IChemE

Sustainability
Special Interest Group

Sustainability SIG Position on Climate Change

Introduction

Climate change is happening and seems to be accelerating. The signals are global temperature increases, rising sea levels, the reducing extent of Arctic sea ice, more frequent and severe weather events and the mass extinction of species. We know the increased rate of climate change results from anthropogenic emissions of carbon dioxide and other greenhouse gases. Under the auspices of the United Nations (UN) world governments agreed in Paris in 2015 to limit the global temperature increase to well below 2°C above pre-industrial levels to avoid potentially catastrophic impacts on human existence. As a result, many governments have set targets for reducing their greenhouse gas emissions but when aggregated these do not meet those necessary to achieve the 2°C target. Emissions pathways generated by the Intergovernmental Panel on Climate Change (IPCC) (1) to limit warming to below 2°C require net zero emissions by around 2050 from a peak in the 2020 to 2030 period. After a lull in 2018 global emissions are again increasing.

The UN Sustainable Development Goals (SDGs) (2) expose the dichotomy between economic growth and the need to stay within ecological boundaries. Currently, global production and consumption levels are overshooting the planet's biocapacity by about 50% each year (3). In other words, we have already grown beyond ecological limits and growth is no longer an option on a global scale. This ecological overshoot is due almost entirely to overconsumption in rich countries, particularly the West, now augmented by increasing demand from poorer developing countries. SDG 8 calls for improving 'global resource efficiency' and 'decoupling economic growth from environmental degradation'. However, global material extraction and consumption has in fact doubled over the past 30 years (4) and accelerated since 2000. Tackling climate change is not about doing the things we do more efficiently or ensuring economic growth based on current measurement criteria it requires a fundamental shift in approach and we have to succeed in implementing this dramatic change within a 30-year time horizon.

Zero carbon is a challenge to the engineering community and chemical engineers in particular need to respond with positive proposals for action. Chemical engineers will play a crucial role in the design of pathways for the decarbonisation process of specific, energy-intensive sectors, notably power, heavy industry and transport and to a lesser extent in buildings and agriculture. We set out here some of the choices which will have to be faced by society as a whole and in which chemical engineering should expect to have a major input.

The development of possible routes to zero carbon will depend on the specific geographical and social contexts, particularly in developing or low-income areas, and no single solution will fit all countries. Secondly a systems approach is essential to cope with the complexity and interconnectivity of possible solutions. For example, a move to zero emission vehicles depends on complementary zero-carbon energy sources and the infrastructure to support them.

To make sense of this very complex and integrated system of energy and power we have utilised the Six Pillars of Decarbonisation approach proposed by the Sustainable Development Solutions Network (5).

Zero-Carbon Electricity

Electricity is key to the low carbon transition. The energy required for electricity generation has made up 71% of global energy demand growth over the last 5 years (6) and 94% of this growth came from emerging economies with renewables supplying almost half of it. In 2017 total energy demand rose by 2% with renewables increasing by 17%. Noticeable too is a 10% increase in lithium production in 2017 driven by the growth in electric car production. Based on these data Carbon Tracker (7) predict a fossil fuel peak in 2025 to be Paris Agreement compliant with many proven reserves being uneconomic to produce. A prediction confirmed by the Governor of the Bank of England Mark Carney (8) who has warned “up to 80% of coal assets will be stranded, and up to half of developed oil reserves”.

The current technologies supporting the low carbon transition are: (1) low-carbon energy sources (on- and offshore wind, solar PV and concentrated solar power, hydropower, biomass, nuclear, geothermal, wave and tidal); (2) short-term and long-term electricity storage solutions and alternative energy vectors such as hydrogen; (3) other flexible options such as network interconnections, sector coupling, supply response (hydro reservoirs, bioenergy) and the big gains to be made by demand side management both via the grid and by user efficiency improvements; (4) carbon capture, utilisation, and storage (CCUS), and negative emission technologies including bio-energy with CCUS and direct air capture.

Reaching zero-carbon will require a combination of multiple technologies and the mix will vary from one country to another. Coal use is already in decline and must be phased out completely and whilst natural gas will contribute during the transition it will also need to be decarbonised or phased out. Many of the above technologies are already cost competitive but electricity storage, hydrogen, CCUS and negative emissions technologies require further development and/or proven application at scale.

Decarbonisation of End Uses

Global industry contributes 21% of greenhouse gas emissions (8) (9) and the principal emitters are cement manufacture, iron and steel production and chemicals. Transportation contributes 14% of global emissions (9) and gas heating/cooling in domestic and business properties is another major source of distributed emissions.

Decarbonising the above industries requires solutions which go beyond electrification of the energy inputs and necessitates adjusting the chemical and physical processes employed. To reduce emissions, these industry sectors will need to replace fossil fuel-based energy inputs with low- to zero emission electricity, along with improved heat integration and energy efficiency, all by taking advantage of new process routes. The chemical industry in particular will need to develop new products and business models which reduce demand for carbon-intensive products and services, meet sustainable development goals and promote the circular economy. Options to decarbonise energy inputs will include electrification, use of biomass, hydrogen and synthetic fuels and application of carbon capture technology.

The transport sector has four main segments namely road, rail, aviation and shipping and within the segments different strategies may be deployed. Short to medium range road transport can be decarbonised by battery or fuel cell electric vehicles. Battery range and recharge speed together with the deployment of recharge infrastructure are issues undergoing major development. Fuel cell vehicles depend on clean hydrogen production and refuelling infrastructure. These technologies are also likely to be deployed for long haul road transport with Scania, a truck manufacturer, expecting electric long-haul trucks to be cost competitive with diesel by 2027, and fuel cell vehicles to be cost competitive by 2047 (10). Decarbonising rail transport is by fuel shift from diesel to electricity or potentially hydrogen. For aviation advanced jet fuels (such as synthetic fuels) are the only way to decarbonise the current fleet and also the only option for the near future. Ultra-high-speed trains, can represent a modal shift from short-haul flights to rail. Options for short-haul sea transport currently being investigated are battery-electric or hydrogen either directly or in fuel cells with ammonia and hydrogen for long-haul shipping   for which nuclear power is also an option.

Decarbonising buildings is a major problem requiring the construction of new buildings and whole districts with zero energy consumption from fossil fuels and the renovation of existing buildings with the same net zero carbon standards. Heat pumps and large-scale fuel cells for large buildings and district heating systems can be solutions with hydrogen supplementing and ultimately replacing natural gas in the gas grid also being proposed. Construction materials represent almost a third of building related emissions and the development of new low carbon materials is essential.

Green Synthetic Fuels

For hard to abate sectors a wide range of potential synthetic fuels are available including hydrogen, synthetic methane, synthetic methanol and synthetic liquid hydrocarbons. Use of biofuels and the sustainability of biomass used for biofuels needs to be carefully assessed so as to avoid competition with food production, deforestation or loss of biodiversity and also competition with industries that currently use the biomass for higher value products or uses. As sustainable biofuels will only be available in limited volumes, their use should be prioritised in hard-to abate modes like aviation.

Smart Power Grids

The transition to renewable power generation with its distributed and intermittent nature will require systems able to shift among multiple sources of power generation and various end users to provide efficient, reliable and low-cost grid operation. Digitalisation and artificial intelligence are essential developments. Energy storage technology is also an essential addition.

Materials Efficiency

Global material extraction and consumption has doubled over the past 30 years (4) and has accelerated since 2000. This is unsustainable. Materials efficiency must be significantly improved by better materials choices including design for end-of-life. Material flows must be improved by employing reduce, reuse, and recycle concepts to achieve a circular economy for all products and services with a greater emphasis on these aspects at the product design stage.

Sustainable Land-Use

The agriculture sector contributes up to a quarter of all greenhouse gas emissions from deforestation, the use of industrial fertilisers, livestock production and direct and indirect fossil fuel uses. Intensive farming which produced the post war “green revolution” has over time resulted in extensive soil loss and degradation. The development of new farming methods together with changes in the distribution, sale and consumption of food products to reduce the enormous wastage in the supply chain is essential.

IChemE Response

The technology to achieve the transition to zero carbon and the expertise to deploy it exists but application has been far too slow. There has been too little investment in innovative low carbon options and too little engagement with business and the public on the behavioural changes needed. Chemical engineers have a major role to play in mitigating climate change and the Institution of Chemical Engineers must be committed to enable its members to discharge that role in their individual spheres of activity. By:

- Engaging in public outreach activities to governments, businesses and communities emphasising the need to accelerate action on climate change and promoting sound science based low carbon policy options.
- Publishing recommendations for action in areas such as zero carbon electricity generation, resource efficiency and the circular economy, low carbon materials use, and the energy/water/food nexus.
- Developing guidelines and project evaluation techniques to assist practicing engineers to apply sustainable design principles.
- Aligning the awards process to reward progress towards the zero-carbon economy and compliance with the Paris Agreement.
- Sharing knowledge on new developments which address climate change through its range of publications and through UK and international contacts with other engineering institutions.
- Ensuring that the degree accreditation process prepares graduating chemical engineers to transition to a zero-carbon world.
- Developing CPD programmes which support chemical engineers in the transition to zero carbon.
- Monitoring and reporting progress on these commitments.

In many of these areas it is necessary to work in partnership with other bodies; likeminded learned societies, governments and non-government organisations such as environmental groups but in doing so IChemE must retain a clear and distinctive stance based on sound science.

Policy Recommendations

a) With major transitions to be made in many sectors all involving a socioeconomic interface and in a short thirty-year time frame planning and implementation must be undertaken at a greatly accelerated rate.

b) National plans should cover the time period to at least 2050. Plans with a time horizon of just 10 to 15 years are far too short to accommodate transformations in energy systems and land use.

Power plants built today will still be operational beyond 2050 and new or retrofitted buildings will be standing well beyond 2050. Land-use choices made today can result in irreversible effects after 2030 resulting in species extinction or permanently degraded ecosystems. Policies, whilst retaining flexibility, must give investors and businesses confidence over the long term.

c) A systems perspective is vital because actions in one area can trigger outcomes in other areas that are detrimental to the aim of sustainable development. An overreliance on biofuels, for example, could reduce the carbon content of energy, thereby slowing the contribution to climate change from anthropogenic emissions, but at the expense of food production and biodiversity. This is not to deny that biofuels are a critical part of the solution. The aim must be to meet the needs of both society and the planet by integrating different resources and technologies whilst avoiding competition between them. This essential integration will require coordinated policy oversight.

d) Whilst countries are responsible for their own resources and energy choices, cross border solutions are required to achieve the common goal of zero carbon. Climate Change is a global issue, which transcends national boundaries. International agreements addressing the rich country/poor country divide and the differing socioeconomic impacts will be necessary.

e) Policy design and implementation must be coordinated to guarantee the inclusion and socioeconomic development of communities and to protect companies' competitiveness in the global market. Policy must encourage the development of the circular economy both nationally and internationally.

f) The fossil fuel industry was subsidised to the tune of $5.2 trillion in 2017 (11). Of this $0.3 trillion was pre-tax subsidy (the difference between what consumers pay and the cost of production) and $4.9 trillion was post-tax subsidy accounting for the full societal and environmental costs of burning the fuels. The pre-tax subsidies should be rapidly reduced, and the post-tax subsidy addressed by introducing carbon pricing mechanisms related to the desired decarbonisation goal.

g) CO2 concentrations in the atmosphere are already locked in for the next decade because of the physical inertia in the geophysical system and they will continue to increase. Alongside action on mitigation governments must plan and implement adaptation measures to cope with the adverse effects of climate change with poorer countries being the most vulnerable to the socioeconomic impacts (12).

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