

AI in Chemical and Process Engineering

Industry Roundtable Summary

- IChemE convened an industry roundtable in Australia bringing together leaders from across the chemical and process industries to explore the opportunities and challenges arising from artificial intelligence (AI).
- Building on previous Australian roundtables addressing the energy transition, battery recycling and the decarbonisation of heavy industry, the discussion considered how AI is already changing engineering practice, where it could deliver the greatest benefits, and the capabilities and safeguards that will be required as its use expands.
- A clear theme emerged: AI is no longer a future consideration for the profession. It is already being used to improve productivity, accelerate learning, support engineering analysis and optimise industrial operations. The challenge is not whether engineers will use AI, but how it can be used responsibly while maintaining engineering judgement, professional accountability and safety. The way in which the role of the chemical engineer might evolve because of AI was also discussed. While AI will not replace chemical/process engineers, the chemical/process engineer will become the developers of models that carry out those designs and calculations.

Key insights

1. AI should augment engineers, not replace engineering judgement

- Participants identified considerable potential for AI to augment human capability. AI can analyse large volumes of information, identify patterns, automate routine activities and support engineers to make faster and better-informed decisions.
- However, participants repeatedly distinguished between supporting a decision and making one. Professional accountability cannot be delegated to an AI system, particularly where decisions have safety, environmental or other significant consequences.
- The ability to challenge an output, understand whether it is reasonable and ultimately take responsibility for a decision remains fundamental to professional engineering practice.
- This means the increasing capability of AI may make human attributes such as critical thinking, curiosity, communication and professional judgement more important rather than less.

2. Significant productivity benefits are already emerging

- AI is already being trialled and deployed across a range of engineering and business activities. Examples discussed included predictive and maintenance modelling, project scheduling and resource planning, meeting capture and summarisation, report and document preparation, knowledge management and information retrieval, and support for engineering design, simulation and scenario analysis.

- By reducing the time engineers spend on routine administrative and analytical tasks, AI could allow greater focus on complex problem solving, stakeholder engagement, innovation and strategic decision-making.
- This also has implications for engineering business models. As AI enables some work to be completed much more efficiently, traditional consulting models based on hours worked may increasingly be challenged. Over time, greater emphasis may be placed on the value of engineering expertise and outcomes delivered rather than simply the time taken to produce them.

3. AI could become an important enabler of industrial transformation

- Beyond individual productivity, participants discussed AI's potential contribution to wider transformation across the process industries.
- Digital twins, virtual plant environments and increasingly connected industrial systems could support process optimisation, predictive maintenance and improved asset performance. These capabilities could also contribute to energy system integration, sustainable fuels, industrial symbiosis, circular economy initiatives and the broader transition towards net zero.
- AI could similarly accelerate research and technology development by improving access to knowledge, enabling faster analysis and prototyping, and shortening pathways between research, demonstration and commercialisation.
- For Australian industry, these capabilities could provide opportunities to accelerate innovation and strengthen competitiveness.

4. Process safety demonstrates both the potential and limitations of AI

- Safety was a recurring focus of the discussion.
- AI could strengthen hazard identification, operational risk assessment, safety case development, predictive maintenance and incident prevention. AI-enabled simulations and digital environments could also allow engineers to explore complex events such as process upsets or gas releases and learn from scenarios that would be difficult, costly or unsafe to reproduce in real operations.
- However, participants cautioned against assuming that greater analytical capability removes the need for established process safety disciplines. Activities such as HAZOPs and hazard identification depend upon questioning, experience and an understanding of how complex systems behave in practice.
- The increased use of AI enabled process systems will also change the guidewords used to identify process deviations in HAZOP. For example, in addition to process guidewords like more flow, less flow the guidewords may also include data-based input to help identify causes of hazards, consequences and safeguards
- AI should therefore complement established safety methodologies rather than replace them.
- This creates an important longer-term challenge: ensuring engineers remain capable of independently recognising hazards and questioning AI-generated conclusions rather than becoming dependent upon the systems designed to assist them.

The next generation of engineers

5. AI could fundamentally change how engineers develop experience

- One of the strongest themes concerned the development of graduates and early-career engineers.
- Many routine or foundational tasks undertaken early in an engineer's career can potentially be automated or significantly accelerated by AI. While this offers immediate productivity benefits, those same tasks have traditionally helped young engineers understand engineering fundamentals, develop professional judgement and learn how real projects and facilities work.
- Participants therefore questioned how future engineers will acquire the experience and instincts needed to recognise when something is wrong if they have not first developed a sufficiently strong understanding of how engineering work is performed.
- This places greater importance on work-integrated learning, internships, industry placements, mentoring and practical site exposure. Employers and educational institutions may need to deliberately redesign development pathways so that efficiency gains from AI do not inadvertently remove the experiences through which professional competence is developed.

6. AI also creates new opportunities for engineering education

- At the same time, AI could provide new ways to accelerate learning.
- Simulation, digital twins and virtual environments could expose students and practising engineers to a much wider variety of operating conditions, incidents and engineering scenarios than conventional education or normal workplace experience can provide.
- Engineers could repeatedly explore complex events, test different responses and examine the consequences of decisions in a lower-risk environment. AI could also support more personalised learning pathways and make high-quality training accessible to a broader range of learners.
- These technologies should complement rather than replace practical experience. Virtual environments cannot fully reproduce the contextual understanding developed by working on real sites and alongside experienced engineers, and different learning technologies will not be equally effective for every individual.
- The opportunity is therefore to combine digital learning with meaningful real-world engineering experience.

Building trust and managing risk

7. Verification and accountability are fundamental

- Verification emerged as one of the most important challenges associated with AI adoption.
- Engineers will increasingly need to determine whether an AI-generated analysis, document, model or piece of software is technically valid. Organisations will also need clear arrangements defining who is accountable when AI contributes to an engineering deliverable or decision.
- This becomes particularly important where engineers formally approve or sign off work.

- AI outputs should therefore be treated as engineering inputs requiring appropriate scrutiny. Engineers need to understand relevant assumptions, test outputs against engineering principles and independent evidence, maintain appropriate records and apply independent review where warranted by the level of risk.
- Existing management of change processes may also need to evolve as AI becomes more deeply embedded within engineering systems and workflows.

8. Explainability and transparency remain critical

- Participants raised concerns about reliance on 'black box' AI models where it may be difficult to determine how an output has been generated.
- Limited transparency creates challenges for verification and can obscure assumptions, biases or limitations within a model. These issues become particularly important in regulated and safety-critical environments, where engineers may need to demonstrate why a decision was made and provide evidence supporting it.
- Explainability, traceability and auditability should therefore be important considerations when determining whether an AI application is appropriate for a particular engineering task.

9. Governance should be proportionate to risk

- The discussion recognised the need to balance appropriate safeguards with the ability to innovate.
- A risk-based approach could allow organisations to distinguish between relatively low-risk applications — such as administrative support or information retrieval — and applications capable of influencing safety-critical engineering decisions.
- Governance arrangements should provide clear accountability, appropriate validation and verification, traceability and ongoing monitoring. Higher-consequence applications should attract correspondingly greater scrutiny and human oversight.
- The objective should not be governance for its own sake, but to create sufficient trust and assurance for AI to be used productively and responsibly.

10. Data, intellectual property and sovereign capability require greater attention

- Participants also identified risks relating to data ownership, cybersecurity, intellectual property and data sovereignty.
- Organisations need to understand where information supplied to AI systems is stored, how it may subsequently be used, what intellectual property protections apply and the implications of dependence on external AI providers.
- Resilience is another consideration: organisations increasingly reliant on AI-enabled workflows need to consider how essential engineering activities would continue if particular systems or services became unavailable.
- At a broader level, participants highlighted the importance of retaining AI expertise, intellectual property, infrastructure and training capability within Australia and New Zealand. Building trusted local capability could help the region capture the productivity benefits of AI while reducing strategic dependence on external platforms and expertise.

What capabilities will the future engineer need?

- The discussion suggests that the successful chemical engineer of the future will need a combination of traditional and emerging capabilities.
- Technical fundamentals and practical engineering experience remain essential. Alongside these, engineers will increasingly require AI literacy: an understanding of what AI can and cannot do, how outputs should be interrogated and how the technology can be used appropriately within professional practice.
- Human capabilities will be equally important. Critical thinking, communication, collaboration, curiosity, ethical awareness and the confidence to question an apparently authoritative answer become particularly valuable when engineers are working alongside increasingly sophisticated digital tools.
- The objective should therefore not be to develop engineers who simply know how to use AI, but engineers who know when to use it, how to challenge it and when not to rely upon it.
- The industry needs to be clear about its expectations on AI because to some students it appears we are sending mixed messages about AI – On one hand we emphasise the risk of an overdependence on AI to the expense of developing important critical learning skills but on the other we talk about its importance to the future of chemical engineering.

Conclusion

- AI presents a significant opportunity for chemical and process engineering. It can improve productivity, accelerate innovation, enhance training and simulation, strengthen engineering analysis and contribute to the transformation and decarbonisation of process industries.
- Its successful adoption, however, will depend as much on people and institutions as on the capability of the technology itself.
- Strong governance, verification and accountability will be essential. So too will continued investment in technical fundamentals, practical experience and the development of professional judgement.
- Perhaps the most important question raised by the roundtable is how the profession ensures that the productivity benefits of AI do not inadvertently remove the experiences through which engineers develop competence. This will require closer collaboration between employers, educators and professional institutions and potentially new approaches to graduate development and lifelong learning.
- The future chemical engineer is therefore likely to be AI-enabled, rather than AI-replaced: combining powerful digital tools with technical knowledge, practical experience, ethical decision-making and sound professional judgement.
- As one participant reflected, 'chemical engineering is not dying — it is evolving'.
- Participants identified a significant opportunity for IChemE to help the profession navigate this transition and provided actions for IChemE to consider.
- IChemE is well placed to connect questions that might otherwise be considered separately — technology adoption, process safety, professional competence, education, ethics and professional accountability — and provide a trusted forum as practice continues to evolve.