM opportunities for master's students to spend 6 months at UPV doing their research project; and writing joint research proposals.

These actions will strengthen ties between the faculties of both institutions and help uplift academic standards at both institutions.

Prof. Dr. Felipe Peñaranda-Foix, Deputy Director of International Relations at the School of Telecommunications Engineering; Prof. Dr. Jorge Martínez-Bauset, from the PELICAN research group (Performance Evaluation and Economic Analysis of communication Networks) at the Department of Communications; and Prof. Dr. Vicent Pla shared insights into their multidisciplinary telecommunications engineering programs, designed to meet the evolving demands of the field.

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* TE + Business administration and management

(GADE)

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Bachelor + Master :

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Predictive Engineering: The Future of Research with Machine Learning

By: Syed Umair Ali

In the rapidly evolving landscape of engineering, the integration of machine learning (ML) has opened up a new frontier — 'Predictive Engineering'.

Gone are the days when engineering research relied solely on traditional models, simulations, and trial-and-error experimentation. Today, data-driven algorithms and intelligent systems are reshaping how engineers design, optimize, and predict the behavior of complex systems. At the heart of this transformation lies machine learning—an indispensable tool enabling engineers to make more informed decisions, accelerate innovation, and tackle previously unsolvable challenges.

What is Predictive Engineering?

Predictive engineering refers to the use of computational tools to forecast the performance, behavior, or failure of systems before they are physically built or modified. Traditionally, this was done using Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD), and other simulation techniques. While these methods remain valuable, they often require extensive computational resources and domain-specific expertise.

Machine learning enhances predictive engineering by learning patterns from historical data, simulations, or real-time sensor inputs. Instead of simulating every possible design variation, ML models can generalize from existing data to predict outcomes faster and with impressive accuracy.

How Machine Learning is Changing Engineering Research

1. Data-Driven Design Optimization
In fields like aerospace and automotive engineering, optimizing the design of components is crucial. Engineers use ML algorithms—such as genetic algorithms, neural networks, and reinforcement learning—to explore vast design spaces and find optimal

configurations that minimize cost, weight, or energy consumption.

2. Failure Prediction and Maintenance
Predictive maintenance is a game-changer in industries like manufacturing and infrastructure. By analyzing sensor data and maintenance logs, ML models can forecast equipment failures before they occur. This reduces downtime, extends equipment life, and cuts operational costs.

3. Smart Materials and Structures
Materials science is embracing machine learning to discover and design new materials

reducing computational time while maintaining acceptable accuracy.

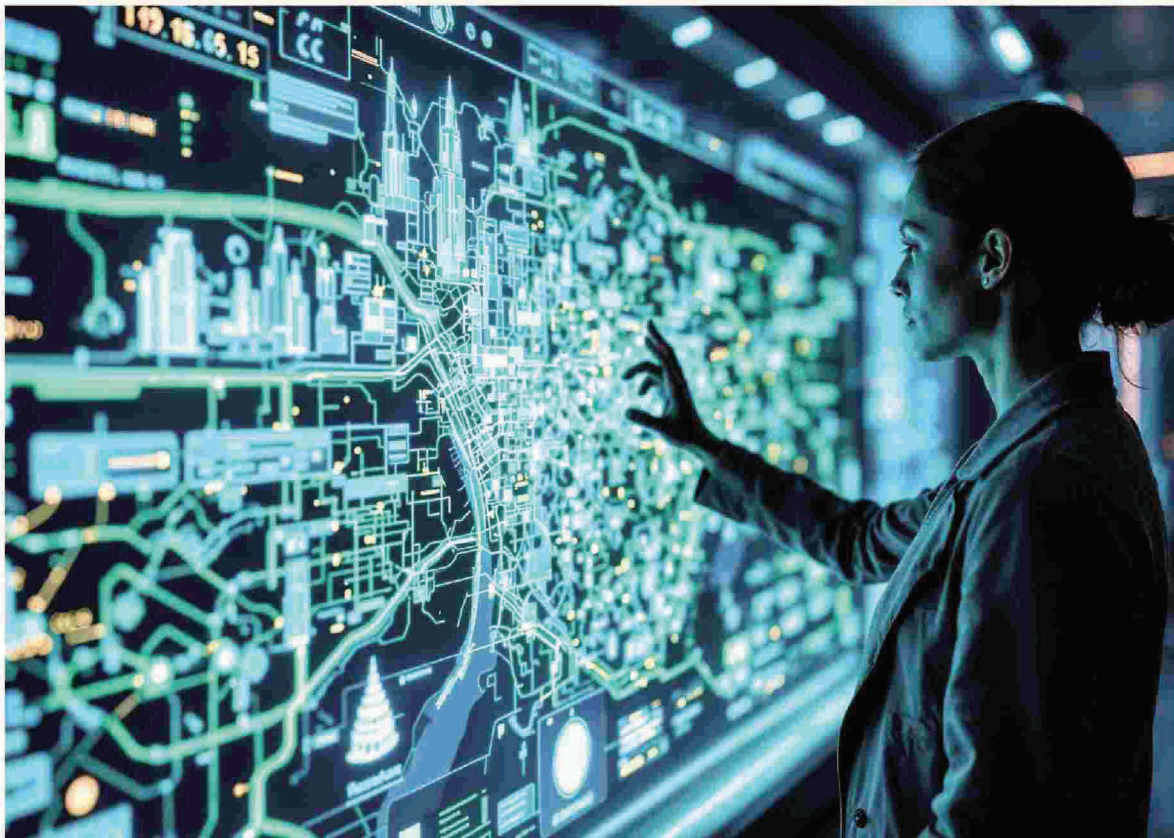
5. Customization and Personalization
In biomedical and consumer engineering, ML enables the design of personalized solutions—prosthetics, wearables, or even smart home systems—tailored to individual needs and behaviors, based on predictive analytics.

Real-World Examples

- Siemens and GE use ML in predictive maintenance to monitor turbines and engines in real time.
- Tesla and other EV companies use pre-

major bottlenecks.

- Model interpretability is critical in high-stakes applications (e.g., aerospace, healthcare).
- Engineers must be trained in data science and ML con-



cepts to effectively integrate them into workflows.

- Ethical concerns around bias and reliability in ML predictions must be addressed.

The Road Ahead

The synergy between engineering and machine learning is only beginning. As Big Data, IoT, and Cloud Computing continue to evolve, the potential for predictive engineering will expand further. Engineers of the future will not only design physical systems—they will also design the intelligent algorithms that govern them.

Investing in interdisciplinary education, developing explainable AI models, and creating robust data infrastructure are key to unlocking the full potential of predictive engineering.

Conclusion

Machine learning is no longer just a futuristic concept—it's a powerful ally in the engineering research process. Predictive engineering, driven by ML,

is shaping a smarter, more efficient, and more innovative future. As we embrace this transformation, engineering research will become not just reactive or descriptive, but truly predictive and prescriptive.

The author is a writer and blogger, and the founder of <https://thepengenius.com>, a platform dedicated to exploring ideas that inspire growth, creativity, and meaningful living. ■

Challenges and Considerations

While the benefits are profound, predictive engineering with ML is not without its challenges:

- Data quality and availability remain

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Fostering Biomedicpreneurship: Bridging Biomedical Engineering and Green Entrepreneurship

Engr. Dr. Muhammad Nawaz Iqbal

An emerging paradigm at the intersection of biomedical engineering and green entrepreneurship—biomedicpreneurship—addresses contemporary health care challenges with sustainable, scalable, and inclusive solutions.

As global healthcare changes, so does the demand for more innovative, greener medical technologies.

This confluence creates possibilities for developing a therapy that not only heals but also preserves nature's integrity. It is no longer an option to consider sustainability in biomedical engineering; it has become a prerequisite. Medical waste, an energy-intensive production process, and excessive use of non-biodegradable materials have caused significant harm to the environment. Green entrepreneurship provides a way forward for biomedical engineers by sharpening their focus on ecological balance and resource efficiency as they invent products with less environmental impact.

From biomedicpreneurship, a visionary fusion is emerged—the technicalism

in biomedical innovation and the environmental ethos at the same time. Neither selfish nor profit-oriented pursuit nor the drive for performance, the bio-medical entrepreneur also pursues an augmented positive environmental and social impact. The acknowledgment that the future of health care is; effectiveness will not be alone determining the future of health care, but sustainability and ethical responsibility as well. The entrepreneurial mindset involves thinking outside the box to solve biomedical problems, developing in an agile fashion, and innovating with commercial opportunities in mind. The infusion of the entrepreneurial spirit with sustainability yields a new generation of medical technologies: biodegradable implants, solar-powered diagnostic devices, and economically sustainable packaging for pharmaceuticals. The creations meet the pressing medical need while forever alleviating some ecological burden.

Biomedicpreneurship is emerging and thriving in startup ecosystems, research incubators, and innovation hubs of universities across the globe. Here, students and professionals alike team up with those from different disciplines to brainstorm and

prototyping of medical devices and health solutions engineered for technological soundness and environmental friendliness. Similarly, hackathons and innovation competitions are quickly becoming great breeding grounds for these projects. One of the biggest factors of success in this kind of entrepreneurship is systems thinking. Biomedicpreneurs should always think of any healthcare solution in the context of the larger social and economic and ecological systems in which it will be applied. This implies that any solution developed should take on board the realities of the world, such as waste management, energy use and supply chain ethics, in addition to therapeutic effectiveness.

It has become very important to apply life-cycle assessment in product design as a biomedicpreneurship strategy. The innovators from having LCA methodology get to see the life of a medical device from conception (harvesting raw materials) through production, use, and ultimately its disposal. This all-encompassing view aids in detecting and preventing imminent threats to sustainability at an early stage of the designing process. Biomedicpreneurs are highly motivated to

bring about affordable and sustainable healthcare in the underprivileged regions. They are in a unique position to develop frugal innovations—medical technologies, which are low-cost, durable, and easy to maintain, tailored to the needs of underserved populations while at the same time conserving resources. The pivot towards social equity and ecological sustainability gives biomedicpreneurship a unique flavor as compared to traditional entrepreneurship.

Growth of biomedicpreneurial ventures requires tailored policy support and funding mechanisms. Governments, philanthropic institutions, and impact investors can all serve as important catalysts in enabling these enterprises to scale. Some forms of funding and incentives have grants, tax incentives, and sustainability-linked funding, which lower barriers for entry into eco-conscious biomedical startups. Institutions of higher learning must embrace the interdisciplinary trend by offering courses and programs that knit together the fabric of biomedical engineering, sustainability science, entrepreneurship, and design thinking. These changes in education can prepare tomorrow's innovators with the mindset

and toolbox to navigate this complex yet promising landscape. Industry collaboration has a great promise for biomedicpreneurship. Established biomedical firms can incubate or partner with startups that innovate sustainably. This promotes corporate social responsibility and ensures the competitiveness of these large firms in an environmental market. Digital technologies such as AI, 3D printing, and IoT act as vital enablers on this journey. They can be utilized for efficiency optimization of biomedical devices, minimize material waste, and maximize recyclability. Take, for example, 3D-printed prosthetics using biodegradable substances, the beautiful marriage of technology, medicine, and sustainability.

The transformation of hospital operations offers a huge potential in biomedicpreneurship. Entrepreneurs can create systems for environmental infrastructure for healthcare facilities, including renewable energy systems, sustainable water use, and zero-waste management models. Such solutions can enable healthcare systems to reduce their carbon footprint while improving patient care. Such ethical dimensions make it an all-encompassing philosophy in biomedicpreneur-



ship. The "do no harm" maxim applies to the environment as well as to the patient. It thus engenders openness, encourages equitable accessibility to innovations, and embeds long-term thinking into the decision-making process. At the same time, it challenges one to see sustainability not as a constraint but as a compass. Ultimately, it is to promote biomedicentrepreneurship to change the future of healthcare into one that is innovative, inclusive, and eco-friendly. It is a clarion call for biomedical engineers, entrepreneurs, educators, and policymakers to come together and co-construct solutions to some of today's most urgent health and environmental issues. The journey may be hard, but the promise of a healthier planet and people certainly makes it worthwhile. ■

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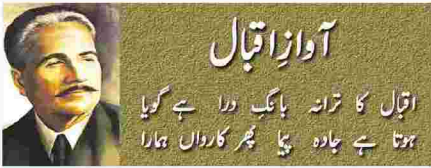
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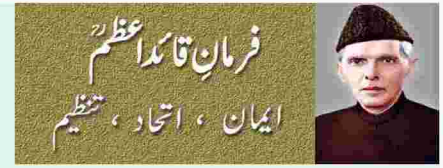


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Supernet Partners with Reko Diq Mining Company to Boost Connectivity in Balochistan

Supernet Limited has announced a strategic partnership with Reko Diq Mining Company to provide advanced internet and communication infrastructure at the Reko Diq Copper and Gold Mine, located in the remote and resource-rich region of Balochistan.

In a statement issued in accordance with Section 96 and 131 of the Securities Act, 2015 and Clause 5.6.1(a) of the Rule Book of Pakistan Stock Exchange Limited (PSX), the company highlighted the importance of the collaboration in strengthening digital connectivity for one of Pakistan's most significant mining ventures.

The initiative aims to deliver robust, secure, and scalable communication solutions to ensure uninterrupted operations in the geographically challenging terrain of Reko Diq.



"This partnership underscores Supernet Limited's unwavering commitment to empowering Pakistan's strategic sectors with world-class technology," said Zia Tariq, Head of Sales – Defense at Supernet Limited.

"Reko Diq is a project of national importance, and we are proud to contribute by enabling connectivity in one of the remotest regions of Balochistan. Our solutions will support safe, efficient, and sustainable mining operations."

Reko Diq Mining Company is developing one of the largest untapped copper and gold deposits in the world. Given the site's remote location, a reliable

and secure communication infrastructure is essential to ensure operational integrity and the project's overall success.

Supernet's integrated services will facilitate real-time operational coordination, strengthen safety and security systems, and streamline administrative communications, supporting long-term efficiency and growth at the site.

With over three decades of experience, Supernet Limited is a leading communication infrastructure and technology solutions provider across Pakistan. The company offers a wide range of services, including end-to-end connectivity, cybersecurity, and managed services for defense, telecom, enterprise, and government sectors nationwide. - ER Report

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Sales Blog for Young Engineers and Entrepreneurs

The key elements in closing sales at various levels of the organization

Muhammad Tariq Haq | ESL

Selling diesel; gas and renewable solutions or any other high value machinery or equipment at higher organizational levels requires a strategic approach tailored to each role's priorities and concerns.

Here are some key elements to consider:

1. Understanding Needs and Pain Points:
 - Foreman: Stresses speed of response;

2. Customized Solutions:
 - Offer tailored solutions that meet the specific needs of the organization. Highlight customization options and flexibility.

3. Value Proposition:
 - Clearly communicate the unique value your generators provide, such as superior technology, durability, and after-sales support.

4. Case Studies and Testimonials / Proof of Performance:
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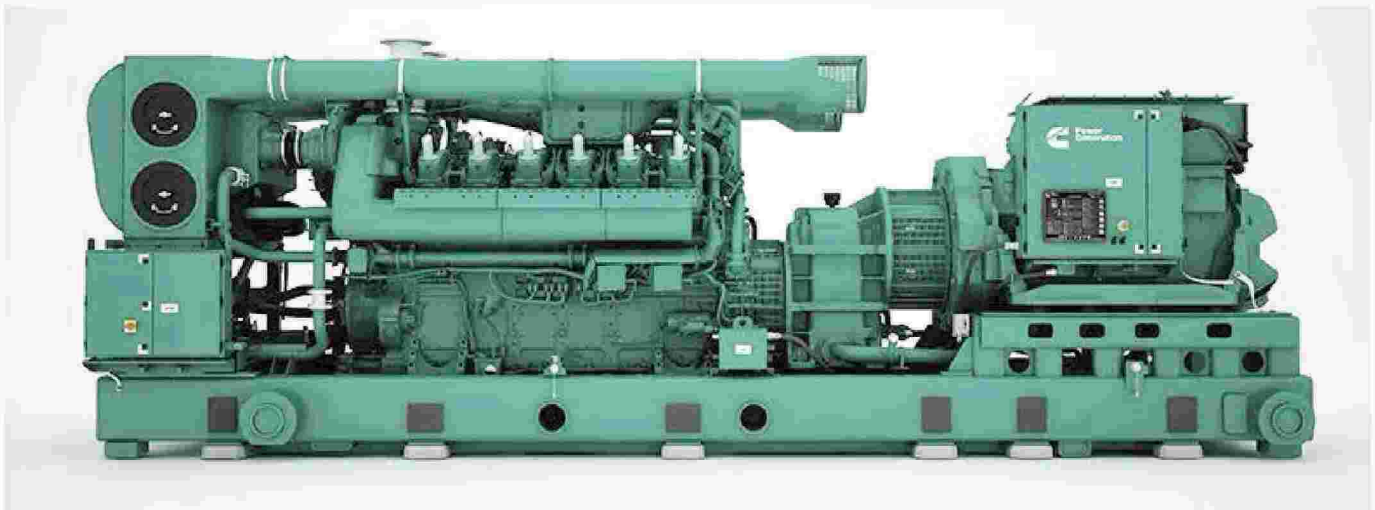
ing their individual and organizational goals.

9. Competitive Analysis:
 - Provide a comparison with competitors, highlighting your differential advantage.

10. Local Market Knowledge:
 - Demonstrate understanding of local market, challenges, and opportunities.

In the above narration, some terms need further elaboration. They are:

1. Scalability:
 - In the context of generators, it means the capacity to support power requirements



integration with existing plant and machinery, training facilities etc

- Plant Engineers: Emphasize technical reliability, ease of integration with existing systems, learning curve advantages; local service availability; MTTR, MTBF etc.
- Directors: Emphasize operational efficiency, scalability, and how the generator aligns with the company's long-term goals.
- CFOs: Present a clear ROI, cost savings, financing options and total cost of ownership.
- CEOs and Chairmen: Align the generator's benefits with the company's strategic vision, sustainability goals, and market competitiveness.

tomers in similar industries or regions.

5. Regulatory Compliance and Sustainability:
 - Discuss compliance with local regulations and environmental standards.

6. Risk Mitigation:
 - Address potential risks and how your solution mitigates them, such as power reliability and backup capabilities.

7. Demonstrations and Trials:
 - Offer demonstrations or trial periods to showcase the generator's performance and reliability in real-world conditions.

8. Strong Relationship Building:
 - Develop trust and truthful relationships with decision-makers by understand-

as a business expands.

2. Sustainability Goals:
 - When selling generators, emphasizing their low emissions, fuel efficiency, or renewable energy compatibility can align with a company's goals to promote eco friendly practices.

3. Customization Options:
 - For generators, this could mean offering different configurations, power outputs, or features that match the unique requirements of a particular business or industry. Customization ensures that the solution is precisely suited to the customer's operational needs e.g data center compliant generators etc ■

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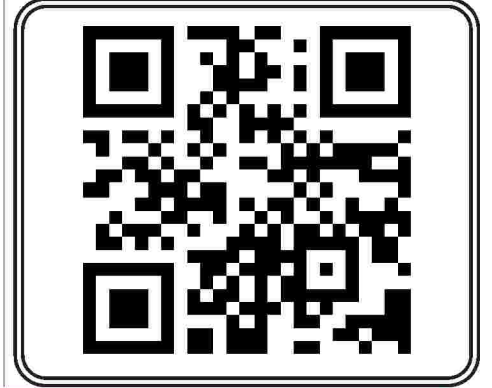
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31 جنوری کو شادہرہ پل پر شاہیہ راکھ پھریس کو حادثہ پیش آیا، جس میں ٹرین کی 3 بوگیاں شادہرہ پل سے ڈی ریل ہوئیں۔ اسی طرح 18 فروری کو مظہرہ کینال برج پر مال گاڑی کی ایک کوچ پٹری سے اتری۔

علاوہ ازیں 20 فروری کو بھی کوٹ رادھا کشن میں مال گاڑی کو حادثہ پیش آیا اور 2 بوگیاں پٹری سے اتر گئیں۔ بعد ازاں 22 فروری کو اوکاڑہ میں مال گاڑی کو افسوسناک حادثہ پیش آیا، جس میں 5 سے زائد بوگیاں پٹری سے اتر گئیں اور مال گاڑی کا انجن ٹریک سے ملحقہ مین روڈ پر پھنچ گیا۔

ریلوے ذرائع کا کہنا ہے کہ انتظامی نااہلی اور باقاعدہ انسپکشن نہ ہونے کے باعث ٹرین حادثات میں اضافہ ہو رہا ہے۔ درج بالا چاروں حادثات میں کسی متعلقہ آفیسر کو سزا نہیں ہوئی اور ریلوے انتظامیہ نے حادثات کا سارا ملہ ٹرین ڈرائیور ہی پر ڈال دیا۔ ذرائع کا کہنا ہے کہ لاہور پیلوے ٹریک خستہ حالی کا شکار ہے۔

مصنوعی ذہانت کا ایک بہترین کورس ڈیزائن کیا ہے جسے جلد ہی لانچ کیا جائے گا، چیئر مین ہائر ایجوکیشن کمیشن سرسید یونیورسٹی کو فنڈ نہیں ملتے، آرٹیفیشل انٹیلی جنس کے کورسز کے لیے نئی لیبارٹریز درکار ہیں، چانسلر اکبر علی ہوں، وہ تو میں ترقی نہیں کر سکتیں پاکستان خوش قسمت ملک ہے جس کی آبادی کا کثیر حصہ نوجوانوں پر مشتمل ہے، جاپان کو 8 لاکھ انجینئرز چاہئیں، ہمیں ہنرمند نوجوان تیار کرنا ہونگے، سرسید یونیورسٹی کو ٹیکنالوجی کورسز پر توجہ مرکوز کرنی چاہیے، ہم نے پرنس اکوٹیشن سینٹرز اور شعبہ اورک قائم کرنے کی ہدایات جاری کیں تاکہ تحقیق اور انوویشن کو فروغ دیا جاسکے ہم نے مصنوعی ذہانت کا ایک بہترین کورس ڈیزائن کیا ہے جسے جلد ہی لانچ کیا جائے گا، سرسید احمد خان نے اسکول قائم کرنے سے آغاز کیا اور پھر علی گڑھ مسلم یونیورسٹی کی بنیاد ڈالی جو ایک بہت بڑا کام تھا اور آج ہم ہندو بننے کے پاس ملازمت کر رہے ہوتے، کتنا بڑا المیہ ہے کہ اگلے چالیس سال اس قوم کے فیصلے وہ لوگ کریں گے جو جانتے بھی نہیں کہ ان کی ذمہ داریاں کیا۔

سرسید یونیورسٹی کے چانسلر اکبر علی خان نے کہا کہ سرسید یونیورسٹی ایک پرائیوٹ یونیورسٹی ہے جسے گورنمنٹ کی طرف سے کوئی فنڈ نہیں ملتا، آرٹیفیشل انٹیلی جنس کے کورسز کے لیے نئی لیبارٹریز درکار ہیں، ایک نیا انفراسٹرکچر چاہیے جس کے لیے ہمیں فنڈز کی ضرورت ہے، فنڈز کی عدم فراہمی کے باعث ہمارے پی ایچ ڈی اساتذہ، ریسرچ کرنے کی بجائے تدریسی فرائض انجام دینے پر مجبور ہیں، ایچ ای سی کی سپورٹ اور تمام اسٹیک ہولڈرز کے تعاون سے مجھے یقین ہے کہ ہم ایک ایسا تعلیمی نظام تشکیل دے سکتے ہیں جو ہمارے نوجوانوں کو بااختیار بنائے اور پاکستان کو علم اور اختراع میں ایک رہنما کے طور پر کھڑا کر سکے۔ پروفیسر ڈاکٹر محمد عامر نے اس موقع پر سرسید یونیورسٹی کے بارے میں ایک مملواتی پریزنٹیشن دی۔

سرسید یونیورسٹی آف انجینئرنگ اینڈ ٹیکنالوجی کے زیر اہتمام ہائر ایجوکیشن کمیشن کے چیئر مین پروفیسر ڈاکٹر مختار احمد کے اعزاز میں استقبال دیا گیا، سرسید یونیورسٹی کے چانسلر اکبر علی خان نے مہمان خصوصی کا استقبال اور یونیورسٹی آف پرنس کا شکریہ ادا کیا، شہر کا میونسپل کونسلر پروفیسر ڈاکٹر سید جعفر نذیر عثمانی، رجسٹرار کوڈور (ر) سید سرفراز علی، ایچ ای سی کے ڈائریکٹر جنرل نذیر حسین، پروفیسر ڈاکٹر محمد عامر، پروفیسر ڈاکٹر میر شہر علی، ڈاکٹر محمد مہمل، نسیم احمد، ڈاکٹر ابراہیم الحق، ڈاکٹر طاہر القادری، ڈاکٹر کاشف شیخ، ڈاکٹر راجہ انعام، ڈاکٹر صہیب، واصف نذر صدیقی دیگر شامل تھے۔

چیئر مین ہائر ایجوکیشن کمیشن پروفیسر ڈاکٹر مختار احمد نے خطاب کرتے ہوئے کہا کہ جس قوم کے امام اور استاد کرپٹ

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چین کا 400 کلومیٹر طویل، 5 کلومیٹر چوڑا سولر فارم ہاؤس

ایک لاکھ میگا واٹ بجلی پیدا ہوگی، 54 ہزار میگا واٹ کے پینل لگ چکے کو بوجی صحرا میں زیر تعمیر سولر فارم اگلے پانچ سال میں مکمل ہوگا

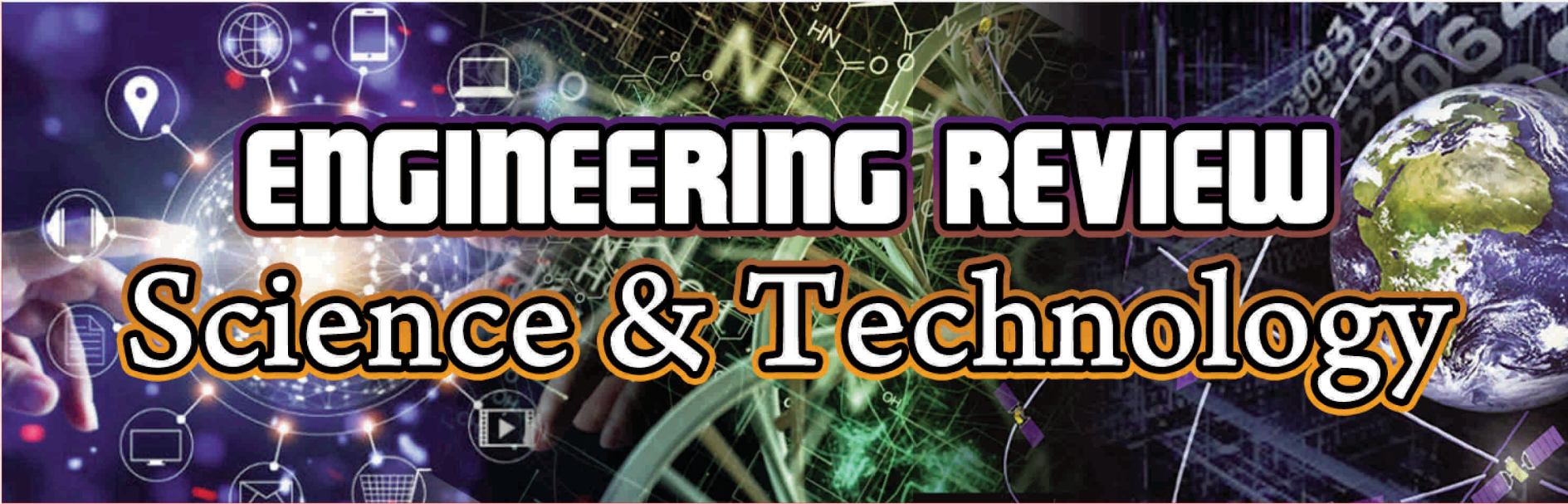
پاکستان 0.071 فیصد رقبہ پر سولر پینل لگا کر 40 ہزار MW بجلی بنا سکتا، ماہرین

چین میں گریٹ وال، کے بعد ایک اور عجوبہ زیر تکمیل ہے جو چار سو کلومیٹر طویل اور پانچ کلومیٹر چوڑا سولر فارم ہاؤس ہے۔ چین کے صحرا کو بوجی میں تبدیل کے بعد اس سولر فارم ہاؤس سے ایک لاکھ میگا واٹ بجلی پیدا ہوگی۔

فارم دو کروڑ سے زائد آبادی والے دارالحکومت بیجنگ کو بجلی فراہم کی جائے گا۔ اعداد و شمار کے مطابق پاکستان جو کہ چینی ساختہ سولر پینل کی تیسری بڑی منڈی ہے، یہاں گزشتہ دو سال کے دوران 20 ہزار میگا واٹ سے زائد بجلی حاصل کر سکتا ہے، ہم چین سے سبق سیکھتے ہوئے تھر، چولستان اور خاران کے صحراؤں میں بڑے سولر فارم بنائیں تو بجلی کی ملکی ضرورت پوری کرنے کے علاوہ ماحول دشمن فوسل فیلڈ سے بھی جان چھوٹ جائے گی۔

میگا واٹ سے زائد بجلی پیدا کر نیوالے سولر پینل لگ چکے، تاہم سرکاری سطح پر بجلی گیس، کوئلے سے بن رہی ہے جو کہ بجلی ہونے کے علاوہ ماحول دوست نہیں۔ ماہرین کے مطابق پاکستان صرف 0.071 فیصد رقبہ پر سولر پینل لگا کر 40 ہزار

تفصیلات کے مطابق صحرائے کو بوجی کا سولر فارم تکمیل کے بعد 400 کلومیٹر طویل اور 5 کلومیٹر چوڑا ہوگا، یہاں لاکھوں پینل لگائے جا رہے ہیں، اب تک 5400 میگا واٹ بجلی پیدا کر نیوالے سولر پینل لگ چکے، باقی اگلے پانچ سال میں لگا دیئے جائیں گے، اس سولر



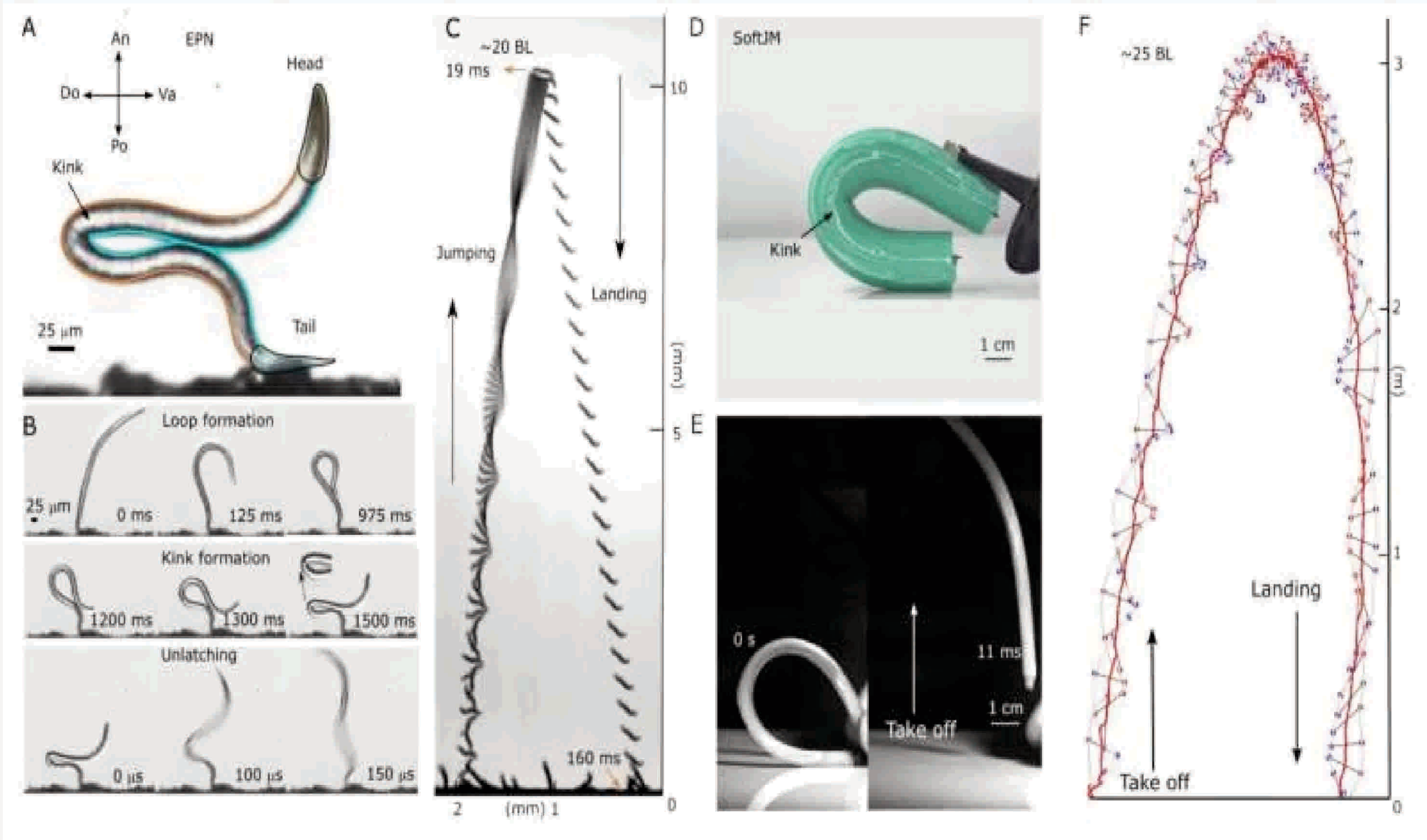
Engineers create a robot that can jump 10 feet high—without legs

Inspired by the movements of a tiny parasitic worm, Georgia Tech engineers have created a 5-inch soft robot that can jump as high as a basketball hoop. Their device, a silicone rod with a carbon-fiber spine, can leap 10 feet high even though it doesn't have legs. The researchers made it after watching high-speed video of nematodes pinching themselves into odd shapes to fling

their body length. That's like me lying down and somehow leaping onto a three-story building." Nematodes, also known as round worms, are among the most abundant creatures on Earth. They live in the environment and within humans, insects, and animals. They can cause illnesses in their host, which sometimes can be beneficial. For instance, farmers and gardeners use nematodes instead of pesticides to kill invasive insects and protect plants.

stored energy in its contorted shape to propel backward, end over end, just like a gymnast doing a backflip. To jump forward, the worm points its head straight and creates a kink on the opposite end of its body, pointed high in the air. The stance is similar to someone preparing for a standing broad jump. But instead of hopping straight, the worm catapults upward. "Changing their center of mass allows these creatures to control which way they jump. We're not aware of any

team created simulations of the jumping nematodes. Then they built soft robots to replicate the leaping worms' behavior, later reinforcing them with carbon fibers to accelerate the jumps. Kumar and Tiwari work in Associate Professor Saad Bhamla's lab. They collaborated on the project with Oretaga-Jimenez and researchers at the University of California, Riverside. The group found that the kinks allow nematodes to store more energy with each jump. They rapidly release



themselves forward and backward. The researchers describe the soft robot in Science Robotics. They said their findings could help develop robots capable of jumping across various terrain, at different heights, in multiple directions. "Nematodes are amazing creatures with bodies thinner than a human hair," said Sunny Kumar, lead co-author of the paper and a postdoctoral researcher in the School of Chemical and Biomolecular Engineering (ChBE). "They don't have legs but can jump up to 20 times

One way they latch onto their host before entering their bodies is by jumping. Using high-speed cameras, Victor Oretaga-Jimenez—a former Georgia Tech research scientist who's now a faculty member at the University of California, Berkeley—watched the creatures bend their bodies into different shapes based on where they wanted to go. To hop backward, nematodes point their head up while tightening the mid-point of their body to create a kink. The shape is similar to a person in a squat position. From there, the worm uses

other organism at this tiny scale that can efficiently leap in both directions at the same height," Kumar said. And they do it despite nearly tying their bodies into a knot. "Kinks are typically dealbreakers," said Ishant Tiwari, a ChBE postdoctoral fellow and lead co-author of the study. "Kinked blood vessels can lead to strokes. Kinked straws are worthless. Kinked hoses cut off water. But a kinked nematode stores energy that is used to propel itself in the air." After watching their videos, the

it—in a tenth of a millisecond—to leap, and they're tough enough to repeat the process multiple times. The study suggests that engineers could create simple elastic systems made of carbon fiber or other materials that could withstand and exploit kinks to hop across various terrain. "A jumping robot was recently launched to the moon, and other leaping robots are being created to help with search and rescue missions, where they have to traverse unpredictable terrain and obstacles," Kumar said. -- TX

Sponge-like carbon nanotube thermoelectric generator easily molds to complex shapes and powers sensors

A Korean research team has developed a novel thermoelectric material and generator (TEG) that leverages sponge-like carbon nanotube (CNT) structures, improving the limitations of organic thermoelectric materials while retaining flexibility.

The resulting device is expected to be useful in powering small-scale wearable sensors through thermal energy harvesting.

The research is published in the journal Carbon Energy.

Led by Drs. Mijeong Han and Young Hun Kang at the Korea Research Institute of Chemical Technology (KRICT), the team combined carbon nanotubes with Bi_{0.45}Sb_{1.55}Te₃ (BST) in a porous foam structure to maximize thermoelectric performance.

While conventional thermoelectric materials are typically metal-based and rigid, the use of CNTs allows for light weight and mechanical flexibility—although previous attempts have resulted in

low thermoelectric performance and poor durability.

To overcome these challenges, the team developed a proprietary fabrication tech-

to create a sponge-like structure.

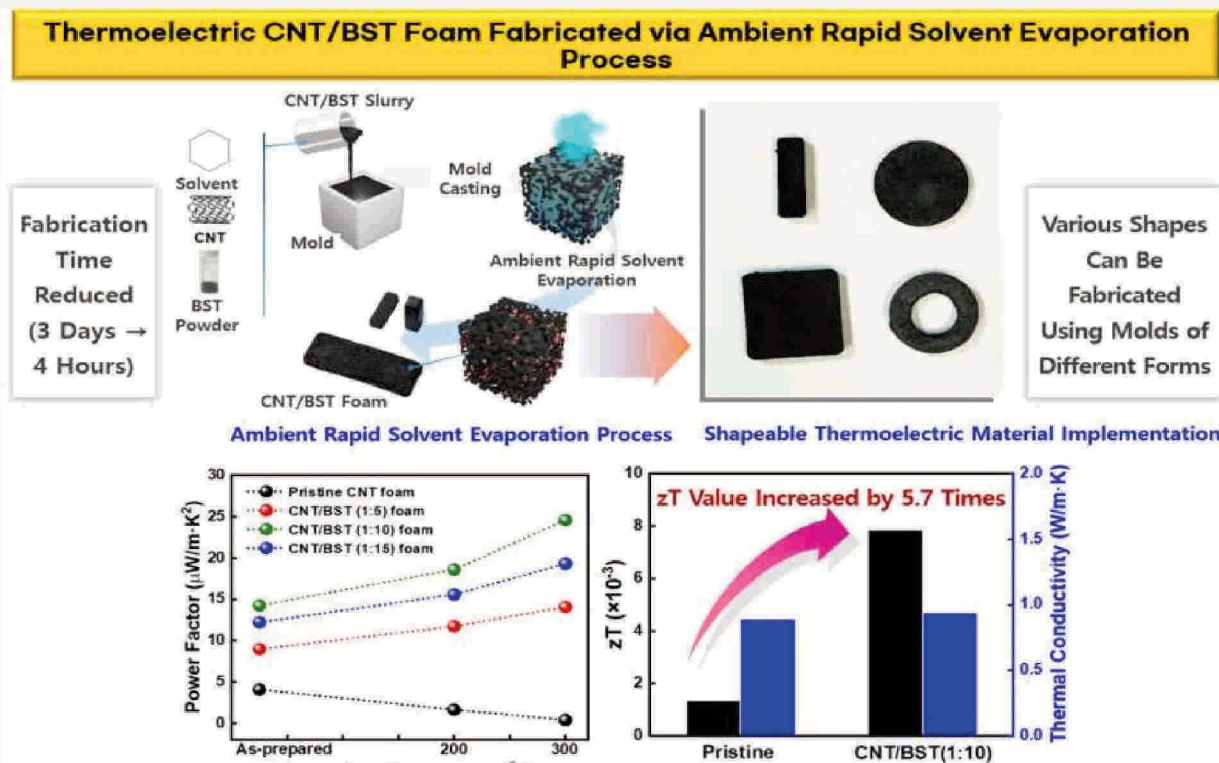
A method was also developed to uniformly distribute the thermoelectric BST particles within the foam's pores, improving

a zT of 7.8×10^{-3} —5.7 times higher than that of pristine CNT foam. When applied to a flexible thermoelectric generator and tested on a glass tube at a temperature difference of 21.8 K, the device generated output power of 15.7 μ W—enough to operate wearable sensors.

Durability was confirmed through 10,000-cycle bending tests, with minimal performance loss. Moreover, the entire fabrication process takes just four hours, compared to over three days for traditional CNT-based TEGs, highlighting the material's excellent scalability.

The team plans to further enhance thermoelectric efficiency through doping strategies and aims for commercialization by 2030. Future applications include integration into thermal management systems for batteries and AI data centers, as well as wearable and autonomous electronic devices.

"This study represents a significant step forward in developing flexible, self-powered devices," said the researchers, adding that the material's moldability and durability open new frontiers in energy harvesting. — TX



nique that transforms CNTs into bulk foams rather than thin films. This was achieved by heating and solidifying a powder-filled mold

both mechanical stability and thermoelectric performance.

As a result, the CNT/BST foam achieved

researchers, adding that the material's moldability and durability open new frontiers in energy harvesting. — TX

A new shape for energy storage: Cone and disc carbon structures offer new pathways for sodium-ion batteries

As global demand for electric vehicles and renewable energy storage surges, so does the need for affordable and sustainable battery technologies.

A new study has introduced an innovative solution that could impact electrochemical energy storage technologies.

The research is published in the journal Advanced Functional Materials. The work was led by researchers from the Department of Materials Science and Nano-Engineering at Rice University, along with collaborators from Baylor University and the Indian Institute of Science Education and Research Thiruvananthapuram.

Using an oil and gas industry's byproduct, the team worked with uniquely shaped carbon materials—tiny cones and discs—with a pure graphitic structure. These unusual forms produced via scalable pyrolysis of hydrocarbons could help address a long-standing challenge for anodes in battery research: how to store energy with elements like sodium and potassium, which are far cheaper and more widely available than lithium.

"For years, we've known that sodium and potassium are attractive alternatives to lithium," said corresponding

author Pulickel Ajayan, the Benjamin M. and Mary Greenwood Anderson Professor of Engineering at Rice. "But the challenge has always been finding carbon-based anode materials that can store these larger ions efficiently."

Breaking the graphite

interactions too complex to slide in and out of graphite's tightly packed layers.

But by rethinking the shape of carbon at the microscopic level, the team found a workaround. The cone and disc structures offer curvature and spacing that welcome sodium and potassium

"We were surprised to see just how well these pure, curved graphitic structures performed," said first author Atin Pramanik, a postdoctoral associate in Ajayan's lab. "Even without heteroatoms, they allowed for reversible intercalation of sodium ions and did so

using sodium ions, and they still held 151 mAh/g even after 2,000 fast charging cycles. They also worked well with potassium-ion batteries, but the performance wasn't quite as strong as with sodium.

Advanced imaging techniques like cryogenic trans-

charge cycles.

"This is one of the first clear demonstrations of sodium-ion intercalation in pure graphitic materials with such stability," Pramanik said. "It challenges the belief that pure graphite can't work with sodium."

The implications are wide-ranging. Not only does this pave the way for more affordable sodium-ion batteries, but it also reduces reliance on lithium, which is becoming more expensive and geopolitically complicated to source. Because the cone/disc carbon can be synthesized from oil and gas industry byproducts, it also presents a more sustainable route for battery anode production.

A turning point for battery design

While most research in this area has focused on hard carbons or doped materials, the new study marks a pivot in strategy—emphasizing morphology over chemical modification.

"We believe this discovery opens up a new design space for battery anodes," Ajayan said. "Instead of changing the chemistry, we're changing the shape, and that's proving to be just as interesting."

"We're not just developing a better battery material," Pramanik said. "We're offering a real pathway to energy storage that's cleaner, cheaper and more widely available to all." — TX



barrier

Traditional lithium-ion batteries rely on graphite as an anode material. However, the same graphite structure fails when it comes to sodium or potassium. Their atoms are simply too big and

ions without the need for chemical doping (the process of intentionally adding small amounts of specific atoms or molecules to change their properties) or other artificial modifications.

with minimal structural stress."

Durable, scalable and green

In lab tests, the carbon cones and discs stored about 230 milliamp-hours of charge per gram (mAh/g)

mission electron microscopy and solid-state nuclear magnetic resonance confirmed that ions were entering and exiting the carbon structure as expected and that the material held its shape over thousands of charge-dis-