



IChemE Just Transition Workshop

25 – 26 October 2023

Organised by the
Delivery against Climate Change Commitments
Working Group

Report and Recommendations

Glossary

IChemE Functions, Groups and Committees

BoT	Board of Trustees
CEO	Chief Executive Officer
Comms	IChemE Communications Team
Ed SIG	Education Special Interest Group
Energy CoP	Energy Community of Practice
ET	Executive Team
HCEUK	Heads of Chemical Engineering UK
ISC	International Safety Centre
LSC	Learned Society Committee
MEC	Membership Engagement Committee
MG	Member Group
MQC	Membership and Qualifications Committee
NB	National Board
R&I CoP	Research and Innovation Community of Practice
SH	Sustainability Hub
SIG	Special Interest Group
SPI	Strategic Partnerships and Impact
TCE	The Chemical Engineer
Training	IChemE Training Team

Other Abbreviations

ACA	Alliance of Chemical Associations
AIChE	American Institute of Chemical Engineers
BECCS	BioEnergy with Carbon Capture and Storage
CA	Chemistry Australia
CCUS	Carbon Capture, Utilisation and Storage
CIA	Chemical Industries Association
COP28	28 th Committee of Parties (United Nations Climate Change Conference, 2023)
CPD	Continuing Professional Development
DC3WG	Delivery Against Climate Change Commitments Working Group (IChemE)
EA	Engineers Australia
EWB	Engineers Without Borders
HEI	Higher Education Institution
IOM3	Institute of Materials, Minerals and Mining
JT	Just Transition
NEPC	National Engineering Policy Centre
RAEng	Royal Academy of Engineering
SCI	Society of Chemical Industry
SME	Small to Medium Enterprise
STEM	Science, Technology, Engineering and Mathematics
USP	Unique Selling Point

Executive Summary

Context and aims of workshop

The workshop was organised by the Delivery against Climate Change Commitments Working Group established to monitor, review and guide the commitments made by the Institution on the UN Sustainable Development Goals and specifically on Climate Change (see [IChemE position on Climate Change](#)). It aimed to progress the large and complex commitment “to develop detailed positions and action plans for **economically sustainable and secure transitions** to net zero carbon emissions in all areas of chemical engineering practice and regions where members are active”. The statement was supported by the Learned Society Committee and the Board of Trustees. Such a transition is also known as a “Just Transition” - greening the economy in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind.

Professor Geoffrey Maitland FIChemE (Professor of Energy Engineering, Imperial College London) was invited to facilitate the workshop. To ensure global participation, the format chosen was virtual and split into two consecutive half day sessions; of the 41 invited participants, 8 were representing bodies external to IChemE.

The Workshop aimed to explore the following questions:

1. What is meant by a ‘Just Transition’ and how can chemical engineers help ensure that the transition to net-zero carbon emissions is ‘just’?
2. Alongside the opportunities, what are the potential ‘unjust’ consequences of the transition and how might these be avoided by the actions of IChemE, companies and individual chemical engineers?
3. What positions should IChemE adopt about chemical engineers ensuring a Just Transition and about these potential ‘unjust’ consequences?
4. For which of these positions should IChemE take specific actions to ensure chemical engineers play a key role in achieving a Just Transition, in collaboration with which organisations?

The purpose of this paper is to summarise the discussion and make recommendations emerging from the Workshop. Nine key recommendations are given in this Executive Summary. A follow-up paper makes recommendations to the Board of Trustees on what IChemE should do next.

IChemE and a Just Transition

The consensus of what will constitute a Just Transition was ensuring social equity at the same time as ensuring sustainable development, including achieving net-zero carbon emissions: ‘Avoiding catastrophic climate change without causing catastrophic damage to people’s lives and livelihoods’. The relationship to “climate justice”, which seeks equitable distribution of the burdens of climate change and mitigation efforts, was noted.

Key recommendation 1:

Whenever IChemE considers or communicates about the Net-Zero Transition, it includes not only the technical options to deliver net-zero but also what should be done to ensure economic and social justice in their delivery. To promote this it should establish a Just Transition “value proposition” conveying this holistic commitment, to encourage buy-in and volunteer action by IChemE members, potential collaborators and stakeholders, accompanied by a ‘Just Transition Primer’ to inform members and others how engineering and social issues might interact on the journey to global net-zero emissions. This should be pursued in collaboration with, *inter alia*, Engineers Without Borders (EWB), and linked to a Just Transition Forum within the Learned Society.

Key recommendation 2:

Looking further into the future, to create a focal point for IChemE action on facilitating a Just Transition, for example by evolving the role of the Sustainability Hub, with a business model based on corporate

membership, emulating the International Safety Centre. Like the ISC, its reach could in time extend beyond IChemE. All this would be a major initiative by IChemE but it is flagged in this report as a potential USP and a visionary, albeit ambitious, medium-long term potential goal.

Five main issues to emerge from the Workshop

The workshop identified five specific areas where IChemE's voice or actions could help ensure the transition was not only technically achievable but also socially just. The key recommendations for these areas are given here, with suggestions for key actors and time scales¹ in italics.

1. Education – the next generation

Enabling a Just Transition requires a strong emphasis on sustainability in its broadest sense to be embedded in accredited university courses, in much the same way as process safety is.

Key recommendation 3:

Work with universities to continue to raise the benchmark in this area, such that climate justice issues are firmly built into the curriculum, alongside technical and environmental aspects, ensuring that all aspects of sustainability are as endemic to the thinking of graduate chemical engineers as process safety has become. Input from social scientists and industrial case studies should be encouraged.

Key recommendation 4:

Explore the potential to support education in the Just Net-Zero Transition space in the global south, through, *inter alia*, student travel/projects, academic secondments, and by collaboration with appropriate funding agencies, national ChE societies, other organisations working in this space such as Engineers Without Borders and volunteer members.

2. Repurposing of Skills and Continuous Professional Development

As some ('sunset') industries decline during the net-zero transition, there will inevitably be loss of jobs and economic/social disruption to local communities. There will also be new employment opportunities in emerging industries based on renewable energy, decarbonised and sustainable processes and industrial clusters, new materials and digital services. The basic skill sets of chemical engineering required in these new areas remain essentially the same; what is required is adaptability and some new knowledge acquisition.

Key recommendation 5:

Sustain, grow and broaden free/low-cost CPD (and credentials with third parties) in the Just and Sustainable Transition space, eg Sustainability Hub. Enhance publicity and availability to those in need, particularly members in SMEs, including via the Benevolent Fund, and consider extension to semi-skilled and manual workers in larger companies.

'Pro bono engineering' was identified as a powerful way for IChemE members to support skills development in less-developed countries ('the global south') on a volunteer basis. This could involve training, knowledge sharing or even project work by volunteer members and most effectively carried out with partners.

Key recommendation 6:

Explore with experienced volunteer members, and with potential partners such as Engineers Without Borders and national chemical engineering societies, the appetite for 'pro bono engineering' and a mechanism for identifying projects that will accelerate a Just Net-Zero Transition in the global south. Similarly explore with EWB and universities establishing 'Sustainable engineering without borders' to give students and early career chemical engineers placement opportunities to understand the Just Transition issues facing the global south through working on local projects.

3. Encouraging the re-engineering of energy intensive processes

There was much discussion at the workshop that a critical technology target for chemical engineers should be the cost-effective decarbonisation of energy intensive processes, such as cement, steel and

¹ eg Short term: 1 – 2 years; Medium term: 3 - 5 years; Long term: 6+ years.

chemicals manufacture. These industries employ large numbers of people and the availability of cost-effective decarbonisation options will probably have a large effect on labour markets and the prosperity of local communities. This is a huge challenge and essentially requires the re-invention of chemicals and materials manufacturing. This issue is core to what IChemE needs to consider and to enable the chemical engineering profession to bring about.

Key recommendation 7:

IChemE to take a position to actively encourage its members to rise to the challenge of re-engineering chemicals and materials manufacturing processes to achieve the decarbonisation targets of the net-zero transition whilst at the same time ensuring that it is fair and just. In particular, work with members (through the Learned Society) to develop methodologies and templates for up-to-date reporting on the engineering, economic and social aspects of new technologies aimed at achieving the net-zero transition, their benefits and downsides within different systems, and appropriate communication platforms that ensure that these analyses reach the policymakers, funders and investors so that they can benefit from them to ensure that their decisions will lead to a Just Transition.

4. Adopt balanced messaging about achieving a Just Net-Zero Transition

The workshop discussion highlighted the challenges facing IChemE in communicating about the technology options and alternative routes to achieving a just, socially and economically equitable transition to net-zero carbon emissions by 2050. We are grappling with complex, difficult messages. There is a danger for IChemE if, in trying to avoid offending some members, it seeks a consensus and adopts a middle ground approach, and in so doing dilutes the clarity and impact of the message. Whilst careful wording is needed, ‘vanilla’ messages should be avoided. The key element in IChemE communication about Just Transition issues is that it should be evidence-based and where choices are involved the messaging should be balanced to the extent that this is consistent with the known evidence. The Institution should not, however, be afraid to pass difficult messages to correct misinformation in the media or from politicians, NGOs and single-solution campaigners. Doing this in collaboration with others will be more effective, both in capacity to deliver and in reaching wider and more diverse audiences.

Key recommendation 8:

Develop, with like-minded organisations (e.g. a ‘chemicals coalition’ including some or all of RSC, SCI, CIA, ACA and IOM3), balanced, responsible and honest evidence-based positions and associated messaging on key issues associated with achieving a Just Transition; IChemE should be bold in sending out clear messages about what is realistically achievable, the pros and cons of different transition routes for different regions and how social and economic justice issues need to be factored in to ensure social equity alongside net-zero carbon emissions and sustainable development.

5. Multiple opportunities for improved and bolder advocacy

There was general agreement in the workshop that there were major opportunities for IChemE to have a greater profile and impact through advocacy and engagement with governments, in the UK and overseas, particularly on issues surrounding achieving a Just Transition. Effective advocacy requires clarity of message and respected partners, and is enhanced by charismatic communicators. There is a strong need for good chemical engineering role models, with an emphasis on younger engineers, to work with the media, in meetings with stakeholders and with the public.

Key recommendation 9:

The Institution is encouraged to have more confidence in the quality and relevance of its messaging and to be bolder, both through the leadership and the membership, in articulating with clarity the complex issues and challenges the world faces in this area and the pros and cons of potential solutions. It should:

- develop a strategy for internal messaging and external advocacy of issues critical to society, including enabling a Just Transition, identifying target audience(s), appropriate partners, the mode and tone of delivery, and the regionality of the messaging;

- identify and promote chemical engineering's USPs, develop key messages for 'Chemical Engineering and a Just Transition' and a value proposition for potential advocacy partners, and form advocacy alliances to inform different audiences about the key Just Transition issues;
- develop effective modes of communication of key issues, including elevator pitches, videos and role models who can reach out to the public, particularly the younger generation, using the Just Transition as one vehicle to convey what chemical engineering can do to address major societal challenges.

Report and Recommendations

Context and aims of Workshop

The workshop was organised by the Delivery against Climate Change Commitments Working Group (Chair Dr Andrew Jamieson FIChemE) established to monitor, review and guide the commitments made by the Institution on the UN Sustainable Development Goals and specifically on Climate Change (see [icheme-climate-change-statement.pdf](#)). The group had covered nine of the commitments and was encouraged to acknowledge the very good progress made by the Institution, its volunteers and members. Subsequently it embarked on one of the remaining large and complex commitments, “to develop detailed positions and action plans for **economically sustainable and secure transitions** to net zero carbon emissions in all areas of chemical engineering practice and regions where members are active.” This topic, also known as “Just Transition”, has been written about, discussed and promoted in the media, governments, NGOs, academia, industry and many groups within IChemE.

Faced with the large quantity of commentary and often diverse opinion on the topic, the group decided on an approach which was member focussed. To this end it proposed to hold a workshop with members representing diverse member groups and with external participants from industry, academia and other professional organisations. This proposal was supported by the Learned Society Committee. Professor Geoffrey Maitland FIChemE (Professor of Energy Engineering, Imperial College London) was invited to facilitate such a workshop. To ensure global participation, the format chosen was virtual and split into two consecutive half day sessions, ahead of which participants were asked to complete a comprehensive questionnaire, the feedback from which set the agenda for the workshop break-out sessions. The participants (38 IChemE volunteers, 3 IChemE Staff, 8 external to IChemE) are listed in Appendix A.

The Workshop aimed to explore the following questions:

1. What is meant by a ‘Just Transition’, particularly in the chemical engineering context and how can chemical engineers help ensure that the transition to net-zero carbon emissions is ‘just’?
2. Alongside the opportunities, how are chemical engineers likely to be adversely affected by the transition towards net-zero energy systems, processes and products? In other words, what are the potential ‘unjust’ consequences of the transition and how might these be avoided or mitigated by the actions of IChemE, chemical engineering companies and individual chemical engineers?
3. What position should IChemE adopt about chemical engineers ensuring a Just Transition and about these potential ‘unjust’ consequences? Prioritise these issues in terms of the level of concern amongst its members and the profession.
4. For which of these positions could/should IChemE take specific action(s) to help/ensure chemical engineers play a key role in achieving a Just Transition such that the impact of potential ‘unjust’ consequences is avoided or mitigated?
5. With which other organisations should IChemE consider collaboration in order to promote their positions and/or enhance the impact of their actions?

The structure of the workshop and the questions posed in the four break-out sessions to address these issues are given in Appendix B. The pre-workshop survey questions and a summary of the responses, the workshop discussion guidelines and the feedback from the break-out groups and plenary session discussions are given in Appendices C – E. This report captures the recommendations emerging from the Workshop regarding the positions and actions IChemE should take, bearing in mind the objects and strategy of the Institution and the resources available to enable initiatives.

IChemE and a Just Transition

In summary, the consensus of the workshop regarding what will constitute a Just Transition was ensuring social equity at the same time as delivering sustainable development, including achieving net-zero carbon emissions. This requires an equitable distribution of benefits and risks across all countries and communities. Another useful articulation of a Just Transition was: ‘Avoiding catastrophic

climate change without causing catastrophic damage to people's lives and livelihoods'. That is: Just Transition means greening the economy in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind. The types of justice considered included ensuring fair procedures for deciding on and implementing net-zero actions; recognising the rights, needs and capacities for change of local communities, particularly in the global south, and the responsibilities of developed industrial nations; fairness in both the distribution of cost and benefits and compensation and retribution for nations disproportionately exposed to the consequences of climate change.

This gave rise to a number of ethical issues regarding IChemE's overall position. Why should IChemE concern itself with the social justice aspects of the Transition as well as its technical realisation? Where do we draw the boundaries of where IChemE assumes responsibility for ensuring technical change is linked to social responsibility? Is its concern confined to its members or for all who work in the chemical engineering profession at all levels, including semi-skilled and manual workers who are not professional engineers? The Institution's objects, as set out in the Royal Charter, referring as it does to '...furthering in a responsible manner both scientific and economic development and the application of sustainable processes...to help bring about or contribute to the benefits of the global community' make it clear that all these issues should fall within the orbit of IChemE.

It is interesting to note that COP28, which took place shortly after this Workshop, spent a great deal of time discussing the Just Transition, with a focus on equity and equality. Global thinking is moving towards a combination of 'leave no one behind' and an application of the precautionary principle ('first do no harm'). Built into the discussions were considerations of circular economy, nature and biodiversity protection, as well as the ethics/people aspects.

The following sections focus on five specific areas where IChemE's voice or actions could help ensure the transition was not only technically achievable but also socially just.

Recommendations to emerge that would bring some or all of these together were:

1. To develop a 'Just Transition Primer' to inform members and others how engineering and social issues interact on the journey to global net-zero emissions.²
2. To establish a Just Transition value proposition, to encourage buy-in and volunteer action by IChemE members, potential collaborators and stakeholders.
3. To ensure that whenever IChemE considers or communicates about the Net-Zero Transition, it does so in the context of ensuring that the transition is just and fair by including not only the technical options to deliver net-zero but also what should be done to ensure economic and social justice in their delivery.
4. To establish an IChemE Just Transition Forum to provide a mechanism to continue to discuss and debate the issues and develop viable positions and actions that the Institution might take³ⁱⁱ.
5. In the medium to longer term, consider evolving the role of the Sustainability Hub to take on the role of being the focal point for IChemE action on facilitating a Just Transition by emulating the International Safety Centre (ISC), with a business model based on corporate membership. Depending on resources available, extension from CPD and re-purposing in this space to spreading of best practice, credentials and even accreditation in Sustainability Engineering in its broadest sense, including mechanisms for climate justice, could be considered. In line with the ISC, its reach could in time extend beyond IChemE. All this would be a major initiative by IChemE but it is flagged in this report as a potential USP and a visionary, albeit ambitious, medium-long term potential goal.

² This could usefully draw on the sustainability criteria drawn up by Engineers Without Borders which sets out the skills needed to ensure projects deliver sustainable, equitable and ethical results: <https://www.ewb-uk.org/global-responsibility-competency-compass/>

³ The IChemE Connect forum could be a useful vehicle for this and/or the Sustainability Hub.

Key issues and recommendations to emerge from the workshop

6. Education – the next generation

- (a) Enabling a Just Transition requires a strong emphasis on sustainability in its broadest sense to be embedded in accredited university courses, in much the same way as process safety is. Much is already in place. Current guidelines require appropriate aspects of sustainability to be both taught in courses and exemplified by university departmental culture. Learning outcomes include the ability to “apply the principles to the analysis of complex systems within a structured approach to safety, health and sustainability”. For example, “Students graduating from an accredited [BEng] programme will (amongst other things) understand and be able to apply the principles of sustainability (environmental, social, economic) and the ability to apply techniques for analysing the interaction of process, product and plant with the environment and minimising adverse impacts.” For an MEng programme, they will “be able to apply principles of sustainability, economics and ethics to novel and complex situations with conflicting requirements.”

Recommendations:

6. Review existing accreditation guidance, and work with existing and new accredited universities to continue to raise the benchmark in this area, ensuring that climate justice issues are built into the curriculum, alongside technical and environmental aspects, to ensure that all aspects of sustainability are as endemic to the thinking of graduate chemical engineers as process safety has become.
 7. Encourage ethical thinking, awareness of social implications, with input from social scientists, to be essential aspects of chemical engineering degree courses (as well as key threads in research on sustainable processes).
 8. Facilitate industry and universities to collaborate on providing guest lectures/courses sharing case studies, knowledge, skills and best practice on just implementation of sustainable processes and learning from failures.
 9. Collaborate with selected HEIs on providing environmental programmes to produce credentials or CPD that IChemE can promote.
- (b) To implement the transition from fossil fuel based materials feedstocks and energy provision, new knowledge and skills will be needed that are not generally included in current chemical engineering degree courses. The inorganic chemistry of critical minerals that feature more strongly in evolving energy generation and storage systems than elements such as carbon, oxygen and hydrogen, and electrochemical engineering to underpin process electrification, are two examples of areas rarely covered at present. Some courses have traditional mining-related content and some have a nuclear specialism, and bio-related content is increasingly widespread, but these are exceptions rather than the rule.

Recommendation:

10. Encourage universities to identify curriculum gaps and include (by replacement) content relevant to the new processes and materials of the net-zero transition, including their sustainability and social justice implications (e.g. mining and processing of critical minerals), either through the accreditation process or through the Education SIG. Consider how to spread best practice of those already being effective in this space and how some of this new/additional knowledge could be made available through credentials or CPD.
- (c) There is a dearth of chemical engineers working in the policy/government space to interact with the technology providers to ensure that policy, incentives and regulation are appropriate to facilitate a transition to net-zero that is both technically achievable and socially just. The need and opportunities for both young and experienced engineers to work in this area is rarely considered and there is scope for IChemE to work with universities and policymakers to increase awareness

of these. Attitudes to, and application of, this also vary in different countries and sharing of good practice where it exists is also important.

Recommendation:

11. Work with universities, policymakers and like-minded organisations to broaden awareness of engineering opportunities in policy, government and supporting civil services. Case study lectures, internships, secondments and mentorships could encourage interest and enthusiasm amongst young chemical engineers and spread good practice.
- (d) There are needs and opportunities for supporting education and transferring best practice in the global south, where the challenges of implementing cost-effective decarbonisation are large and may require alternative or modified solutions to those being implemented in developed countries, including technology leapfrogging. This is an area where IChemE might act as a facilitator by collaborating with universities, other organisations (e.g. RAEng Africa Prize and Catalyst, Engineers Without Borders (EWB) whose main current focus is often civil engineering) and volunteer members, identifying opportunities outside traditional oil and gas.

Recommendation:

12. Explore the potential to support education in the Just Net-Zero Transition space in the global south, through for instance student travel/projects, academic secondments, collaboration with appropriate funding agencies, national ChE societies, and other organisations working in this space such as EWB and volunteer members.

7. Repurposing of skills and Continuous Professional Development

- (a) As some ('sunset') industries decline during the net-zero transition, there will inevitably be loss of jobs and economic/social disruption to local communities. There will also be new employment opportunities in emerging industries based on renewable energy, decarbonised and sustainable processes and industrial clusters, new materials and digital services. The basic skill sets of chemical engineering required in these new areas essentially remain the same; what is required is adaptability and some new knowledge acquisition. There was a strong feeling at the Workshop that professional chemical engineers are adept at re-purposing their skills to new areas with many examples of chemical engineers in oil and gas or traditional chemicals manufacturing making new careers in pharmaceuticals or new materials and formulation. Some may require some assistance through CPD or credentials; company support to meet the cost of training courses is usually more available in large organisations than in SMEs involved in the supply chains of sunset industries. There was much discussion of the role and potential of the new Sustainability Hub. It already provides free CPD courses to members in areas relevant to the Just Transition; this should be built upon and in time expanded along the lines suggested in Recommendation 4.

Recommendations:

13. Sustain, grow and broaden the CPD available through Sustainability Hub courses, free/low-cost to members, in the Just and Sustainable Transition space. Enhance publicity and availability to those in need, including via the Benevolent Fund.
14. Take steps to identify the potential technical skills gaps and required enhancements, and the associated CPD and credentials needs, especially for members needing to transition from SMEs. It is likely that these will mirror the changes being made in accredited degree courses.
15. Consider whether funding support could be provided if third party training (possibly with partner organisations) was needed.
- (b) A potentially larger problem exists with semi-skilled and manual workers working in process industries that are winding down and the knock-on effects for the local communities in say oil and gas or traditional refining or chemicals manufacturing areas/regions. These will not be

professionally qualified or members of IChemE or other engineering bodies. They will also be less able to afford the cost of retraining or upskilling.

Recommendation:

16. Consider IChemE's commitment to work with members and the industries they work in to support re-training and upskilling semi-skilled and manual workers needing to transfer from sunset industries centred on chemical engineering and/or working with chemical engineering employers and local communities to facilitate job transfers as part of a Just Transition to Net-Zero. Consider adopting a position on this issue to encourage companies and governments to address it.

- (c) 'Pro bono engineering' was identified as a powerful way for IChemE members to support skills development in the global south on a volunteer basis. This could involve training, knowledge sharing or even project work by members and most effectively carried out with partners with aligned values, such as national chemical engineering societies or EWB. For instance, there are links with the Nigerian Society of Chemical Engineers that could be built upon. Topics such as dealing with plastic waste in rural Africa would be good areas to work together on with such organisations. Given that access to fossil fuels is transforming living standards in the developing world, facilitating the decarbonisation of fossil fuel processes would be one way to promote the net-zero transition globally in a way that promotes local social justice. Alternatively helping to identify where and how 'leapfrogging' to renewables is viable and economic would accelerate the adoption of long-term sustainable solutions.

Recommendations:

17. Explore with members, and with potential partners such as EWB and national chemical engineering societies, the appetite for 'pro bono engineering' and a mechanism for identifying projects that will accelerate a Just Net-Zero Transition in the global south.
18. Explore with EWB and universities establishing 'Sustainable engineering without borders' to give students and early career chemical engineers opportunities to understand the Just Transition issues facing the global south and work on projects to address these.

8. Encouraging re-engineering of energy intensive processes

There was much discussion at the workshop that a critical technology target for chemical engineers should be the decarbonisation of energy intensive processes, such as cement, steel and chemicals manufacture. These industries employ large numbers of people and the availability of cost-effective decarbonisation options will have a significant effect on labour markets and the prosperity of local communities. Options range from removing emissions by the introduction of CCUS technologies and electrification to using alternative feedstocks and radical re-design of processes. Chemical engineers are key to accelerating the provision of greener and more sustainable alternatives which are cost-effective and therefore not dependent on low labour costs to be competitive with traditional processes and capable of producing products at comparable or lower cost. **This is a huge challenge which essentially requires the re-invention of chemicals and materials manufacturing.** This issue is core to what IChemE needs to consider and to enable the chemical engineering profession to bring about.

Chemical engineers will be key to this revolution and our accredited education and training courses should equip them to do this. IChemE itself will not be directly involved in the re-engineering activity. However, many new technologies are being proposed and will continue to emerge in the years ahead. There is a need for much better communication about these processes with some independent analysis of their benefits and downsides. Too often technologies are pushed by proponents who may be unaware of or blinkered to the pragmatics of implementation or resultant unintended consequences. There is a need to share information about emerging technologies and best practice in as objective a way as possible. The current debates around hydrogen for domestic heating or the potential impact of direct capture of CO₂ from the atmosphere are good examples

of where technology ‘owners’ can sometimes lose objectivity or fail to adopt a systems approach. More generally, the feasibility of having enough green hydrogen, green electricity and fresh water to achieve globally the scale of industrial transformation required, using these vectors, needs to be understood. We should equip chemical engineers to provide this objectivity and to analyse and explain comparisons often in a systems engineering context.

Members are in a good position to provide this objective analysis. Currently some articles in TCE serve this purpose but there is a need to consider the most effective communication platforms for such information – best practice-comparison commentaries – and how they can be regularly and relentlessly refreshed and updated in this era of rapidly emerging and changing technology. Exploring platforms that engage younger engineers is particularly important.

Recommendations:

19. IChemE to take a position to actively encourage its members to rise to the challenge of re-engineering chemicals and materials manufacturing processes to achieve the decarbonisation targets of the net-zero transition whilst at the same time ensuring that it is fair and just.
20. Work with members (through the Learned Society perhaps) to develop methodologies and templates for up-to-date reporting on the engineering, economic and social aspects of new technologies aimed at achieving the net-zero transition, their benefits and downsides within different systems, and appropriate communication platforms that ensure that these analyses reach the policymakers, funders and investors who can benefit from them.

9. Adopt balanced messaging in communicating options for achieving the (Just) Net-Zero Transition

- (a) The workshop discussion highlighted the challenges facing IChemE in communicating about the technology options and alternative routes to achieving the transition to net-zero carbon emissions by 2050. If we add the dimensions of making the transition ‘just’, socially and economically equitable, then the challenge is even greater. We are grappling with difficult messages, both because the transition options are technically and logistically complex and geographically varied and because they involve a wide spectrum of views, some quite polarised or biased, in favour of or opposed to certain technologies sometimes on emotional or ideological grounds rather than by an objective analysis of the evidence. The danger is that IChemE, in trying to avoid offending some members, seeks a consensus and adopts a middle ground approach, so diluting the clarity and impact of the message. Whilst careful wording is needed, ‘vanilla’ messages should be avoided. The key element in IChemE communication about Just Transition issues is that it should be evidence-based and where choices are involved the messaging should be balanced to the extent that this is consistent with the known evidence. The Institution should not, however, be afraid to pass difficult messages to correct mis-information in the media or from politicians, NGOs and single-solution campaigners.

There is a lot of material in our publications, including *Sustainable Production and Consumption*, *Carbon Capture Science and Technology* and *TCE*, which is seen as our mouthpiece, and activity in our SIGs, member and regional groups. However, effective knowledge exchange and clear messaging is sometimes stymied by entrenched positions. In some cases SIG or MG approaches do not align; even if they agree on the net-zero destination, the Sustainability, Clean Energy and Oil & Gas SIGs often have strong disagreements about viable transition pathways that will lead us there. This should not prevent IChemE being bold and making strong statements about alternative routes that the evidence (often based on integrated assessment models of alternative mitigation transition pathways) demonstrates could be viable even if they include some technologies that some factions wish to avoid, such as abated fossil fuels or nuclear. Universal consensus will not be possible, therefore the Institution needs to develop an agreed mechanism for deciding the positions and messages to adopt, showing leadership in advocating realistic pathways which on balance will enable a Just Transition to be achieved on an acceptable timescale.

- (b) A good example, discussed at the workshop, of where IChemE is in a better position than most organisations to send a clear message relevant to achieving a Just Transition is the role that oil and gas will play in such a transition. The clear evidence-based message, which few are articulating, is that whilst in the long term phasing out oil and gas for energy and maybe as a materials feedstock should be part of the transition to a sustainable global economy, this cannot happen in the abrupt 'just stop' manner that several activist groups are campaigning for without severe consequences for the quality of life in both the developed and developing economies. It will be several decades before the world has enough affordable renewable or nuclear energy in place to fully replace that from existing fossil fuel generation, let alone the additional demand from a growing world population. It will take a similar timescale to transform the chemicals and materials manufacturing industries to using renewable (bio) feedstocks to produce all the clothing, furnishings, plastic casings and films, vehicle chassis and components etc that comprise or are used to distribute the vast majority of the consumables, objects and possessions in our lives. With any precipitous reduction of fossil fuels use, it is in the global south where living standards would fall most and the reality is that all countries will continue to use indigenous or imported fossil fuels to maintain those standards until sufficient quantities of alternative energy and materials become available.

However, this does not mean that with this continued use of oil and gas the transition to net-zero by 2050 cannot be achieved. Carbon capture, utilisation and storage (CCUS) technologies, which are now being installed at a greater rate globally, enable a decoupling between using oil and gas for heavy industry (cement, steel...), materials manufacture, (blue) hydrogen manufacture and power generation, and the emission of CO₂ to the atmosphere. Abated (or decarbonised) fossil fuel use is an essential component of all viable net-zero 2050 scenarios. Not to have CCUS available to abate fossil fuels emissions in countries where their use will persist for economic and political reasons (rather than unavailability of enough renewable options) will almost certainly ensure that the 2050 net zero target will not be achieved globally.

So IChemE needs to convey strongly the message that to ensure that the net-zero transition is economically and socially just, oil and gas must be used for several more decades (most credible scenarios predict they will still contribute at least 40% to the global energy mix in 2050) but that if emissions are abated where possible using CCUS the 2050 net-zero target can still be met. This will come with sustained economic benefits to many developing countries in terms of living standards, quality of life, continued jobs in oil and gas and a large CCUS industry, with a transition to more sustainable energy and manufacturing sectors once these can perform at the scale and affordability required. This does not deny the need for renewable energy, fuels and feedstocks to be produced at the fastest rate possible but it does re-set expectations about what is realistic in achieving a Just Transition and the rate at which it is sensible for fossil fuels and associated industries to be phased out. It is a brave message to transmit in the face of many activist campaign messages and the political barriers preventing governments being too explicit about it, but it is realistic, responsible and honest. In fact, the need to keep some fossil fuels makes the requirement to develop and use alternatives at the scale required more urgent, not less.

- (c) Other Just Transition areas for which honest and realistic messaging are needed include:
- Critical minerals, essential for batteries, fuel cells, solar photovoltaics, fibre optics etc. but with many challenges for ethical and managed extraction, re-use and recycling, as well as availability in the amounts needed and consequent concerns about being a sustainable resource into the future.
 - The role of (fresh) water in the net-zero transition, given the enormous quantities needed for bio-product production, green hydrogen supply and delivering nuclear power; depleted

natural supplies and volumes of sustainable desalination required, with consequences for amount of additional decarbonised electricity needed.

- The role of biomass in the net zero-solution; amount and geographical location of supplies to replace fossil fuel feedstocks; potential requirements for land clearing; associated demand for renewable electricity to power bioprocesses; carbon negative energy production and manufacture (BECCS)

- (d) As well as being balanced and evidence-based, communication to members and beyond IChemE to schools, business and policymakers has to be consistent. IChemE does some outreach on its own (STEM in schools, WhyNotChemEng, Discover ChemEng...) but doing this in collaboration with others will be more effective, both in capacity to deliver and in reaching wider and more diverse audiences. In the 'chemicals' space, the RSC is experienced in public communication and an ideal partner. A wider 'chemicals coalition' could be formed by adding SCI, CIA, ACA, CA and maybe IOM3 (although industry bodies may not be seen as sufficiently unbiased compared to member organisations). Sharing this report with these bodies and other outside organisations such as RAEng, EWB, AIChE and Engineers Australia (EA) could be one contribution to identifying and developing viable communication partnerships.
- (e) Messaging could also usefully address the fact that accelerated development of new more sustainable processes is likely to lead to mistakes and unintended consequences. Being open about these and learning from them is a key part of learning while doing, alongside scale-up issues, and developing case studies to help ensure continuous process improvement is a communication service IChemE could consider, exploiting the knowledge and experience of members. One vehicle could be the journal *Sustainable Production and Consumption*, with its scope and profile potentially increasing beyond IChemE and chemical engineering – a flagship journal for sustainable process improvement?

Recommendations:

21. Develop balanced, responsible and honest evidence-based positions and associated messaging on key issues associated with achieving a Just Transition; IChemE should be bold in sending out clear messages about what is realistically achievable, the pros and cons of different transition routes for different regions and how social and economic justice issues need to be factored into technology options in determining best energy and manufacturing systems for ensuring social equity at the same time as ensuring net-zero carbon emissions and sustainable development.
22. Partner with like-minded organisations (e.g. a 'chemicals coalition') for more effective messaging, both in the capacity to deliver and in reaching wider and more diverse audiences and stakeholders.
23. By analogy with the *Loss Prevention Bulletin*, explore how mistakes and unintended consequences in the accelerated development of more cost-effective sustainable processes can be captured and made available across the process engineering community and industries to ensure continuous process improvement and innovation in future sustainable, decarbonised energy production and materials manufacturing.

10. Multiple opportunities for improved and bolder advocacy

- (a) There was general agreement in the workshop that there were major opportunities for IChemE to have a greater profile and impact through advocacy and engagement with governments, in the UK and overseas, particularly on issues surrounding achieving a Just Transition. The Institution will need to have more confidence in the quality and relevance of its messaging and be bolder, both through the leadership and the membership, in articulating with clarity the complex issues and challenges the world faces in this area and the pros and cons of potential solutions. In some cases, particularly in developing sustainable manufacturing processes and

the systems thinking required for decarbonisation, IChemE is uniquely placed to deliver informed, credible evidence-based messages. Where issues clearly fall within the Institution's domain, opportunities to influence policy and the choice of technology options as the distinct voice of process engineering should be sought and exploited.

- (b) However, in most cases the impact will be greater by working with other organisations so IChemE should seek collaborations and build communication platforms with other PEIs and industry bodies in order to have its voice heard on the Just Transition. A good example of where this is already effective is the engagement with the RAEng National Engineering Policy Centre (NEPC) in the UK where white papers on the net-zero transition are well-regarded and proving effective with government and other stakeholders. To enable effective collaborations it would be valuable for IChemE to articulate and promote its 'USPs'; sustainable processes, process systems engineering and safety together form a very powerful core strength of chemical engineering. Developing a value proposition based around these for potential collaborators would help build effective alliances. Such a value proposition could then be adapted to focus on specific advocacy targets, including Chemical Engineering and a Just Transition.
- (c) For IChemE's advocacy on the need for a Just Transition and how to achieve it, to be effective, work needs to be done on (*inter alia*) identifying the target audience(s), selecting the most appropriate partner(s), the key messages for that audience, which are USPs and which are joint messages, the mode and tone of delivery, the regionality of the messaging. These are issues which the DC3WG might continue to help develop. As well as through media opportunities and meetings with, and reports ('white papers') for, targeted stakeholders, a short elevator pitch on Chemical Engineering and a Just Transition could be developed for use across IChemE and a video for wider audiences similar to the one created with ITN on Chemical Engineering Serving Society. External advocacy needs to be consistent with member-focused messages. Inspiring local member and regional groups to customise the messaging to their country/region would be a way to encourage member engagement and to build on local opportunities with emerging industries and activities seeking to address the net-zero transition e.g. centres like the Materials Innovation Factory in Liverpool or low-carbon industrial clusters.
- (d) Effective advocacy is enhanced with charismatic communicators. Engineering messages in the media are too often delivered by role models from other disciplines. There is a strong need for good chemical engineering role models, with an emphasis on younger engineers, to work with the media, in meetings with stakeholders and with the public. IChemE should work with university departments and industry partners to identify role models and 'heroes' at all levels of experience and membership. We could learn from or indeed collaborate with other organisations seeking to identify and promote engineering role models e.g. the RAEng's 'This is Engineering' campaign. The concept of a Just Transition, embracing social and ethical issues as well as technical and economic, is an excellent area with which to engage and inspire the next generations, as well as enabling the general public to see more clearly that their social and economic well-being is a key consideration in what we do to mitigate and adapt to the effects of climate change.

Recommendations:

- 24. The Institution is encouraged to have more confidence in the quality and relevance of its messaging and to be bolder, through the leadership, assisted by member volunteers, in articulating with clarity the complex issues and challenges the world faces in this area and the pros and cons of potential solutions.

25. Develop a strategy for internal messaging and external advocacy of issues critical to society, including enabling a Just Transition. Key issues include: target audience(s), appropriate partners, the mode and tone of delivery, the regionality of the messaging.
26. Identify and promote chemical engineering's USPs, develop key messages for 'Chemical Engineering and a Just Transition', develop a value proposition for potential advocacy partners and form advocacy alliances to inform different audiences about the key issues surrounding a Just Net-Zero Transition.
27. Develop effective modes of communication of key issues, including elevator pitches, videos and role models who can reach out to the public, particularly the younger generation, using a Just Transition as one vehicle to convey what chemical engineering can do to address major societal challenges.