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Research Bulletin

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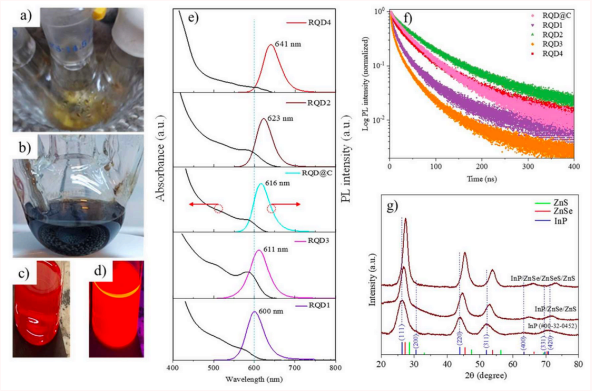
January 2026 Publications

LIGHT-SENSITIVE NOVEL SENSORS DEVELOPED USING ECO-FRIENDLY QUANTUM DOTS

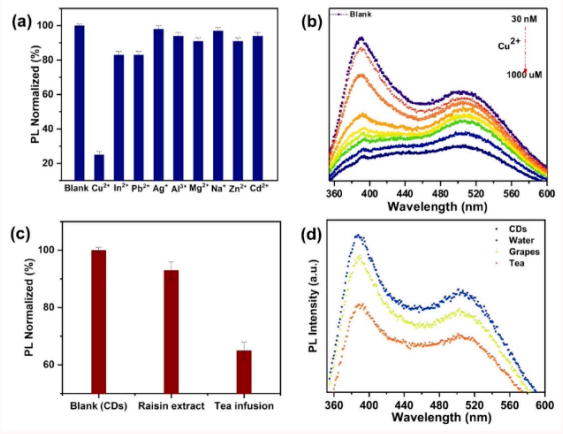
In this study, a novel light sensor was developed using indium phosphide (InP)-based quantum dots that do not contain harmful heavy metals. Thanks to a specially designed multilayer structure, the stability and light-emission properties of these nanomaterials were significantly enhanced. The resulting quantum dots were integrated into detector devices using a simple fabrication approach and exhibited high sensitivity to visible light. The study demonstrates that this approach is promising for the development of safer and more sustainable optoelectronic technologies.



Akrema, E., Erol, E., Savaş, M., Yazıcı, A. F., Erdem, T., & Mutlugün, E. (2026). Colloidal Photodetectors Based on Engineered Multishelled InP Based Quantum Dots. *Nano Express, 7*(1), Article 015004. https://doi.org/10.1088/2632-959X/ae2afa

A SENSITIVE AND SELECTIVE COPPER ION SENSOR DEVELOPED USING CARBON DOTS

A highly sensitive copper ion (Cu^{2+}) sensor was developed using environmentally friendly carbon dots (CDs). Green-emitting CDs were synthesized within one hour via a vacuum-assisted method using citric acid and urea, achieving a detection limit of 26 nM for Cu^{2+} in aqueous solution. Among the tested metal ions, Cu^{2+} exhibited the strongest photoluminescence quenching effect. Time-resolved measurements revealed a mixed quenching mechanism. The applicability of the sensor was successfully validated in raisin extract and brewed tea samples.



Sahin-Tiras, K., Karabel Ocal, S., & Mutlugün, E. (2026). Photoluminescent Carbon Dots for Sensitive and Selective Cu2+ Ion Detection. *Nano Express, 7*(1), Article 015003. https://doi.org/10.1088/2632-959X/ae263d

MACHINE LEARNING–BASED SMART THERMOSTAT CONTROL ENHANCES ENERGY EFFICIENCY

A machine learning–based smart thermostat control system was developed for residential heating and cooling applications. Optimal deadband values were generated using mixed-integer linear programming, and a machine learning model was trained accordingly. By modeling thermostat hysteresis behavior, a real-time decision policy was established. Among six evaluated models, Random Forest achieved the best performance with an accuracy of 95.75%. Tested using Kayseri 2024 weather data, the system delivered energy savings of up to 18%. The proposed approach offers a practical solution for grid-aware flexible demand management.

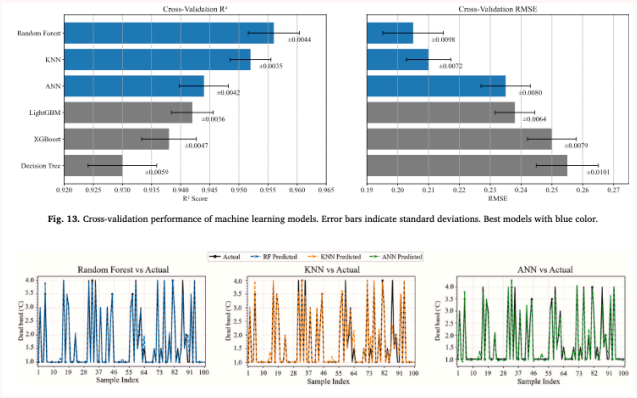
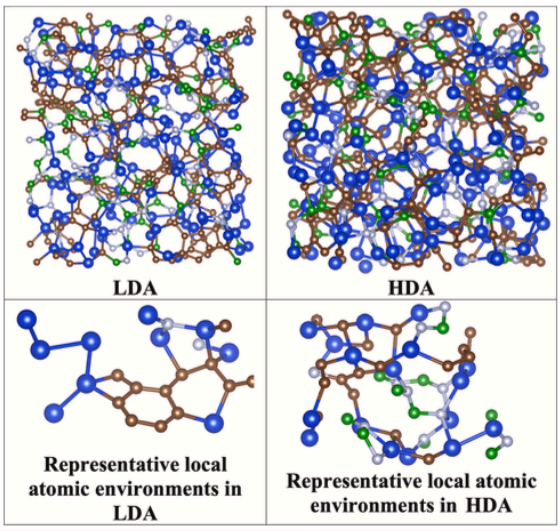


Fig. 13. Cross-validation performance of machine learning models. Error bars indicate standard deviations. Best models with blue color.

Savasci, A., Ceylan, O., & Paudyal, S. (2026). Supervised Learning-Driven Dead Band Control of Occupant Thermostats for Energy-Efficient Residential HVAC. *Sustainable Energy, Grids and Networks, 45*, Article 102110. https://doi.org/10.1016/j.segan.2025.102110

MECHANICAL STRENGTH ENHANCED THROUGH DENSIFICATION IN AMORPHOUS SILICON BORON CARBONITRIDE

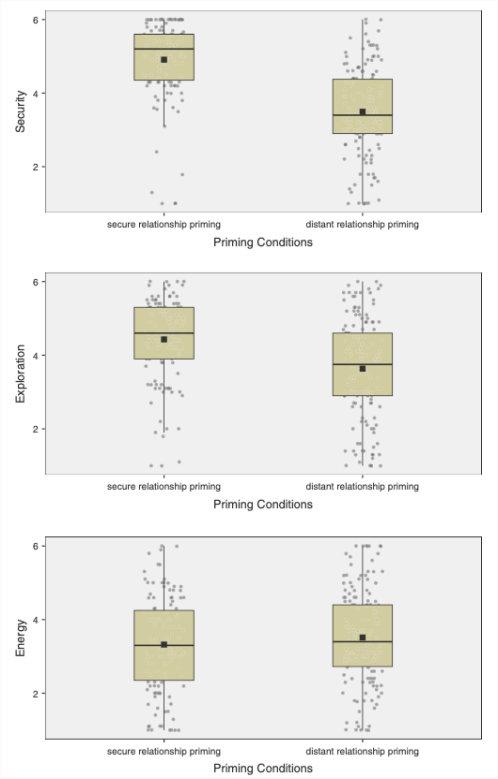


The effect of density on the mechanical properties of amorphous silicon–boron–carbonitride (Si_2BC_3N) was investigated using computer simulations. Low-density (2.20 g/cm³) and high-density (2.53 g/cm³) structures were generated. With densification, the number of interatomic hetero-bonds increased, while carbon–carbon and silicon–silicon bonds decreased. In the high-density phase, a 48% increase in bulk modulus (130 GPa) was achieved, along with a Young's modulus of 266 GPa and a shear modulus of 112 GPa. The results show that densification suppresses weak bonds and promotes the formation of a robust network structure. These findings provide guidance for the design of durable ceramics suitable for extreme environments.

Durandurdu, M. (2026). Densification-Induced Chemical Reorganization and Mechanical Enhancement in Amorphous Si_2BC_3N. *Journal of Non-Crystalline Solids, 675*, Article 123936. https://doi.org/10.1016/j.jnoncrysol.2025.123936

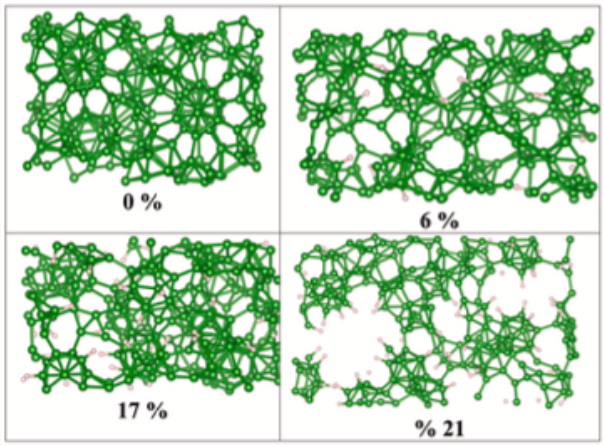
FINDINGS CONFIRM ONCE AGAIN THAT SECURE RELATIONSHIPS ENERGIZE PEOPLE

In this study, the relationship between secure romantic relationships and individuals' feelings of vitality was re-examined. A previously published study was directly replicated using the same methods. The findings showed that individuals with a perception of secure attachment consistently felt more energetic and motivated in their daily lives. The results support the role of interpersonal relationships in psychological well-being. Overall, the findings indicate that close relationships are linked not only to emotional experiences but also to individuals' general sense of life energy.



Lağap, A. C., & Harma, M. (2026). Does Your Love Lift Me Higher? A Direct Replication of the Energising Role of Secure Relationships. *International Journal of Psychology, 61*(1), Article e70144. https://doi.org/10.1002/ijop.70144

TUNABLE ELECTRONIC AND MECHANICAL PROPERTIES IN AMORPHOUS BORON VIA HYDROGEN INCORPORATION



In this study, the effects of hydrogen incorporation on the properties of amorphous boron materials were investigated using computer-aided calculations. The structure, mechanical strength, and electrical behavior of boron were evaluated simultaneously at different hydrogen concentrations. As the hydrogen content increased, the density and hardness of the material decreased, while its semiconducting properties were enhanced. The results demonstrate that the properties of boron-based materials can be tuned in a controlled manner. The study highlights that this approach may provide valuable guidance for advanced materials and energy-related applications.

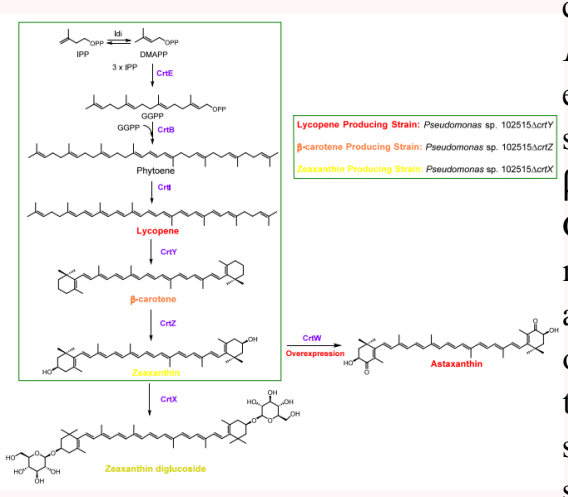
Durandurdu, M. (2026). Tuning Properties of Amorphous Boron via Hydrogenation: An Ab Initio Study. *Journal of Non-Crystalline Solids, 673,* Article 123874. https://doi.org/10.1016/j.jnoncrysol.2025.123874

THE STRENGTH OF ENVIRONMENTALLY FRIENDLY CONCRETE COLUMNS WAS COMPARED IN DETAIL

In this study, the behavior of geopolymer concrete columns was numerically investigated using the finite element method and compared with experimental results. The effects of different eccentricities, reinforcement ratios, curing methods, and activator solution ratios were examined. According to the numerical results, geopolymer concrete columns exhibited 7% higher moment capacity and 30% greater curvature values compared to Portland cement concrete columns. In addition, they were found to have higher energy dissipation capacity. It was also determined that the ACI 318 and Eurocode 2 design codes can be applied to geopolymer concrete columns.

Özbayrak, A., Kucukgoncu, H., Aslanbay, H. H., Aslanbay, Y. G., & Altun, F. (2026). Numerical Analysis and Experimental Comparison of Stress and Stiffness Parameters of Steel Reinforced Geopolymer Concrete Columns. *Composite Structures, 376,* Article 119833. https://doi.org/10.1016/j.compstruct.2025.119833

NATURAL FOOD COLORANTS PRODUCED FROM AN ENDOPHYTIC BACTERIUM USING CRISPR

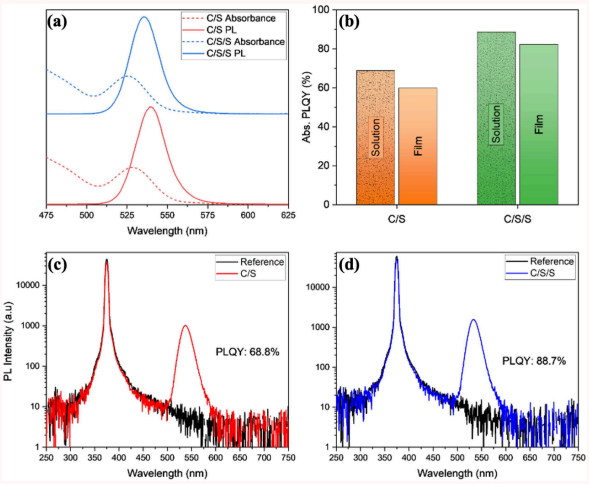


To enable the sustainable production of high-value carotenoids, the endophytic bacterium *Pseudomonas loganensis* sp. nov. was genetically engineered. Using CRISPR-Cas9 technology, strains capable of producing zeaxanthin, lycopene, β-carotene, and astaxanthin were developed. Culture conditions were optimized through response surface methodology, resulting in approximately a fivefold increase in the production of zeaxanthin, lycopene, and β-carotene, and a twelvefold increase in astaxanthin production. This study demonstrates that endophytic bacteria can serve as effective microbial platforms for the production of natural food colorants.

Arslansoy, N., Karaman, M. Z., & Fidan, O. (2026). CRISPR/Cas9-mediated metabolic engineering of endophytic Pseudomonas loganensis sp. nov. for the production of nutritionally valuable carotenoids. *ACS Omega, 11*(1), 535–551. https://doi.org/10.1021/acsomega.5c05877

EFFICIENCY IMPROVEMENT ACHIEVED IN QUANTUM DOT LEDS WITH A NOVEL SHELL STRUCTURE

A new synthesis method was developed to enhance the performance of quantum dot-based light-emitting diodes (QLEDs) for next-generation display technologies. In the study, an additional ZnS shell supported by octanethiol was grown on CdZnSeS/ZnS quantum dots. With the developed core/shell/shell structure, the photoluminescence quantum yield was increased from 68.8% to 88.7%. The fabricated QLED devices achieved an external quantum efficiency of 4.1% and a maximum luminance of 85,000 cd/m². The results demonstrated that short-chain thiol ligands significantly improve charge balance and emission efficiency.



Yazici, A. F., Yüruc, A. M., Kelestemur, Y., Serin, R. B., Kacar, R., Ülkü, A., Ucar, E., Erdem, T., & Mutlugün, E. (2026). Performance boost in QLEDs using octanethiol-capped core/shell/shell quantum dots. *Nanotechnology, 37*(1), 015206. https://doi.org/10.1088/1361-6528/ae2a3b

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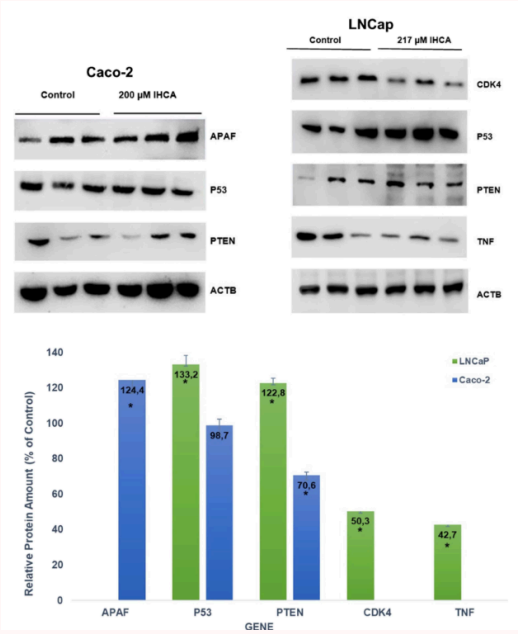
COMPOUND ISOLATED FROM CAPER PLANT SHOWS PROMISE IN PROSTATE CANCER

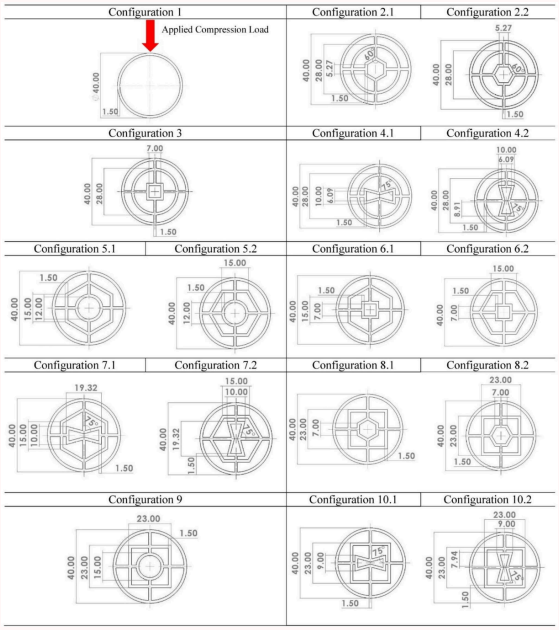


A newly identified indole derivative isolated from the caper plant (Capparis ovata) has been shown to trigger apoptosis in prostate cancer cells. The compound, named 1H-indole-2-hydroxy-3-carboxylic acid (IHCA), was found to initiate programmed cell death by activating the tumor suppressor gene P53. Molecular dynamics simulations conducted in silico revealed that IHCA binds more strongly to the MDM2 protein than the reference drug Nutlin-3a. These findings suggest that this naturally derived compound may serve as a promising candidate for anticancer drug development.

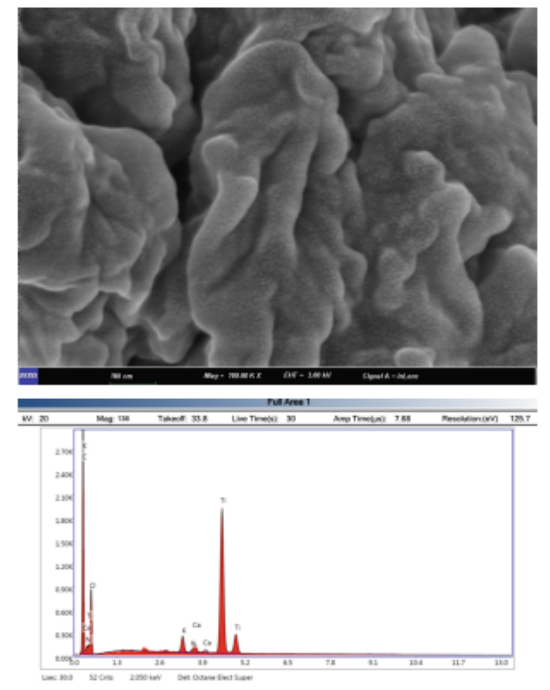
Özgün-Acar, Ö., Gazioğlu, I., Oruç, H., Kale, E., Şenol, H., Topçu, G., & Şen, A. (2026). A small indole derivative isolated from caper (Capparis ovata) as an inducer of P53-mediated apoptosis in prostate cancer: Comprehensive in vitro and in silico studies. *Journal of Biochemical and Molecular Toxicology, 40*(1), e70666. https://doi.org/10.1002/jbt.70666

3D-PRINTED ENERGY-ABSORBING STRUCTURES DEVELOPED FOR UNMANNED AERIAL VEHICLES

Hybrid-designed, multi-cell energy-absorbing structures were developed to protect the structural integrity and electronic components of unmanned aerial vehicles (UAVs) during crash events. In the study, 17 different configurations were designed using circular, square, hexagonal, and re-entrant geometries and were manufactured via 3D printing. The crashworthiness of the structures was experimentally evaluated. The best-performing configuration increased energy absorption by 4.47 times and specific energy absorption by 1.41 times compared to a single-cell circular structure.



Atahan, M. G., Zeybek, H., & Ozturk, S. (2026). Crashworthiness evaluation of 3D-printed hybrid-design multi-cell energy absorbers under lateral compression for unmanned aerial vehicles. *Journal of the Brazilian Society of Mechanical Sciences and Engineering, 48*(1), Article 46. https://doi.org/10.1007/s40430-025-06043-5



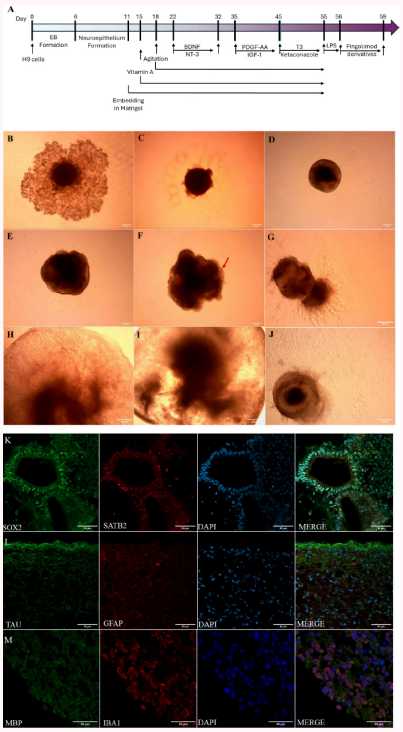
AN ECO-FRIENDLY WATER TREATMENT MATERIAL DEVELOPED FROM WALNUT SHELLS

A novel approach has been introduced in the fight against water pollution. Using waste walnut shells, a dual-functional nano-titania composite material with both photocatalytic and adsorption properties was developed. Prepared via the sol–gel method, this material demonstrated significantly higher dye removal rates compared to commercial nano-titania—2.83 times higher under UV light, 9.35 times higher under visible light, and 12.25 times higher in dark conditions. The developed material is considered a promising candidate for sustainable water treatment technologies.

Erdem, İ. (2026). A novel bifunctional organic supported nano-titania photocatalyst via the sol–gel method using walnut-shell. *Materials Science and Engineering: B, 323*, 118753. https://doi.org/10.1016/j.mseb.2025.118753

DRUG SCREENING FOR MULTIPLE SCLEROSIS CONDUCTED USING BRAIN ORGANOIDS

A novel drug screening platform was developed for neuroinflammatory brain diseases. In the study, brain organoids containing neurons, astrocytes, microglia, and oligodendrocytes were generated from human stem cells. Inflammation was induced using lipopolysaccharide to model multiple sclerosis–like pathology. The anti-inflammatory and neuroprotective effects of fingolimod and its derivatives were evaluated. In particular, the ST-1505 derivative was found to reduce inflammatory markers and enhance myelination. The results support the applicability of brain organoids in drug development studies for neuroinflammatory disorders.



Acar, B., Pepe, N. A., Zivkovic, A., Stark, H., & Sen, A. (2026). Neuroinflammatory human brain organoids enable comprehensive drug screening studies: Fingolimod and its analogues in focus. *Current Medicinal Chemistry*. https://doi.org/10.2174/0109298673435364251002112630

A NEW INDEX DEVELOPED FOR NATURAL POZZOLAN–SUPERPLASTICIZER COMPATIBILITY

Researchers have developed a new method to evaluate the compatibility of superplasticizers in natural pozzolan-blended cement systems, which are used to reduce carbon emissions in cement production. The approach, named the Multi-Criteria Compatibility Index (MCCI), integrates rheological properties and hydration kinetics into a single numerical score. The study found that poly-melamine sulfonate-based superplasticizers exhibited the highest overall compatibility. The developed index is expected to be used in the optimization of environmentally friendly cement formulations.

Argın, G., & Uzal, B. (2026). Compatibility of superplasticizers with natural pozzolan blended cement: multi-criteria compatibility index through rheology and hydration kinetics. *European Journal of Environmental and Civil Engineering, 30*(1), 1–30. https://doi.org/10.1080/19648189.2025.2545452

OPTIMAL DECISION-MAKING FOR OPERATIONS OF SMART GRIDS AND MICROGRIDS

A new study presents a multi-stage framework to address the challenges of power system coordination and reliability arising from the increase in renewable energy and decentralized electricity production. This framework integrates probabilistic modeling, centralized optimization, and adaptive control within smart energy communities. By adapting to dynamic conditions and optimizing energy distribution, it improves long-term system performance under uncertainty, facilitating the transition to sustainable and resilient power systems.

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