# Clean Energy SIG Climate Change Context and Action Plan

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| Introduction - Overall problem statement | The Clean Energy SIG notes the Institution of Chemical Engineers' (IChemE) position on climate change.<br><br>The action plan presented here follows on from this statement and forms part of IChemE's delivery against several of the commitments set out, namely to:<br><br>▪ develop detailed positions and action plans for economically sustainable and secure transitions to net zero greenhouse gas (GHG) emissions in all areas of chemical engineering practice and regions where members are active.<br><br>It will also help underpin work on several other commitments, including<br><br>▪ provide policy advice to governments based on chemical engineering experience and expertise<br>▪ engage in public outreach activities with businesses and communities, to understand their concerns about the threats and uncertainties posed by climate change<br>▪ develop training courses and mandate CPD to provide the knowledge and skills to support members in the transition to a net zero carbon economy and in climate change adaptation<br>▪ encourage all regional member groups and special interest groups to hold webinars and seminars as part of the CPD programme to enhance skills and knowledge in pursuit of zero carbon futures and understanding of climate risks, and to engage with the wider membership. |
| Specific problem statement | Use of energy is the greatest source of anthropological (or man-made) greenhouse gas emissions (globally over 70%)[1] and is a key sector to be decarbonised (see Table 1). Reducing greenhouse gas (GHG) emissions to net zero by 2050 is consistent with meeting IPCC GHG targets. A complete transformation of how we produce, transport and consume energy is needed and a huge amount of collaborative effort is needed to turn today's ambitions into reality across the world. |

[1] Source: Our World in Data (website) Sector by sector: where do global greenhouse gas emissions come from?

Table 1. National emission data for dominant IChemE membership nations[2]

| | Australia | Malaysia | New Zealand | UK | OECD | World |
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| $CO_2$ Emissions (tpa per capita) | 17.0 | 7.7 | 8.0 | 5.7 | 9.2 | 4.8 |
| Primary Energy Use (GJ per capita) | 264 | 133 | 192 | 116 | 178.5 | 75.7 |
| Primary energy use EJ/year (2020) | | | | | | |
| - Oil | 1.83 | 1.38 | 0.30 | 2.39 | 89.6 | 193.0 |
| - Gas | 1.47 | 1.37 | 0.16 | 2.61 | 64.8 | 141.5 |
| - Coal | 1.69 | 1.14 | 0.06 | 0.19 | 32.1 | 157.9 |
| - Nuclear | - | - | - | 0.45 | 17.8 | 24.9 |
| - Hydroelectricity | 0.13 | 0.18 | 0.22 | 0.06 | 12.3 | 37.6 |
| - Renewables | 0.45 | 0.04 | 0.10 | 1.20 | 16.8 | 29.0 |
| - Total EJ/year | 5.57 | 4.11 | 0.84 | 6.89 | 233.4 | 583.9 |
| Fossil Fuel % (total) | 89.6% | 94.6% | 61.9% | 75.3% | 80.0% | 84.3% |
| Stated Policy | 26-28% reduction by 2030; Plan to deliver net zero by 2050 (announced Oct 2021) | Reduce GHG intensity of GDP by 35% by 2030 from 2005 level, increase to 45% reduction with enhanced international support | Net-zero by 2050 | Net-zero by 2050 | n/a | n/a |

The changes needed to reach net zero by 2050 are poorly understood – and different countries/regions are, as of 2021, at different starting points (Table 1). The UK has set a binding net zero target by 2050 while Australia, for example, has set a reduction target. Building knowledge, understanding and consensus; driving change; and staying on path all require immediate action and immediate and material deployment of all available decarbonisation technologies. While the technologies needed to achieve deep cuts already exist, new technologies need to be rapidly developed and deployed at scale if advances beyond 2030 to net zero are to be met.

The Clean Energy SIG has chemical engineers who are involved across the whole energy supply chain, covering all four sectors of power, industry, heat and transport whose efforts are being steered to deliver emissions reductions and emissions removals from the atmosphere. Necessarily, these efforts might need to vary regionally, according to existing national fixed asset bases, available energy resources, and national resolves for emissions reductions (Table 1).

[2] Sources: BP statistics Review 2020; IEA. Energy Policies of IEA Countries: Australia 2018 Review; IEA. Southeast Asia Energy Outlook 2019

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| What actions need to be taken to address the issue? | The path to net zero will see a major restructuring across industry, transport, heating and power generation. The coal and oil sectors will diminish while other new sectors such as CCS, hydrogen, solar and the wind industry will expand. Some industrial assets may become stranded or will be repurposed. Increased use of minerals in Solar PV, batteries and other applications will lead to increased mining and minerals processing. Land use will change to accommodate the need for renewable materials, bioenergy, and CO2 removal (BECCS).<br><br>The technologies needed to achieve deep emissions cuts already exist – these include, for example:<br><br>▪ driving reductions in use and efficient use<br>▪ wind generation, both onshore and offshore<br>▪ solar generation technologies<br>▪ CCS and CCU<br>▪ hydrogen<br>▪ biomass<br>▪ electrification (use in heating, transport and industry)<br>▪ energy storage<br>▪ system control and digitalisation<br>▪ geothermal<br>▪ nuclear<br><br>Reaching net zero by 2050 will require the widespread use of technologies not yet on the market including perhaps Direct Air Capture (DAC) technologies, synthetic fuels, and advanced, high performance, $CO_2$ capture technologies.<br><br>As well as technological change, social and behavioural changes are also likely to be needed. This could include changes to diets and to energy demand, for example, the need for smart home energy use, and reduced demand for aviation. This will require chemical engineers to work with other professions including social scientists and communications specialists.<br><br>To identify workable pathways towards net zero, action is needed at a number of levels:<br><br>▪ at the macro/governmental level (national and local levels). Goals and policy are set, budget resources are assigned which facilitate public/private investments to transition to a new infrastructure base aligned with net zero outcomes<br>▪ at the industry level, industrial national bodies establish roadmaps for participant implementation. For example, cement industry and aviation industry working groups<br>▪ at the corporate level, portfolios and capital investments are repositioned, often elevating participation in the renewable economy. Examples include repositioning by BP, Equinor, Orsted<br>▪ at the site level, focus may be redirected towards new energy efficiency and low carbon projects, displacing and reducing the use of fossil fuels, and/or preparing for the use of CCS<br>▪ at the individual level, equipping individuals with the skills and motivations needed to make change within their influence (eg home energy, diet, lobbying green policies, electric vehicles) |

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| | The CESIG will continue to publicise the climate crisis – members are actively driving the development and implementation of the decarbonisation technologies needed to deliver net zero, including hydrogen, CCUS, biomass/BECCS and new refrigerants/refrigeration processes. More can be done to improve – to achieve this, IChemE's CESIG needs to:<br>▪ drive and build consensus amongst chemical engineers so that we will all take rapid action on climate change<br>▪ take a technology neutral, system led, stance<br>▪ assist with the delivery of robust science and engineering inputs into policy making, industry, and education<br>▪ develop and expand knowledge in the low carbon space<br>▪ support the existing and next generation sets of chemical engineers during the transition to a low carbon economy<br>▪ educate and inform, across all sectors and demographics |
| What skills, training gap or facilitation requirements need to be addressed? | The CESIG recognises the value that a chemical engineering education brings to the climate crisis issue, particularly in respect of systems thinking. Practicing chemical engineers and others educated and trained in chemical engineering are working across the range of technologies and sectors to deliver the outcomes needed to meet net zero. We recognise the need for high quality education, training and continuous professional development to equip current and future engineers with the knowledge and skills needed to meet the climate change challenge.<br><br>The CESIG committee membership currently comprises engineers with mainly technical expertise covering, (at least) biomass and bioenergy, CCUS, energy storage, hydrogen, and transport. We recognise that there is a wider CESIG community that may include chemical engineers who have built up other valuable skills which will be of use in delivering the changes needed to educate, inform and influence.<br><br>Skills will be needed in the following areas – as appropriate, CESIG should seek to co-opt members onto the committee with skills and expertise in the following:<br>▪ upskilling and continuous development of chemical engineers<br>▪ transformational change<br>▪ policy and policy change<br>▪ communications to support the professional delivery of articles and presentations that 'land well', to expand the audience<br>▪ networking and workshop techniques to gain maximum added value from events and meetings<br>▪ educational materials<br>▪ social media to lead on, and maximise the potential of, social media platforms including, for example, blogs and vlogs<br>▪ scientists and engineers with specific skill sets related to the range of new technologies including (for example) whole systems thinking, digitalisation and artificial intelligence, energy storage, solar, heat storage, fuel cells, life cycle analysis, carbon economics. This could include members with relevant expertise in chemistry, data science, materials engineering, and social science. |
| What actions should the SIG and its members take to | Building on the high-level ambitions described above, the Action Plan is as follows.<br><br>**Reviewing CESIG ways of working**<br><br>1. Review the CESIG's ToR (Terms of Reference) – in particular, to ensure compliance with IChemE's position on climate change. |

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| support delivery of the above actions? | 2. Review and build up as necessary the CESIG committee's membership, recognising and filling the skills gaps that may need filling. Eg, co-opting CESIG members with expertise in, for example, social media, social science, materials engineering, battery, chemistry. There may especially be benefit in co-opting a wider set of early career members to provide new skill sets and ideas combined with mentoring such that new members gain valuable, early career experiences (eg opportunities to publish, present, respond to consultations, build new understanding of non-technical aspects including policy and economics).<br>3. Review and update as necessary the annual planning process. For example, to choose an annual theme (eg hydrogen) and based on this, the range of activities to be delivered (eg blogs/articles, site visits, webinars, workshops, meetings).<br>4. As a SIG, identify and decide how to<br>a. Identify priority themes on which the SIG should have viewpoints so as to facilitate responses to calls for evidence. Themes could be both sector based (eg cement decarbonisation) and technology based (e.g. CCS).<br>b. Respond to calls for evidence.<br><br>**Robust science and engineering inputs**<br><br>1. Chemical engineers are experienced in taking a systems view of processes, taking into consideration the fundamentals of mass and energy flows, and profitability. In meeting net zero, there is an urgent need to identify key pathways that can be delivered at scale. The CESIG team should use this expertise to provide rigorous science and engineering inputs into policy makers across government (local and national), industry, other non-profit organisations such as the IEA, and academia, providing a balance of opinions and viewpoints.<br>2. The CESIG should identify priority themes and prepare position articles and/or other outputs such as presentation slides and diagrams. These can be used in a variety of ways including as short articles, blog posts, LinkedIn posts.<br>3. The CESIG will support members working on the development of safety and new standards related to the decarbonisation agenda.<br><br>**Engaging, informing and educating, influencing (directly and indirectly)**<br><br>1. As stated above, the CESIG will undertake a review of key industries and key technologies which will identify a set of priority themes. This short analysis should take into consideration spatial renewable resources and the impacts these bring (eg solar in Australia will be a significant resource but brings with it the need for developments in energy storage).<br>2. The identified themes will be used to identify a set of communication outputs with the objectives of engaging, educating, informing, and influencing. The key audience should be, in priority order:<br>a. IChemE CESIG members<br>b. Wider IChemE<br>c. Other government, industry, other non-profit organisations such as other Institutions, the IEA, and academic stakeholders.<br>3. Outputs are expected to/could include:<br>a. Webinars and specially convened panel discussions |

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| | b. Site visits for IChemE members.<br>c. Workshops and meetings including conferences.<br>d. Short articles/blogs plus any other social media.<br>e. Insightful diagrams, charts and tools.<br>f. Medal awards and related media activities.<br>g. Working with and alongside other Groups and other Learned bodies (eg RSC, Energy Institute, SCI) to deliver the above.<br><br>The CESIG recognises that there may be overlap with other Action Plans so will coordinate and collaborate its work with other IChemE groups as required. |
| What actions will you encourage others to take? | Reaching net zero needs urgent, widespread and large-scale action. The UK leads the world in setting $CO_2$ targets, yet its actions are often at odds with the target (eg increased roadbuilding, cutting aviation taxes on domestic flights) and/or not yet sufficiently, concrete. Other countries have similar issues as do industries which are making net zero targets but as a sector are yet to make any significant progress beyond making pledges around new technologies and offsets.<br><br>Programmes of work are underway. For example, in the UK to electrify light duty transport and to decarbonise large energy intensive industrial clusters so as to achieve deep emissions cuts by 2030 and net zero by 2040 (per cluster). IChemE's CESIG has team members who are deeply embedded within these projects.<br><br>As noted above, chemical engineers are experienced in taking the systems view of processes, taking into consideration the fundamentals of mass and energy flows, and profitability. IChemE, at the SIG level, and the staff level need to take action to provide rigorous and robust evidence and advice, to identify priority solutions that can be achieved quickly and at scale. At the IChemE level, key calls for evidence need to be identified and working groups convened to deliver submissions, using a library of already prepared technology and sector position statements. Such submissions must be balanced, providing both the positive and negative. Where appropriate, work teams should collaborate with other learned bodies (eg RSC, IMechE).<br><br>The actions needed means there will be changes to the ways we work, make products, heat our homes and travel (or commute). There is a risk that negative opinions slow or limit technology deployments. There is already evidence of this on biofuels, wind power and CCS. In addition to technology research, therefore, social science and effective communications research is needed to mitigate this 'negative opinions' risk, to facilitate the deployment of low carbon technologies and identify the best approaches to take. There may be a benefit in IChemE engaging with a suitable learned body focussed on social science in the energy space to establish a path forward.<br><br>As noted above, the technologies needed to achieve deep cuts in $CO_2$ emissions already exist, while new technologies need to be rapidly developed and deployed at scale if targets beyond 2030 to net zero are to be met. IChemE and others need to keep up to date with all these technologies to understand their pros and cons and to provide the balanced views and advice needed by priority stakeholders, for example, policy makers. In particular, given the non-dispatchable nature of large-scale renewables, energy storage (for both heat and power) and advanced system controls will likely be a priority area of interest. |

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| Next steps | **In the next 12 months**<br>1. CESIG will review its ToR to ensure it is compliant with the IChemE's position on climate change.<br>2. CESIG will review and build up as necessary the CESIG committee's membership, recognising and filling the skills gaps that may need filling.<br>3. The CESIG will have identified a set of priority themes.<br>4. The CESIG committee will convene a subgroup to lead on the development of key performance indicators (KPI's) to monitor progress and assess the success of its work on decarbonisation.<br>5. Within the limitations of the COVID pandemic rules, the CESIG will deliver a series of webinars, conferences and articles providing guidance, explanation and understanding on the technologies needed to meet net zero across industry, power, heat and transport.<br>6. CESIG members will engage and partner with other IChemE groups and learned bodies to support their clean energy and decarbonisation strategies.<br>a. In September 2021, IChemE CESIG will deliver with the SCI Energy Group an online conference on the subject of Energy Storage.<br>b. The CESIG is working with the first Feria conference to deliver understanding around fuel and energy research.<br>7. The CESIG will actively support members working on the development of safety and new standards related to the decarbonisation agenda.<br>**By 2024**<br>1. The CESIG team will have reviewed its annual planning process (identification of annual objectives). As appropriate, an updated annual planning process will be in place.<br>2. Diversity within the CESIG team will have been widened with respect to areas of expertise, age and other dimensions. CESIG will use this diversity to its advantage, delivering outputs with value to a wider and more diverse audience.<br>3. CESIG will aim to bring on board more early career members who can both provide and receive value (eg in terms of mentorship).<br>4. The metrics identified by the CESIG KPI team to monitor progress and success will be in place. Metrics will be formally reported at each AGM.<br>5. The CESIG will have identified and worked on at least two priority themes, and delivered a series of outputs (eg webinars, site visits, short articles, conferences focussed around these themes etc). The CESIG will have carried out a review of key industries and key technologies to support identification of priority themes.<br>6. The CESIG will have supported IChemE with inputs into calls for evidence.<br>7. At least two Medals will have been awarded – these awards will be consistent with the IChemE's position on climate change and, where possible, with selected priority themes.<br>**Beyond 2024**<br>1. The variety of outputs generated by the CESIG will be valued by a wide variety of stakeholders. KPI data will evidence the value generated.<br>2. Younger CESIG team members, attracted by the focus on decarbonisation technologies, will progress and become CESIG leads having gained and shared valuable experience up to 2024. |