The six principles of sustainability

David Bogle and **Miles Seaman** explain what sustainability means to the chemical engineer

Sustainability is a great catchword, but what does it mean in practice? What are the principles engineers should adhere to when designing a supposedly sustainable process?

The Engineering Council – a forum drawing together all the engineering institutions in the UK – has recently issued a set of sustainability principles and related guidance that seeks to answer just that question. The purpose was to give a set of high level principles to guide the work of all engineers, and to reinforce the leadership role that engineers are taking in confronting the sustainability challenge. The engineering profession has long taken responsibility for reminding its members of the context of their activity and its possible consequences.

In addition to the three traditional pillars of sustainability – social, economic and environmental considerations – engineers increasingly have to consider the ethical dimension, which includes goals such as poverty alleviation, social justice and the long-term consequences of engineering decisions.

The business of engineers is to provide solutions. This gives us a unique opportunity to lead and influence, particularly in advising clients about more sustainable options. And we should appreciate that we are a part of multi-disciplinary teams that include non-engineers. Our role should be wider than seeking technical solutions to a tightly prescribed brief.

The Engineering Council has identified six high-level principles:

- contribute to building a sustainable society, present and future;
- apply professional and responsible judgement and take a leadership role;
- do more than just comply with legislation and codes;
- use resources efficiently and effectively;
- seek multiple views to solve sustainability challenges; and
- manage risk to minimise adverse impact to people or the environment.

Each of these six simple but aspirational and interdependent principles is of equal importance. Within the document (www.engc.org.uk/sustainability) each of the principles is discussed more fully. Below we have sought to flesh out the thinking behind the principles and to give some examples in the world of chemical engineering which demonstrate good practice.

contribute to building a sustainable society, present and future

Engineers have a responsibility to maximise the value of our activity towards building a sustainable world. We need to understand the social and cultural context of our work. We believe that we do this, but nevertheless engineers have a reputation for only thinking about narrow technical considerations. We must be sure to recognise and take account of the effects that projects have on communities, both local and global, and consider the views of those communities.

There have already been many examples of the role of engineers in obtaining a more sustainable environment. For example, the broad implementation of SO_2 and NOx capture was responsible for abating the acid rain which was of considerable concern during the 1970s and 80s. While there was much debate about the economic impact of implementing SO_2 and NOx capture, a Dutch engineering evaluation that showed the cost of the available technology in an economic input-output model showed that the effect on the economy as a whole would be minimal.

apply professional and responsible judgement and take a leadership role

Engineers clearly have a leadership role to take – we have the technical understanding and must step forward to take the lead to ensure that projects are both possible and desirable. We must identify options that take account of global, economic, social and environmental outcomes and be prepared to influence decision-makers who authorise projects to go ahead. We are very aware of inherently conflicting aspects of sustainability and must keep in mind both measurable and unmeasurable aspects in our advice. With leadership comes the responsibility of keeping up to date and always looking at the broader picture.

Staying with the theme of NOx reduction, there are a number of engineering solutions to abating emissions which of course depend upon the source of the NOx. Clearly more concentrated sources (such as the off gas from nitric acid production) are easier to deal with. However there are a number of proven options for reducing emissions from either production plant or the much larger quantities produced by the combustion of fuels (NOx generated within a flame). To identify the best available technology (a requirement of legislation) the economic considerations must be evaluated alongside the environmental impact. Life cycle analysis (LCA) of options including absorption in water, absorption in caustic solution, selective and non selective catalytic reduction were considered to provide a framework for selecting the best abatement strategy in each case. Of course the input of engineers is central to this process.

do more than just comply with legislation and codes

As part of our leadership role we should always seek to go beyond the minimum compliance solution. The safe way is to just comply, but with a little thought large gains can be made by keeping ahead – being prepared for tighter legislation, goodwill from stakeholders, and sometimes financial savings. We should seek to anticipate legislation and seek to drive future legislation to meet the demands of society, ensuring that it is technically sound and alerting authorities if sustainable solutions are endangered by poor legislation. This helps meet the big challenges facing society but will also help to raise the awareness and appreciation of the role of engineers.

Thinking outside the box is a natural habit for the chemical engineer. Hence we participate in many areas, which are outside the normal realm of process engineering. One such case is the recent evolution of systems to cope with municipal waste. Questions about how to collect and process such waste entail looking at the issue with respect to the system boundaries, which do not necessarily fit with organisational boundaries or legislation. Hence, the entropy increase implied by the method of collection (kerbside separation or co-mingling of recyclables) will have a significant effect on the overall efficiency of a system, which should be designed to maximise the proportion of 'waste' being reused. The use of life cycle analysis in the hands of a process engineer is essential for finding an optimum solution.

use resources efficiently and effectively

Engineers have a stewardship role with respect to resources and perhaps this is the most clearly understood of the principles with emphasis on minimising the use of raw materials, energy and water.

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However we should be extending our traditional role always using full life cycle assessment in the whole supply chain of a product, and promoting re-use, recycling, decommissioning and sustainable disposal.

A concept that makes a significant contribution to the development of sustainability is industrial ecology. Industrialised economies depend on consuming primary resources at the rate of approximately one ton per person per week. Synergies in the ecosystems are often the driving force for evolutionary development. 'Waste' produced by one organism may become the nutrient for another and as a result of this a virtuous circle of regeneration is created. Industrial ecology can develop principles, which result in lesser use of primary resources from examples in nature. Creative use of the waste of a process as a substitute for product which is derived from primary resources has already been achieved in, for example, the use of slag from steelmaking used as a replacement for lime in cement manufacture.

seek multiple views to solve sustainability challenges

The sustainability challenges are becoming increasingly complex, which means we need to work with others. We often talk of how projects have become more interdisciplinary, with the need to bring together specialists from several technical disciplines. Yet there's long been a need for interdisciplinarity as engineers have always had to take in both technical and non-technical views. It is increasingly important to take account of all views at as many stages of a project as possible. Fresh and varied viewpoints so often see new solutions to difficult problems. We must always be seeking balanced solutions that address the complex sustainability challenges that face us.

By definition we cannot build a sustainable society through technical considerations alone. Much has been said and written about the multi-facetedness of the most general definitions of the subject. Environmental, socio-economic and technological considerations have to be properly integrated for the new paradigm to work. It has been posited that the engineer and scientist has to play a role in developing sustainable solutions by acting as an 'honest broker'; in bringing together social, ethical and ecological considerations for a sustainable world. The evolving debate on climate change as dealt with by the Royal Commission on Environmental Pollution study of 2000 exemplified this in as much as the engineer's voice was represented in arriving at its conclusions. Chemical engineers could assess the possible levels of abatement that could be achieved against the predictions of the climate models to arrive at a conclusion that the UK should be considering a 60% GHG reduction target by 2050.

manage risk to minimise adverse impact to people or the environment

Every project has its risks, so it is important that these are formally and comprehensively assessed and that the assessment includes the potential environmental, economic and social impacts with potential mitigating actions formulated. As with all major risks we need to use the precautionary principle, always giving sustainability the benefit of the doubt. And we should seek to ensure that all stakeholders are aware of risks and potential consequences and are comfortable with mitigation strategies.

Identifying and managing the risks connected producing and using chemicals has been part of the chemical engineer's tool bag for at least three decades now. We have wanted to fight against the undeserved negative reputation of an industry, which experienced several major incidents in the past. This has been achieved by introducing into project design and implementation the concept of risk assessment. Health and safety professionals usually have an engineering background. Many plants have been subjected to such analysis. The obvious candidates for such scrutiny are processes involving large quantities of common hazardous materials such as ammonia, chlorine and LPG but the principle for assessing and controlling risk can be applied to any hazardous material. Ensuring that all significant hazards are properly identified and characterised is followed by applying analytical techniques to estimate the likelihood of accidentally releasing a hazardous material, determining its possible consequences, and, if the combination of likelihood and consequence are above a predefined threshold, implementing mitigation measures. This is, in essence, the way of controlling risk set out in the Seveso Directive **tce**

David Bogle (d.bogle@ucl.ac.uk) is chairman the UK Engineering Council's sustainability working group. **Miles Seaman** is former chair of IChemE's Sustainability Subject Group

In keeping with the ethos of sustainability, the Engineering Council has avoided printing a large quantity of the guidance document, and an electronic version is available at www.engc.org.uk/sustainability. In addition, in a first for the Engineering Council, a handy wallet-size card (*pictured*) summarising the six principles, designed to act as a reminder, is also available and this has been enthusiastically received. In this way, by being concise and accessible, the Engineering Council believes that the wider public will appreciate the important role that engineers play in sustainability. To get your card, send an email to info@engc.org.uk