

The Third International conference on Environmental Sciences and Engineering for Sustainable Development AI & Emerging Technologies for a Net-Zero Future



AI & Emerging Technologies for a Net-Zero Future.

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Broad Horizons آفاق واسعة

Table of Contents

Contents

P1: Poster Session 1	8
P1008-AI-Driven Indoor Surveillance for Predicting Robbery Behavior: Advancing Oman Vision 2040's Safe Society Goals.....	8
P1067-Machine Learning based Investigation and Optimization of Electric and Magnetic Field Profiles in Power Distribution Networks.....	9
P1085 Design and Development of a Smart System for Sustainable Agriculture in Oman	10
P1088-IoT-Enabled Smart School Bus Monitoring and Notification System Powered by Renewable Energy.....	11
P1101- Integration of 3D Printing and Arduino in the Fabrication of a Sustainable Plant Irrigation System.....	12
P1108-AI Enhanced Smart Pen for Real-Time Handwritten Calculation	13
P1113-Digital Twin Applications in Oil and Gas ICS/OT Infrastructure	14
P1114-Securing Communication Networks in Smart and Connected Critical Infrastructure Systems	15
P1116-OWLEDGE-IoT: An Explainable, Low-Power IoT Architecture for Early Detection of Water Losses in Oman.....	16
P1132-IoT-Based Electrical Fault Detection for Equipment Located in Remote Areas	17
P1141- Microgrid Master Controller – A Laboratory Model	18
P1142-Smart Eco House – A Laboratory Model	19
P1032-Aerodynamic Performance of Archimedes Spiral Wind Turbines under Different Blade Angles.....	20
P1061-Food waste into energy using smart anaerobic bacterial digester (ABD)	21
P1069-Green Conversion of Desalination Reject Water into Value-Added Chemicals	22
P1072-Design and Implementation of an Inverter System for a Ducted Archimedes Wind Turbine (DAWT)	23
P1091- Evaluating Lithium-Ion and Vanadium Redox Flow Battery Systems for Peak Shaving in a 500 MW PV Plant: A Techno-Economic Study for Oman's Grid	24
P1096-EVs as Synthetic Inertia Providers: A Systematic Review of Control, Degradation, and User Participation	25
P1097-Sustainability Consideration in Green Buildings in Oman: A Review.....	26
P1098-Sustainable Valorization of Spent Coffee Grounds into Activated Carbon for Circular Economy and Net-Zero Strategies	27
P1122-Analysis of Dust Impact on the Output of the PV panels	28
P1107-The Accidental Therapist: Evaluating the Viability of Generative AI for Emotional Support	29
T1: AI & IoT Applications in Environment & Sustainable Development-I	30
T1001-An AI big data approach for Fault Prediction and Grid Healing in Smart Microgrid	30

T1010-Design of Green Composite Materials using Artificial Intelligence Based Design and Optimization	31
T1011-Federated Learning Framework for Monitoring Carbon Emissions Toward Oman's Net-Zero 2050 Vision.....	32
T1068-Short-Time Load Forecasting for 33/11kV Distribution Substation Using XGBoost33	
T1037-A Hybrid IoT–Machine Learning System for Predictive Indoor Air Quality Assessment and Intelligent Environmental Control in Academic Facilities	34
T2: Engineering Design to Serve Sustainability Purposes	35
T2015-Experimental Evaluation of a Continuous-Flow Photocatalytic Reactor for Azo Dye Degradation Using a Hybrid Nanocomposite of TiO ₂ Nanoparticles and ZnO/Graphene/Fe ₃ O ₄	35
T2104-Design and Development of a Solar-Powered Smart Plastic Waste (PET Bottle) Shredding System for Campus Sustainability.....	36
T2035-Development of a Tailstock-Mounted Die Holder to Enhance Hands-On Learning in Technical and Special-Education Workshops	37
T2140-Sustainable fabrication and surface morphological studies of biodegradable nanothin films for food packaging application.....	38
T2139-Design and Fabrication of a Die for the Process Equal Channel Angular Extrusion (ECAE) and the Application of ECAE for Aluminum Alloy Electrical Conductors	39
T3: AI & IoT Applications in Environment & Sustainable Development-II	40
T3089-Interpretable Deep Learning for Intracranial Hemorrhage Detection: A GradCAM Analysis on CT Images	40
T3046-Technological Advancements in Addressing Cyber - Security Measures in Distributed Energy Resource Management Systems and Suggested Solutions with Integration of Artificial Intelligence	41
T3050-AI-Driven Multi-Objective Optimization for Performance Optimization of a Blade-Defective Wind Turbine	42
T3038-Development of a Microbial Fuel Cell–Based IoT Biosensor for Real-Time COD Monitoring in Smart Water Systems.....	43
T3103-Explainable Ensemble Machine Learning for Sustainable Predictive Maintenance of Computer Systems.....	44
T4: Renewable Energy & Circular Economy.....	45
T4156-Catalytic Enhancement of Bio-Oil formation in Hydrothermal Liquefaction Interpreted through Shrinking Core Kinetics	45
T4004-Design, Analysis, and Development of a Plastic Crusher for Recycling.....	46
T4044-Solar-Powered Green Ammonia Production: Process Simulation and Energy Optimization using DWSIM.....	47
T4144-CFD Based Study on Wind Turbine Layout Optimization and Yaw Control for Wake Mitigation in the Dhofar Wind Farm.....	48
O1: Online Session 1.....	49
O1003-Numerical and experimental validation of solidification process enhancement of double coils latent heat storage units.....	49

O1007-Simulation of a Variable-Load Cogeneration Plant for an Industrial Ecozone Park: Power and Steam for Industrial Process	50
O1009-Thermodynamic Analysis and Simulation of a Regenerative Gas Refrigeration System	51
O1012-Maize (Zea mays L.) productivity and profitability response to inorganic N-P nutrients, biochar and vermicompost levels in acidic soils of Northwestern Ethiopia.....	52
O1017-Energy Harvesting from Waste.....	53
O1020-Enhancing Transparency Using Blockchain Technology Implementation in Green Hydrogen Supply Chain Finance	54
O1024-GIS-Based Ward-Level Spatial Assessment of Urban Air Quality for Monitoring Sustainable Development Goal Target 11.6.2.....	55
O1025-Development of the Optimal Composition of Concrete Mixes Based on Limestone Shell Rock Waste	56
O1031-Geo-Epidemiological Analysis of Malaria Cool and Hotspots in the Sahelian Drylands of Nigeria.....	57
T2016-Condition monitoring of Power transformers.....	58
T1033-AI-Driven Wastewater Treatment Pathways Toward Zero-Liquid-Discharge in Lignocellulosic Biorefineries	59
T1018-Oman’s Strategic Leap toward a Resilient Energy Future Integrating AI	60
P2: Poster Session 2	61
P2084-Facile Synthesis of Iron oxide Nanoparticles from Omani Alovera leaf extracts for Oily Wastewater Treatment	61
P2119- Utilization of Lime Purge Waste from Desalination Plants for Sustainable Carbon Capture Using a Solar-Driven Spray Reaction System.....	62
P2014- Functionalize Activated Carbon for Efficient Adsorptive Removal of Methyl Orange from Aqueous Solution	63
P2022-RO membrane recycling to UF for industrial uses	64
P2026- Computational Approaches to Hydrogen Storage in High-entropy Alloys.....	65
P2074-Design and Development of a Solar-Powered Wireless Charging Station for Electric Vehicles	66
P2078- Enhanced Infiltration Capacity of Cementitious Materials for Stormwater Management	67
P2079-Implementation of iNav in the Design and Installation of an Unmanned Aerial Vehicle for rescue missions during natural disasters	68
P2087- Design and Fabrication of an Automated Machine for Preparing Traditional Omani Arsiya	69
P2092-A Simulation-Based Assessment of Courtyard Shading and Thermal Comfort Informing A ‘Daylightophilia’ Sustainable Design Concept at The University of Nizwa New Campus.....	70
P2093-Condition Monitoring of Distribution Transformer at Local Utility using Gasses Liberated from Transformer Oil.....	71

P2095-Simulation-Based Design of Plantation Shading Strategies for Heat Mitigation in Campus Parking Areas: A Case Study of Nizwa University	72
P2124-Design, Mixing Performance, and Mass-Transfer Evaluation of a Thermophilic Bioreactor System	73
P2149-AI-Driven Specimen Classification and Measurement System	74
P2030-Use of Additive to Study the Physical Properties of Cohesion Soil	75
P2137-A Comprehensive Review of the Design and Fabrication of Polymeric Nano/Micro Composites: Foaming Processes and Their Impact on Material Performance	76
P2006-Sustainability Comparison of Petrol Vehicles (ICEVS), Electric Vehicles (EVS), and Hydrogen Fuel Cell Vehicles (HFCVS) Using the Analytic Hierarchy Process (AHP)	77
P2110-Phase-Specific Dynamics and Transformation of Microplastics During Windrow Composting in Arid Environments	78
P2100-Autonomous waste detection and classification for nuclear environments using YOLOv4 deep learning algorithm.	79
P2071-AI-Enabled Robotic System for Date Palm Harvesting and Pest Detection	80
P2135-Secure Edge Gateway for IoT Data Integrity and Real-Time Anomaly Detection ..	81
P2041-Testing the Efficiency of Natural Coagulants in Turbid Water.....	82
P2138- AI-Enabled IoT-Based System for Sustainable and Energy-Efficient Network Quality Monitoring	83
T5: AI & IoT Applications in Environment & Sustainable Development-III	84
T5106-Machine Learning-Based Prediction of Extremely Low Frequency Electromagnetic Fields from 220 kV Transmission Lines: A Data-Driven Approach for Safety Compliance in Oman.....	84
T5109-Deep Learning Across Image and Tabular modalities for sustainable development applications	85
T5121-Development of Wavelet Neural Network Denoising Model for MEMS INS/GNSS Integrated System and Application to LiDAR Mobile Mapping	86
T5123-An Explainable Deep Learning Framework for Intelligent Fish Feeding Systems. .	87
T5146-Prediction of e-Waste in Oman based on Exponential growth model with solutions in AI	88
T5151-A Systematic Review of Machine Learning Techniques for Downscaling GRACE-derived Groundwater Storage	89
T6: Materials Science & its Applications for Sustainability	90
T6013-Performance Studies on Sustainable Roofing System.....	90
T6154-Material Degradation of Stainless Steel under Simulated Algal HTL Conditions	91
T6043-AI-Driven Hydro-Geomechanical Water Quality Prediction Using AFSSO-Optimized LSTM for Assessing Micro–Macro Impacts on Geomaterials	92
T6055-Green Nanotechnology mediated Antimicrobial Activity of Copper oxide Nanoparticles synthesized from Omani Curcas bean Leaf extract	93
T6062-Development of Sustainable Anti-corrosive Smart Composite Coating on External surface of Carbon Steel Pipeline	94
T6117-Capacitance and Dielectric properties of cerium phosphoarsinate glasses.....	95

T7: Carbon Neutrality, Pollution & Carbon Emission Management-I.....	96
T7027-Intensified removal of Methylene orange dye using cost-effective Dhofar based tree leaves (Anogeissus dhofarica) using Bio-sorption	96
T7120-Monitoring the Thermal Condition of Organic PCM Solar Panels in Oman with a Parrot Anafi Drone	97
T7036-Path forward to Oman net zero 2050	98
T7049-Advancements in Renewable Energy Technologies and Data Augmentation Strategies for Developing Carbon Neutrality Pathways	99
T7075-Bridging Adaptation and Mitigation in the Built Environment.....	100
T8: Carbon Neutrality, Pollution & Carbon Emission Management-II.....	101
T8127-Toward Sustainable 2D Materials: Transforming CO ₂ into Graphene via Advanced Catalyst Design.....	101
T8136-Evolutionary Optimization of the Industrial Carbon Capture Process towards Carbon Neutrality	102
T8153-A Comparative Analysis of the Performance and Cost of Bentonite-Water and Silica Gel-Water Working Pairs for Adsorption Cooling and Desalination Applications in Oman.	103
T8023-AI and Human Behavior in Sustainable Construction: Driving Societal Change Toward a Net-Zero Oman Future	105
T8073-Development of a Sustainable and Cost-effective Produced Water treatment in the Lekhwair Field water injection system at Petroleum Development Oman	106
O2: Online Session 2.....	107
O2052-A Scalable Biogas-to-Electricity System for Campus food Waste Management ..	107
O2059-Designing Next-Generation Hydrogen Storage Materials: A Computational Exploration of High Entropy Alloy	108
O2060-Supercapacitor/Battery Hybrid Powered Electric Bicycle via BLDC Drive for Sustainable Transportation.....	109
O2065-Solar Powered Agricultural ai Robot.....	110
O2066-Self-Supported molybdenum sulphoselenide catalyst for high-Performance Electrochemical hydrogen production.....	111
O2082-Intelligent network management with the presence of batteries and electric vehicle charging stations and considering charging and discharging	112
O2083-Management of distributed production resources in the smart grid to reduce power outages	113
O2090-Simulation and Performance Analysis of Balance of Plant (BoP) Components in a Solar PV System for Enhanced Efficiency	114
T6028-Sustainable Bio-Cellulose from Food-Waste: Advanced Composites for Environmental and Biomedical Applications	115
O2105-Balance of Plant (BoP) and its Performance Analysis for Solar Photovoltaic (PV) System to Achieve Enhanced Efficiency	116
T4039-Optimizing Hydrogen Production from Waste Metals for Fuel cells: An Evaluation of Different Alkali Activation Methods	117

T4040-Sustainable Valorization of Local Animal Waste for Biomethanation and Efficient Waste Management.....	118
T4064-Sustainable Production of Bioplastics from Waste Milk as an eco-friendly and Renewable Resource for Circular Economy.....	119
O3: Online Session 3.....	120
O3112-The Uneven Impact of Digital Development on Economic Performance: Quantile Evidence from Malaysia	120
O3125-Building Resilience and Sustainability in Spices Supply Chain Through the Convergence of Digital Twins, Blockchain, and Artificial Intelligence (AI): An Insight from Indonesia	121
O3143-Stakeholder Dynamics in Smart Street Lighting PPP: Social and Political Influences on Environmental Sustainability in Madiun Regency	122
O3145-Exergy analysis of a dual recuperative dual expansion s-CO2 energy system for utilizing industrial waste heat.....	123
O3148-IMPACT OF SUGAR REDUCTION IN BISCUITS AND ITS ANTIMICROBIAL AND ANTIOXIDANT PROPERTIES.....	124
O3157-Manufacturing, and Testing of High-Performance CNT coated/ CF reinforcement polymer composite.....	125
T7094-From Mining Waste to Construction Resource: A Sustainable Approach for Copper Tailings Reuse in Oman.....	126

P1: Poster Session 1

P1008-AI-Driven Indoor Surveillance for Predicting Robbery Behavior: Advancing Oman Vision 2040's Safe Society Goals

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Abstract

In an era of rapid urbanization and digital transformation, crime prevention has become a critical priority for nations striving to ensure public safety and economic stability. Oman Vision 2040 emphasizes building a secure, technology-driven society as a cornerstone for sustainable development. In alignment with this vision, this research introduces the first Artificial Intelligence (AI)-based approach for predicting Robbery Behavior Potential (RBP) using indoor security cameras. The proposed framework leverages advanced computer vision and intelligent decision-making to enable proactive crime deterrence and rapid response. Our methodology integrates three specialized detection modules—head-cover detection, crowd detection, and loitering detection—designed to identify suspicious behavioral patterns. A manually annotated dataset was developed to retrain the YOLOv5 model for robust object recognition, while the DeepSORT algorithm enhances loitering detection through real-time tracking. To address the complexity of varied robbery styles, fluctuating camera angles, and low-resolution footage, a fuzzy inference system translates expert knowledge into adaptive rules for estimating robbery probability. Experimental validation using real surveillance footage achieved an initial F1-score of 0.537, which improved to 0.607 after introducing a threshold-based classification for RBP, outperforming existing robbery detection techniques. These results demonstrate the potential of AI-driven predictive surveillance to minimize theft-related losses and strengthen situational awareness in security control centers. By enabling scalable monitoring across multiple cameras, this approach supports Oman's strategic objectives for smart infrastructure, digital innovation, and societal safety under Vision 2040. Ultimately, this research lays the foundation for intelligent crime prevention systems that not only protect assets but also foster trust and resilience in modern urban environments.

Keywords: Surveillance videos, low resolution, RBP prediction, deep learning method, fuzzy inference machine, Artificial Intelligence (AI), Robbery Behavior Prediction (RBP), Video Surveillance Systems, YOLOv5 and DeepSORT Algorithms.

P1067-Machine Learning based Investigation and Optimization of Electric and Magnetic Field Profiles in Power Distribution Networks

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Abstract

The rapid expansion of power distribution networks in the Sultanate of Oman has intensified the need for precise assessment of Extremely Low Frequency (ELF) electric and magnetic fields (EMF) to ensure public safety and regulatory compliance. While traditional assessment methods rely on static measurements and conservative clearance estimates, this project proposes a novel, data-driven approach for 11 kV and 33 kV distribution lines. Comprehensive field campaigns were conducted using high-precision NARDA EHP-50F analyzers to generate a robust dataset capturing field intensities alongside Oman-specific environmental variables, including temperature and humidity. This data drives the development of a Weighted Ensemble Machine Learning Framework, which integrates the predictive strengths of Random Forest, XGBoost, LightGBM, Support Vector Regression (SVR), and Deep Neural Networks (DNN). Unlike single-model approaches, this ensemble technique minimizes predictive variance and quantifies uncertainty. The study aims to achieve a prediction accuracy of $R^2 > 0.90$ and a Mean Absolute Percentage Error (MAPE) of $< 10\%$, enabling the derivation of optimized, data-backed clearance distances. This framework provides utility operators and regulators with a scientifically grounded tool to balance infrastructure efficiency with strict adherence to ICNIRP and Omani Electrical Standards (OES) safety guidelines.

Keywords: Machine Learning, Electromagnetic Fields, Power Distribution Networks, Ensemble Modeling, Environmental Safety, ICNIRP Compliance

P1085 Design and Development of a Smart System for Sustainable Agriculture in Oman

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Abstract

This project showcases the design and implementation of an Internet of Things (IoT)-enabled solar-powered automated irrigation system. This system aims to solve some of the agricultural problems Oman faces. The system uses soil moisture sensors to determine when to irrigate soil. Moisture depletion irrigation occurs only when soil moisture is depleted to a certain level. Solar-powered irrigation is environmentally friendly, cost-effective, and sustainable. This is a vital characteristic for Oman, a country that has an abundance of sunlight, but a scarcity of water. The project enables the automation of irrigation and the increased efficiency of agricultural practices through the IoT technology for remote soil moisture sensing and control over the irrigation system, whereby irrigation can be controlled from a mobile device. This encourages less physical presence of the farmer. Accuracy, efficiency, and precision in controlled irrigation is the main objective of the project and is accomplished by the system designed to be easily deployable, scalable, and adjustable to the varying crops and soil moisture and conditions across Oman. The system advances Oman's agricultural sustainability in line with the overall proposed system.

Keywords: IoT; Solar energy; Automated irrigation; Soil moisture sensors; Smart agriculture; Renewable energy

P1088-IoT-Enabled Smart School Bus Monitoring and Notification System Powered by Renewable Energy

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Abstract

This project presents an IoT-enabled smart school bus monitoring system designed to advance student safety while supporting national sustainability goals. The system integrates environmental sensors, GPS tracking, and real-time alerting, with a Raspberry Pi handling data processing and communication. A cloud-connected web platform enables parents and school administrators to monitor bus location and safety conditions instantly. By incorporating solar energy as the primary power source, the system reduces reliance on conventional electricity and aligns with emerging net-zero strategies. The proposed solution demonstrates how IoT and renewable energy can work together to create safer, more efficient, and low-carbon school transportation reflecting the conference's focus on intelligent technologies that contribute to a net-zero future.

Keywords: IoT, Smart Transportation, Renewable Energy, School Bus Safety, Real-Time Monitoring, Raspberry Pi

P1101- Integration of 3D Printing and Arduino in the Fabrication of a Sustainable Plant Irrigation System

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Abstract

This project presents an innovative prototype of a sustainable plant irrigation system that relies on the integration of 3D printing technologies with an Arduino controller. The objective is to develop an engineering solution that supports water and energy use efficiency in small-scale agricultural applications. The system components, including the reservoir, valve, and structural stand, were designed using SolidWorks software and then manufactured by a Bambu Lab A1 Mini printer to ensure manufacturing accuracy and ease of low-cost parts production. The system depends on the Arduino controller to measure soil moisture and automatically operate the pump. The pump is powered by a photovoltaic (PV) cell that draws water from the reservoir through a tube connected to the plant, achieving smart and efficient use of energy and water. The results from manufacturing and operating the prototype showed full agreement with the expected performance, confirming the effectiveness of integrating digital manufacturing technologies, renewable energy, and smart control in developing practical solutions with environmental and economic feasibility. This project highlights the potential of adopting modern technologies to support sustainable irrigation systems in homes, greenhouses, and educational gardens. This project presents an innovative prototype of a sustainable plant irrigation system that relies on the integration of 3D printing technologies with an Arduino controller. The objective is to develop an engineering solution that supports water and energy use efficiency in small-scale agricultural applications. The system components, including the reservoir, valve, and structural stand, were designed using SolidWorks software and then manufactured by a Bambu Lab A1 Mini printer to ensure manufacturing accuracy and ease of low-cost parts production. The system depends on the Arduino controller to measure soil moisture and automatically operate the pump. The pump is powered by a photovoltaic (PV) cell that draws water from the reservoir through a tube connected to the plant, achieving smart and efficient use of energy and water. The results from manufacturing and operating the prototype showed full agreement with the expected performance, confirming the effectiveness of integrating digital manufacturing technologies, renewable energy, and smart control in developing practical solutions with environmental and economic feasibility. This project highlights the potential of adopting modern technologies to support sustainable irrigation systems in homes, greenhouses, and educational gardens.

Keywords: Arduino, Plant Watering System, sustainable irrigation systems

P1108-AI Enhanced Smart Pen for Real-Time Handwritten Calculation

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Abstract

The rapid growth of digital tools has changed how people learn, work, and communicate, yet handwritten notes and quick calculations remain essential in everyday academic and professional life. This study sets out to design and build a Smart Pen that bridges traditional writing with modern computational power, offering a portable solution for fast, real-time arithmetic. The purpose was to create a device that feels natural to use like a pen, while adding the intelligence of embedded systems and AI-based recognition. The project followed a structured design process. Existing smart writing devices were reviewed to identify gaps and requirements. Hardware components such as an ESP32 microcontroller, sensors, and an OLED display were selected for efficiency and portability. The pen's mechanical design was modeled in SolidWorks to ensure ergonomic handling. Software development involved programming the microcontroller with the Arduino IDE, integrating input detection, computation, and output display. AI algorithms were explored to improve recognition accuracy of handwritten numbers. Testing showed that the prototype could reliably capture handwritten input, process arithmetic operations in real time, and display results instantly. The device operated smoothly on a rechargeable battery and maintained stable performance. In conclusion, the Smart Pen successfully demonstrated how traditional writing can be enhanced with embedded intelligence. It offers a practical tool for students and professionals who need quick calculations on the go. Future work will focus on refining AI recognition and enabling wireless data storage for broader applications.

Keywords: Smart Pen Embedded Systems, AI Algorithms, Handwriting Recognition, Wireless Communication, ESP32 Microcontroller

P1113-Digital Twin Applications in Oil and Gas ICS/OT Infrastructure

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Abstract

Digital twin technology has rapidly evolved from traditional simulation models into advanced cyber-physical systems capable of mirroring real-time industrial assets and processes. In the oil and gas industry, where unplanned downtime-harsh environments, aging infrastructure, and rising cybersecurity threats create substantial operational challenges-digital twins offer a transformative capability for improving efficiency, reliability, and safety. The purpose of this study is to investigate how digital twins can be effectively integrated into Industrial Control Systems (ICS) and Operational Technology (OT) environments to enhance operational performance, strengthen cyber resilience, and enable greater value creation across oil and gas operations. This research matters because ICS/OT systems control critical functions such as drilling, separation, refining, and pipeline transportation, where even minor failures can lead to significant HSE incidents, production loss, or cyber-physical disruption. This study adopts a hybrid methodology comprising a systematic literature review (2020–2025), comparative analysis of existing ICS/OT-aligned digital twin architectures, and the development of a conceptual multi-layer framework aligned with ISA-95, the Purdue Model, and Zero-Trust principles. Key findings indicate that digital twins can reduce equipment downtime by predicting failures earlier than traditional monitoring tools, improve maintenance accuracy, enhance anomaly detection in PLC and SCADA systems, and support safer cyber-attack simulation environments. Results also show strong business value through cost savings, improved asset lifecycle management, and enhanced safety outcomes. The implications of this study are significant for operators seeking to modernize their critical infrastructure. Digital twins not only improve day-to-day operations but also provide strategic benefits, including resilience against cyber threats, optimized production workflows, and data-driven decision-making. Overall, results suggest that digital twins represent a high-value pathway for the future of ICS/OT innovation in the oil and gas sector.

Keywords: Keywords: Digital Twin, ICS/OT, Oil & Gas, Predictive Maintenance, Cybersecurity, Operational Efficiency, Asset Lifecycle, Industrial Control Systems.

P1114-Securing Communication Networks in Smart and Connected Critical Infrastructure Systems

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Abstract

The increasing integration of digital technologies into critical infrastructure has transformed sectors such as energy, transportation, and healthcare into smart and interconnected systems. These systems leverage intelligent sensors, Internet of Things (IoT) devices, and cloud-based analytics to enhance operational efficiency and service quality. However, this interconnectivity also introduces substantial cybersecurity challenges. Communication networks in smart grids, intelligent transportation systems (ITS), and healthcare environments are particularly vulnerable to cyberattacks that can compromise confidentiality, integrity, and availability. This research investigates strategies to secure communication networks in smart and connected critical infrastructure. Using a multidisciplinary approach grounded in systems engineering and cybersecurity frameworks, the study reviews existing literature, analyzes domain-specific threats, and develops an integrated framework combining architectural defenses, lightweight cryptography, anomaly detection, and regulatory governance. The results emphasize that ensuring resilience in critical communications requires layered defenses that integrate both technical and organizational measures. The study concludes that adopting secure communication architectures, implementing adaptive monitoring, and enforcing international standards can significantly reduce risks in these interconnected systems.

Keywords: Critical Infrastructure Security, Operational Technology (OT), Industrial Control Systems (ICS), Smart Grid Cybersecurity, Zero Trust Architecture (ZTA), AI-Driven Intrusion Detection

P1116-OWLEDGE-IoT: An Explainable, Low-Power IoT Architecture for Early Detection of Water Losses in Oman

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Abstract

Aging pipes and inadequate leak detection are the leading causes of the 37-40% non-revenue water losses of Oman's water distribution infrastructure. Current systems that rely on regular meter readings allow existing leaks to persist for long periods. This work presents OWLEDGE-IoT, a scalable and autonomous sensing framework that combines LoRaWAN's low-power connectivity, leak classification using Random Forests, explainability via TreeSHAP, and sensor auto-calibration. The hardware can support operation at temperatures up to 125 °C, consumes 2.94 mAh per day, and provides 3 years of autonomy with solar energy harvesting, which leverages the high solar irradiance (≥ 6.4 kWh/m²/day) in Oman. The system reliably detects leaks with high accuracy and produces interpretable model outputs suitable for operators to review within a few seconds, while maintaining a low per-node cost and supporting potential scalability across large pipeline networks relevant to Oman's long-term water-management objectives.

Keywords: Water Leak Detection, LoRaWAN, Random Forest Classification, Explainable Artificial Intelligence (XAI), TreeSHAP, Virtual Reference Calibration, Low-Power IoT.

P1132-IoT-Based Electrical Fault Detection for Equipment Located in Remote Areas

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Abstract

This paper addresses the limitations of traditional inspection techniques for remote electrical infrastructure, high maintenance costs, inspection delays, and lack of continuous monitoring, by developing an AI-enabled Internet of Things (AIoT) system for real-time electrical fault detection that also supports environmental sustainability and net-zero energy goals. The proposed system uses a Raspberry Pi as a low-power edge device connected to voltage, current, temperature, vibration, and humidity sensors to continuously monitor the health and operating conditions of electrical equipment in remote and off-grid environments. Multi-sensor data are locally preprocessed and analysed using lightweight machine learning models for anomaly detection and early fault prediction, reducing dependence on manual inspection and enabling a shift from reactive to predictive maintenance. Initial laboratory tests with induced overcurrent, overheating, and abnormal vibration scenarios showed that the prototype detected faults in near real time and successfully triggered automated alerts, indicating its suitability for deployment in remote settings. Relevant features and events are transmitted via MQTT to a cloud platform, where web-based dashboards provide remote visualisation, alarm management, and decision support for operators. By reducing unnecessary site visits, shortening fault detection lag, and improving the reliability of remote and renewable-powered assets, the proposed AIoT framework aims to decrease energy waste and indirectly lower emissions associated with inefficient power distribution, aligning with net-zero and sustainable development objectives in industrial, telecommunication, and off-grid energy applications.

Keywords: Internet of Things, Raspberry Pi 4, Power Meter, Temperature, Humidity, Vibration, Remote Monitoring

P1141- Microgrid Master Controller – A Laboratory Model

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Abstract

The sustainable development of human society is currently threatened by the energy crisis, the increase in greenhouse gas emissions, and the effects of global warming. Increased penetration of renewable energy and the electrification of transportation are identified as the potential solutions to these problems. Due to the bidirectional power flow over distribution lines brought on by renewable energy sources, intermittent power generation, the high penetration of electric vehicles the distribution networks pose technical challenges for the current power system. One of the possible solutions of the same is the formulation of smart grid and community microgrid. Community micro grid is a controlled small-scale power system that can be operated in an islanded and/or grid-connected mode in a defined area to facilitate the provision of additional power and/or maintain a standard service. It is made up of small-scale emerging generators, loads, energy storage components, electric vehicles, and a control unit. The microgrid's energy management system needs to dynamic to respond to environmental changes The sustainable energy transition requires robust control architectures, that can integrate Distributed Energy Resources (DERs) to the grid. The work deals with the development of a small laboratory model of microgrid master controller than can integrate multiple microgrid to the grid. The laboratory model integrates a hybrid AC/DC microgrid comprising emulated photovoltaic arrays, battery energy storage systems, and critical loads. The controller is powered by Arduino based intelligent system that performs key functions such as autonomous islanding, predictive energy management for economic dispatch, and hierarchical voltage/frequency regulation. By utilizing IoT, this project suggests a smart community micro-grid system that link user loads and generational units together. Based on the total load demand, the decision-making algorithm will decide which sources to be integrated to the microgrid. Also, various microgrids are interconnected by a microgrid master controller which is powered by means of Arduino. The Arduino based intelligent controller decides the power exchange between the microgrids.

Keywords: Renewable Integration, smart grid, microgrid, Microgrid Master Controller

P1142-Smart Eco House – A Laboratory Model

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Abstract

The Smart eco house is a novel concept of residential automation system that integrates advanced digital automation along with sustainable architectural practices. It outlines how a residence can transform from a passive shelter to an active, self-regulating ecosystem that optimizes resources, minimizes carbon footprints, and enhances occupant well-being. The smart eco house integrates Internet of Things (IoT) sensors and Artificial Intelligence (AI) with green building techniques to achieve up to 70-80% gains in energy efficiency compared to the traditional architecture. By utilizing hybrid renewable energy systems — such as combined solar and wind generation paired with battery storage — the modern home functions as a “prosumer” (both a producer and consumer of energy). A small prototype of such a residence set up has been formulated and tested for the optimal operation. The features of the system are Intelligent Energy Management system which is nothing but an AI-driven Home Energy Management Systems (HEMS) utilizing predictive analytics to forecast energy demand and adjust heating, cooling, and appliance usage in real-time, the control is driven by Arduino Uno and Raspberry Pie in the integrated AI environment. Some of the add on features are Theft Security, Water Conservation, Fire and Gas Leak, Efficient Water management System for irrigation along with Smart vehicle management system. Renewable Sources, wind and solar along with smart sensors and load integration system provides efficient management of generation and load demand. The system will sense the abnormal conditions/security features and send messages to the identified end user. The smart AI driven vehicle management system with tools such as highway line keeping, obstacle avoidance, Automatic gate opening to the specified user are some of the addon features. The system could save around 25% of the electricity bill when compared to normal operation along with the reduction in the carbon footprint.

Keywords: Renewable Integration, Home energy management System, Sustainable Energy transition.

P1032-Aerodynamic Performance of Archimedes Spiral Wind Turbines under Different Blade Angles

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Abstract

Archimedes Wind Turbines AWT are considered one of the latest horizontal axis wind turbines HAWT which have shown the ability to produce reasonable amounts of energy at low wind speed regimes for small scale power generation. It works on angular momentum conservation, it uses both lift and drag force, and cutoff speed of its rotor is quite low, which increases its efficiency in comparison to conventional horizontal axis and vertical axis wind turbines. In this project an experimental study will be carried out to study the effect of blade angle on the aerodynamic performance of AWT.

Keywords: Archimedes Wind Turbines, Low wind Speed, HAWT, Wind Energy

P1061-Food waste into energy using smart anaerobic bacterial digester (ABD)

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Abstract

Growing global concerns over fossil fuel dependency emphasize the urgent need for sustainable energy solutions. Food waste, rich in organic matter, represents a highly promising substrate for biogas production through anaerobic digestion (AD). This study introduces an advanced Smart Anaerobic Bacterial Digester (Smart ABD), integrated with IoT-based monitoring and control systems to optimize critical operational parameters such as temperature, pH, and feedstock particle size. The system is engineered to process household food waste and produce cooking-grade biogas within 24 hours, while simultaneously generating nutrient-rich bio-slurry for agricultural applications. Design analysis indicates a digester volume of 0.3848 m³, supporting a daily feed of 3 kg of food waste and yielding approximately 0.7738 m³ of biogas per day, including 0.4433 m³ of methane—equivalent to 4.43 kWh of energy. This rapid conversion approach ensures efficient digestion, minimal environmental impact, and practical scalability. The proposed solution not only addresses waste management challenges but also contributes to clean energy generation, aligning with Oman Vision 2040 objectives for green technology adoption and sustainable development.

Keywords: Keywords: Anaerobic Digestion, Biogas, Food Waste, IoT Monitoring, Sustainable Energy, Oman Vision 2040

P1069-Green Conversion of Desalination Reject Water into Value-Added Chemicals

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Abstract

Desalination is essential for freshwater security in arid regions such as Oman, yet it produces high-salinity reject water that threatens marine ecosystems when discharged. This project proposes a pilot-scale, circular-economy solution to transform desalination brine into three value-added products: high-purity sodium chloride (NaCl), sodium hypochlorite (NaOCl), and hydrogen gas (H₂). The objective is to demonstrate a sustainable alternative to brine disposal while reducing Oman's dependence on imported chemical-grade sodium hypochlorite. The proposed system integrates a vacuum salt plant for brine pre-treatment and salt recovery, followed by an electrochlorination unit capable of producing NaOCl at 12–12.5% concentration. Brine undergoes multi-stage filtration, anti-scalant dosing, activated carbon treatment, and optional acidification to ensure the purity required for efficient evaporation and electrochemical reactions. Titanium anodes with mixed metal oxide coatings and stainless-steel cathodes enable safe, on-site conversion of chloride ions into NaOCl, while hydrogen generated at the cathode is captured as a potential clean-energy byproduct. Preliminary results indicate effective removal of impurities, stable NaOCl generation, and promising hydrogen yields under optimized pH, current density, and electrolyte conditions. By converting a harmful waste stream into commercially valuable products, this integrated approach directly addresses critical environmental challenges associated with brine disposal, supports marine ecosystem protection, and provides a scalable model aligned with Oman Vision 2040 goals in sustainability, clean energy, and circular resource management.

Keywords: Desalination Brine, Resource Recovery, Electrochlorination, Sodium hypochlorite production, Circular Economy, Green Hydrogen generation

P1072-Design and Implementation of an Inverter System for a Ducted Archimedes Wind Turbine (DAWT)

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Abstract

Wind energy systems often suffer from unstable electrical output due to fluctuating wind speeds, especially in small-scale turbines such as the Ducted Archimedes Wind Turbine (DAWT). This study focuses on designing and implementing an efficient inverter system capable of converting the DAWT's irregular electrical generation into a stable AC supply suitable for practical use. The proposed system employs a three-stage power conversion approach consisting of an AC–DC rectifier with Maximum Power Point Tracking (MPPT), a DC-link for voltage stabilization, and a DC–AC inverter using Sinusoidal Pulse-Width Modulation (SPWM). The methodology includes simulation-based modeling using software tools such as Multisim and Proteus to design and analyze various inverter control techniques, including square wave, single PWM, multiple PWM, bipolar SPWM, and unipolar SPWM. An Arduino microcontroller was used to generate PWM control signals, allowing the system to approximate a pure sinusoidal output through modulation index and switching frequency adjustments. Simulation results demonstrate that SPWM significantly improves voltage quality, reduces harmonic distortion, and enhances system efficiency compared to other techniques. The study confirms that a carefully designed inverter system can transform the DAWT's varying output into a stable 230 V, 50 Hz waveform, supporting its application in small-scale renewable energy systems. The findings also provide a foundation for further improvements, including hardware implementation and integration with energy storage or grid-tied systems.

Keywords: Ducted Archimedes Wind Turbine (DAWT), Inverter System, Sinusoidal PWM (SPWM), Modulation Index, Renewable Energy Conversion, Arduino-Based Control

P1091- Evaluating Lithium-Ion and Vanadium Redox Flow Battery Systems for Peak Shaving in a 500 MW PV Plant: A Techno-Economic Study for Oman's Grid

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Abstract

The rapid expansion of renewable energy in Oman highlights the need for reliable storage solutions that support grid stability and peak-demand management. Utility-scale Battery Energy Storage Systems integrated with photovoltaic plants offer a promising approach to reduce reliance on fossil fuels and advance national carbon-neutrality targets. This study aims to evaluate the techno-economic performance of two storage technologies, lithium-ion batteries and vanadium redox flow batteries, when connected to a 500 MW PV plant for peak-shaving applications in the Ibri region. The combined photovoltaic–battery configurations were modelled using the System Advisor Model software, incorporating capital cost, degradation, replacement thresholds, and round-trip efficiency. Key economic indicators included the levelized cost of energy, Net Present Value, and simple and discounted payback periods. The lithium-ion battery achieves a round-trip efficiency of 85.28%, compared to 76.99% for the vanadium redox flow battery. It records a higher levelized cost of energy, with a real value of 13.54 ¢/kWh and a nominal value of 16.03 ¢/kWh, while the vanadium redox flow battery system achieves lower values of 11.01 ¢/kWh and 13.10 ¢/kWh, respectively. Despite the efficiency advantage of lithium-ion, the vanadium redox flow battery delivers stronger long-term economics, achieving a Net Present Value of 953 million dollars with payback periods of 5.7 and 8.5 years. In comparison, the lithium-ion system reaches a Net Present Value of 631 million dollars with payback periods of 6.3 and 9.9 years. These findings highlight the trade-off between short-term performance and long-term economic value.

Keywords: Battery Energy Storage System; Techno-Economic Analysis; Levelized Cost of Energy; Lithium-Ion Battery; Vanadium Redox Flow Battery

P1096-EVs as Synthetic Inertia Providers: A Systematic Review of Control, Degradation, and User Participation

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Abstract

The fast growth of renewable energy integration in power systems resulted in major decline in grid inertia, increasing vulnerability to frequency deviations, and instability. This systematic review investigates the current state of research addressing low-inertia challenges and evaluates emerging solutions, particularly focusing on virtual inertia provision from inverter-based resources, stationary storage and electric vehicles. Through the literature, advanced inverter control techniques like Volt/Var regulation, frequency-watt response, and virtual inertia emulation shows improvements in grid dynamic performance and reduction in RMS voltage deviation, rate of change of frequency (RoCoF), and frequency nadir when synthetic inertia is deployed. Microgrid scale research shows the benefits of combining virtual inertia with virtual damping, which smoothens post-disturbance response and faster stabilization. Recent studies recognize potential of electric vehicles as distributed synthetic inertia providers. Most studies prioritize user convenience maintaining high state of charge (SOC) while forgetting the long-term battery health. Battery aging studies shows that high SoC, wide cycles and high C-rates accelerate degradation. This shows that current EV based inertia strategies exposes batteries to degradation conditions faster. A critical gap appears: existing articles treat virtual inertia control, battery degradation, and user participation as separate topics to be studied. No unified framework simultaneously accounts for those pillars: grid stability, battery health, and real-world practicality. To address this gap, the present study outlines a potential integrated framework combining optimized inertia control, anti-degradation operation and user participation model to enable practical and sustainable EV-based inertia support in modern grids.

Keywords: EV , synthetic inertia , battery degradation , renewable penetration

P1097-Sustainability Consideration in Green Buildings in Oman: A Review

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Abstract

This study analyses the implementation of sustainability measures with respect to green buildings in Oman. The research assesses the environmental, economic, and social impacts of green building practices with particular attention to the use of renewable energy, water conservation (especially grey water recycling), and construction materials. The attempt aims at collecting primary data through conducting a qualitative survey through the literature reviews and interviews were achieved. A quantitative survey was done for the check on greywater conservation to identify the challenges faced, used technologies to reuse wastewater, and protect the environment and their effect achieved through Google survey and interviews with LEED certified building to make community awareness to increase the use of sustainable materials and to check the challenges faced by the LEED-certified buildings. Statistical evaluation utilizing SPSS to determine the extent of internal consistency of data. The initiative's effectiveness of sustainable measures was part of the analysis. The results indicate that there is an increase in green practices in Oman, but the adoption is being hampered by high costs, scant availability of materials, and shallow policies. This study adds to the understanding of how Oman Vision 2040 can be complemented by green building practices within the context of the country's efforts towards a low-carbon, resilient built environment.

Keywords: Green buildings; sustainability; renewable energy; water conservation; grey water, cost efficiency

P1098-Sustainable Valorization of Spent Coffee Grounds into Activated Carbon for Circular Economy and Net-Zero Strategies

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Abstract

Climate change and unsustainable waste disposal from rapidly growing industries, including the food sector, are intensifying environmental degradation. Spent coffee grounds (SCGs), a major residue from the coffee industry, represent a large and underutilized waste stream; global coffee consumption generates an estimated 6 billion kg of SCGs annually, much of which is landfilled. Under such conditions SCGs can leach organic pollutants, foster pathogen growth, and release methane during anaerobic decomposition, contributing to greenhouse gas emissions. This study explores the valorization of SCGs into activated carbon (AC) as a low-cost, circular-economy solution for waste management and pollution control. SCGs were subjected to pyrolysis followed by physical (CO₂) and chemical (KOH) activation at temperatures between 300 and 800 °C to optimize AC yield and surface properties. The resulting ACs were characterized using Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and scanning electron microscopy (SEM). The process achieved AC yields of 23–30% at an estimated production cost of 0.1045 USD per kilogram. FTIR and XRD analyses indicated stable carbonaceous structures with temperature-dependent enhancement of functional groups relevant for adsorption, while SEM images revealed well-developed porosity, particularly at higher activation temperatures. Chemically activated SCG-derived AC exhibited adsorption performance comparable to commercial AC. This study is particularly relevant for coffee-consuming regions such as the Middle East and aligns with net-zero and circular-economy agendas. Overall, the results demonstrate the technical and economic feasibility of converting SCG waste into high-value AC, supporting zero-waste strategies, resource recovery, and low-carbon development in the coffee-producing and processing sectors.

Keywords: Spent coffee grounds (SCG), Activated carbon, Pyrolysis, Waste valorization, Circular economy, Greenhouse gas mitigation, Sustainable materials

P1122-Analysis of Dust Impact on the Output of the PV panels

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Abstract

The performance of photovoltaic (PV) systems is significantly influenced by environmental conditions, among which dust accumulation is one of the most critical yet often underestimated factors. This study under the advanced diploma technical project presents a seven-day experimental analysis (due to time constraint of project) aimed at quantifying the impact of dust and airborne pollutants on the output characteristics of PV panels under typical operating conditions. Two identical PV panels were installed side by side, with one panel maintained in a clean state and the other left uncleaned to allow natural deposition of dust particles. Output voltage measurements were recorded at regular intervals throughout the observation period to evaluate performance degradation due to surface contamination. Results indicate a measurable decline in electrical performance, with the dust-exposed panel exhibiting an average voltage drop of approximately 6.1% compared to the clean reference panel. This degradation corresponds to reduced solar irradiance reaching the PV surface due to the shading and scattering effects of accumulated dust. The study also highlights daily fluctuations in voltage reduction, influenced by environmental factors such as wind activity, humidity, and particulate concentration. The findings underscore the importance of effective cleaning and maintenance strategies, particularly in regions prone to high dust levels, to ensure optimal energy yield and system reliability. Overall, the experiment confirms that even short-term dust accumulation can lead to considerable electrical losses in PV systems. The observed 6.1% voltage reduction over a single week demonstrates the need for incorporating dust-mitigation and panel cleaning techniques considerations into PV system design, operation, and economic assessment.

Keywords: Sunlight irradiance, Dust effect, Output voltage, Environmental conditions, Panel cleaning techniques, Performance of PV Panels

P1107-The Accidental Therapist: Evaluating the Viability of Generative AI for Emotional Support

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Abstract

Surprisingly, Generative AI has turned out to be an emotional booster to people in need of mental-health help, raising the question of whether it can be used therapeutically. The paper will answer whether AI can be used as a long-term therapeutic intervention, whether it is effective in decreasing depression and anxiety symptoms, and whether the absence of emotional intelligence influences how suitable AI tools can be used. Methods: A systematic literature review of 13 articles published in 2017-2024 was performed based on academic databases such as Google Scholar, IEEE Xplore, and PubMed. The synthesis was based on randomized controlled trials, exploratory studies, and perspective articles to review AI's role in mental-health support. Results: Clinical trial evidence indicates that therapeutic chatbots such as Woebot can effectively decrease depression ($d=0.44$) and anxiety ($d=0.37$) symptoms. Higher effects ($d=0.83$) were obtained with a CBT-based chatbot in university students compared to self-help resources. Nevertheless, there are significant issues: AI does not have real emotional insight, generates superficial answers, and fails to cope with complicated psychological problems. Users report the experience of developing therapeutic relationships with non-humans is both positive and negative as some feel uncomfortable. Conclusion: AI chatbots have quantifiable therapeutic effects with evidence-based interventions in accessible formats. Yet, they remain shallow because they cannot truly comprehend emotions. The results imply AI works best as an addition to regular therapy—to provide short-term support, develop healthy behavior, and address care gaps, but with human expert assistance for complicated psychological demands.

Keywords – 4–6 relevant terms that help index your paper.

AI Chatbots, Mental Health, Emotional Support, Empathy, Therapeutic Alliance, Systematic Review, Generative AI, Digital Therapy, Depression

T1: AI & IoT Applications in Environment & Sustainable Development-I

T1001-An AI big data approach for Fault Prediction and Grid Healing in Smart Microgrid

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Abstract

The increasing complexity and decentralization of modern power systems have intensified the need for intelligent fault prediction and self-healing capabilities in smart microgrids. As smart microgrids become integral to modern energy systems, ensuring their reliability, resilience, and autonomy is critical. This paper proposes an AI-driven big data framework for real-time fault prediction and automated grid healing in smart microgrids. By leveraging machine learning, deep learning, and data analytics on large-scale, the system predicts faults before they occur and triggers self-healing actions to heal the same, without any human intervention. The developed algorithm has been tested on IEEE 14 bus based modified microgrid system. The algorithm developed on Complex Value Neural Network could predict the fault value in the 8th cycle of the voltage waveform based on the data from previous cycles. The self-healing property is initiated through Power Oscillation Damper (PoD) to damp the oscillations and make the system to damp the oscillations. Experimental results from simulations and case studies demonstrate enhanced grid stability, reduced downtime, and improved energy quality. Experimental validation demonstrates that the proposed system improves fault detection accuracy by up to 20% and reduces recovery time by 30% compared to conventional rule-based systems. The results highlight the potential of AI and big data integration to enhance reliability, resilience, and autonomy in next-generation smart microgrids.

Keywords: Smart Microgrid, Fault Prediction, Grid Healing, Artificial Intelligence, Big Data, Machine Learning, Reinforcement Learning, Energy Resilience

T1010-Design of Green Composite Materials using Artificial Intelligence Based Design and Optimization

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Abstract

This research explores the pivotal role of Artificial Intelligence (AI) in the design and optimization of green composite materials. Green composites, composed of renewable and bio-based resources, aim to minimize environmental impacts by reducing CO₂ emissions, conserving energy, and enhancing recyclability. AI-driven techniques, including machine learning and computational modeling, enable the intelligent selection of natural fibers, resins, and additives to achieve optimal mechanical, thermal, and environmental performance. By integrating lifecycle assessment (LCA), AI systems predict material behavior, optimize manufacturing processes, and facilitate sustainable end-of-life recycling strategies. These advancements lead to faster prototyping, cost reduction, and improved eco-efficiency. The convergence of AI and materials science is thus revolutionizing sustainable material development, fostering innovation across sectors such as automotive, aerospace, and construction. This study highlights AI's transformative potential in achieving a circular economy through the development of high-performance, environmentally friendly green composites.

Keywords: Artificial Intelligence (AI); Green Composite Materials; Machine Learning; Sustainable Design

T1011-Federated Learning Framework for Monitoring Carbon Emissions Toward Oman's Net-Zero 2050 Vision

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Abstract

Achieving Oman's Net-Zero 2050 Vision requires advanced and privacy-preserving technologies to monitor and optimize carbon emissions across the industrial sector. This paper proposes a Federated Learning (FL) framework designed to enable real-time monitoring and predictive analysis of carbon emissions in industrial areas without the need to centralize sensitive operational data. The proposed model integrates distributed data from multiple industrial facilities—such as energy consumption, production rates, and emission sensor data—into a secure FL environment. By training shared AI models locally at each site and aggregating global updates, the framework ensures data privacy, reduced communication costs, and improved model generalization across heterogeneous environments. The study evaluates the framework's performance in terms of accuracy, scalability, and energy efficiency, comparing it to centralized machine learning methods. Findings demonstrate that the federated model achieves comparable or superior predictive capability while maintaining compliance with data protection policies and sustainability objectives. This research contributes to Oman's strategic transition toward a low-carbon industrial economy by providing a scalable, intelligent, and collaborative data-driven monitoring system that supports policy decisions and emission reduction initiatives

Keywords: Net-Zero, Oman's Vision 2050, Federated Learning (FL), emission reduction

T1068-Short-Time Load Forecasting for 33/11kV Distribution Substation Using XGBoost

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Abstract

Load forecasting is required in electrical distribution systems for different applications with respect to operational planning, such as generation scheduling, demand-side management, and grid stability enhancement. Accurate short-term load prediction at 33/11 kV substations is critical for preventing equipment overloading, reducing operational costs, and maintaining voltage stability. However, traditional forecasting methods fail to capture the nonlinear relationships between environmental factors, temporal patterns, and electricity demand, particularly in rapidly growing consumption scenarios. The main novelty in this paper is that an optimized XGBoost machine learning model is proposed to improve load forecasting accuracy at distribution substations by leveraging multiple data sources including SCADA measurements, weather data, and operational records. A real-world dataset from Al Humbar Power Substation System (PSS) 11kV network in Oman, spanning March 2025 to August 2025, is considered as a case study in order to properly validate the designed method. The model incorporates features such as historical load patterns, temperature, humidity, current measurements, and maintenance schedules, with hyperparameter tuning applied to optimize performance. Based on the presented numerical results, the proposed tuned XGBoost approach achieved a Root Mean Square Error (RMSE) of 2.2004 and an R^2 score of 0.9789, representing a 77.77% improvement in RMSE and 66.81% improvement in R^2 compared to the baseline model, thus demonstrating significant enhancement in prediction accuracy and reliability for substation load forecasting applications.

Keywords: Load forecasting, XGBoost, machine learning, distribution substation, SCADA data, time-series prediction

T1037-A Hybrid IoT–Machine Learning System for Predictive Indoor Air Quality Assessment and Intelligent Environmental Control in Academic Facilities

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Abstract

This paper introduces a framework for predictive indoor air quality (IAQ) assessment and intelligent environmental control in academic facilities that combines Internet of Things (IoT) and Machine Learning (ML). Key air quality parameters such as room temperature, relative humidity, CO₂ concentration, CO level, and particulate matter (PM_{2.5}) are continuously monitored by the system using Particle Photon microcontrollers and electronic sensors. The system then uploads the acquired data to the ThingSpeak cloud and stores them in a MariaDB database. Exhaust fans, cooling fans, air purifiers, and humidifiers are automatically controlled based on the published IAQ standards to ensure a healthy indoor learning environment while optimizing energy efficiency. An ensemble ML model using Random Forest (RF), K-Nearest Neighbor (KNN), and Support Vector Machine (SVM) classifiers combined via the majority voting method predicts overall IAQ levels as good, moderate, or poor, allowing proactive environmental management. Moreover, all the sensor-read data and forecasted air quality levels can be accessed through an interactive mobile application. Experimental results indicate that the ensemble ML model predictions are comparable with the published air quality guidelines, commercially available air quality detectors, and safety engineer's advice, with an accuracy of 0.997. By enhancing IAQ and optimizing energy use, the system supports sustainable, smart, and occupant-centered educational facilities in line with green building practices.

Keywords: Indoor Air Quality, Environmental Control, Green building practices, Machine Learning, IoT, Energy Efficiency

T2: Engineering Design to Serve Sustainability Purposes

T2015-Experimental Evaluation of a Continuous-Flow Photocatalytic Reactor for Azo Dye Degradation Using a Hybrid Nanocomposite of TiO₂ Nanoparticles and ZnO/Graphene/Fe₃O₄

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Abstract

Obtaining to clean and safe water has become one of the major global challenges. This was driven by industrial growth and the continuous discharge of organic pollutants into water bodies. Traditional wastewater treatment technologies sometimes fail to totally remove persistent contaminants such as dyes, surfactants, heavy metals, and pharmaceutical residues, leading to serious environmental and health issues. This research introduces a sustainable and efficient approach to wastewater treatment by the integration of photochemical degradation followed by a filtration process. The developed system uses the principles of photocatalysis to enhance degradation efficiency and ensure continuous operation. A hybrid nanocomposite catalyst consisting of Fe₃O₄, ZnO, and graphene (Fe₃O₄/ZnO/Gr) was synthesized using an dual-method strategy: electrochemical exfoliation of graphite to produce high-quality graphene sheets (top-down) and in-situ growth of ZnO nanoparticles (bottom-up). This combination produced a material with high surface area, excellent light absorption, and strong magnetic recoverability, which together improved charge transfer and minimized electron-hole recombination. The nanocomposite was incorporated into a custom-built continuous-flow photoelectrochemical reactor and tested under solar-simulated irradiation and controlled voltage conditions. Experimental results showed a remarkable enhancement in the degradation rate of organic dyes, with the pollutants being fully converted into harmless end products such as carbon dioxide and water. More than 90% of dye has been removed using combination of TiO₂ and the prepared nanocomposite. The effect of water flowrate, % of TiO₂, and nanocomposite recyclability has been studied. This study demonstrates that continuous photoelectrochemical oxidation of dyes can be done with high treatment efficiency, reduce operational costs, and minimize environmental impact. The proposed approach provides a promising and scalable pathway toward cleaner industrial effluents and supports the global transition to sustainable water management and renewable environmental technologies.

Keywords: Photochemical oxidation, Hybrid nanocomposite, Wastewater treatment, Graphene-based catalyst

T2104-Design and Development of a Solar-Powered Smart Plastic Waste (PET Bottle) Shredding System for Campus Sustainability

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Abstract

The vision of Oman 2040 mostly focuses on effective waste management strategies for a greener and sustainable feature. Bottled water offers ease, especially in public places, offices, schools, malls and during travel. When the usage is more it contributes to environmental challenges related to plastic waste. The large volume of plastic bottles that are used and discarded daily increases plastic waste, which if not managed properly can harm the environment. The packaging is done by using type one plastic called Polyethylene terephthalate (PET) plastic, commonly used for beverage bottles. This paper presents an efficient and sustainable method for handling plastic water bottles on campus by designing and developing a solar powered smart plastic bottle shredding system. The design IoT Based plastic bottle shredding system is powered up by using solar energy. which can be used on the college campus to reduce the PET plastic waste generated. Students are encouraged to recycle plastic bottles and effectively reduce plastic trash through the plastic shredding process.

Keywords: Plastic waste, Shredder. Solar energy, Arduino, Sensors, Internet of Things

T2035-Development of a Tailstock-Mounted Die Holder to Enhance Hands-On Learning in Technical and Special-Education Workshops

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Abstract

This paper presents a new design and fabrication of a tailstock-attached die holder specifically designed for precise external threading operations on a lathe, with focus on engineering sustainability and educational impact. The main purpose of the developed tool is to improve the precision, safety and overall effectiveness of manual threading. The die holder is designed to fit standard 25 mm round dies and supports metric thread sizes from M3 to M12, including different pitch specifications. Incorporating linear guidance and alignment feature ensures accurate axial movement and reduces the risk of misaligned threads during operation. The manufactured die holder was practically tested on a stepped aluminum rod incorporating three specific thread standards of M6, M10 and M12 with respective pitch values of 1 mm, 1.5 mm and 1.75 mm. The practical results demonstrated significant improvement in threading in terms of operational efficiency and quality when compared to manual die stock. The experimental results revealed a remarkable reduction in threading time when using the fabricated die holder compared to manual die stock. For producing 10 mm thread for M6, M10 and M12, the time required for threading reduced by 87.2%, 88.3% and 89.0% respectively. Furthermore, the measurements of pitch accuracy demonstrated minimal deviation from nominal values, indicating reliable precision and suitability for standard thread specifications.

Keywords: tailstock, die holder, external threading, manual die stock, metric thread sizes.

T2140-Sustainable fabrication and surface morphological studies of biodegradable nanothin films for food packaging application

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Abstract

Biodegradable plastics derived from renewable resources are receiving considerable attention in recent times owing to their versatile properties of reduced environmental impact, biodegradability, improved tensile strength and enhanced surface functionality. The current research study focused on the preparation of bioplastics from waste milk by green extraction technique followed by fabrication of nano thin films for food packaging. The nanothin films were developed on glass substrate by dip coating technique. The stability studies of the thin films were assessed by exposure to varying environmental conditions. The influence of pH, bioplastic concentration, temperature and the number of dipping cycles on thin film thickness and surface roughness was studied. The thin films were characterized using Atomic Force Microscopy (AFM), Energy Dispersive X-Ray (EDX) analysis, Scanning Electron Microscopy (SEM), and Fourier Transform Infrared Spectroscopy (FTIR) analysis. The thickness of the fabricated thin film was measured using Ellipsometry and the surface topology and roughness were determined using Atomic Force Microscopy (AFM). The outcome of the study indicates that the thickness increased with increase in pH up to 5.0 and above pH 5.0, there exhibited a diminishing trend. The highest surface roughness of the thin film was observed at pH 6.0. For an increase in bioplastic concentration, the thickness also increased, whereas the roughness indicated decreasing trend. The surface morphological and roughness studies revealed perfect loops and permeable structure at the surface of thin films as evident from AFM topological image. The fabricated films were subjected to biodegradability study and showed excellent biodegradation rate.

Keywords: Bioplastic, dip coating, green extraction, roughness, thin film, topology, nanocomposite.

T2139-Design and Fabrication of a Die for the Process Equal Channel Angular Extrusion (ECAE) and the Application of ECAE for Aluminum Alloy Electrical Conductors

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Abstract

Equal Channel Angular Extrusion (ECAE) is a severe plastic deformation technique that helps improving the mechanical properties of lightweight metallic alloys. ECAE grain refines the microstructure without a change in the cross-sectional area. A laboratory-scale die for ECAE was designed and fabricated for non-ferrous lightweight metals. The die involves two equal channels, which intersect at an intersection angle 115° . Aluminum alloy 6201 is commonly used as an electrical conductor material in overhead power transmission lines. Prolonged exposure to elevated temperatures and mechanical loading can cause degradation in its mechanical properties, leading to brittleness and eventual failure. Increasing the diameter of the conductor to improve strength is not desirable, as it results in increased weight and installation challenges. Therefore, there is a need to enhance the mechanical properties of aluminum alloy 6201 without altering its cross-sectional dimensions. 9.5 mm diameter rods of the aluminum alloy 6201 were subjected to ECAE at room temperature. The mechanical properties of the specimens before ECAE processing (as-received) were initially characterized; the ultimate tensile strength is 236 MPa, percentage total elongation is 14.5 %, and hardness is 64.8 HV/0.5. Results showed that there is an increase in UTS and hardness by 20% and a decrease in total percentage elongation by 50%. The increase in strength and hardness indicates that large number of microstructural defects (e.g., dislocations, grain boundaries, sub-grain boundaries, etc.) were generated. However, these microstructural defects obstruct the material flow hence cause reduction in ductility.

Keywords: Aluminum Electrical Conductor, ECAE

T3: AI & IoT Applications in Environment & Sustainable Development-II

T3089-Interpretable Deep Learning for Intracranial Hemorrhage Detection: A GradCAM Analysis on CT Images

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Abstract

Intracranial hemorrhage (ICH) is a life-threatening neurological emergency that contributes significantly to global morbidity, mortality, and long-term disability. Early diagnosis is essential for reducing the societal and economic burden associated with stroke, aligning with the broader goals of sustainable healthcare systems and the United Nations Sustainable Development Goals (SDG 3: Good Health and Well-being). Computed tomography (CT) remains the first-line modality for rapid ICH assessment; however, increasing clinical demand places pressure on healthcare resources, particularly in low-resource and remote environments. Artificial intelligence (AI)-based decision-support tools have the potential to enhance diagnostic efficiency, improve resource utilization, and support more sustainable, resilient health systems. This study introduces an explainable deep learning framework for automated ICH classification using CT scans, integrating Gradient-weighted Class Activation Mapping (Grad-CAM) to enhance transparency and trust in AI-assisted diagnostic workflows. A convolutional neural network is trained on the RSNA ICH dataset to classify major hemorrhage subtypes, and Grad-CAM heatmaps are used to identify clinically relevant regions influencing the model's decisions. Qualitative visualization and insertion/deletion-based fidelity analyses demonstrate that Grad-CAM provides meaningful insights into diagnostic features, thereby supporting safer deployment of AI tools in real-world clinical settings. By promoting interpretable AI-assisted decision-making, this work contributes to sustainable and equitable healthcare delivery, particularly in environments where radiological expertise is limited. The findings lay the foundation for future research targeting reliable, transparent, and resource-efficient medical AI systems within broader sustainability frameworks.

Keywords: *Explainable AI, Sustainable Healthcare, Intracranial Hemorrhage, Computed Tomography, GradCAM, Deep Learning, Clinical Decision Support, Trustworthy AI, Resource-Efficient Diagnostics, SDG 3*

T3046-Technological Advancements in Addressing Cyber - Security Measures in Distributed Energy Resource Management Systems and Suggested Solutions with Integration of Artificial Intelligence

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Abstract

Smart grids (SGs) consist of an integrated infrastructure with multiple sub-systems for controlling and monitoring power generation, energy transmission, power distribution, and energy consumption. Also, integration of renewable energy resources into modern power grids enhances new challenges in overall energy management and leads to cyber security threats. This review work primarily focuses on identifying possible cyber-security events like communication deprivation, false data injection, network vulnerabilities, distributed service denial, etc. After the identification of possible cyber-security challenges, this article is summarized with a comprehensive review of possible solutions for reducing cyberattacks on various Distributed Energy Resource Management (DERM) system-based testing models and explains the methodologies to address these attacks. Role of technological advancements like Machine Learning (ML), Artificial Intelligence (AI), Information Systems using quantum computing techniques are also discussed along with necessary technical challenges and future directions towards guaranteed integrated power infrastructure facilities. This review open-up the way to address challenges due to possible cyber-threats and recommends technological resolutions to ensure secure SGs through advanced DERM systems.

Keywords: Smart Grids; Cyber Security; Distributed Energy Resource Management (DERM)

T3050-AI-Driven Multi-Objective Optimization for Performance Optimization of a Blade-Defective Wind Turbine

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Abstract

The structural defects in wind turbine blades significantly impair aerodynamic performance and reduce energy generation. This is due to the increase in the mechanical vibration. This study develops an AI-based optimization framework that integrates AI-based mathematical predictive modelling using Artificial Neural Networks (ANN) and Adaptive Neuro-Fuzzy Inference Systems (ANFIS) with AI-based optimization techniques. The aim of the study is to enhance the operational performance of horizontal-axis wind turbines exposed to blade defects. The experimental data were collected from a wind turbine system which is operating under systematically varied pitch angles and rotational speeds. Predictive models were constructed using conventional Quadratic Regression (QR) to estimate power output and vibration levels. The ANFIS demonstrated superior capability in modeling vibration responses whereas the ANN achieved high accuracy in predicting power output. These models were subsequently embedded into an AI-based multi-objective optimization process using three AI-based techniques including Genetic Algorithms (GA) and Gaussian Process Regression (GPR). The optimized parameters achieved simultaneous power maximization and vibration minimization with experimental verification which confirms the reliability of the proposed framework. Both GA and GPR optimization techniques revealed the effectiveness of AI AI-based optimization framework in supporting performance optimization and structural health management in wind turbines.

Keywords: Wind Turbine Optimization, Artificial Neural Networks, Adaptive Neuro-Fuzzy Inference System, Genetic Algorithm, Gaussian Process Regression

T3038-Development of a Microbial Fuel Cell–Based IoT Biosensor for Real-Time COD Monitoring in Smart Water Systems

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Abstract

Water is the backbone of sustainable development and socio-economic advancement, underpinning ecosystem health and human survival. In the context of smart city development, reliable and continuous monitoring of water and wastewater quality is a prerequisite. Among key chemical indicators, Chemical Oxygen Demand (COD) is widely recognized as a critical metric for quantifying organic pollution and evaluating water quality. However, conventional COD monitoring relies on wet-chemical methods that involve hazardous reagents, have long processing times, and incur significant operational costs, making them unsuitable for real-time and environmentally friendly applications. Notably, no practical and widely adopted online COD monitoring systems currently exist, leaving municipalities and industries dependent on intermittent laboratory analyses that fail to capture dynamic pollution events. This study addresses this critical gap by developing a low-cost, eco-friendly microbial fuel cell (MFC)-based biosensor for accurate COD quantification and coupling it, for the first time, with an Internet of Things (IoT) platform for real-time environmental monitoring. The MFC biosensor converts biochemical energy from organic pollutants directly into electrical signals, which are continuously captured and transmitted through an IoT-based system for remote, user-friendly access. This integrated framework provides an innovative and scalable approach to COD monitoring in smart city infrastructures, enabling the development of early warning systems and facilitating rapid decision-making to protect public health and aquatic environments. Experimental validation demonstrated that the biosensor, after microbial enrichment, exhibited high sensitivity across a COD range of 0.1–0.5 g/L, with sensitivity gradually decreasing from 0.5 to 1 g/L while retaining reliable performance. A strong correlation was observed between closed-circuit voltage and COD ($R^2 = 0.9734$), as well as between current output and COD concentration, confirming the system's quantitative robustness. Although the coulombic efficiency requires further optimization to enhance sensitivity and accuracy, the biosensor's performance already represents a significant step beyond conventional approaches. The absence of chemical reagents and their ability to deliver continuous, in-situ measurements highlight their environmental and operational advantages. By overcoming the limitations of traditional COD monitoring, the developed MFC-IoT biosensor bridges a critical technological gap. It not only enables online COD tracking but also aligns with the broader vision of smart and sustainable cities by offering an integrated, low-cost, and eco-friendly water quality monitoring solution.

Keywords: Biosensor, Microbial Fuel Cell, Chemical Oxygen Demand, IoT

T3103-Explainable Ensemble Machine Learning for Sustainable Predictive Maintenance of Computer Systems

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Abstract

This research introduces an ensemble machine learning (ML)-driven predictive maintenance system for evaluating the health risk of computer systems in educational laboratories. The system monitors vital parameters such as AC operating voltage, temperature, humidity, PM2.5 dust levels, computer age, history of failures, and CPU utilization to classify the equipment health as Healthy, Warning, or Critical/At Risk. A majority vote ensemble is used to combine four supervised ML models: Random Forest (RF), Logistic Regression (LR), Support Vector Machine (SVM), and Naive Bayes (NB), which enhances prediction reliability. The system integrates Explainable AI (XAI) reasoning statements, providing clear and comprehensible explanations for each forecast to facilitate informed decision-making and effective preventative maintenance. Based on experimental results, the ensemble achieved an overall accuracy of 97%, closely aligning with assessments by laboratory technicians and standard computer operating guidelines. The predictive system facilitates early detection of potential issues, reduces unexpected downtime, extends hardware lifespan, and supports sustainable resource management by minimizing electronic waste and optimizing energy use.

Keywords: Predictive Maintenance, Ensemble Machine Learning, Explainable AI, Computer System Health, Sustainable Resource Management

T4: Renewable Energy & Circular Economy

T4156-Catalytic Enhancement of Bio-Oil formation in Hydrothermal Liquefaction Interpreted through Shrinking Core Kinetics

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Abstract

This research examines the effectiveness of catalysts in improving bio-oil production from macroalgae during hydrothermal liquefaction. The performance of different catalysts (KOH and gC3N4) was investigated in this process. The use of gC3N4 catalysts in the hydrothermal liquefaction process of macroalgae has demonstrated notable improvements in the yield and quality of bio-oil. These catalysts have played a crucial role in reducing the oxygen content, increasing the heating value, and promoting the formation of desirable compounds such as alcohols, phenolic compounds, and long-chain hydrocarbons. This innovative approach shows promising results(23.8wt%) for improving bio-oil production from macroalgae. In addition, the reaction mechanism is analyzed by the shrinking core model. It is a widely accepted approach in modeling gas-solid and liquid-solid reactions. Additionally, the paper highlights several key assumptions made during the modeling process. These include assuming a single interface between the solid substance and product, uniform particle porosity within each layer, constant temperature and pressure within the particle, immediate dissolution of products without forming a layer, and rapid dynamics of water concentration compared to the reaction rate.

Keywords: macro algae, catalyst, HTL, shrinking core model, ulwa

T4004-Design, Analysis, and Development of a Plastic Crusher for Recycling

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Abstract

The plastic crushing process reduces large pieces of recycled plastic into smaller sizes, making them easier to handle, transport, and recycle. The plastic crusher is machine consisting of four main components: the feeding unit, responsible for feeding plastic materials into the machine; the crushing chamber unit, where the materials are crushed; the power unit, and the machine frame, which holds all the components together. The main aim of this research is to design and manufacture a crusher machine that can crush recycled plastics. Pahl and Beitz method is used to create a detailed description of how the machine should be designed in each part. Five design concepts are presented, and selection criteria are set to choose the best design to develop. SolidWorks modeling and analysis tools, along with manual calculations, were used to design the final concept and determine the appropriate dimensions of the machine's main components. The selected design features a five-blade system with a diameter of 200 mm and a thickness of 20 mm, each blade equipped with five cutting teeth. The power requirement was determined to be 1.5 hp, with a rotating speed of 142 rpm. The manufacturing phase was completed successfully, resulting in a high-quality, well-performing machine. Testing showed that the size of the shredded plastic ranged from 1 to 4.5 cm in the initial run, with an additional size reduction of 10% to 20% achieved through re-cutting. The cutting rate, based on the chamber size, was found to be 1 to 2 kg per minute.

Keywords: Plastic Recycle, crushing machine, Pahl and Beitz method, machine design

T4044-Solar-Powered Green Ammonia Production: Process Simulation and Energy Optimization using DWSIM

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Abstract

This study presents a comprehensive process modelling approach for the carbon-neutral production of ammonia using renewable solar energy, water electrolysis, and air-derived nitrogen, developed and simulated in DWSIM. The system boundary encompasses all major subsystems required for green ammonia synthesis, including solar photovoltaic (PV) electricity generation, electrolyzer-based hydrogen production, air separation for nitrogen, gas compression and conditioning, Haber–Bosch synthesis loop, NH₃ condensation, separation, recycling, purge handling, and product storage. The Peng–Robinson property package is employed to model high-pressure thermodynamic behaviour of hydrogen, nitrogen, ammonia, and inert gases. Water electrolysis is simulated using a stoichiometric reactor linked to an energy stream representing solar-derived electricity, allowing quantification of hydrogen production based on electrolyzer efficiency and power availability. Nitrogen is produced via air separation modelled with a Splitter unit, delivering a high-purity N₂ stream for stoichiometric mixing with hydrogen. The ammonia synthesis loop is constructed using a Mixer, multi-stage Compressors, Heaters, Equilibrium or Conversion Reactor, Coolers, Flash Separator, Splitter (for purge), and Recycle block to replicate industrial Haber–Bosch loop dynamics. Mass and energy balance equations, thermodynamic relations, compressor power equations. Key performance metrics include ammonia yield, overall nitrogen conversion, separation efficiency, recycle ratio, specific energy consumption (kWh/kg NH₃), electrolyzer efficiency, and carbon-neutrality validation. Initial operating conditions include reactor pressure of 150 bar, temperature of 450 °C, electrolyzer efficiency of 70%, and a purge fraction of 2%. The simulation incorporates recycle convergence, reactor conversion assumptions, and sensitivity analysis on pressure, temperature, purge fraction, and H₂:N₂ feed ratio to optimize production and energy efficiency. The results demonstrate the feasibility of ammonia synthesis without fossil fuels by leveraging renewable electricity and electrochemical hydrogen production. The model provides a replicable and scalable blueprint for academic research, energy system optimization, and industrial transition toward sustainable ammonia manufacturing. This DWSIM-based framework establishes a structured foundation for evaluating green ammonia viability, lifecycle energy intensity, and process integration in future renewable chemical engineering systems.

Keywords: Green ammonia, DWSIM simulation, Haber–Bosch, electrolyser modelling, renewable energy, process optimization

T4144-CFD Based Study on Wind Turbine Layout Optimization and Yaw Control for Wake Mitigation in the Dhofar Wind Farm

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Abstract

Oman Vision 2040 emphasizes the transition toward renewable energy, supported by national investments in large-scale solar and wind projects. However, one of the main challenges facing the wind energy sector is the wake effect phenomenon, which significantly reduces overall power production in wind farms. This study investigates the impact of wake effects on the power performance of the Dhofar I Wind Farm in Oman using computational fluid dynamics (CFD). The existing turbine layout and prevailing wind conditions were analyzed based on wind rose diagram data. Three GE Vernova 3.8 MW wind turbine models were employed in ANSYS Fluent to evaluate wake interactions under rated wind speed conditions. Wake mitigation strategies were assessed by modifying turbine spacing and applying yaw control to upstream turbines. Simulations were conducted using the SST $k-\omega$ turbulence model for turbine spacings of 5D, 7D, 9D, and 11D (where D is the rotor diameter) and yaw angles of 0°, 5°, 15°, and 30°. Results show that increasing turbine spacing from 5D to 9D enhances total power output by 11.7%, while further spacing to 11D results in marginal gains of only 1.3%, indicating diminishing wake recovery benefits. Applying a 15° yaw offset to upstream turbines increases overall power production by 16.4%, confirming the effectiveness of wake steering. A hybrid strategy combining 9D spacing and yaw control achieves a significant improvement of 14.7%. These findings highlight the importance of optimized wake aware design and control strategies for future wind energy projects such as Dhofar II and for supporting Oman's renewable energy targets.

Keywords: Wind energy; Wind Farm Wake Effect; CFD Simulation; Wake Mitigation; Wake Mitigation; Yaw control

O1: Online Session 1

O1003-Numerical and experimental validation of solidification process enhancement of double coils latent heat storage units

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Abstract

In the present experimental study, a normal double helical coil (NDHC) tube was designed and utilized to investigate the convective heat transfer process inside a cylindrical latent heat storage unit (LHSU). The LHSU was employed to validate the corresponding numerical model. Water was used as the heat transfer fluid (HTF) circulating through the helical coil, while paraffin wax served as the phase change material (PCM) within the shell. The numerical analysis incorporated five physical models, focusing on the effects of coil pitch and geometry modifications. Two modified configurations were examined—inner coil compact down (ICCD) and outer coil compact down (OCCD). Numerical simulations were performed using ANSYS Fluent. The results showed that the NDHC configuration outperformed the modified designs. The complete solidification time for the NDHC was 165 minutes, whereas complete solidification was not achieved even after 190 and 230 minutes for the ICCD and OCCD configurations, respectively.

Keywords: Phase change materials; energy storage; double coil; latent heat.

O1007-Simulation of a Variable-Load Cogeneration Plant for an Industrial Ecozone Park: Power and Steam for Industrial Process

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Abstract

PEZA-initiated industrial parks developer/operators in the Philippines centralize shared utility services for heterogeneous tenants, creating a distinctive scheduling problem in which electricity and process-steam demands peak at different times. This study formulates an estate-scale operating strategy for a gas-turbine heat-recovery steam generator plant by quantifying how two levers—air–fuel and a controllable exhaust split to the HRSG—shape the attainable heat-to-power envelope. A rigorously specified DWSIM model represents a single-shaft gas turbine exhausting to an unfired, single-pressure HRSG that feeds an approximately 4 bar process header. Hourly off-peak, shoulder, and peak schedules are mapped to net electric power and delivered process heat. At fixed AFR, power is effectively invariant to exhaust split, whereas heat increases monotonically with split and flattens near full recovery due to a process-side overall heat-transfer-coefficient limitation rather than a shortage of exhaust enthalpy. Rich operation around AFR approximately 24 maximizes recoverable heat, while very lean operation depresses both power and heat. From calibrated points, three operator presets emerge for estate dispatch: Balanced CHP, Steam-priority (Fuel 1.20 kg/s, AFR 24, split at 100 percent; Power 18.3 MW and heat 20.7 MW), and Power-priority (AFR 24, split 50 to 60 percent; Power 17.7 to 18.0 MW and heat 9 to 12 MW). Treating exhaust split as the primary heat dial enables hour-by-hour alignment to tenant demand without sacrificing power. Incremental hardware such as added economizer and evaporator surface, or a multi-pressure HRSG configuration, would raise the heat-recovery frontier and reduce throttling losses with minimal fuel penalty.

Keywords: DWSIM; combined heat and power (CHP); cogeneration; gas turbine; HRSG; exhaust split control; UA limitation; single-pressure HRSG; dispatch scheduling

O1009-Thermodynamic Analysis and Simulation of a Regenerative Gas Refrigeration System

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Abstract

Gas refrigeration cycles based on the reverse Brayton (Bell–Coleman) cycle employ air or other inert gases as working fluids. Although environmentally benign, these cycles typically exhibit low coefficients of performance (COP) because the working fluid remains gaseous and therefore has a relatively low specific heat. Regeneration, pre-cooling the compressed gas by recuperating heat from the turbine exhaust, has been identified as a key strategy to improve performance. This paper reviews the recent literature on regenerative reverse-Brayton refrigeration (since 2016) and presents a DWSIM process simulation of a single-stage regenerative air cycle. The baseline case uses a pressure ratio of 4, a regenerator effectiveness of 0.80, and a refrigeration load of 10 kW. Results show that regeneration reduces the turbine inlet temperature from 308 K to 222 K and produces a turbine outlet temperature of 190 K. The net work input is 154 kW, yielding a COP of 0.065. Parametric studies indicate the COP is maximized at pressure ratios between 3 and 5, and that matching mass flow to the load can increase COP above 0.5. These results are discussed relative to published research and used to recommend design improvements for regenerative gas refrigeration system.

Keywords: Gas Refrigeration, Reverse Brayton Cycle, Regeneration, Coefficient of Performance, Process Simulation

O1012-Maize (*Zea mays* L.) productivity and profitability response to inorganic N-P nutrients, biochar and vermicompost levels in acidic soils of Northwestern Ethiopia

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Abstract

Maize (*Zea mays* L.) is sensitive to abiotic factors that can severely diminish crop yields. The combined use of organic and inorganic sources of nutrients enhances soil fertility and crop productivity. However, site and crop-specific integration levels are essential for optimal outcomes. These studies aimed to identify the optimal N/P₂O₅, BC, and VC combination to improve the physiological traits, growth, yield components, and yield of maize (BH-661) under rainfed agriculture. A field experiment (2023/24 and 2024/25) at Debre Markos University, Burie Campus, Burie district, Northwestern Ethiopia, aimed to identify the optimal combination of N/P₂O₅, BC, and VC for improving physiological traits, growth, yield components, and yield of maize (BH-661). The experiment was laid out in a 3 × 3 × 3 RCBD with three replicates. Treatments included three levels each of N/P₂O₅ (0/0, 120/69, 240/138 kg ha⁻¹), BC (0, 4, 8 t ha⁻¹), and VC (0, 5.02, 10.04 t ha⁻¹). Days to 90% physiological maturity (PM), NLPP, PH, EL, ENPP, GNPE, NRPE, TGW, BY and GY traits were recorded. The analysis of variance (ANOVA) indicated that maize phenology, growth, yield components and GY has significant difference (p < 0.01). The highest GY (12.13 t ha⁻¹), PH (320.5 cm), and GNPE (647.11) were recorded under integrated applications, particularly combined application of 120 kg N ha⁻¹ + 69 kg P₂O₅ ha⁻¹ + 8 t BC ha⁻¹ + 10.04 t VC ha⁻¹ + 0.63 t CaCO₃ ha⁻¹ (T24). The lowest values were observed in the control (T1). Notably, 120/69 kg N/P₂O₅ + 4 t BC + 5.02 t VC ha⁻¹ (T14) consistently produced high economical yields (12.09 t ha⁻¹) and the highest net benefit (289,124 ETB ha⁻¹) with a marginal rate of return of 3949.82%. Among the treatments, T24 yielded 12.13 t ha⁻¹, a 63.73% increase over the control (4.4 t ha⁻¹) and a 29.52% increase over the full inorganic recommendation (T7, 8.55 t ha⁻¹). Thus, combining 120/69 kg N/P₂O₅, 8 t BC, and 10.04 t VC ha⁻¹ (T24) is recommended to enhance maize yield and profitability in the area followed by T14. Further multi-season, multi-location studies with additional data on physiological, molecular and nutritional traits are needed to validate and consolidate these findings.

Keywords: *Biochar, Maize, Nitrogen, Phosphorus, Vermicompost, Yield.*

O1017-Energy Harvesting from Waste

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Abstract

Traditional fuels for the manufacture of strength are becoming scarcer by the day and it is becoming increasingly important to identify potential assets that can be utilised as fuel for the production of energy, particularly in emerging countries like India. The main goal of the project is to utilize the waste material and convert to energy by using TEG module by reducing air pollution by using carbon converters. As a consequent of the oil prices rises and climate change being attributed to the GHGs emissions caused by fossil fuel burning, one of the innovative energy harvesting techniques is the use of thermoelectric generators, which exploit the thermoelectric effect to generate electricity from temperature difference, this opened the way for a reliable waste heat recovery through installing this device wherever it is possible to increase the system efficiency.

Keywords: Waste managemen, Heat energy Utilisation, Zero cost energy generation New energy generation method, Reduce waste filling

O1020-Enhancing Transparency Using Blockchain Technology Implementation in Green Hydrogen Supply Chain Finance

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Abstract

This study analyzes the financial feasibility of implementing blockchain technology to enhance transparency within the Green Hydrogen Supply Chain Finance (GHSCF) context. Recognizing the critical need for verifiable green credentials and fund flow in the emerging hydrogen economy, this research specifically targets financial decision-making for firms involved in the GHSCF, such as specialized logistics or financing entities. Using the Benefit-Cost (B/C) Analysis method, this study evaluated three distinct implementation scenarios, each developed with fundamental financial and operational assumptions to complement the B/C analysis. The initial custom blockchain development scenario yielded a B/C ratio of 0.8, indicating short-term financial infeasibility due to high initial costs. To address this, two alternatives were tested. Adopting a Blockchain-as-a-Service (BaaS) platform (Scenario 2) significantly reduced capital expenditure, boosting the B/C ratio to 1.6 and making the project viable. The most optimal strategy (Scenario 3) combined BaaS with transparency monetization, such as a "green hydrogen passport" service and carbon credit leveraging. This integrated approach resulted in a B/C ratio of 2.4, proving the project highly profitable. The study concludes that financial success hinges on smart business strategies, aligning reduced BaaS implementation costs with the creation of monetizable, transparency-based value propositions

Keywords: green hydrogen; green supply chain finance; blockchain technology, transparency

O1024-GIS-Based Ward-Level Spatial Assessment of Urban Air Quality for Monitoring Sustainable Development Goal Target 11.6.2

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Abstract

Evaluating urban air quality is crucial for protecting public health and promoting sustainable urban development, particularly in rapidly expanding cities. Fine particulate matter (PM_{2.5}) is a significant contaminant owing to its durability, substantial particle distribution, and recognized correlations with respiratory and cardiovascular diseases. This study presents a GIS-based, ward-level spatial evaluation of urban air quality and assesses progress toward SDG Target 11.6.2, which quantifies the percentage of urban residents exposed to air pollution exceeding acceptable levels. MODIS-derived Aerosol Optical Depth (AOD) data were analysed and transformed into ground-level PM_{2.5} concentrations. Population-weighted PM_{2.5} levels were computed for each ward utilizing ward boundaries and demographic data, yielding an accurate depiction of population exposure. Achievement scores for SDG 11.6.2 were calculated in accordance with the United Nations air quality criteria to assess compliance and identify wards with elevated exposure risk. The spatial analysis uncovers considerable intra-urban variability, identifies pollution hotspots, and emphasizes that regions need immediate mitigation efforts. This study develops a technically robust approach for high-resolution, micro-scale air quality evaluation by merging remote sensing, GIS-based spatial analytics, and SDG monitoring frameworks, providing actionable information for urban planners, environmental managers, and policymakers.

Keywords: Air quality, urban environment, spatial analysis, AOD, PM_{2.5}, SDG 11.6.2

O1025-Development of the Optimal Composition of Concrete Mixes Based on Limestone Shell Rock Waste

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Sh Esenov atyndagy Kaspiy memlekettik tekhnologiyalar zhene inzhiniring universiteti

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Abstract

Background/Purpose. In the Mangystau region of Kazakhstan, up to 1.5 million m³ of limestone shell waste is generated annually due to the high fracturing of the rock and significant losses during stone sawing. These wastes accumulate in large volumes, occupy significant territories and contribute to dust pollution, which causes deterioration of soil fertility and negatively affects ecosystems and public health. The purpose of the study is to evaluate the possibility of using limestone shell waste from various deposits as a coarse aggregate for concrete mixtures and to determine the strength characteristics of the resulting carbonate concrete. **Methods.** Laboratory studies of the chemical composition of the waste were carried out, and the physico-mechanical properties of limestones from five deposits in the Mangystau region were determined. Based on the data obtained, concrete samples with various carbonate aggregates were produced. Compressive and flexural strength was determined according to GOST 10180-2012 on 28-day samples. **Results.** The analysis showed that carbonate aggregates are involved in chemical interaction with cement minerals, forming carbonic-aluminate phases, which improves adhesion to cement stone. The obtained concrete samples demonstrated compressive strength in the range of 30.8–40.6 MPa, meeting the requirements of GOST 25192-2012. The strength differences are directly related to the characteristics of specific deposits. **Conclusion/Conclusions.** The study confirms the possibility of effective use of limestone shell waste as a coarse aggregate for concrete grades M200-M350. This approach reduces the environmental burden, reduces the need for natural resources and ensures economic efficiency.

Keywords: sawing waste, shell limestone, concrete mix, strength, utilization, production, concrete.

O1031-Geo-Epidemiological Analysis of Malaria Cool and Hotspots in the Sahelian Drylands of Nigeria

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Abstract

Malaria is still persisting as a complex geo-epidemiological challenge across sub-Saharan Africa, where transmission dynamics are mediated by interlinked climatic and environmental factors. In Nigeria's Sahelian drylands, this challenge is amplified by ecological fragility and erratic climate regimes that complicate intervention planning. Thus, this study employed a geo-epidemiological approach to analyze malaria "cool" and "hot" spots across Yobe State, integrating epidemiological datasets and climatic indicators to unravel spatio-temporal risk heterogeneity. Using malaria incidence data (2014–2023) obtained from the Yobe State Disease Epidemic Repository, the study applied unsupervised machine learning algorithms to classify malaria risk zones across three micro-climatic settings. Findings revealed substantial temporal and spatial variability in malaria burden across ecological gradients. Temporal trend analysis indicated a weak but persistent rise in malaria incidence in the SuSZ ($R^2 = 0.77$), reflecting sustained environmental favorability for vector breeding, while the SaSZ and TZ showed fluctuating patterns shaped by rainfall variability and inconsistent intervention continuity. Seasonal decomposition highlighted a clear transmission cycle peaking in August – September, synchronized with the rainy season, underscoring the climatic sensitivity of malaria in dryland contexts. The clustered hotspots are observed to be around irrigation corridors and floodplains in the SuSZ, particularly around Fika and Gadaka, while coldspots were concentrated in the arid northern SaSZ around Dagona and Azaam Kura. These spatial patterns confirmed that malaria risk is strongly conditioned by hydrological systems, land use and settlement morphology. The study advanced the understanding of malaria eco-epidemiology in semi-arid settings by demonstrating that climate variability and anthropogenic factors jointly determine malaria persistence. It underscores the necessity of climate-informed and zone-specific malaria surveillance systems that integrate geospatial data, environmental modeling and socio-economic profiles. By identifying both persistent hotspots and emerging coolspots, the study provides a data-driven foundation for adaptive, spatially targeted malaria control strategies in Nigeria's drylands.

Keywords: Malaria hotspots, Geo-epidemiology, Climate variability, Yobe State, Sahel drylands

T2016-Condition monitoring of Power transformers

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Abstract

Power transformers are the most critical and expensive components of electric power transmission substations, and their outage causes, catastrophic, damages to the operation of the electric system and industrial production. Therefore, regular condition monitoring of transformer is necessary. The use of condition monitoring allows maintenance to be done in a scheduled manner before it leads to occurrence of any severe failure. To assess the extent of deterioration in equipment, it is necessary to employ appropriate diagnostic tool. Many measurement techniques like Tan delta/Insulation Resistance measurement, monitoring of temperature, Partial Discharge Measurement, Thermo-vision Measurement, checking break down voltage of oil and fault gas analysis, formed the part of condition monitoring strategy. In this paper an attempt is made to analyze the dissolve gases, because Dissolved Gas Analysis (DGA) is a widely used technique to estimate the condition of oil-immersed Equipment. The experimental results of the level and the change in concentration of different combustible gases in the insulating oil is a trustworthy diagnostic tool which can be used as indicator of undesirable events occurring inside the equipment, such as hot spots, electrical arcing or partial discharge. It is the best indicator of overall condition. It will provide useful information about the condition of oil and help to identify the type of fault in the transformer.

Keywords: Condition monitoring , Power transformers , Dissolved Gas Analysis (DGA) , Partial Discharge

T1033-AI-Driven Wastewater Treatment Pathways Toward Zero-Liquid-Discharge in Lignocellulosic Biorefineries

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Abstract

Integrated lignocellulosic biorefineries process agricultural residues for the production of biofuels, chemicals and energy from agriculture crops but processing phases (e.g., size reduction, pretreatment, enzymatic hydrolysis, fermentation and product recovery) produce complex wastewaters with lignin, cellulose derivatives, organic acids and enzymes as well as other impurities. The effluent is generally too variable and recalcitrant for economically feasible treatment by conventional approaches such as sedimentation, filtration, neutralization and biological treatment. In such systems energy consumption is also high, sludge production 180 mg/hem.aty, inverter rate of these systems undergo reducing and ZLD particularly cannot remove any emergent contaminants. Wastewater treatment performance can be effectively improved through machine learning (ML). Using big process data, ML models can predict the effluent quality, optimize operational settings, find anomalies and provide support bid real-time process operation. Methods like PCA, t-SNE and autoencoders reduces the complexity of data; supervised, unsupervised and reinforcement to model predictive as well as optimization problems. The adoption of ML in biorefinery plants contributes to the treatment efficiency, cost and regulatory compliance, and adaptation to changing feedstock compositions. Therefore, ML-oriented plan is an acceptable and a feasible route to promote wastewater treatment into ZLD for lignocellulosic biorefineries.

Keywords: Lignocellulosic biorefinery, Wastewater treatment, Zero liquid discharge (ZLD), Biomass processing effluents, Emerging contaminants, Machine Learning.

T1018-Oman's Strategic Leap toward a Resilient Energy Future Integrating AI

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Abstract

Oman is undergoing a transformative energy transition aligned with Vision 2040 and its commitment to achieve net-zero emissions by 2050. Recent trends highlight rapid progress in renewable energy deployment, with solar and wind projects boosting clean energy's share to 21% of electricity generation in 2025, up from 9% in 2024. Landmark initiatives include the Manah I & II solar plants (1,000 MW), Ibri II (500 MW), and Dhofar Wind Farm, complemented by upcoming projects exceeding 4,500 MW of solar capacity and 1 GW of wind power by 2030. Parallel investments in green hydrogen, targeting 1 million tons annually by 2030, position Oman as a global hub for low-carbon fuels. Carbon neutrality strategies are reinforced through the National Net-Zero Programme, the Oman Net Zero Centre, and over 200 decarbonization projects spanning energy, transport, and industry. These include carbon capture, utilization and storage (CCUS) pilots, electrification of operations, and afforestation initiatives. Emerging technologies and AI applications are accelerating this transition: predictive analytics for solar and wind forecasting, AI-driven grid optimization, and smart charging networks for EVs enhance system reliability and efficiency. Industrial decarbonization leverages AI for real-time process optimization, solvent screening in carbon capture, and green hydrogen supply chain modeling, reducing costs and emissions across Oman's industrial hubs. This paper explores how AI integration, renewable energy innovations, and systemic carbon neutrality strategies converge to create a resilient, low-carbon economy. It emphasizes Oman's roadmap for scaling these technologies, fostering public-private partnerships, and leveraging digital intelligence to achieve a net-zero future, offering a replicable model for sustainable development in the Gulf and beyond.

Keywords: Carbon neutrality strategies ,National Net-Zero Programme , Oman Net Zero Centre ,Decarbonization projects

P2: Poster Session 2

P2084-Facile Synthesis of Iron oxide Nanoparticles from Omani Alovera leaf extracts for Oily Wastewater Treatment

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Abstract

The search for locally available and environmentally friendly nanomaterials has garnered considerable attention due to their potential application in pharmaceutical, environmental and biomedical fields. This research focused on the sustainable production of iron oxide nanoparticles (IONPs) from natural resources by green synthesis technique using Alovera leaf extract as a plant based reducing and stabilizing agent. The development of IONPs formation was monitored by a visible color change corresponding to an absorbance peak at 292 nm in the UV-Vis spectroscopic analysis. The various characterization tools employed are X-Ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Dynamic Light Scattering (DLS), and Energy Dispersive X-Ray (EDX) analysis. The FTIR spectra revealed the contribution of hydroxyl and phenolic functional groups responsible for the reduction and stabilization processes, while SEM micrograph displayed the successful formation of IONPs in the form of aggregate showcasing the surface morphological features. The XRD spectral distribution revealed a single broad peak at 2θ , signifying amorphous nature of the sample. The green synthesized IONPs are mixed with Poly Styrene Sulphonate (PSS) polymer to form a nanocomposite solution. The nanothin films were fabricated by dip coating method by immersing the glass substrate into the nanocomposite solution. The resulting nanothin films were used in the batch treatment of oily wastewater by altering the processing conditions (pH, exposure time, number of dipping cycles and amount of IONPs) and the optimum pollutant removal efficiency was established. The effectiveness of oily wastewater treatment was assessed by measuring the Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), and Turbidity values. The outcome of the study showed a significant reduction in COD (87%), TDS (89%), TSS (78%) and turbidity (91%). These findings underscores the potential of Alovera leaf extract mediated IONPs in the development of nanocomposite thin film formation. The nanocomposite thin film demonstrates an economical and sustainable nanomaterial for environmental remediation by removing organic contaminants from oily wastewater, and hence offers a feasible solution to wastewater treatment applications.

Keywords: *Alovera leaf, Chemical Oxygen Demand, Nanocomposite, Oily wastewater, Poly Styrene Sulphonate, Iron oxide nanoparticles, Scanning electron microscopy, Sour water.*

P2119- Utilization of Lime Purge Waste from Desalination Plants for Sustainable Carbon Capture Using a Solar-Driven Spray Reaction System

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Abstract

This research explores the utilization of lime purge waste from desalination plants as a sustainable calcium source for carbon capture inside an innovative spray reaction chamber. Lime purge, which typically contains CaCO_3 , is currently discarded as waste, creating environmental and economic challenges. By repurposing this by-product for CO_2 absorption, the project aligns with Oman's Vision 2040 goals for circular economy development, waste valorisation, and low-carbon industrial technologies. The study introduces a closed-loop system in which CaCO_3 is thermally decomposed into CaO using concentrated solar energy, simulated experimentally through controlled calcination at temperatures ranging from 650°C to 850°C . The regenerated CaO is then intended for use in a spray reaction chamber to capture CO_2 efficiently through gas–liquid interaction. To evaluate the effect of temperature on CaCO_3 decomposition, pellets of CaCO_3 and starch were heated at varying temperatures and subsequently analyzed using acid–base titration to quantify CaO formation. Results showed a strong positive correlation between calcination temperature and CaO yield. Low temperatures (650°C – 700°C) resulted in limited decomposition, while higher temperatures significantly improved CaO regeneration. The highest CaO yield, 0.01373 mol, was observed at 850°C , confirming that efficient CaCO_3 decomposition requires temperatures near complete calcination thresholds. These findings validate the feasibility of using solar-driven heating—such as Fresnel lens concentration systems—to regenerate CaO sustainably. The project demonstrates that lime purge waste can serve as an effective, low-cost material for CO_2 capture while enabling a renewable-energy-powered regeneration cycle. This work establishes the foundation for developing a scalable, environmentally friendly carbon capture system suitable for industrial use in Oman.

Keywords: Calcination, calcium carbonate, Fresnel lens, Solar irradiation

P2014- Functionalize Activated Carbon for Efficient Adsorptive Removal of Methyl Orange from Aqueous Solution

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Abstract

Water scarcity and pollution have become a global concern, hence the need for continuous innovation in wastewater treatment technologies. This study looks into the application of functionalized activated carbon in the removal of synthetic dyes from industrial wastewater. Functionalization of the activated carbon was done by acid treatment, which enhanced its surface chemistry for higher adsorption capacity and selectivity compared to commercial activated carbon. This enables efficient targeting of complex dye molecules in ways that will reduce their harmful impact on aquatic ecosystems and public health. Results obtained from the experiments have been further analyzed using Microsoft Excel in order to enhance the analytical reliability of the adsorption study. A linear regression model and Goal Seek function were used for the prediction and optimization of the dye removal efficiency, thus providing a simple digital tool for process enhancement. These results, obtained with functionalized activated carbon, are promising for low-cost, eco-friendly, and regenerable adsorbents in the search for sustainable wastewater treatment. Integration of analytical modeling inspires the project to further address Oman Vision 2040, together with the Sustainable Development Goals, toward smarter, low-carbon water purification technology.

Keywords: Functionalized Activated Carbon, Adsorption, Wastewater Treatment, Methyl Orange, Data-driven Optimization.

P2022-RO membrane recycling to UF for industrial uses

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Abstract

Desalination plants play a significant role in providing water resources in the Sultanate of Oman and other GCC countries. Most of these plants utilize RO membrane technology, which becomes obsolete and inefficient over time; therefore, a high number of RO membranes need to be replaced after a period of 3–5 years, increasing environmental pollution and its associated impacts. To address this issue, the current research proposes the reuse of end-of-life reverse osmosis (RO) membranes. This project focuses on identifying the most effective method to give a second life to old RO membranes used in wastewater treatment units, with potential applications in industrial and agricultural sectors. This approach relies on a conversion process in which the membrane is transformed from reverse osmosis (RO) to ultrafiltration (UF) by oxidizing the active polyamide layer using sodium hypochlorite. In addition, the membrane's performance was examined by evaluating fouling, scaling, protein rejection, and humic compound removal to determine its suitability for reuse. The major objective of this research is to assess the feasibility of converting end-of-life RO membranes into UF membranes through appropriate pre-treatment using sodium hypochlorite, to develop and design the water setup for the UF unit, to evaluate and compare the performance of the converted membranes, to analyze the economic viability of the proposed system, and to characterize the membrane properties before and after treatment to understand the effectiveness of the conversion process.

Keywords: RO membrane, UF membrane, WT water treatment

P2026- Computational Approaches to Hydrogen Storage in High-entropy Alloys

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Abstract

Hydrogen is widely recognized as a major component of future clean energy systems due to its high energy content and carbon-free combustion. Despite its advantages, storing hydrogen safely and efficiently remains a major obstacle to large-scale implementation. Solid-state hydrogen storage using high-entropy alloys (HEAs) has gained significant attention because these materials offer adjustable crystal structures, high configurational entropy, and excellent stability under mechanical and thermal stress. This study examines the hydrogen storage performance of a Zr–Hf–Ti–V–Nb HEA through computational modeling supported by thermodynamic, electronic, and mechanical analyses. The HEAPS (High Entropy Alloy Property Simulator) software was used to evaluate phase stability, mixing enthalpy, hydrogen absorption behavior, and hydride formation energies under different temperature and pressure conditions. The results indicate that the alloy retains a stable BCC solid-solution phase, with hydride formation enthalpies between -35 and -45 kJ/mol H, reflecting strong yet reversible hydrogen bonding. Electronic structure evaluations show favorable d-orbital interactions and lattice distortions that support hydrogen diffusion and trapping. Mechanical assessments confirm high strength, excellent structural durability, and resistance to hydrogen-induced degradation. These outcomes are consistent with recent computational studies using DFT and CALPHAD methods and demonstrate that HEAs containing Ti, V, Zr, Nb, and Hf possess the necessary thermodynamic, structural, and electronic qualities for efficient and reversible hydrogen storage. Overall, this project contributes to Oman's emerging hydrogen economy by advancing the development of innovative and reliable materials for clean-energy storage.

Keywords: High-Entropy Alloys (HEAs), Hydrogen Storage, Computational Modeling; Thermodynamic Analysis, Electronic Structure, Refractory Metals

P2074-Design and Development of a Solar-Powered Wireless Charging Station for Electric Vehicles

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Abstract

The transition to electric vehicles (EVs) is key to reducing greenhouse gas emissions and dependence on fossil fuels, yet the widespread adoption of EVs remains challenged by limited charging infrastructure, range anxiety, and reliance on non-renewable energy sources. This project focuses on the design and development of a solar-powered wireless charging station for electric vehicles, aiming to address these issues by integrating renewable energy and innovative charging technologies. The proposed system harnesses solar energy to provide a clean, sustainable power source, reducing the carbon footprint associated with EV charging. The wireless charging station is designed to be efficient, user-friendly, and adaptable to various environmental conditions. By utilizing photovoltaic panels, energy storage solutions, and resonant inductive coupling for wireless energy transfer, the system allows for convenient, contact-free charging. Key components include solar panels for power generation, a battery storage unit for energy management, a control system for optimizing power flow, and a wireless charging pad that interacts seamlessly with EVs equipped for inductive charging. The project explores optimal placement and orientation for solar panels to maximize energy capture, investigates power conversion efficiencies, and addresses safety protocols for wireless energy transfer. A prototype of the station will be developed, tested, and evaluated for energy efficiency, charging speed, and overall feasibility. This solar-powered wireless charging station has the potential to expand the EV charging infrastructure in a sustainable manner, supporting the shift towards greener urban transportation networks.

Keywords: wireless charging, solar panel, solar energy, car

P2078- Enhanced Infiltration Capacity of Cementitious Materials for Stormwater Management

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Abstract

Urban areas increasingly face major challenges related to stormwater accumulation, insufficient drainage capacity, and the environmental impact of traditional pavement systems. This research aims to engineer a sustainable, high-performance permeable concrete incorporating silica fume, polymer additives, and recycled tire rubber to enhance infiltration, reduce flooding risks, and support circular economy principles. The mix design replaces a portion of fine aggregates with crumb rubber while integrating silica fume to improve matrix density and mechanical performance, and polymer to enhance bonding, flexibility, and resistance to micro-cracking. Laboratory testing included permeability assessment, compressive strength evaluation, and visual inspection of pore connectivity. Results indicate that the optimized composite achieves high infiltration capacity while maintaining adequate load-bearing strength suitable for parking lots, walkways, and low-speed traffic zones. The addition of rubber increased void content and improved drainage, while silica fume and polymer compensated for strength loss typically associated with rubberized mixes. Beyond performance improvements, the material offers significant environmental and economic benefits. It reduces reliance on natural aggregates, diverts tire waste from landfills, lowers carbon emissions associated with cement usage, and decreases pressure on municipal drainage systems. This work demonstrates a viable engineering solution that supports sustainable urban development and advances environmentally responsible construction practices.

Keywords: Permeable Concrete, Stormwater Management, Silica Fume, Polymer-modified Concrete, Recycled Tire Rubber, Sustainable Materials Engineering, circular economy

P2079-Implementation of iNav in the Design and Installation of an Unmanned Aerial Vehicle for rescue missions during natural disasters

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Abstract

This project introduces a UAV designed for search and rescue missions during natural disasters, equipped with the iNav flight control system. iNav enables autonomous GPS-based navigation, precise waypoint tracking, automatic return-to-home, and real-time flight stabilization — making the drone capable of operating with minimal manual control. Field tests demonstrated that the UAV could follow programmed waypoints accurately while transmitting live aerial video to rescue teams, improving situational awareness and reducing risk before physical entry into affected zones. The system successfully reached locations that are difficult or unsafe for human responders. Although flight duration is limited by battery capacity, the integration of iNav proved highly effective in enhancing autonomy and reliability for disaster-response applications.

Keywords: drone, rescue, disasters, Flight control system , iNav

P2087- Design and Fabrication of an Automated Machine for Preparing Traditional Omani Arsiya

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Abstract

Arsiya is an Omani cuisine with cultural importance frequently made for celebrations. The classic way of making it demands effort takes a long time and necessitates considerable expertise posing difficulties for contemporary homes and professional kitchens. This initiative seeks to create an automated device that streamlines Arsiya preparation while maintaining its flavor and consistency. The suggested apparatus combines heating, with mechanical stirring to mimic the traditional techniques of lessening manual labor and guaranteeing uniformity. The design approach included determining customer needs implementing Quality Function Deployment (QFD) and creating concepts, which were then narrowed down using screening and scoring matrices. SolidWorks software was used for 3D modeling and structural evaluation while manual computations were conducted to establish design parameters. The ultimate design incorporates a stainless-steel mixing bowl, adjustable mixing blades, heating elements and an intuitive control panel, for temperature and speed adjustments. Safety considerations, such as insulated components and detachable parts for easy cleaning, were prioritized. The prototype is intended for home or small-scale use, offering portability, efficiency, and durability. By automating the cooking and mixing stages, the machine significantly reduces preparation time and labor, ensuring consistent quality and supporting the preservation of Omani culinary heritage. This innovation also opens opportunities for smart kitchen solutions tailored to traditional recipes.

Keywords: Automated food preparation machine, Omani Arsiya, Traditional dish automation, Mechanical mixing system, Controlled heating, and SolidWorks design

P2092-A Simulation-Based Assessment of Courtyard Shading and Thermal Comfort Informing A 'Daylightophilia' Sustainable Design Concept at The University of Nizwa New Campus

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Abstract

Oman's Vision 2040 emphasizes the preservation of Islamic architectural heritage while pursuing rapid technological and sustainable development. Moreover, the phenomenon of Daylightophilia, in reference to the human connection with daylight, needs redefinition because hot desert environments convert beneficial daylight into a major thermal discomfort factor. The article assesses the courtyard microclimate of the Girls' Dormitory building at University of Nizwa through two simulation scenarios which compare an unshaded courtyard to a shaded courtyard proposal using canopy structures. The assessment created using an integrated digital workflow that combine Revit 2025 for 3D modelling, Rhino/Grasshopper for parametric coordination, and Ladybug Tools for environmental simulation. The simulations were performed for 21 June 2023, corresponding to the summer solstice at four different times—08:00 AM, 11:00 AM, 01:00 PM, and 04:00 PM—using climate data from the Nizwa TMYx weather file. The article produces three main outputs direct sun exposure percentage visualization, shaded area percentage, and comparative solar exposure charts that jointly demonstrate the effect of shading on courtyard thermal comfort. The article investigates how passive architectural solutions improve thermal comfort and outdoor accessibility through natural methods which replace mechanical cooling systems. By exploring how local climate conditions affect shading design to develop sustainable courtyard design solutions for hot-arid areas. Results illustrates that shading interventions significantly reduce direct solar load, improve shaded area coverage, and enhance courtyard usability during critical daytime periods. The findings demonstrate that shading serves as an effective passive design solution which aligns with Oman Vision 2040 sustainability goals for urban development and environmental protection.

Keywords: Courtyard microclimate, Shading analysis, Ladybug Tools, Thermal comfort, Hot-arid climate, Daylightophilia.

P2093-Condition Monitoring of Distribution Transformer at Local Utility using Gasses Liberated from Transformer Oil

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Abstract

The health assessment of distribution transformers is essential for ensuring reliable power delivery, reducing unplanned outages, and extending asset life in local utility networks. Dissolved Gas Analysis (DGA) has emerged as one of the most effective diagnostic tools for monitoring the internal condition of transformers by detecting incipient faults through the presence and concentration of characteristic gases dissolved in insulating oil. This study evaluates the health of distribution transformers in a local utility using DGA techniques aligned with leading international standards, including IEC 60599, IEEE C57.104, and ASTM D3612. These standards provide structured methodologies for gas extraction, measurement, interpretation, and fault classification, enabling consistent and comparable assessments across diverse transformer populations. As this is the final year technical project of the Electrical Engineering in collaboration with NAMA, group students are using the NAMA facilities to identifying key fault indicators such as thermal degradation, electrical arcing, and partial discharge by analysing gas ratios, total dissolved combustible gas and trend behaviour over time. By applying internationally recognized interpretation methods—such as the Duval Triangle condition-based thresholds the study establishes a comprehensive diagnostic framework tailored to local operational environments. Findings highlight the importance of routine oil sampling, timely data analysis, and the integration of DGA results with overall transformer condition monitoring strategies. The assessment demonstrates that systematic DGA application can significantly improve maintenance planning, reduce the risk of catastrophic transformer failure, and optimize investment decisions for utilities managing aging infrastructure. The study underscores DGA's role as a cost-effective, non-intrusive tool that supports the transition from reactive to predictive maintenance within modern power distribution systems.

Keywords: Condition Monitoring, Distribution Transformer, Dissolved Gas Analysis, Duval's Triangle, Gas Ratio

P2095-Simulation-Based Design of Plantation Shading Strategies for Heat Mitigation in Campus Parking Areas: A Case Study of Nizwa University

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Abstract

The rich architectural approaches that address unique microclimate challenges provide a valuable technique rely on simulation-based research. In the hot-arid context of Nizwa, it offers a critical starting point for research to evaluate heat gain, evaluate shading performance, and investigate vegetation scenarios and their contribution to alleviating extreme thermal conditions. Due to the extremely hot climate, this research examines how plantation strategies contribute to cooling in outdoor spaces at Nizwa University. Additionally, the exposed asphalt in parking lots and surrounding landscape of the buildings experience high thermal stress due to extensive use of low-albedo asphalt surfaces. Such conditions impair landscaping performance and weaken pedestrian comfort, as recorded in the older campus setting, while simultaneously exacerbating urban heat island effects and restricting the usability of outdoor environments. Moreover, this paper investigates a specific parking zone within the College of Engineering and Architecture as an example of testing the plantation effect on the average surface reduction. Observations and documentation of the old university campus showed that pedestrians experienced an uncomfortable walking flow while moving through these areas. This paper examines how plantation-based design strategies could reduce heat gain and enhance microclimate performance through simulation-based study. The results indicate that plantation coverage, specifically dense planting and the following shading layouts, which can substantially lower the ambient temperature of the surface, can improve overall pedestrian comfort. These simulation findings will be validated by comparing average surface temperatures before and after interventions during the peak summer months. Ultimately, the study proposes planting strategies for a representative parking area, adaptable to different regions, within a scalable framework that illustrates how simulation-based design can create sustainable outdoor landscapes and enhance long-term environmental responsiveness and campus walkability.

Keywords: plantation shading, climate-responsive architecture, microclimate simulation, heat gain, thermal comfort, hot-arid climate, university campus design, Nizwa University

P2124-Design, Mixing Performance, and Mass-Transfer Evaluation of a Thermophilic Bioreactor System

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Abstract

This study presents the systematic design, structural evaluation, and hydrodynamic assessment of a continuous stirred-tank bioreactor (CSTR) intended for the biological conversion of acetic acid to methane under optimal thermophilic conditions. The reactor was designed to operate at 40 °C with a hydraulic retention time of 2 h and an influent flow rate of 373 L/h, yielding a required working volume of 0.746 m³. The geometric configuration was developed using standard CSTR height-to-diameter ratios to ensure uniform mixing, effective mass transfer, and mechanical stability. Structural design, undertaken in accordance with ASME pressure-vessel criteria, resulted in a calculated wall thickness of 0.455 mm and an outer diameter of approximately 983 mm, confirming the adequacy of the vessel for the specified operating conditions. Impeller sizing and flow analysis demonstrated fully turbulent hydrodynamics, as indicated by a Reynolds number of 9.83×10^4 , with a corresponding mixing power requirement of 21.55 W. Validation against online bioreactor design tools showed strong concordance with manual computations, reinforcing the reliability of the adopted methodology. Gas-liquid mass-transfer evaluation further revealed that non-coalescing media significantly enhance volumetric mass-transfer coefficients and oxygen-transfer rates compared with coalescing systems. Collectively, the findings confirm that the proposed bioreactor design satisfies functional, structural, and operational criteria and is well-suited for stable and energy-efficient methane bioproduction.

Keywords: Bioreactor; Mass Transfer Coefficient; Anaerobic; Mixing; CSTR

P2149-AI-Driven Specimen Classification and Measurement System

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Abstract

Artificial intelligence (AI) offers significant potential to enhance the sustainability of healthcare systems by improving diagnostic efficiency, reducing resource consumption, and minimizing avoidable waste. This work presents an engineering solution that integrates a custom-built Convolutional Neural Network (CNN), image processing, and augmented reality to support more efficient and sustainable clinical workflows in pathology and related medical disciplines. The proposed CNN architecture, implemented using PyTorch and OpenCV, accurately differentiates various tissue types and organs in medical images, enabling precise automated assessment and reducing the need for repeated manual examinations. An experimental evaluation shows that the proposed approach outperforms existing methods in terms of accuracy and efficiency, with the measurement system achieving a standard deviation of less than 0.05 cm, demonstrating high repeatability and robustness. By improving accuracy, consistency, and workflow efficiency, this AI-driven engineering design contributes to more sustainable healthcare practice through optimised use of time, materials, and clinical resources, aligning with the broader goals of sustainable development in the medical sector.

Keywords: Artificial Intelligence, Computer Vision, Convolutional Neural Networks, Image processing, Sustainable Clinical Workflow.

P2030-Use of Additive to Study the Physical Properties of Cohesion Soil

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Abstract

Clay soils typically exhibit low strength, high plasticity, and significant volume changes, which make them unsuitable for construction without modification. The clay soil used in this study was collected from Al Ansab, located 15 km from Muscat's city center, and is representative of locally encountered problematic soils. The purpose of this research is to evaluate the effectiveness of silica fume—an industrial by-product—as a stabilizing additive to improve the engineering properties of this clay. Laboratory experiments were conducted on untreated and silica-fume-treated soil samples, with additive contents of 4%, 8%, and 12%. Tests performed included the Atterberg Limits, Specific Gravity Test, Water Content Test, Compaction Test, Sieve Analysis, and California Bearing Ratio (CBR) Test. These tests assessed changes in strength, plasticity, compaction characteristics, and load-bearing capacity following stabilization. Results show that the natural soil is highly plastic clay with poor engineering performance. The addition of silica fume significantly improved soil behavior, particularly in terms of compaction efficiency and penetration resistance. Among all mixtures, the 8% silica fume sample exhibited the highest increase in CBR value and overall strength. This study demonstrates that silica fume is an effective and sustainable stabilizing agent for clay soils. Further research is recommended on field-scale performance, environmental impacts, and long-term durability of silica-stabilized soils.

Keywords: Clay Soil Stabilization, Silica Fume, California Bearing Ratio (CBR), Compaction Characteristics, Atterberg Limits, Soil Improvement

P2137-A Comprehensive Review of the Design and Fabrication of Polymeric Nano/Micro Composites: Foaming Processes and Their Impact on Material Performance

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Abstract

This review paper focuses on polymeric porous nano/micro composites, which have garnered significant attention in materials science due to their lightweight, high strength-to-weight ratios, and tunable properties. These composites, characterized by a three-dimensional porous structure with nano/micro scale fillers, enhance mechanical, thermal, and functional properties, making them suitable for various applications in aerospace, automotive, and construction sectors. The review explores the design and fabrication of these composites, emphasizing foaming production techniques, including solid-state foaming, continuous foam extrusion, and semi-continuous foaming. Each method presents unique advantages and challenges in achieving uniform particle distribution and controlling foam morphology. Furthermore, the review examines the critical role of foaming parameters—such as temperature, pressure, saturation time, and cooling rate—on the quality of foamed materials. Studies highlight how precise control over these parameters can optimize foam structure, morphology, and overall performance. For instance, the addition of nano/micro particles influences cell nucleation and growth, leading to desirable foam characteristics. Research findings indicate that polymers like low-density polyethylene (LDPE) exhibit stability across a wide foaming temperature range, while polypropylene (PP) demonstrates sensitivity to foaming conditions, affecting cell structure and mechanical properties. The incorporation of short carbon fibers (SCF) into polypropylene composites shows that increased SCF content leads to larger cell sizes, while higher saturation pressures promote smaller cells and higher density. This review aims to provide valuable insights into the advancements in polymeric porous nano/micro composites and their foaming processes, contributing to the development of high-performance materials tailored for diverse applications..

Keywords: Polymeric Composites, Nano/Micro Fillers, Foaming Techniques, Cell Morphology, Material Properties

P2006-Sustainability Comparison of Petrol Vehicles (ICEVS), Electric Vehicles (EVS), and Hydrogen Fuel Cell Vehicles (HFCVS) Using the Analytic Hierarchy Process (AHP)

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Abstract

This project presents a comprehensive sustainability comparison of three prominent vehicle technologies: Petrol Vehicles (Internal Combustion Engine Vehicles – ICEVs), Electric Vehicles (EVs), and Hydrogen Fuel Cell Vehicles (HFCVs). The study aims to evaluate and rank these vehicles based on their overall sustainability performance to support informed decision-making for future transportation strategies. Utilizing the Analytic Hierarchy Process (AHP), a structured multi-criteria decision-making methodology, the study evaluates these vehicle types across five critical sustainability criteria: environmental impact, fuel cost, ownership cost, driving range, and refueling or charging time. Expert input was collected through structured surveys to perform pairwise comparisons, from which normalized weights were derived to reflect the relative importance of each criterion. The findings reveal that Electric Vehicles outperform the other alternatives in terms of environmental sustainability and long-term economic efficiency, despite limitations in charging infrastructure and initial cost. Petrol Vehicles remain cost-effective in the short term with mature infrastructure but are increasingly misaligned with environmental goals. Hydrogen Fuel Cell Vehicles, while offering rapid refueling and zero emissions, currently face barriers related to high costs and limited infrastructure. The study concludes that Petrol Vehicles are the most viable and sustainable option under current conditions, offering valuable insights for policymakers, consumers, and industry stakeholders seeking to align transportation systems with future sustainability objectives. However, these results could change significantly with the rapid advancement of electric vehicles, particularly in terms of charging time, cost, and driving range.

Keywords: Petrol Vehicles (ICEVs), Electric Vehicles (EVs), Hydrogen Fuel Cell Vehicles (HFCVs), Sustainability Comparison, Analytic Hierarchy Process (AHP), Environmental Impact, Fuel Cost, Ownership Cost, Driving Range, Charging Time, Multi-Criteria Decision Making

P2110-Phase-Specific Dynamics and Transformation of Microplastics During Windrow Composting in Arid Environments

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Abstract

Microplastics (MPs) are emerging contaminants in organic waste management, yet their behavior during composting, particularly under arid conditions, remains poorly understood. This study aims to characterize the temporal and process-driven dynamics of MPs in a large-scale windrow composting facility in Oman. Samples will be collected across all composting phases to assess changes in MP concentration, size distribution, morphology, and polymer composition. Environmental parameters, including temperature, moisture, and microbial activity, will be monitored to identify factors influencing MP transformation and fate. Phase-specific analysis is expected to reveal degradation patterns and mechanisms, providing a deeper understanding of the interaction between MPs and composting conditions. By addressing a critical knowledge gap in arid-region composting, this study will contribute to understanding MP persistence and inform strategies for safer compost production. The findings will serve as foundational data for subsequent experimental optimization and predictive modeling of MP degradation in composting systems.

Keywords: Windrow composting, Polymer transformation, Phase-specific analysis, Organic waste.

P2100-Autonomous waste detection and classification for nuclear environments using YOLOv4 deep learning algorithm.

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Abstract

Managing and segregating process of waste materials in dangerous environment like nuclear plants, presents a high safety and operational challenges. This study explores the applicability of a deep learning algorithm (You Only Look Once version 4) for automated detection and segregation of waste-like materials designed for robotic sorting systems. Rubber, plastic and steel are the representative of the normal nuclear waste pieces with variable physical features. A comprehensive dataset of more than 6,300 images was developed incorporating domain randomization techniques including geometric shapes, lighting conditions, varied backgrounds and object orientations. The YOLOv4 algorithm was trained and tested using a systematic assessment under three experimental situations: isolated objects, objects with distracts and mixed multi-material components. In the optimal scenarios, the results validate detection accuracies of 100%, 70%, and 40% for the plastic, steel, and rubber materials respectively with processing speeds between milliseconds per frame. The outcomes demonstrated that YOLOv4 is suitable for real-time waste classification, while highlighting that dataset quality and the complexity of the materials features play key roles in determining detection performance. This research contributes to the development of autonomous robotic systems ability to operate in hazardous environments, advancing both safety and the efficiency of waste management in nuclear facilities.

Keywords: Nuclear waste management, waste detection, YOLOv4, deep learning, autonomous sorting, domain randomization.

P2071-AI-Enabled Robotic System for Date Palm Harvesting and Pest Detection

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Abstract

The Automated Robotic System for Early Detection of Red Palm Weevil (ARS-EDRPW) aims to address one of the most critical challenges facing date palm cultivation in the Arab region: the difficulty of detecting early-stage Red Palm Weevil infestations. Early detection is essential because the larvae cause hidden internal damage that can kill the palm tree and result in major economic losses. Traditional detection methods, such as manual inspection and pheromone traps, are often slow, inaccurate, and unable to identify internal infestation at its earliest stage.

The research introduces an integrated robotic platform equipped with acoustic and vibration sensors capable of capturing internal signals generated by weevil larvae inside the palm trunk. The collected data is processed using machine learning algorithms trained to differentiate weevil-related signals from normal environmental noise. The robot is designed for autonomous navigation around palm trees using balance control, positioning sensors, and obstacle-avoidance mechanisms to ensure stable operation in outdoor agricultural environments.

Preliminary tests indicate that the system can reliably detect characteristic acoustic patterns associated with early infestation. The wireless communication module enables real-time transmission of alerts to farmers or monitoring centers, supporting rapid intervention before the infestation spreads.

The proposed system enhances sustainability by reducing reliance on chemical pesticides and minimizing manual labor. The results highlight the potential of integrating robotics and AI into smart agriculture, contributing to improved food security and supporting the goals of Oman Vision 2040.

Keywords: Smart agriculture, Acoustic sensing, Machine learning, Autonomous robot Early pest detection.

P2135-Secure Edge Gateway for IoT Data Integrity and Real-Time Anomaly Detection

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Abstract

The exponential growth of Internet of Things (IoT) applications has introduced critical challenges in maintaining data integrity, confidentiality, and reliability. Traditional cloud-based security solutions are insufficient for real-time edge protection, where most IoT data is generated and processed. To address these limitations, this research proposes a Secure Edge Gateway, an intelligent and scalable security framework designed to safeguard IoT data pipelines and detect anomalies at the edge. The proposed system utilizes Raspberry Pi 4B as the hardware platform for its cost-effectiveness and energy efficiency. It employs containerization through Docker to enable modular services, including a Mosquito MQTT broker secured via MQTTS over TLS encryption. IoT data is collected from ESP32 sensor nodes integrated with DHT11/DHT22 sensors, authenticated using Access Control Lists (ACLs) to prevent unauthorized access and topic spoofing. For intelligent security monitoring, an Isolation Forest machine learning model is deployed on the gateway to perform real-time anomaly detection and identify patterns indicative of cyberattacks or data tampering. In addition to security features, the system incorporates a web-based Digital Twin interface developed using JavaScript, Three.js, Grafana, and InfluxDB, providing real-time visualization of device connections, system health, and anomaly alerts. Experimental results demonstrate improved security posture and responsiveness compared to conventional cloud-based approaches. By combining edge computing, cryptographic controls, and AI-driven monitoring, the Secure Edge Gateway offers a robust and scalable solution to mitigate evolving cyber threats in modern IoT ecosystems.

Keywords: Machine Learning, IoT Security, Docker, secure edge gateway

P2041-Testing the Efficiency of Natural Coagulants in Turbid Water

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Abstract

This paper examines how natural and organic coagulants: drumstick (*Moringa oleifera*) seeds, okra (*Abelmoschus esculentus*) mucilage, fenugreek (*Trigonella foenum-graecum*), tamarind (*Tamarindus indica*) seed powder, banana (*Musa*) peel extract, and orange (*Citrus x sinensis*) peel. These coagulants vary in their efficiency to remove turbidity from highly turbid water. They contain active biopolymers such as cationic proteins, polysaccharides (mucilage), tannins, polyphenols, and pectins, which facilitate particle destabilization, flocculation, and sedimentation, through neutralization, bridging, adsorption. Jar-test experiments were conducted to determine turbidity removal efficiency, sedimentation rate, pH stability, and organic residue levels. This natural coagulant solution is low-cost, biodegradable, and environmentally sustainable, aligning directly with Oman Vision 2040 goals for clean water, a circular economy, and community well-being. The results demonstrate that organic coagulants have strong potential to reduce dependence on chemical coagulants such as alum, thereby supporting safer water treatment methods for both rural and urban communities in Oman. Table 1 below compares the efficiency of the various natural coagulants. Furthermore, this study proposes extending the experimental findings toward real-time, industrial-scale water purification applications.

Keywords: water purification, natural coagulants, recycling water, plant-based water purifiers, moringa oleifera, seeds, orange peel, okra mucilage, tamarind seed, banana peel, fenugreek powder, turbidity levels, biopolymers, sustainability

P2138- AI-Enabled IoT-Based System for Sustainable and Energy-Efficient Network Quality Monitoring

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Abstract

Background: Telecommunication networks are essential to modern digital infrastructure; however, inefficient monitoring and reactive maintenance practices lead to excessive energy consumption, increased operational costs, and unnecessary environmental impact. There is a growing need for intelligent and sustainable monitoring solutions that support energy-efficient network operation. This study proposes an Artificial Intelligence (AI) and Internet of Things (IoT) based network quality monitoring system aimed at improving sustainability in telecommunication infrastructures.

Methods: The proposed system utilizes distributed IoT nodes based on Raspberry Pi devices to continuously collect network performance parameters such as received signal strength, latency, and throughput. The collected data is transmitted to a cloud platform for storage and analysis. Machine learning techniques are applied to detect anomalies and predict potential network degradation, enabling proactive maintenance and optimized resource utilization. A visualization dashboard is used to present real-time insights for decision support.

Results: Preliminary results indicate that the system effectively identifies abnormal network behavior and performance degradation at early stages, reducing the need for manual field testing and reactive interventions.

Conclusion / Implications: By enabling proactive monitoring and optimized network management, the proposed system contributes to reduced energy consumption and supports environmentally sustainable digital infrastructure. The approach demonstrates the potential of AI-enabled IoT systems in advancing sustainable smart-city and telecommunication solutions.

Keywords: Machine Learning, Network Quality Monitoring, Artificial Intelligence, IoT

T5: AI & IoT Applications in Environment & Sustainable Development-III

T5106-Machine Learning-Based Prediction of Extremely Low Frequency Electromagnetic Fields from 220 kV Transmission Lines: A Data-Driven Approach for Safety Compliance in Oman

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Abstract

The rapid expansion of high-voltage transmission networks in the Sultanate of Oman has intensified the need for a precise assessment of Extremely Low Frequency (ELF) electric and magnetic fields (EMF) to ensure public safety and regulatory compliance. While traditional assessment methods rely on static measurements and conservative clearance estimates, this project proposes a novel, data-driven approach for 220 kV transmission lines. Comprehensive field campaigns were conducted using high-precision NARDA EHP-50F analyzers to generate a robust dataset capturing field intensities alongside Oman-specific environmental variables, including temperature and humidity. This data drives the development of a Random Forest Regression model, selected for its ability to capture non-linear relationships, robustness to outliers, and interpretable feature importance analysis. The research aims to achieve a prediction accuracy of $R^2 > 0.90$ and a Mean Absolute Percentage Error (MAPE) of $< 10\%$, enabling the derivation of optimized, data-backed clearance distances. This framework provides transmission system operators and regulators with a scientifically grounded tool to balance infrastructure efficiency with strict adherence to ICNIRP and Omani Electrical Standards (OES) safety guidelines.

Keywords: ELF-EMF, Random Forest Regression, machine learning, ICNIRP guidelines, clearance distance optimization, Oman electrical standards

T5109-Deep Learning Across Image and Tabular modalities for sustainable development applications

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Abstract

Deep learning (DL) plays a transformative role in modern environmental monitoring and sustainable development, especially as AI and IoT systems generate vast volumes of heterogeneous data ranging from remote-sensing imagery to sensor-based tabular measurements. However, systematic comparisons of pretrained models across these modalities remain limited. This research proposes a novel comparative framework evaluating the appropriateness and effectiveness of pretrained models for image and tabular data commonly encountered in environmental and sustainability applications. Representative pretrained convolutional neural networks (CNNs) were examined for image-based tasks such as land-use classification and vegetation health assessment using satellite or drone imagery. For structured IoT-based environmental data, deep feedforward networks and transformer-based tabular models were analyzed to understand their ability to capture nonlinear feature interactions present in climate, air-quality, and hydrological datasets. Architectural principles of both modalities were compared to assess suitability, efficiency, and feature extraction capabilities. Experimental results show that pretrained CNNs consistently deliver high accuracy in image-centric environmental classification tasks due to their hierarchical feature extraction. In contrast, transformer-based models outperform conventional deep feedforward networks for complex tabular sensor data because of their capacity to model long-range dependencies and interactions among environmental variables. These findings highlight that modality-specific pretrained models remain critical: CNNs are the preferred choice for image-based ecological and sustainability analyses, while tabular transformers offer superior performance for IoT sensor analytics. The study provides practical guidance for selecting DL models in environmental AI and sustainable development systems. Future work will expand the evaluation to larger, multimodal environmental datasets and additional metrics such as robustness, interpretability, and energy efficiency.

Keywords: *Deep Learning, Pretrained models, Convolutional Neural Network, Tabular transformers, Environmental monitoring, Sustainable development, Multimodal Data Analysis*

T5121-Development of Wavelet Neural Network Denoising Model for MEMS INS/GNSS Integrated System and Application to LiDAR Mobile Mapping

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Abstract

LiDAR mobile mapping systems depend mainly on accurate Inertial Measurement Unit (IMU)/Global Navigation Satellite System (GNSS) integration for direct georeferencing. The current state-of-the-art IMU/GNSS integrated systems that meet the accuracy requirements for LiDAR mobile mapping applications utilize high-cost tactical grade IMUs. The production of low-cost industrial-grade IMUs using Micro-Electro-Mechanical System (MEMS) technologies has evolved rapidly, improving IMU accuracy and achieving comparable accuracy to tactical-grade IMUs. However, the challenge of using MEMS IMUs lies in their contamination with high levels of noise and bias stability error. This research addresses this limitation by developing a Wavelet Neural Network (WNN) denoising model. The proposed WNN enhances MEMS INS/GNSS integration accuracy, providing precise navigation solutions essential for generating accurate point clouds in mobile LiDAR applications. Its performance is evaluated against American Society of Photogrammetry and Remote Sensing (ASPRS) accuracy standards. The paper will discuss the results and findings on how the WNN model can enhance the MEMS INS/GNSS integration system for LiDAR mobile mapping applications.

Keywords: MEMS, INS/GNSS, WNN, LiDAR, Denoising

T5123-An Explainable Deep Learning Framework for Intelligent Fish Feeding Systems.

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Abstract

The aquaculture sector in the Sultanate of Oman faces growing challenges in improving fish growth efficiency while reducing feed waste, environmental impact, and operational costs, particularly under variable local environmental conditions. Conventional feeding practices often lack the flexibility needed to respond to changes in fish behavior and water conditions, leading to inefficient feeding and increased pollution. In this paper, we propose a smart feeding system based on a deep learning approach that evaluates fish behavior in real time to support optimal feeding decisions in aquaculture farms. The system analyzes behavioral indicators such as swimming activity and feeding responses to determine appropriate feeding timing and quantity. To enhance trust, transparency, and reliability, Explainable Artificial Intelligence (XAI) methods are integrated to interpret and validate the decision-making process of the deep learning model. These XAI techniques highlight the most influential behavioral features driving feeding actions, supporting practical implementation and acceptance by aquaculture operators in Oman. Experimental results demonstrate improved feeding efficiency and reduced feed waste, confirming the potential of the proposed system to support sustainable aquaculture development in the Sultanate of Oman.

Keywords: Smart feeding system, Feeding Optimization, Explainable Artificial Intelligence (XAI), Fish Behavior Analysis and aquaculture.

T5146-Prediction of e-Waste in Oman based on Exponential growth model with solutions in AI

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Abstract

The ever-growing need for electrical and electronic equipment has increased e-waste generation to unparalleled rates across the globe. On the other side of the Gulf, economic development, population increase, urbanization, and national digital emergence have vastly accelerated the consumption of electronic products in Oman, thus increasing the volume of e-waste. In any case, this study tries to propose a data-driven framework for forecasting the e-waste generation in Oman using exponential growth models integrated with AI solutions as part of supportive action towards sustainable environmental planning according to Oman Vision 2040. The paper proposes an integrated approach based on historical data of electronic devices usage, population trends, and the e-waste generated to model the future growth pattern. In this paper, the exponential growth model represents the non-linear increase in the generation of e-waste, while AI-based techniques incorporate machine learning regression and optimization algorithms to estimate parameters, identify patterns, and enhance prediction accuracy. The performance of the proposed forecasting model will be evaluated based on the statistical measures such as mean absolute error, mean squared error, and coefficient of determination (R^2). The forecasted values represent a continual and significant increase in e-waste generation in Oman for the forecasted period and further raise several concerns about the existing waste management system. Integrating AI into the exponential model increases its reliability and adaptability since large sets of data can be handled without much forecast error. This demands that sustainably sound e-waste management be considered, including improved recycling infrastructure, policy formulation, and public awareness. Therefore, the proposed data-driven e-waste forecasting framework has proven to be a useful instrument for anticipation of prospective trends of e-waste in Oman. Based on exponential growth modeling and AI solution, the study provides substantial insights for policymakers and environmental authorities with respect to sustainable development goals and further advancement of the environmental agenda in Oman Vision 2040.

Keywords: e-Waste Forecasting, Artificial Intelligence (AI), Exponential Growth Model, Sustainable Waste Management

T5151-A Systematic Review of Machine Learning Techniques for Downscaling GRACE-derived Groundwater Storage

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Abstract

Groundwater level (GWL) related to the vertical distance to the water table or subsurface water level in below ground formations. In arid region like Oman where there is a significant rainfall deficit, it is crucial to monitor and manage this main water resource which used for irrigation, drinking and different uses. Groundwater level forecasting requires reliable and high-efficiency modelling techniques. Traditional monitoring of groundwater using observation wells suffers from sparse coverage and high maintenance costs, hindering comprehensive water resource management. NASA's GRACE and GRACE-FO satellite missions have produced crucial data on total water and groundwater storage measurements. However, GRACE data has low spatial resolution ($\sim 1^\circ$) limits their direct application for detailed and regional groundwater management and planning. This study provides an overview of the applied machine learning models for GWL prediction. In total, 162 research articles published from 2010 to 2025 from well-known databases were analyzed. The study highlights the attributes involving types of ML models, input variables used, evaluation metrics, and output resolution obtained. The analysis of the article papers illustrated that a large portion utilized random forest (RF) method. Whereas the most widely used ML methods were gradient boosting (GB), deep learning (DL) and artificial neural network (ANN), respectively. Taking into consideration the input variables selected that have a significant impact on the model performance such as precipitation, temperature and evapotranspiration. More than 10 years of data are needed to establish an acceptable ML model. In conclusion, ML and DL techniques are highly effective in modelling groundwater levels. Furthermore, recommendations and possible future directions to increase the GWL prediction model's accuracy are listed.

Keywords: Remote Sensing, Machine Learning, GRACE, Groundwater, Downscaling

T6: Materials Science & its Applications for Sustainability

T6013-Performance Studies on Sustainable Roofing System

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Abstract

The rising levels of CO₂ emissions contribute greatly to climate change, and the construction sector is a major contributor to global CO₂ emissions. With the growing demand for concrete, the cement and steel manufacturing industries are experiencing depletion of natural resources required for the manufacturing of these products. Hence there is a dire need for alternative building material that is as durable as the present building materials and sustainable. The roofing system forms a major part of any structural system and most of the roofing systems are constructed using RCC which has very high embodied energy. This paper aims to study an alternative arch panel roofing system made up of low-grade concrete with equivalent strength brick masonry. Recycled aggregates are used to replace conventional aggregates (fine) that are used in concrete mix. Concrete designed for M10 grade with use of recycled fine aggregates as a replacement for conventional fine aggregates proved to give desired strength at 7 days for 80% replacement, when compared to 40%, 60% and 100% replacement. The constituents that replaced M-sand were Recycled Aggregates (RCA) and brick waste. The arches cast for 80% replacement of M-Sand have been tested for two-point loading with different support conditions. Further, the cost of the panel was ₹ 86 and the cost for three panels was estimated to be ₹ 258 which was 11.5% lower than the control mix. The cost can further go down when products are produced commercially on a large scale.

Keywords: Alternate Building materials, Sustainable material, Construction waste management, Recycled Aggregates

T6154-Material Degradation of Stainless Steel under Simulated Algal HTL Conditions

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Abstract

In this study, the corrosion behavior of stainless steel was examined in a simulated aqueous phase representative of algal hydrothermal liquefaction under subcritical conditions. Corrosion rates were determined using the weight-loss method as a function of chloride concentration, temperature, and material type. The results show that corrosion rate increased steadily with chloride concentration, rising from approximately 0.05 mm/year in chloride-free solution to about 0.9 mm/year at 10 g/L chloride, indicating a strong susceptibility to chloride-induced attack. Temperature also had a pronounced effect, with corrosion rates increasing from 0.08 mm/year at 150 °C to 0.55 mm/year at 220 °C, consistent with thermally activated corrosion processes. A comparative material assessment demonstrated that SS316L exhibited a significantly lower corrosion rate (0.35 mm/year) than SS304 under identical conditions, while titanium showed negligible degradation. Based on these results, the optimum operating window for stainless steel in simulated algal HTL aqueous environments was identified at chloride concentrations below 2 g/L and temperatures not exceeding 180 °C, where corrosion rates remained below 0.2 mm/year. These findings provide practical guidance for material selection and process control in algal hydrothermal liquefaction systems.

Keywords: HTL, corrosion, Stainless steel, algae

T6043-AI-Driven Hydro-Geomechanical Water Quality Prediction Using AFSSO-Optimized LSTM for Assessing Micro–Macro Impacts on Geomaterials

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Abstract

Water-Geomaterial interactions significantly influence geotechnical stability, groundwater safety, and environmental resilience. Contaminated water can induce chemical changes in soils and rocks, altering permeability, compressibility, and shear strength. This study presents an AI-driven hydro-geomechanical framework for predicting and classifying water quality parameters that directly impact micro–macro geomaterial behavior. A dataset encompassing key water quality indicators was pre-processed through normalization, partitioning, and data transformation techniques to prepare it for modelling. A Long Short-Term Memory (LSTM) neural network, optimized using Artificial Fish Swarm Optimization (AFSSO), was applied for time-series water quality classification. Predictions were conceptually linked to hydro-mechanical effects in geomaterials using a coupled understanding of contaminant transport and geotechnical performance. The proposed LSTM–AFSSO model, implemented in Python, demonstrated superior performance over baseline methods in both classification and regression tasks, offering a decision-support tool for early detection of hydro-geomechanical hazards and for guiding nature-based remediation strategies such as bio-cementation and vegetative stabilization.

Keywords: Hydro-geomechanics, Artificial Fish Swarm Optimization, Long Short-Term Memory, Water Quality Prediction, Nature-Based Remediation

T6055-Green Nanotechnology mediated Antimicrobial Activity of Copper oxide Nanoparticles synthesized from Omani Curcas bean Leaf extract

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Abstract

Facile and low-cost technologies in the fabrication of novel nanomaterials for antibacterial studies are getting enormous attention owing to their versatility in bio sensing, environmental, and medical applications. The concept of green nanotechnology is considered as a ground-breaking scientific research appropriate in the fabrication of nanomaterials utilizing simple, economical and sustainable technique. The application of cutting edge green nanotechnology in synthesising copper oxide nanoparticles (CuONPs) utilizing locally available Omani Curcas bean leafextract for antibacterial activity study are not attempted by researchers. Hence, this novel research focused on the sustainable fabrication of CuONPs from locally available natural resources Curcas bean leaf extract for the antibacterial activity studies using E. Coli. The resulting CuONPs were tested using Energy Dispersive X-Ray (EDX), Fourier Transform Infrared Spectroscopy (FT-IR), X-Ray Diffraction (XRD), and Field Emission Scanning Electron Microscopy (FESEM) analysis. The in vitro antibacterial property of CuONPs was investigated using gram negative bacteria (E Coli) by agar well diffusion method. The EDX analysis exhibited 64% Cu and 21% Oxygen endorsed the purity of CuONPs. The microstructural surface features of the nanoparticles are revealed through FESEM image with a scattered distribution of the nanoparticles with an average particle size around 25 nm. The multiple sharp and intense peaks observed in the XRD pattern demonstrated the formation of CuONPs with good crystallinity and small grain size. The FTIR analysis indicated sharp absorption peaks at wave number from 400 cm⁻¹ – 700 cm⁻¹. The green synthesized CuONPs revealed excellent antibacterial activity against E Coli contribute in mitigating the bacterial contamination. This novel research recommends a facile and sustainable production of CuONPs without consuming any noxious chemicals and linked with the 2030 agenda of the United Nations Sustainable Development Goals (UNSDG-2030), i.e. UNSDG-Goal 6: Industry, Innovation and Infrastructure) and UNSDG – Goal 12 (Responsible consumption and production), and also, directly connected with Oman Vision 2040 by supporting the sustainability aspects in the Arab region, by promoting green initiative and offer clean environment.

Keywords: Curcas bean; Copper oxide; Green nanotechnology; Nanoparticles; Fourier transform infrared spectroscopy; Scanning electron microscopy.

T6062-Development of Sustainable Anti-corrosive Smart Composite Coating on External surface of Carbon Steel Pipeline

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Abstract

The oil and gas industry in the Sultanate of Oman contributes 45% of the GDP and one of the prominent issues is external surface corrosion in oil and gas pipelines, which results in huge economic loss due to the deterioration of material surfaces and hence damages the industrial equipments. The National Association of Corrosion Engineers (NACE) report shows the global cost of corrosion is almost 2.5 trillion USD, which is estimated as 3.6% of the world's GDP. The external surfaces of carbon steel pipelines are damaged due to external corrosion and lead to oil spillages and eventually end up in environmental pollution. The conventional corrosion control techniques are highly expensive and declined durability necessitating frequent maintenance and replacement of pipelines. Regardless of the widespread investigations carried out during the past few decades, the surface coatings and corrosion protection performance studies of carbon steel are not fully understood. Hence, this research aims to develop stable composite thin film as anticorrosive coating for the external corrosion control of carbon steel (CS) pipe using Zinc Oxide nanoparticles (ZnONPs) synthesized from Nerium Oleander leaf extract, curry leaf extract and epoxy. The developed composite was deposited on CS surface by dip coating technique and the coated pipes were subjected to film stability studies by exposing them in various environmental conditions. The characterization tools used are Fourier Transform Infrared Spectroscopy (FTIR), Photon Correlation Spectroscopy (PCS), Scanning Electron Microscopy (SEM), X-Ray diffraction (XRD), and Energy Dispersive X-Ray Analysis (EDX). The surface corrosion behaviors were investigated by exposing the coated CS pipe in saline soil, high temp & sunlight, acidic environment and at ambient conditions. The developed sustainable smart coating showed excellent corrosion control at varying environments and hence addressed the critical industrial issues of corrosion in oil pipelines. This innovative research is well aligned with the UNSDG 2030 goals and targets (Goal 9-Industry, Innovation and Infrastructure & Goal 12 Responsible Consumption and Production) and Oman vision 2040.

Keywords: Carbon steel, External corrosion; Fourier transform infrared spectroscopy, Nerium Oleander, Zinc oxide nanoparticles, scanning electron microscopy.

T6117-Capacitance and Dielectric properties of cerium phosphoarsinate glasses

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Abstract

The dielectric behavior of arsenate-phosphate glasses formulated as (5-x) mol% As_2O_3 -70 mol% P_2O_5 -25 mol% CaO -x mol% CeO_2 is examined over a frequency range of 80 Hz to 5 MHz and temperatures spanning 300–523 K. X-ray diffraction (XRD) confirms the fully amorphous structure across all compositions. Analysis of the electric modulus employed Debye, Cole–Cole, Davidson–Cole, and Havriliak–Negami relaxation models, yielding the best fits with Cole–Cole and Davidson–Cole equations. Static relaxation times (τ_0) ranged from 7.6×10^{-9} s to 22.7×10^{-9} s, with asymmetry parameters of $\alpha = 0.056$ – 0.065 (Cole–Cole) and $\gamma = 0.94$ – 0.99 (Davidson–Cole), reflecting a narrow distribution of relaxation times and non-Debye relaxation typical in CeO_2 -modified phosphate systems. The studied glasses exhibit two distinct regimes with temperature coefficients of capacitance (TCC) $\leq 10\%$ and $\leq 15\%$, fulfilling the stringent requirements for P-type and R-type commercial capacitors, respectively. These outcomes resonate with prior investigations into CeO_2 -doped phosphate glasses, where such additions enhance polaronic transport, elevate permittivity while minimizing losses, and improve thermal stability for dielectric applications. Consequently, these materials emerge as strong contenders for high-voltage capacitors and energy storage systems.

Keywords: Dielectric properties, Phosphate glasses, Temperature coefficients of capacitance (TCC).

T7: Carbon Neutrality, Pollution & Carbon Emission Management-I

T7027-Intensified removal of Methylene orange dye using cost-effective Dhofar based tree leaves (*Anogeissus dhofarica*) using Bio-sorption

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Abstract

This research work is focused on biosorption of Methylene Orange dye containing model effluent using Salalah based tree viz., *Anogeissus dhofarica*. Methylene orange dyes are highly carcinogenic in nature and when it mixed with drinking water sources, it will affect the community and animals too. Previous literatures clearly explored the methods to reduce the impact caused by these dye effluents. One of such studies is to use no cost and easily available tree leaves for biosorption process. Very limited studies were performed on biosorption using Salalah based *Anogeissus dhofarica* tree. In this work, the tree leaves were oven dried and size reduced. It was found that activated adsorbents produced good results compared to that of un-activated adsorbents. The dosage of adsorbent has strong positive influence on adsorption of dye. Similar trend was observed with the studies on effect of concentration of model effluent on dye removal. From the results obtained, low-cost adsorbents like *Anogeissus dhofarica* leaves (both activated and un-activated) was found to be an effective adsorbent for the treatment of dye effluents.

Keywords: Methylene Orange dye, Anogeissus dhofarica, activated adsorbent, biosorption

T7120-Monitoring the Thermal Condition of Organic PCM Solar Panels in Oman with a Parrot Anafi Drone

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Abstract

One of the most promising ways to lessen the negative consequences of global warming is to use renewable energy sources. With a particular focus on solar and wind power, the Sultanate of Oman has set an ambitious goal to increase renewable energy generation by 30% by 2030. However, high operating temperatures in severe weather conditions have a substantial impact on solar photovoltaic (SPV) panel efficiency. Phase Change Materials (PCMs) can be incorporated as a passive cooling technique to control the temperature of SPV panels in order to overcome this difficulty. The use of paraffin wax as a PCM to enhance SPV performance is examined in this study. An SPV panel was covered with 700 grams of paraffin wax, which has a melting point range of 46–68 °C depending on purity and kind. Under comparable operating conditions, the PCM-integrated panel's performance was contrasted with that of a traditional panel. According to the results, the paraffin wax-cooled panel produced an open-circuit voltage that was up to 10% greater than the traditional panel and showed a temperature reduction of up to 10%. Additionally, the parrot thermal ANFI drone is used to monitor the temperature of the SPV panels. When compared to a conventional panel, the temperature of the PCM-applied panel is 0 to 10% lower. These results demonstrate how paraffin wax-based PCMs might improve solar panel efficiency in Oman's hot climate, supporting the country's renewable energy objectives. The study creates new opportunities for further investigation into PCM applications for sustainable energy solutions in the Sultanate of Oman.

Keywords: Parrot ANFI drone, Paraffin wax, solar PV power, Open circuit voltage, short circuit current

T7036-Path forward to Oman net zero 2050

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Abstract

Escalating greenhouse gas emissions have driven the global climate system beyond its historical equilibrium, compelling nations to formulate long-term decarbonization strategies. Within this global momentum, Oman has declared its national climate commitment and framed the energy transition as a defining instrument for achieving a net-zero future. Despite these emerging efforts, a cohesive academic account of Oman's transition trajectory and its alignment with widely accepted net-zero principles remains underdeveloped. This research provides a critical synthesis of Oman's strategic direction, examining how the national approach integrates economic diversification, environmental stewardship, and system-level energy reform. The transition framework distributes mitigation responsibilities across key sectors while reserving residual emissions to be addressed through advanced reduction and offsetting mechanisms. The electricity sector represents the earliest site of visible structural change, but broader transformation requires cross-sectoral integration and the embedding of sustainability considerations across interconnected resource systems. Expanding the national plan to encompass full life-cycle footprints and interlinked environmental nexuses is essential for ensuring a comprehensive, resilient, and development-aligned transition.

Keywords: Net zero 2050; Energy transition; decarbonization; Green hydrogen; oil & gas

T7049-Advancements in Renewable Energy Technologies and Data Augmentation Strategies for Developing Carbon Neutrality Pathways

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Abstract

Achieving carbon neutrality has become a global priority, especially in developing countries where cities are on the edge of rapid energy demand and urbanization which in turn leads to effects on environmental constraints. Recent developments in renewable sources such as solar, wind, hydrogen, and hybrid renewable configurations highlight their capacity to facilitate sustainable energy transitions. To address data limitations is often encountered in efficient resource management. This paper presents a comprehensive data investigation of renewable energy technologies with data augmentation techniques. To improve the renewable energy technologies performance, reliability, and scalability for carbon-neutral energy efficient systems. This incorporates state-of-the-art data augmentation methods for modelling of synthetic dataset generation. And analysis of synthetic dataset using machine learning models to assist pattern expansion. These approaches improve predictive accuracy and optimize system design. And enable robust energy forecasting under varying climatic and operational conditions. A conceptual framework is proposed that links renewable energy deployment with augmented datasets, and carbon-neutrality strategies within developing economies.

Keywords: Renewable Energy Technologies; Carbon Neutrality; Data Augmentation; Synthetic Dataset Generation

T7075-Bridging Adaptation and Mitigation in the Built Environment

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Abstract

The building sector plays a pivotal role in tackling climate change. However, prevailing regulatory frameworks often treat climate change mitigation, which involves reducing emissions, and adaptation, which involves building resilience to impacts, as distinct concerns. Building codes typically focus on baseline safety and energy efficiency (mitigation), while voluntary green building standards initiate additional sustainability metrics. The absence of integration often leads to lost opportunities for interactive design and, at times, conflicting requirements. Today's fragmented building practices call for an urgent shift toward a unified strategy that delivers both climate-friendly performance and resilience, ensuring structures remain safe and operational in the face of growing climate volatility. This project proposes a thorough examination and gap analysis of leading international building codes and voluntary green building standards to advance sustainable practice. It will also examine building regulations across the globe and draw on real-world case studies to highlight practical challenges, for instance, how green spaces can simultaneously reduce energy demand and mitigate flooding. The primary goal is to map where adaptation and mitigation requirements currently intersect and identify significant policy gaps. Based on this analysis, the research will synthesize clear recommendations for governments and professionals to establish a unified regulatory framework that supports resilient, low-pollution buildings worldwide.

Keywords: building resilience , energy efficiency , climate friendly performance , sustainable practice , adaption

T8: Carbon Neutrality, Pollution & Carbon Emission Management-II

T8127-Toward Sustainable 2D Materials: Transforming CO₂ into Graphene via Advanced Catalyst Design

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Abstract

Direct conversion of CO₂ into graphene and related nanocarbons is advancing through four main routes—CO₂-fed CVD/PECVD, molten-salt electrolysis, plasma-assisted processes, and aqueous electrochemical deposition. Catalyst choice governs nucleation density, layer number, and crystallinity: Cu supports surface-mediated monolayer growth with very low carbon solubility; Ni admits dissolution–precipitation pathways with multilayer risk; W and Mo promote carbide-mediated nucleation that can yield graphitic nanoplatelets or films. This review synthesizes how carbon solubility, carbide stability, surface texture, and process knobs (H₂:CO₂, temperature, pressure, plasma duty cycle, quench rate) map to graphene quality. We assemble a diagnostic/metrics playbook (Raman/XPS/TEM/XRD, sheet resistance–transmittance, areal growth rate) for fair benchmarking, and outline design rules for nucleation control and sp² yield per kWh. Finally, we present a research roadmap of selective catalysts, pulse-power operation, operando control, and hybrid routes that can lower energy intensity while preserving film quality or powder graphitization.

Keywords: Cu/Ni/Mo/W Catalysts, Carbide-Mediated Pathways, Surface Nucleation Control, Catalyst Architecture

T8136-Evolutionary Optimization of the Industrial Carbon Capture Process towards Carbon Neutrality

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Abstract

Nowadays, natural gas is one of the most essential sources of energy and power worldwide. The main component of natural gas is methane (C₁), which accounts for 80–85 mol% of the gas, along with other light alkanes. Since natural gas is formed naturally, it contains various components, some of which are undesired, such as hydrogen sulfide (H₂S), carbon dioxide (CO₂), carbonyl sulfide (COS), and mercaptans. The presence of these impurities in natural gas will lead to adverse effects and operational issues, such as corrosion in the piping system and equipment, especially when natural gas is saturated with water, which is usually the case. The presence of CO₂ in the exported gas will reduce its heating value, thereby failing to meet the gas specifications. In this study, the multi-objective optimization of the industrial carbon capture process is carried out considering the environmental (global warming potential) and economic (return on investment) based objectives. Seven decision variables and two constraints on the concentrations of CO₂ and H₂S are considered. In the results, it's observed that in the first interval (between point A and B), all design variables are almost constant except the feed molar flow, which is increased by 21% (from 3718.6 kmol/hr to 4500 kmol/hr), and due to this increase in feed flow, the return on investment jumps to 31.3%.

Keywords: Carbon Neutrality, Optimization, Carbon Capture, Natural Gas, Environmental, Economic

T8153-A Comparative Analysis of the Performance and Cost of Bentonite-Water and Silica Gel-Water Working Pairs for Adsorption Cooling and Desalination Applications in Oman.

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Abstract

Adsorption cooling and desalination technology provides a heat-driven and low-electricity consumption technique for simultaneous space cooling and freshwater generation, which finds applicability in hot and arid areas near the coast, like Suhar in Oman. However, the scale of implementation of this technology has been restricted because of the high cost and demand for standard adsorbent materials like silica gel. This study investigates if a cheap natural clay, named 'bentonite,' can effectively act as an alternative for the above-mentioned silica gel used in an adsorption cycle involving water as the adsorbent system. A transient lumped parameter adsorption cycle model was established and validated against experiments for bentonite-water and silica gel (RD)-water. The model captures the dynamic interactions of the bed energy balances with the adsorption equilibrium or kinetics during the adsorption and desorption cycles, while the condenser and evaporator sections are characterised by their respective saturation constraints according to the boundary temperatures set. The theoretical results were verified after comparing with the experiments. The examined operation condition is set to $T_{hot} = 95^{\circ}\text{C}$, $T_{cond} = 25^{\circ}\text{C}$, and $T_{evap} = 18.5^{\circ}\text{C}$, suggesting low to medium-grade waste heat or solar thermal energy supplies in industry. Under the mentioned testing conditions, it is found that the performance of the silica gel-water pair is better, with $\text{COP} = 0.44$ compared to $\text{COP} = 0.39$ for bentonite, while SCP is found to be 241 W kg^{-1} compared to 146 W kg^{-1} for bentonite, respectively. For the desalination capacity, silica gel produces $\text{SDWP} = 9.3 \text{ kgwater kgsilica-gel day}^{-1}$, whereas it is $4.2 \text{ kgwater kgbentonite day}^{-1}$ for bentonite. To express performance in terms of cost, the specific manufacturing cost (SCOM) is evaluated using a correlation formula for COP and SCP, which results in a value close to 616 Omani rial per kW of cooling for silica gel material compared to a value of around 698 Omani rial per kW of cooling for bentonite. In terms of overall performance, the capability of the bentonite at 95°C can be considered significant. Although silica gel continues to possess a better performance index with a performance index-related manufacturing cost at the point considered in the present study, the model developed, with experimental validation, can be considered a reliable tool for choosing the appropriate material. The current study is a significant contribution in respect that it can tackle the implementation routes of carbon-neutral cooling technologies with a focus on the Oman Vision 2040.

Keywords: *Carbon neutral; adsorption cooling; adsorption desalination; oman vision 2040*

T8150-A Deep Learning-Based System for Multi-Lane, Vehicle-Type Traffic Counting using Real-Time Video Analysis

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Abstract

This study investigates a deep learning-based multi-lane, vehicle-type traffic counting system as a decision-support tool for pollution and carbon emission management in congested urban corridors, where rising traffic volumes contribute significantly to local air pollution and transport-related greenhouse gas emissions. Transportation is a major source of CO₂ and other pollutants, and congestion management and intelligent transport systems are recognized as effective levers for reducing emissions by smoothing traffic flow and reducing idling and stop-and-go conditions. The proposed method employs a real-time video analysis framework that integrates a YOLO-based object detection model with object tracking techniques to detect, classify, and count vehicles across multiple lanes, generating lane-wise and class-wise traffic profiles that can be coupled with emission factors to support high-resolution emission estimation and targeted mitigation strategies. The system is implemented and evaluated using offline video footage captured from a multi-lane roadway in Oman, with vehicle counts manually verified to assess performance. Experimental results show that the YOLO-based model achieves a maximum accuracy of 98% over a 5-minute video segment, demonstrating reliable operation under realistic traffic conditions. By providing accurate, disaggregated traffic data, the framework can enhance pollution and carbon emission analysis, support the design of smart traffic management measures, and contribute to data-driven policies aimed at reducing vehicle emissions and improving urban air quality.

Keywords: Intelligent Transportation Systems, Deep Learning, YOLO, Object Tracking, Carbon Emission.

T8023-AI and Human Behavior in Sustainable Construction: Driving Societal Change Toward a Net-Zero Oman Future

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Abstract

Achieving a net-zero future in Oman will involve not only technological innovation but also a fundamental shift in human behaviors and societal engagements. This research explores how AI can be utilized to drive behavioral change and inform sustainable construction practices supportive of Oman Vision 2040's aspirations for economic diversification, environmental protection, and digital transformation towards sustainability goals by mid-century. Building on research such as Ali (2025), which evidences the impact of AI on operational efficiency, sustainability through reduced emissions and resource wastage by up to 15%, and workforce transformation in Oman's industrial sector, including smart infrastructure and predictive maintenance, this study also draws from frameworks such as that proposed in Integrating AI and Sustainability into Supply Chain Resilience (2025), which highlights AI's potential role in improving supply chain agility and robustness in Oman's engineering and construction industry. This research adopts a mixed-method approach to identifying key societal drivers and barriers towards the adoption of sustainability in the construction sector, such as cultural attitudes, regulatory hurdles, and skills gaps, by coupling AI-driven data analytics with survey-based behavioral assessment. Information will be acquired from a heterogeneous group comprising engineers, project managers, policymakers, and stakeholders, using structured questionnaires across key regions in Oman. These will be analyzed using advanced AI-based sentiment analysis, pattern recognition models, clustering techniques to group similar behavioral profiles, regression analysis to predict factors driving commitment to sustainability, and other machine learning algorithms that will reveal nuanced behavioral patterns and predictive insights. It is envisaged that the findings will highlight significant correlations between AI-enabled awareness campaigns and digital sustainability tools, such as integrated BIM platforms, and increased behavioral commitment toward greener practices, including the adoption of energy-efficient building design and effective waste minimization strategies. This research also explores how AI-powered applications, including predictive analytics for resource optimization, real-time environmental monitoring by means of IoT sensors, and decision-support systems for eco-friendly material selection, can favorably influence sustainable human behavior in the built environment to eventually reduce carbon footprints aligned with global SDGs. Expected outcomes from the results will be actionable policy insights, including recommendations on government incentives and training programs, coupled with a scalable framework of integrating AI-enabled behavioral strategies that accelerate net-zero transitions in Oman and, potentially, across GCC nations.

Keywords: Artificial Intelligence, Sustainable Construction, Oman Vision 2040, Net-Zero Future, Green Innovation, Digital Transformation

T8073-Development of a Sustainable and Cost-effective Produced Water treatment in the Lekhwair Field water injection system at Petroleum Development Oman

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Abstract

The Lekhwair field is located in the northwest corner of the Petroleum Development Oman (PDO), equipped with a central production station that processes all produced fluids from various fields within the Lekhwair area. The Lekhwair field relies on water injection to maintain its production. It re-injects all produced water and compensates for additional shortfalls by extracting water from a local shallow aquifer called the 'Fars aquifer and from Yibal-produced water'. Sour water is a by-product of oil and gas production processes. Over the years, there has been a noticeable trend indicating several drilled wells contain elevated levels of dissolved hydrogen sulfide (H₂S), which necessitates treatment prior to safe utilization. Both sources of sour water require effective treatment and management to ensure safety and compliance with relevant standards. This research focuses on the development of a sustainable and cost-effective produced water treatment system in the Lekhwair Field water injection system by using nanostructured thin films. The nanothin films were developed from titanium dioxide and chitosan by dip coating method for a sustainable water treatment employing green nanotechnology. The titanium dioxide nanoparticles (TiO₂NPs) are prepared by green synthesis techniques using *Azadirachta indica* leaves followed by analysis using X-Ray diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Dynamic Light Scattering (DLS), Scanning Electron Microscopy (SEM), and Energy Dispersive X-ray (EDX) analysis. The surface characterization using SEM image showed slight aggregation of the nanoparticles with high yield exhibiting excellent surface morphology. The representative peaks in the FTIR spectra confirmed the successful synthesis of TiO₂NPs. XRD results indicate that the green-synthesized TiO₂NPs has spherical shape with an average crystalline size of 33.91 ± 0.5 nm. The produced water treatment was performed using fabricated thin films by varying the pH (pH 2.0 to 10), number of layers (1 to 8), dosage of nanoparticles (0.1g to 1.0 g) and exposure time (15 min to 120 min) and the optimum treatment conditions were established. The nanocomposite thin film revealed good stability, uniform coating thickness without any defects, rendering them suitable for applications in the treatment oil produced water from the Lekhwair field.

Keywords: *Azadirachta indica; Nanothin films; Oily wastewater; Titanium dioxide nanoparticles; Scanning electron microscopy; Sour water.*

O2: Online Session 2

O2052-A Scalable Biogas-to-Electricity System for Campus food Waste Management

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Abstract

This project presents the design and development of a campus-scale biogas plant that converts food waste into electrical energy through an efficient and sustainable process. The system integrates anaerobic digestion, multi-stage biogas purification, and electricity generation, providing a low-cost and scalable solution for renewable energy production. The biogas plant is constructed using a 240-litre drum, PVC piping, and standard fittings, ensuring both affordability and ease of deployment. Organic waste is fed into the digester through an inlet pipe, while an integrated mixer enhances the digestion process by ensuring uniform slurry agitation. A controlled gas outlet enables safe biogas extraction, and an overflow mechanism maintains internal pressure within safe limits to prevent structural failures. To achieve high-quality methane suitable for combustion, a three-stage gas scrubbing unit is employed. The purification process includes water absorption for CO₂ removal, cat litter desiccation for moisture elimination, and iron-wool filtration for hydrogen sulphide reduction. The purified biogas is supplied to a modified 1000 VA generator (230/415 V, 50 Hz, two-stroke engine, recoil start), enabling reliable conversion of biogas into electrical energy. Safety and performance are further ensured through overload protection systems and an integrated lubrication method using an oil–fuel mixture. This biogas-based energy system offers an environmentally friendly alternative to conventional power sources, simultaneously reducing organic waste accumulation and mitigating methane emissions on campus. The project demonstrates a practical and replicable approach to harnessing food waste for electricity generation. Future developments—including automated system monitoring, expanded digester capacity, and potential grid integration—could further enhance its efficiency, reliability, and applicability at larger scales.

Keywords: Biogas generation, Food waste management, Anaerobic digestion, Micro-scale biogas plant

O2059-Designing Next-Generation Hydrogen Storage Materials: A Computational Exploration of High Entropy Alloy

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Abstract

High-entropy alloys (HEAs) have gained advantages in hydrogen storage. One significant feature of HEAs is their adaptable composition, which allows for changes that improve hydrogen diffusion, surface area, and hydrogen uptake and release rates. These characteristics contribute to increased hydrogen storage capacity and efficiency as compared to conventional materials. This research investigates the evolution of HEA with computational tools such as HEAPS and Model MH. HEAPS estimates the thermodynamic parameters of HEAs, such as atomic weight, density, specific heat, atomic misfit, valence electron concentration (VEC), Gibbs free energy, enthalpy, entropy, and probable phases. Over 500 HEA variants were analyzed using HEAPS. The primary goal is to identify HEA with a hydrogen storage capacity of 3–4% and high stability at room temperature. ten alloy compositions with BCC and Laves phases were chosen based on hydrogen storage, and kinetics were selected. VEC was a controlling parameter, as BCC forms occur at a VEC < 6.87 and Laves phase at VEC 4-8. A VEC of 4-6 was chosen for the best hydrogen characteristics. PCT diagrams were simulated using Model MH, and hydrogen storage capacity was measured.

Keywords: Hydrogen storage, High Entropy Alloy, Computational Tools, Hydrogen storage capacity, hydrogen absorption , Phase Stability

O2060-Supercapacitor/Battery Hybrid Powered Electric Bicycle via BLDC Drive for Sustainable Transportation

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Abstract

The global shift toward sustainable and energy-efficient mobility has significantly accelerated the adoption of electric vehicles, particularly electric bicycles (e-bikes). E-bikes offer an affordable, safe, and environmentally friendly mode of transportation, helping reduce carbon emissions and dependence on fossil fuels. Traditional e-bikes typically employ DC motors, which face challenges such as mechanical commutation issues, lower reliability, and higher maintenance requirements. To overcome these limitations, this work adopts a Brushless DC (BLDC) motor, which uses electronic commutation to deliver higher efficiency, improved durability, and minimal maintenance. Batteries provide good energy storage but cannot efficiently handle sudden high-power demands during acceleration or climbing, leading to increased stress, heating, faster aging, and reduced lifespan. This study proposes a sustainable hybrid energy storage system that combines a battery and a supercapacitor connected in parallel. A microcontroller-based power management system intelligently regulates energy flow between the two sources. During high-load or acceleration periods, the supercapacitor supplies additional power to reduce stress on the battery. Under low-load conditions, the supercapacitor is recharged by the battery. This hybrid configuration enhances energy efficiency, minimizes voltage fluctuations, improves performance, and significantly extends the battery's operational life. A DC–DC converter provides stable and efficient power regulation between the hybrid storage system and the BLDC motor drive, ensuring smooth operation under varying load conditions. Overall, the proposed system presents a promising pathway toward more sustainable, efficient, and durable electric mobility solutions.

Keywords: Supercapacitor–Battery Hybrid System; Brushless DC (BLDC) Motor; Electric Bicycle; Sustainable Transportation; Hybrid Energy Storage System (HESS); DC–DC Converter.

O2065-Solar Powered Agricultural ai Robot

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Abstract

Agriculture faces numerous challenges, including labour shortages, inefficient resource management, and crop losses due to diseases. Traditional farming methods rely heavily on manual labor and non renewable energy sources, making them less sustainable and cost-effective. To address these issues, this project proposes the development of a Solar Powered AI Agricultural Robot that automates essential farming operations such as seeding, ploughing, irrigation, and disease detection. The robot is powered by solar energy, making it an eco-friendly and self sustaining solution suitable for diverse agricultural environments. It incorporates smart irrigation technology that uses soil moisture sensors to optimize water usage, reducing waste and improving crop health. Additionally, the system employs machine learning-based image processing to detect plant diseases early, allowing farmers to take timely corrective actions. By integrating renewable energy, automation, and artificial intelligence, this project enhances agricultural productivity, reduces costs, and promotes sustainable farming practices. The proposed system has applications in precision agriculture, small-scale and commercial farming, greenhouse farming, and agricultural research, making it a versatile and impactful innovation in modern farming.

Keywords: machine learning, automation, and artificial intelligence

O2066-Self-Supported molybdenum sulphoselenide catalyst for high-Performance Electrochemical hydrogen production

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Abstract

Hydrogen (H_2) is a promising clean energy carrier that can mitigate environmental pollution arising from fossil fuels. Among the available production routes, electrochemical water splitting is an attractive pathway for sustainable hydrogen generation. Although platinum-based materials are the benchmark catalysts for the hydrogen evolution reaction (HER), their high cost and scarcity hinder large-scale deployment. Transition metal dichalcogenides (TMDs), such as MoS_2 and $MoSe_2$, have emerged as cost-effective alternatives due to their favourable hydrogen adsorption free energies. In this study, we report the synthesis of a self-supported molybdenum sulphoselenide (MoS_xSe_y) catalyst directly grown on carbon fiber paper (CFP) via a facile hydrothermal method. Structural and compositional analyses, including XRD, Raman spectroscopy, XPS, and electron microscopy, confirmed the successful incorporation of selenium into the MoS_2 lattice and revealed a defective, disordered morphology that facilitates catalytic activity. Electrochemical evaluation in acidic medium demonstrated that MoS_xSe_y/CFP exhibits superior HER activity compared to pristine MoS_2/CFP and $MoSe_2/CFP$, achieving a low overpotential of 174 mV at 10 mA cm^{-2} and a favorable Tafel slope of 46 mV dec^{-1} . Furthermore, the catalyst exhibited excellent long-term stability, retaining its activity after 5000 cyclic voltammetry cycles. These results highlight the crucial role of selenium doping in enhancing electronic structure and active site availability, thereby boosting HER kinetics. The findings suggest that MoS_xSe_y is a promising non-precious catalyst for scalable hydrogen production, offering an effective pathway toward sustainable energy technologies.

Keywords: water electrolysis; hydrogen production; molybdenum sulphoselenide; clean energy

O2082-Intelligent network management with the presence of batteries and electric vehicle charging stations and considering charging and discharging

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Abstract

There is a significant push to promote the adoption of electric vehicles and highlight their advantages, particularly in reducing environmental pollution and dependence on fossil fuels. This has resulted in the initiation of numerous research projects. Experts have provided significant support for the existence of this field in the electrical market and energy management. The extensive integration of electric vehicles into the electrical market presents numerous technical challenges. Unregulated charging and discharging of the electric car could harm the safety and dependability of the power distribution system. Hence, it is essential to establish a sophisticated plan for the process of recharging and discharging electric vehicles. This study introduces an advanced model for controlling and organizing electric vehicles parked in a city parking facility. Previous studies have identified practical constraints in typical models, with the condition and lifespan of the battery being frequently neglected as crucial elements. In this study, charge and discharge timetables have been devised considering the elements that have been discussed. The findings indicate that the suggested method successfully fulfills technical and economic objectives while also ensuring owners' satisfaction. This is accomplished by considering the battery's healthiness and ensuring an effective charging condition when the car leaves the station.

Keywords: electric vehicles, smart parking, Vehicle-to-grid, energy management system

O2083-Management of distributed production resources in the smart grid to reduce power outages

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Abstract

This article presents a new model for intelligent blackout management planning. Based on this, in the first step, by solving an optimization function, taking into account the limitations of the fault distance, the expertise of the incident teams, and the resources available in the incident station, each fault is classified into an incident team. In the second step, a multi-objective optimization function is presented, in which, by considering different coefficients, the cost and downtime, the arrival time of incident teams (using the routing of incident teams), and the cost of distributed production resources are optimized. The output of this step is the optimal path of the incident teams according to parameters such as the priority of fixing each fault in the network, the time to reach each fault, the number of generation resources distributed in each time step, the number of resources allocated to each incident team. The objective function of both stages is of mixed integer linear programming (MILP) type, which has been solved in GEMS software using the CPLEX solver. In order to check the efficiency, the proposed method has been implemented on the IEEE standard 34 bus network. The results show that the proposed intelligent model can reduce the cost of the distribution network during blackouts to a reasonable extent.

Keywords: Dispersed production resources, Smart network, optimization

O2090-Simulation and Performance Analysis of Balance of Plant (BoP) Components in a Solar PV System for Enhanced Efficiency

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Abstract

This project focuses on understanding and simulating the Balance of Plant (BoP) in a solar power system using MATLAB/Simulink. While solar panels are the main source of electricity generation, they cannot operate effectively on their own. They depend on several supporting systems—such as converters, inverters, filters, sensors, and control units—to ensure the power is stable, safe, and usable. These supporting elements together form the BoP, and they play a key role in keeping the plant reliable and efficient. The purpose of this study was to explore how these BoP components function and how they influence system performance under changing environmental conditions. Using MATLAB/Simulink, a complete model of a solar PV system was built, including a boost converter, inverter, LC filter, MPPT controller, and measurement blocks. The Perturb & Observe (P&O) MPPT algorithm was implemented to maximize power extraction from the PV array. The simulation tested how the system responds to variations in solar irradiance, voltage fluctuations, and dynamic load conditions. Results showed that the MPPT-controlled boost converter significantly improves efficiency, while the inverter and LC filter ensure smooth AC output suitable for practical use. Overall, the study highlights the importance of BoP in ensuring stable, efficient, and continuous solar power delivery. It also demonstrates how simulation tools can help predict system behavior, optimize design decisions, and improve the performance of modern renewable energy systems.

Keywords: Balance of Plant (BoP), MATLAB/Simulink, Solar PV System, Boost Converter, MPPT (Perturb & Observe), Inverter and LC Filter

T6028-Sustainable Bio-Cellulose from Food-Waste: Advanced Composites for Environmental and Biomedical Applications

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Abstract

The growing demand for sustainable biomaterials has intensified interest in bacterial cellulose (BC) due to its exceptional purity, mechanical strength, hydrophilicity, and biocompatibility. However, large-scale utilization of BC remains limited by the high cost of conventional culture media. This study presents a green and cost-effective strategy for producing BC using locally available food-waste resources, with coconut water serving as the primary fermentation substrate. The resulting BC exhibited uniform nanofibrillar architecture, high crystallinity, and excellent water-holding capacity comparable to BC obtained from synthetic media. To further enhance its functional performance, bioactive plant-based extracts were incorporated into BC to fabricate sustainable composite films. These advanced BC-based composites demonstrated improved moisture management, robust structural stability, and notable antibacterial activity, highlighting their applicability in both environmental remediation and biomedical systems. Overall, the work underscores the potential of food-waste valorization as a circular-economy pathway for generating high-value BC materials and developing eco-friendly composites suitable for wound care, packaging, filtration, and other sustainability-driven applications

Keywords: Bacterial cellulose; Food-waste valorization; Sustainable biomaterials; Eco-friendly composites; Biomedical applications

O2105-Balance of Plant (BoP) and its Performance Analysis for Solar Photovoltaic (PV) System to Achieve Enhanced Efficiency

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Abstract

Solar photovoltaic (PV) systems rely not only on PV modules for power generation but also on Balance of Plant (BoP) components that enable safe, reliable, and efficient energy conversion and delivery. This work focuses on modelling and performance evaluation of key BoP systems—including boost converters, inverters, power protection units, monitoring systems, and filtering elements—in a solar power plant environment. MATLAB/Simulink-based simulations were developed to analyse how variations in environmental conditions such as irradiance, temperature, and dust accumulation influence system stability and power output. A SunPower SPR-445NX-WHT-D PV module (445 W, $V_{oc} \approx 85$ V, $I_{sc} \approx 6.4$ A) was used as the primary source in the simulation. Under typical irradiance conditions (around 800 W/m²), the PV array generated nearly 120 V DC, which was boosted to approximately 220 V DC using the newly designed DC–DC boost converter. The inverter stage successfully converted this boosted voltage into a 220 V AC sinusoidal output, which was further smoothed using an LC filter. A Perturb and Observe (P&O) Maximum Power Point Tracking (MPPT) algorithm was integrated to ensure optimal energy extraction under dynamic conditions. The results demonstrate improved voltage regulation, reduced harmonic content in the AC output, and enhanced system responsiveness due to real-time control and monitoring strategies. This study emphasizes that well-designed BoP architecture is essential for maintaining efficiency, prolonging equipment lifetime, and supporting reliable operation of solar power plants.

Keywords: Solar Photovoltaic System, Balance of Plant (BoP), MPPT algorithm

T4039-Optimizing Hydrogen Production from Waste Metals for Fuel cells: An Evaluation of Different Alkali Activation Methods

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Abstract

This project investigates the sustainable generation of hydrogen gas for fuel cell applications via the alkaline hydrolysis of aluminum waste. The study systematically examines the reaction of aluminum waste with strong alkalis, including potassium hydroxide (KOH), sodium hydroxide (NaOH), lithium hydroxide (LiOH), and their mixtures, across varying concentrations and volumes. The primary focus is to quantify the effects of key operating parameters such as alkali concentration and solution volume, on the resulting hydrogen yield and reaction efficiency. Experimental results demonstrate a clear relationship where increasing alkali concentration and solution volume lead to enhanced hydrogen production. The reaction using an equal-volume mixed solution of KOH and NaOH was the most efficient, producing a maximum hydrogen yield of 3570 mL over a period of 19 minutes. This result confirms that alkali mixtures are more effective for hydrogen generation than individual alkali solutions. By utilizing aluminum waste as a cost-effective reactant. This research simultaneously advances sustainable energy production and contributes to effective waste management practices. The findings robustly demonstrate the feasibility of producing hydrogen from recyclable resources, thereby supporting a circular economy and reducing environmental impact.

Keywords: Aluminum Waste, Fuel cells, Green Hydrogen, Lithium Hydroxide, Alkali.

T4040-Sustainable Valorization of Local Animal Waste for Biomethanation and Efficient Waste Management

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Abstract

This research investigates the sustainable valorization of local animal waste (cow, camel, and goat dung) in the Dhofar Governorate, Oman for the simultaneous production of biogas (a renewable energy source) and organic fertilizer. This project addresses the challenge of underutilized organic waste by employing anaerobic digestion (AD) technology to develop a localized, sustainable energy and waste management solution. The study commenced with a physicochemical characterization of the raw feedstocks, analyzing key parameters such as pH, dissolved oxygen (DO), electrical conductivity, total dissolved solids (TDS), salinity, and NPK content. This analysis revealed that cow dung possessed the highest nutrient content and moisture level, followed by goat and then camel dung, establishing baseline characteristics critical for the AD process. Experimental procedures involved subjecting various dung slurries, prepared at concentrations ranging from 5% to 20% (dung-to-water ratio), to batch anaerobic conditions. Daily monitoring and recording of biogas output were performed throughout the experiment. Results indicate a strong correlation between increasing slurry concentration and enhanced biogas production. The 20% cow dung slurry achieved the highest overall gas volume, followed by the 20% camel dung and 20% goat dung slurries. Notably, while goat dung exhibited a delayed onset of gas production, it ultimately contributed a respectable amount of biogas. Overall, this research successfully demonstrates the technical feasibility of transforming readily available animal waste in Dhofar into valuable resources, offering dual benefits for renewable energy generation and the creation of nutrient-rich organic fertilizer.

Keywords: Biogas Production, Anaerobic Digestion, Animal Waste, cow dung, camel dung, goat dung

T4064-Sustainable Production of Bioplastics from Waste Milk as an eco-friendly and Renewable Resource for Circular Economy

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Abstract

The worldwide production of plastics reached up to 480 million tons in 2024 and it is anticipated to reach up to 595 million metric tons by 2050. The accumulation and improper disposal of plastic waste lead to severe health and environmental issues by releasing huge amounts of greenhouse gases. The dairy industry discharges considerable amount of waste milk, which contains naturally occurring biopolymer known as "Casein", which has a great potential as a biodegradable plastic precursor. Casein based plastics are renewable, biodegradable and nontoxic. No major studies have been carried out in the production of biodegradable bioplastics from expired milk employing green extraction technique. Hence, to promote sustainable practices, this research aims to produce bio plastics from discarded milk using citric acid and glycerol as ecofriendly green solvents by minimizing the environmental impact and support circular economy. The resulting bio plastics were characterized using Thermo Gravimetric Analysis (TGA), Energy Dispersive X-Ray (EDX), X-Ray diffraction (XRD), Scanning Electron Microscopic (SEM), and Fourier Transform Infra-Red Spectroscopy (FTIR) analysis. The SEM and EDX analysis revealed the surface morphology and elemental composition of the sample shows 71.3% carbon, 28.2% oxygen and 0.5% nitrogen demonstrated the high purity of the bio plastics. The single peak in the XRD analysis conform the amorphous nature of the bio plastic. The FTIR spectra indicate the various functional groups present in the sample. The biodegradability test confirms excellent degradation rate of the bioplastics with an optimum degradation time of 7 days as revealed by the weight loss percentage of bio plastic. The study shows that the bio plastics produced by a cost effective and environmental friendly method has the advantage of being renewable, biodegradable and nontoxic. This research satisfies the goals and targets of United Nations Sustainable Development Goals (i.e. UNSDG-12). Additionally, this community engagement project will serve the society and support the national priorities of Oman Vision 2040 by the effective implementation of sustainable consumption and production rules. The transformation of waste milk to bio plastics supports the principles of circular economy, by converting the waste into value added product and represent a "win-win-win situation" for industry, farmers, and consumers. The green extraction of bio plastics will tend to suppress the carbon emissions associated with plastic production through a clean and integrated approach.

Keywords: *Biodegradability, Casein, Circular economy, Green solvents, Glycerol, silver nanoparticles, scanning electron microscopy.*

O3: Online Session 3

O3112-The Uneven Impact of Digital Development on Economic Performance: Quantile Evidence from Malaysia

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Abstract

This study examines the impact of digital development on Malaysia's economic performance through fixed-line telephone (FTS), mobile penetration (MOB), and internet bandwidth per capita (IBWpc). Using annual data from 1970–2023, Ordinary Least Squares (OLS) and quantile regression are applied to capture both average effects and distributional heterogeneity across real GDP (RGDP). Results show labour as the most consistent growth driver, though with diminishing returns at higher income levels. The human capital proxy, primary school enrolment, shows a negative link with output, highlighting the weakness of flow-based measures for skills. Consumer Price Index (CPI) effects shift between positive and negative, reflecting structural and policy changes, while capital (K) impacts are unstable, likely due to collinearity, measurement in shares, and the transition from physical to ICT-driven investment. Among digital indicators, FTS shows a U-shaped effect, stronger at low and high output levels, while MOB and IBWpc have no significant impact, possibly due to mobile saturation and bandwidth data gaps. Slope equality tests suggest stable digital–growth relationships across quantiles. Overall, findings stress the need to improve education quality, channel capital toward innovation, and strengthen digital skills and adoption to harness Malaysia's digital economy potential.

Keywords: Digital development, Quantile regression, ICT infrastructure, Economic growth, Malaysia

O3125-Building Resilience and Sustainability in Spices Supply Chain Through the Convergence of Digital Twins, Blockchain, and Artificial Intelligence (AI): An Insight from Indonesia

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Abstract

Spices remain Indonesia's mainstay source of foreign exchange due to their stability. Indonesia's spice supply chain faces major challenges in terms of quality variability, lack of transparency of origin, counterfeiting practices, and increasing global demands for sustainability in cultivation and processing. Focus on spice commodities is crucial due to their sensitivity to storage environments and their economic value, which demands responsible end-to-end quality integrity assurance. This study proposes a framework that integrates Digital Twin (DT), Blockchain, and Artificial Intelligence (AI) to address these challenges and improve supply chain resilience. The method used is a conceptual case study with interviews of a number of informants, consisting of 2 sustainability experts, 2 agricultural commodity supply chain experts, 1 digital supply chain expert, and 3 industry practitioners related to the spices supply chain. DT is used to create a real-time virtual representation of critical physical conditions, from efficient drying processes to cargo logistics environments. AI/Machine Learning analyzes this data, predicts the risk of spoilage, and prescriptively optimizes operational processes and environmentally friendly cultivation practices. To ensure data integrity, all quality information, AI decisions, and sustainability practice records are permanently recorded on Blockchain, which provides an immutable audit trail from origin to delivery. This integration enables the implementation of Smart Contracts that automatically release incentive payments to farmers who meet quality standards and sustainability practices verified by DT/AI, accelerating settlement and encouraging responsible practices. This model produces an adaptive, autonomous supply chain supported by digital trust. It is hoped that the application of these three technologies can mitigate losses, combat counterfeiting, and strengthen the competitive position of Indonesian spices in a global market that increasingly prioritizes credible sustainability verification

Keywords: Digital Twin, Blockchain, Artificial Intelligence (AI), Spice Supply Chain, Sustainability

O3143-Stakeholder Dynamics in Smart Street Lighting PPP: Social and Political Influences on Environmental Sustainability in Madiun Regency

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Abstract

The Availability Payment (AP) scheme of Public Private Partnership (PPP) is a crucial mechanism for local governments in Indonesia to overcome budget constraints in infrastructure provision. Although the potential of the AP model is enormous, its success is largely determined by effective stakeholder management amidst the dynamics of contradictory interests. This study examines the Smart Street Lighting (SSL) project in Madiun Regency, the only AP project successfully implemented at the district/city level in Indonesia, making it a revelatory case. A key driver of this project is the transition to smart street lighting technology, which serves as a strategic effort to enhance energy efficiency and promote environmental sustainability by reducing regional carbon footprints. Using a qualitative approach and case study, this study aims to identify and classify stakeholders based on the Benefit-Engagement model, as well as analyze the dynamics of their relationships. Primary data were obtained through semi-structured interviews with ten key informants. The results classify the main stakeholders as Key Players: Special Project Vehicle (SPV) and Local Government Contracting Agency; Supporters: Financial Institutions, Third Parties, and Users; and Supervisors (Monitors): Ministries/Institutions. Crucial findings indicate that the success of the Madiun project was based not only on compliance with central regulations but primarily on the GCA's unique engagement strategy involving the Regional People's Representative Council.

Keywords: availability of payment, public-private partnership, smart street lighting, stakeholder engagement

O3145-Exergy analysis of a dual recuperative dual expansion s-CO₂ energy system for utilizing industrial waste heat

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Abstract

Energy efficiency is key to utilizing natural resources effectively with minimal impact on the environment. Exergy analysis or Exergy analysis gives an in-depth insight into areas where scope for improvement is practical. Power plants using Super-critical Carbon dioxide (s-CO₂) as the working fluid utilize CO₂ which otherwise would have to be dealt with for safe disposal. Moreover, due to the high density of the s-CO₂, the power plant components become very compact making them possible for use in applications where space is a constraint. Also, it has been established that a proper choice of system layout could result in higher overall thermal efficiency of the power plant. However, due to various reasons like high temperature, high pressure, steep variation of properties near the critical point, the s-CO₂ power plants have not yet been commercialized. Work needs to be carried out in choosing appropriate layout for each specific application. Also, materials which can withstand high temperatures and pressures need to be developed, which implies that commercialization could take close to a decade. For the present study, a dual recuperated dual expansion s-CO₂ power cycle meant to utilize waste heat has been chosen and an energy as well as exergy analysis has been carried out. The system consists of a waste heat source which is utilized by a waste heat recovery heat exchanger after which the CO₂ would pass through the high pressure turbine producing power. The turbine exhaust is passed through two recuperators and a cooler before being compressed in a compressor which is driven by the turbines. The compressor exhaust is split into two streams and passed through the main heat exchanger and the two recuperators respectively. The second stream exiting the recuperators is passed through the low pressure turbine to produce further power. The exhaust of the high pressure and low pressure turbines is merged and passed through the low temperature recuperator and the cycle repeats. The exergy analysis of the system shows that the main heat exchanger is responsible for 68.21 kW of exergy destruction while the compressor, LP turbine, LT recuperator, HP turbine are responsible for 20.57, 16.71, 10.39 and 9.39 kW respectively. The result implies that the temperature difference through which heat is transferred in the main heat exchanger is high and needs to be decreased but at the expense of cost and compactness of the system.

Keywords: Thermal power, Exergy analysis, System layout, Efficiency

O3148-IMPACT OF SUGAR REDUCTION IN BISCUITS AND ITS ANTIMICROBIAL AND ANTIOXIDANT PROPERTIES

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Abstract

Biscuits hold a versatile position in the food sector, with options spanning multiple flavors, textures, and claims. Sugar is one of the crucial ingredients in the preparation of biscuits. It plays a major role in the sensorial properties of the biscuit along with its textural properties. In our research work, we have focused on reducing the sugar % in three different variants of biscuits – Cocoa Biscuits, Crème Biscuits and Crème and Jam Biscuits. The Sugar reduced biscuits are compared against the control samples of all three variants. Sensory evaluation for all three variants of the biscuits was conducted by analysis the Sugar reduced biscuits against the control samples. The sensorial of the biscuits were evaluated along with its appearance and mouthfeel of the product. An analysis was conducted to evaluate the nutritional composition of the biscuits. Antibacterial and Antifungal Properties of the biscuits were also studied along with its antioxidant properties. These studies shows if the samples used as an alternative for sugar reduction can also have any therapeutic claims to it.

Keywords: Biscuits, Sugar Reduction, Sensory Evaluation, Therapeutic Claims

O3157-Manufacturing, and Testing of High-Performance CNT coated/ CF reinforcement polymer composite

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Abstract

Polymer composites reinforced with carbon fiber composites (CFRP) are popular due to their strength, light weight, and durability, but due to the poor bond between CFs and epoxy resins, they can only perform because of limited epoxies. This research study was designed to determine the effect of CNT on the mechanical and microstructural behavior of CF/epoxy composites. To achieve those three types of laminates were manufactured utilizing Carbon Pure (CF/epoxy) with no CNT layer, S and/or CC1--two CNT layers combined located at the centre and CC2-distributed amongst the plies of CF. All specimens were fabricated using the same procedures to maintain consistency. The mechanical properties of the components were tested through flexural bend tests, while optical microscopy was used to assess the internal microstructural properties and fibre/matrix interfaces. As shown in the data from the bending tests, Carbon Pure provides the highest level of flexural performance with the least variability in results from each tested piece. Overall, the performance of the CC1 composite was marginally outperformed by the CC2 composite due to both being less consistent when above that of CC1. Analysis of microscope images for the CF/epoxy formulations that contained CNT indicated that the variations in CNC-CC formulation-CNC levels were due to the increased porosity and reduced interface strength that these variations created, particularly in CC2. It can be concluded from these findings that the addition of CNTs will not yield increased strength in composites when using CFRP technology, and constancy in CNT formulations (placement, dispersion, and use of connector medium) is paramount to maximize the benefits from those advantages.

Keywords: Polymer composites, carbon fibers, carbon nanotubes, microstructural properties

T7094-From Mining Waste to Construction Resource: A Sustainable Approach for Copper Tailings Reuse in Oman

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Abstract

Rapid expansion of mining and mineral processing in arid regions has intensified environmental concerns associated with the management of copper tailings, which represent one of the largest and most persistent industrial waste streams. In Oman, sustainable mining and waste reuse have become key priorities under Oman Vision 2040 and national circular economy strategies. This study evaluates the environmental risks, material characteristics, and sustainable valorization potential of copper flotation tailings generated from large-scale beneficiation operations in Oman. The research is based on environmental impact assessment, physicochemical characterization, and evaluation of wet-grinding activation as a low-energy valorization technique for producing supplementary cementitious materials. The activated tailings exhibit enhanced particle fineness and surface reactivity, enabling partial replacement of cement clinker and contributing to reduced carbon emissions. Technical, economic, and environmental feasibility analyses confirm the suitability of this approach under hot-arid conditions. The findings demonstrate that copper tailings, traditionally regarded as an environmental liability, can be transformed into value-added construction resources. This waste-to-resource framework offers a practical pathway for reducing long-term tailings storage risks, promoting green construction, and strengthening sustainable mining development in Oman.

Keywords: Copper tailings; Sustainable mining; Circular economy; Wet-grinding activation; Supplementary cementitious materials; Oman Vision 2040