

PLANT DESIGN

THEME

Synergising Chemical Engineering and Sustainable Microelectronics for a Greener Future

THEME DESCRIPTION

The microelectronics industry is the foundation of modern technology, powering essential devices from smartphones to advanced computing systems. Nonetheless, this advancement has incurred considerable environmental expenses. As the demand for more powerful and efficient microelectronics increases, so too does the energy consumption, resource depletion, and development of electronic trash (e-waste) linked to their manufacturing.

Microelectronics manufacturing, particularly semiconductor fabrication and nanomaterial synthesis, is among the most resource-intensive industrial processes, consuming significantly more energy than conventional material processing. The business significantly relies on essential raw minerals like gallium and indium, which are at risk of supply constraints within the next two decades due to increased demand and limited natural reserves. The improper disposal of microelectronic components, including printed circuit boards and semiconductor chips, contributes to environmental pollution and potential emissions from hazardous substances, with global waste projections reaching 74.7 million metric tonnes by 2030.

The production of microelectronics has considerable environmental consequences, including resource extraction, high energy consumption, and toxic emissions. Semiconductor etching, an essential process, depends on fluorinated gases such as CF_4 and NF_3 , which possess significant global warming potentials. It also generates wastewater pollutants, including PFAS, which threaten water quality and public health. The escalating problem of e-waste underscores the necessity for more sustainable procedures in microelectronics industries.

The theme, "Synergising Chemical Engineering and Sustainable Microelectronics for a Greener Future," underscores the vital contribution of chemical engineering to promoting sustainability in the microelectronics sector. This theme promotes the integration of chemical engineering concepts with advanced green technologies, urging participants to create new, environmentally friendly solutions that mitigate environmental damage, enhance resource circularity, and foster a sustainable, low-carbon future. By addressing these challenges, this theme aligns with key Sustainable Development Goals (SDGs), including SDG 9 (Industry, Innovation, and Infrastructure), SDG 12 (Responsible Consumption and Production), and

SDG 13 (Climate Action), fostering a more sustainable and responsible future for the microelectronics industry.

Key focus areas include:

- Identifying and creating safer, sustainable alternatives to hazardous compounds in microelectronics manufacturing, thereby mitigating toxicity and environmental dangers.
- Developing and implementing energy-efficient and low-carbon manufacturing techniques that optimize resource utilization, minimize emissions, and enhance overall efficiency in microelectronics production..
- Implementing effective recycling and resource recovery systems to recover valuable materials, prolong the lifespan of microelectronic components, and advance towards a circular economy.

This theme utilises chemical engineering expertise to push participants to devise practical and significant ways that integrate sustainability with technological progress. By integrating chemical engineering with sustainable microelectronics, we can create a more environmentally responsible future for the microelectronics sector.

OBJECTIVES

1. To design an eco-friendly microelectronics manufacturing plant that integrates sustainable chemical processes and green technologies to minimize hazardous waste, reduce energy consumption, and enhance resource efficiency while ensuring scalable production.
2. To advance the development of sustainable microelectronic materials by incorporating biodegradable, recyclable, and non-toxic alternatives to conventional electronic components, reducing environmental pollution and promoting a circular economy.
3. To raise public awareness and foster innovation in green microelectronics by promoting eco-friendly processes, sustainable solutions, and responsible management practices to drive the transition towards a more sustainable microelectronics industry.

COMPETITION DESCRIPTION

- This is a **GROUP** competition, with **THREE (3) to FIVE (5) participants per group**, and will be conducted **PHYSICALLY**.
- Each university/institution may enroll a maximum of **THREE (3)** groups in this competition.

- This competition aims to advance the field of plant design by cultivating a new generation of skilled and innovative engineers and designers.
- This competition also serves the purpose of providing a platform for participants to showcase their potential and understanding of the microelectronics industry. Reactive processes must be included in any plant or process design, regardless of size, type or technology used in this competition.
- Each team will be assigned a task to design a plant/process related to the specific theme, which will be announced during the participant briefing session on **18 October 2025**.
- There are no restrictions on the types, scales, or technology of plants being used. However, the plant/process must contain reactive processes and the details must be included in the work. The winner of the competition will be determined from a judging stage.

ELIGIBILITY

- For group competition, each participant must be a **full-time undergraduate student** enrolled in the **Chemical Engineering Program** (or equivalent) offered by one of the participating universities / institutions OR a **fresh graduate** within **one year** of completing undergraduate degree in Chemical Engineering Program (or equivalent) on the deadline of registration.
- Participants must submit an **APPROVED** original copy of their **student identity card (Matric Card)** together with the **LATEST module registration** file. For fresh graduates, participants must submit an **APPROVED** copy from their respective institutions which includes the date of graduation.
- Each participant is only allowed to participate in **ONE (1) physical mode competition** and **ALL online mode competitions** are allowed to participate.
- Each participant in a team must be from the **SAME** university / institution.

FORMAT

1. Plant Design Report

- The report must be written in **English**.
- The maximum number of pages is **TWENTY-FIVE (25)** (excluding a cover page, table of contents, acknowledgement, executive summary, references and appendices).
- The cover page of the report should consist of these information:
 - Title of Project

- Name of University / Institution
- Team Name
- List of group members with their details as followed:

(Name of the group leader should be placed first, followed by team members in alphabetical order)

 - Name
 - IC Number (Malaysian) or Passport Number (Non-Malaysian)
 - Contact Number
 - Email Address
- Content of the Report should include:
 - Table of Contents
 - Acknowledgement
 - Executive Summary
 - Report Body
 - Conclusion and Suggestions
 - References following APA 7th format
 - Appendices
 - The appendix must have at least two A3-sized process flow diagrams (PFDs) with stream summaries, one for manual computation and the other for the simulation findings must be included in the appendix.
 - Stream Summary must include:
 - Stream number
 - Temperature
 - Pressure
 - List of components
 - Phase, mass and mole of each component
 - Mass and mole fractions
 - Total mass and total mole of each component
 - Enthalpy for each stream
 - On the PFD, indicate the operating conditions (T and P) for all equipment. For reactors, include the reaction equations, conversion, yield, selectivity etc.
- All submission must follow the Essay Format:
 - **Font Name and Size:** Times New Roman, 12 pt.

- **Line Spacing:** 1.5 pt.
- **Space before Paragraph:** 6 pt. with indentation of 12 mm from left on the new paragraph
- **Page Layout:** Standard A4 size (210 mm × 297 mm)
- **Margin:** Left to right: 2.54 cm
Top to bottom: 2.54 cm
- Page numbers should be included at the bottom of each page, excluding the cover page.
- All soft copy report submissions must be in **pdf** file and should be adhered to the guidelines.

2. Excel File - Mass and Energy Balance

- This file must contain a process flow diagram (PFD). According to the names and number of the streams, label the process units, equipment and streams.
- Provide the mass and energy balance calculations for the following in separate sheets:
 - The overall process (which should include the designed PFD) and the stream summary below the PFD.
 - Each equipment involved in the process is listed on a single sheet, with diagrams and inlet-outlet streams.
- The computations of the inlet-outlet streams in each equipment sheet need to be linked to the streams of the other equipment in those sheets and must be shown clearly.
- Create an Excel file that automatically recalculates mass and energy balances as the basis changes.

3. Poster Presentation

- The oral presentation will be held physically through a poster presentation method.
- Booths must be set up by each team at competition venues to deliver their final report in poster style for the judges.
- The poster must be prepared by each team **THEMSELVES** in **A1 size** and include the overview of the design criteria.
- The following presenting abilities will be assessed besides the content of the plant design:

- Communication skills (Effectiveness interaction with judges and language proficiency)
- Time management (Adherence to the allotted time for the presentation)
- Visual aids (Effectiveness and quality of poster)
- Personal appearance (Wearing appropriate attire)
- Q&A handling (Effectiveness in responding to questions from the judges)
- The presentation duration is carefully controlled by a timekeeper. In any case of technical difficulties, promptly notify the timekeeper.
- Participants will be notified before the competition starts.
- Time allocated for each team for technical set up is **30 minutes (during break), 15 minutes for presentation and 15 minutes for Q&A and feedback from judges.**
- Bell will be rung **once** when the presentation has 2 minutes left, and rung **twice** when the presentation time has ended. Teams that surpass the time constraints may be imposed with marks deduction.

4. Plant Layout

- A plant layout should be designed with Plant Design Software, like AutoCAD, and include detailed labeling for every part of the plant.
- The layout must include all necessary features, including plant sections, utilities, facilities, infrastructure and the workflow must be well-explained.
- Plant layout, safety, economic factors as well as other contributing factors (if any) must be considered and explained well throughout the presentation.

5. Powerpoint Presentation

- The oral presentation will be held physically on the second day for the **FIVE (5)** short-listed teams through a powerpoint presentation method.
- Each team must submit a presentation slide in both **pptx** and **pdf** format.
- Each team will be given **5 minutes** for technical set up, **15 minutes** for presentation of their plant design and followed by **20 minutes** for Q&A and feedback from judges.
- Every participant is **compulsory to present**.
- All presentation slides must be created in **pptx** format, with a maximum limit of **20 SLIDES**.
- All the references must be cited as a footnote in the presentation slides.

- The sequence of each team's presentations will be determined by lot.
- Bell will be rung **once** when the presentation has 3 minutes left, and rung **twice** when the presentation time has ended. Teams exceeding the time limit may be imposed with mark deduction.

RULES AND REGULATIONS

- Each university/institution is entitled to send a maximum of **THREE (3)** teams. Each team must consist of **THREE (3) to FIVE (5)** members only.
- Both presentations will be done **PHYSICALLY** at *Lecture Hall Complex*.
- All teams are given **30 MINUTES** for preparation at the competition site. Hence, participants will be notified one hour before the start of the competition. Punctuality is expected of all teams.
- Any team that fails to attend the competition site after **15 MINUTES** from the start of the competition will be considered disqualified.
- The presentation should be genuine with no plagiarism. Participants need to ensure that they have acquired permission to use any resources having the copyright.
- Decisions by judges are **FINAL** and **NOT** open to appeal.
- Late submissions will not be entertained under any circumstances.
- Entries that do not comply with any one of the above rules will be **DISQUALIFIED AUTOMATICALLY**.
- Upon the submission, any modification on the contents is not allowed. Evaluators have the right to penalise the participating team for the change of contents.

SOFTCOPY REPORT AND PRESENTATION SUBMISSION

- Submission deadline: **5 December 2025**
- Submissions can only be made **ONE week** before the submission deadline (**29 November 2025 - 5 December 2025**). Any soft copy materials that are not submitted online shall not be displayed during the physical presentation.
- All the copy materials must be submitted in the required format together and reached the organiser (via email) before the submission deadline.
 - Report in **.pdf**
 - Excel file in **.xlsx**
 - Poster in **.jpeg** or **.png**

- Plant in both in **respective file format** (e.g. AutoCAD in .dwg) and in **.pdf**
- Powerpoint in both **.pptx** and **.pdf**
- Email: regnaces.usm@gmail.com
 - Email Subject: **[PDC]_Name of University/Institution_Team Number**
 - Attachments include:
 - (1) [PDC]_Name of University/Institution_Team Number_Report
 - (2) [PDC]_Name of University/Institution_Team Number_Excel
 - (3) [PDC]_Name of University/Institution_Team Number_Poster
 - (4) [PDC]_Name of University/Institution_Team Number_Plant
 - (5) [PDC]_Name of University/Institution_Team Number_Powerpoint
 - Example: **[PDC]_USM_Team01**
 - (1) [PDC]_USM_Team01_Report
 - (2) [PDC]_USM_Team01_Excel
 - (3) [PDC]_USM_Team01_Poster
 - (4) [PDC]_USM_Team01_Plant
 - (5) [PDC]_USM_Team01_Powerpoint
- All successful receipt if submissions will be notified via the provided email within 3 working days. If the participants do not receive any reply from us, please do not hesitate to contact the organiser.

JUDGEMENT CRITERIA

1. Design Report

- Literature Review and Project Conception
 - Chemical product background including detailed data on chemical and physical properties of the product
 - Market survey
 - Review and screening of alternative process route (must take into account aspects of safety, environment and economy)
- Process synthesis of Process Flow Diagram
 - Process database
 - Process synthesis approaches and heuristics
 - Preliminary process screening
 - Development of base case flowsheet and plant layout

- Mass and Energy Balance
 - Manual material and energy balances (using Microsoft Excel)
 - Simulation using available commercial process simulators (Aspen Plus, Aspen Hysys etc.)
- Waste Treatment
 - Design of waste treatment process
 - Environmental effect
- Plant Design and Cost Estimation
 - General equipment design specification (function, type and capacity of equipment)
 - Plant cost components
 - Cost estimation for auxiliary equipment, major equipment and plant component
- Process Control and Safety Studies
 - General process safety procedures and risk assessment, including safety operation in industrial processes and identified potential hazardous material
 - Control approaches, P&ID and HAZOP study on major equipment
- Economic and Profitability Analysis
 - Total Capital Investment (Equipment cost, production and operation cost)
 - Payback Period or Return of Investment (ROI)

2. Style and Presentation

- Communication skills
- Time management
- Visual aids
- Personal appearance
- Q&A handling
- Confidence

3. Excel File of Mass and Energy Balance

- Provide labelled Process Flow Diagram (PFD) with all process units, equipment and streams, and provide a stream summary table below it.
- Provide mass and energy balance calculations in separate sheets for the overall process and for each piece of equipment, with clear inlet-outlet stream diagrams.

- Ensure all computations are linked between equipment sheets, and set up the Excel file to automatically recalculate mass and energy balances when input conditions change.

4. 2D plant design model

- Provide the clarity of layout and spacing, safety, efficiency, aligned with the project's goals and regulations.

RESULT

The winners of the competition will be announced during the NACES 2025 Closing Ceremony on 14 December 2025.

PRIZES

- 1st Prize - RM 1000
- 2nd Prize - RM 850
- 3rd Prize - RM 690

All prizes were subjected to increment based on decisions from the organizer.

IMPORTANT NOTES

- Each participant must agree to be bound by the official contest rules. The organizer has all the rights to eliminate or disqualify any participants that violate the guidelines as stated above. Such actions may be taken by the host without any prior notice.
- The judges' decisions are final and any appeals to the decisions will not be entertained.
- Participants must complete the registration form by **10 October 2025** to be eligible for participation.
- Any changes on the confirmed participants' list must be informed before **17 October 2025**. Any changes after the date will not be entertained.
- Organisers will hold the right to publish submitted presentations for future publications without prior notice to the participants. Kindly notify the organiser if you have a patent or copyright reserved.
- Registration fees are non-refundable.
- The contents of this booklet are subjected to amendment and improvisation. Participants will be notified when the amendments are made.

CONTACT INFORMATION

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