HackAP Hackathon
Theme: ChemTech 2025

Problem Statements

Problem 1. **Efficient CO_2 Capture and Utilization**

Objective:

Develop scalable, energy-efficient methods to capture carbon dioxide from industrial emissions (e.g., cement, steel, or power plants) and convert it into useful products like fuels, chemicals, or construction materials.

Scope:

- Focus on large-scale deployment feasibility.
- Ensure cost-effectiveness and energy efficiency in the proposed method.
- Highlight potential end-use products and their market viability.

Demonstration:

Participants should use process simulation tools like Aspen Plus or MATLAB to model the capture and conversion process. Deliverables include:

- A detailed process flow diagram.
- Simulated results for CO_2 capture efficiency and product yield.
- An economic feasibility report, including metrics such as cost per ton of CO_2 captured and ROI.

Problem 2. **Water Desalination and Purification for Remote Areas**

Objective:

Design a low-cost, modular, and energy-efficient water purification system for rural or disaster-affected areas.

Scope:

- Use renewable energy (e.g., solar, wind) or innovative materials to minimize costs.

- Ensure the system is scalable, easily transportable, and has low maintenance requirements for remote deployment.

Demonstration:

Teams can create a 3D design or simulation of the system, supported by:

- An energy consumption analysis, including lifecycle energy costs.

- A conceptual process diagram showing purification steps.

- A cost-benefit analysis, including initial setup costs and maintenance over 5 years.

Problem 3. **Waste-to-Energy for Chemical Industry Byproducts**

Objective:

Develop innovative processes to convert chemical waste (e.g., solvents, sludge, plastics) into energy or reusable materials.

Scope:

- Focus on reducing environmental impact and enhancing resource recovery.

- Ensure scalability to pilot or industrial levels.

Demonstration:

Deliverables may include:

- A process flow diagram with mass and energy balances.

- A simulation-based energy recovery model.

- A financial and environmental impact assessment, including metrics like carbon footprint reduction and payback period.

Problem 4. **Smart Monitoring of Chemical Processes (IT-Integrated)**

Objective:

Integrate IoT and AI for real-time monitoring and optimization of chemical processes.

Scope:

- Implement predictive maintenance to minimize downtime.
- Use anomaly detection to prevent failures.
- Optimize energy usage to reduce operational costs.

Demonstration:

Participants can present:

- A software prototype or interactive dashboard with real-time alerts and historical data visualization.
- Simulated scenarios for anomaly detection or energy savings.
- An architecture diagram illustrating IoT sensor placement and data flow.

Problem 5. **Sustainable Polymer Production**

Objective:

Create a novel process for manufacturing biodegradable polymers from renewable resources (e.g., plant-based oils, agricultural waste, algae).

Scope:

- Address the scalability of the proposed process.
- Demonstrate cost-effectiveness for commercial production.
- Highlight the polymer’s performance in real-world applications.

Demonstration:

Teams can present:

- A conceptual process supported by computational simulations (e.g., molecular modelling).

- A comparative analysis of costs and environmental benefits.

- A sample product prototype or mock-up, if feasible.

Problem 6. **Green Hydrogen Production through Innovative Electrolysis**

Objective:

Design a more efficient electrolysis process for green hydrogen production, minimizing energy loss and utilizing renewable energy sources.

Scope:

- Focus on reducing energy input for hydrogen generation.

- Integrate potential byproducts into the process to enhance efficiency.

- Explore renewable energy integration (e.g., solar, wind).

Demonstration:

Deliverables may include:

- A computational model or simulation of the electrolysis process.

- A flow diagram with energy efficiency metrics (e.g., kWh per kg of hydrogen produced).

- A proposal for renewable energy integration, including lifecycle energy analysis.

Problem 7. **Cross-Disciplinary: Reducing Urban Heat Using Chemical Engineering Solutions**

Objective:

Develop chemical-based materials or coatings to mitigate urban heat islands and improve energy efficiency in cities.

Scope:

- Collaborate with civil and environmental engineering for practical deployment.

- Use reflective or heat-absorbing materials (e.g., cool roofs, phase-change materials).

- Propose strategies for large-scale implementation in urban settings.

Demonstration:

Teams can showcase:

- A prototype design using computational tools (e.g., ANSYS, EnergyPlus) for thermal simulations.

- A heat map analysis comparing pre- and post-implementation scenarios.

- A material lifecycle analysis highlighting environmental benefits.

General Notes for All Problem Statements

- Timeline: Participants should aim for proof-of-concept solutions rather than fully optimized systems due to the short timeline.
- Evaluation Criteria: Solutions will be judged based on innovation, feasibility, scalability, and environmental impact.
- Support: Mentors and domain experts will be available for guidance during the hackathon.

Recommendation for Participants:

We understand that many of you may rush to use AI tools. We want you to be aware that AI tools lack the ability to independently innovate or deeply understand domain-specific challenges without substantial guidance. Human expertise remains crucial for conceptualizing novel processes, interpreting results, and ensuring practical feasibility. Our recommendation:

- Teams with a mix of domain experts (chemical engineers, material scientists) and AI/IT specialists will likely find it easier to leverage AI tools effectively.
- We encourage participants to use AI for tasks like process simulation, energy optimization, and data-driven decision-making, while relying on your own expertise for creative problem-solving and experimental validation.