Society, through networking and information flow, is interacting more directly with the profession, becoming increasingly more vocal in the debate on environmental, safety and ethical issues associated with the types of work that chemical engineers do. A community motivated and inspired to action is a force that cannot be ignored — nor should it be. All professions operate within the context of general acceptance by the community. That is to say, it is society (the community) which provides our licence to operate. Relationships with the community need to be rooted in notions of mutual respect. To not listen to the public is dangerous.

There has not been much in the way of change yet in terms of the way in which the chemical engineering profession interacts with the community. The current focus is on meeting forced (regulatory) compliance. Where we do interact with the community, it tends to be reactive — such as in response to community concerns over environmental emissions. This is often not constructive — with community in outrage and the profession on the defensive. The profession needs to be more proactive with regard to setting the agenda for its interaction with the community. More active engagement needs to take place by, for example, taking the initiative in informing the public of actions and outcomes and addressing the issue of science literacy.

This is general stuff, but let's be more specific: to what extent should we be engaging proactively and in what direction?

Chemical engineers and the societies and institutions that represent them already hold positions within the community (such as on advisory panels to governments and NGOs). This is not enough, but how close to enough is it? Do we need to step things up incrementally or substantially? Given the exponential pace of change as outlined above, it follows that it needs to be the latter. So, in what direction? In the last twenty years, the catch-cry was 'the environment', and we sat up and took note and responded accordingly — tighter regulations on contaminant levels in water, air etc, focus on responsible rehabilitation of old industrial sites. And it was within a structured framework of regulations and accountabilities (forced interactions).

The catch-cry for the new century is 'sustainability'. It is the bigger picture, taking 'environment' to the next level. It is a logical extension of current community concerns — looking after the planet and still maintaining a comfortable lifestyle. This is set against a background of less defined interactions, where the regulatory framework is not a clearly defined set of forced interactions, and with a shift to self-regulation and the abandonment of detailed prescriptive guidelines.

The chemical engineering profession needs to develop a strategic framework that fits with the current world in which we operate — flexible, proactive, engaging, communicating. Sustainability is a new concept for a new century. The elements of sustainability are more like the network (multi-faceted interactions) than the 'hub-and-spoke'. Sustainability offers a framework for proactive interaction with the community by the chemical engineering profession. This chapter seeks to explore this concept and to outline what such a framework might look like.

2. Framework of chemical engineers' interaction with the community

What defines the profession?

> 'I am, and ever will be, a white-socks, pocket-protector, nerdy engineer — born under the second law of thermodynamics, steeped in the steam tables, in love with free-body diagrams, transformed by Laplace, and propelled by compressible flow... dedicated to doing things better and more efficiently' [1].

2.1. *Subject matter*

Chemical engineers develop, operate and optimise chemical and physical processes that take raw materials and transform them into products that are either feedstocks for the domestic market or have direct application in it: refining of petrol, production of acids or alkalis, processes to produce foods and medicines. They must simultaneously understand the micro (chemistry, physics, mathematics) and macro (engineering) elements. The ability to make the link between the two is expanding the horizons of chemical engineering into areas of new technology, particularly those with a biotech focus.

There is an expectation from the community that we supply the products they need and/or desire and that these products are safe to use and produced with minimum impact on the environment. It is the application of the 'doing things better and more efficiently' which brings chemical engineers into contact with the community in a manner which can have significant impact on the communities where we operate and the way in which we operate.

2.2. *The profession*

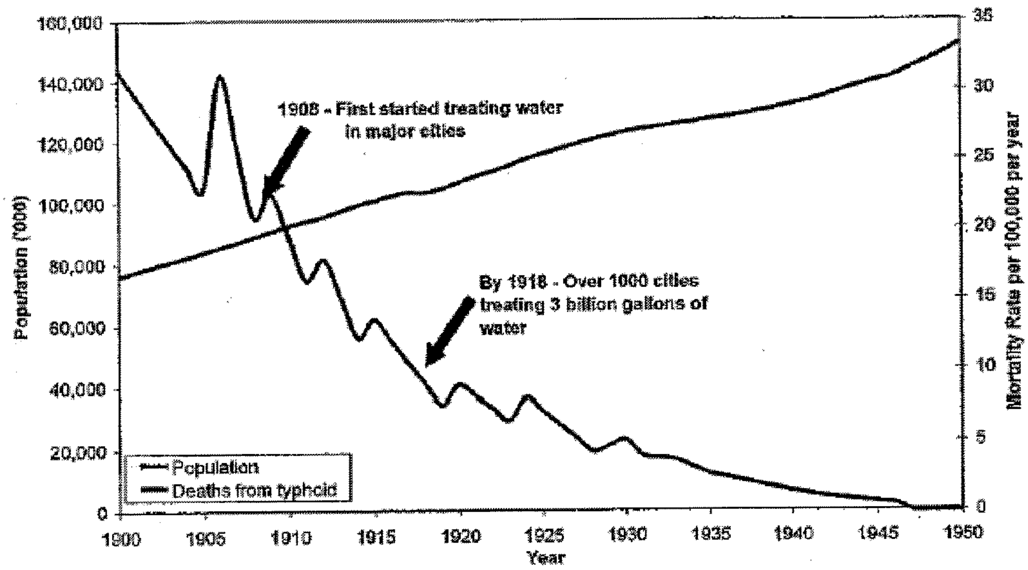
Societies and institutions represent the corpus of chemical engineers and the subject matter of the profession. Chemical engineers look to their professional societies and educational institutions to set the standards and framework for their conduct as professionals. Our societies, institutions and professional bodies play an important role in supporting the profession in its engagement with the community. There is a direct role through recognised positions within the community — e.g. advisory role to government, provision of educational material to schools, production of public publications and developing and maintaining websites. Indirectly, these organisations oversee the individual chemical engineer's engagement with the wider community through the codes of conduct they set and formal processes such as accreditation of course and certification of practising professionals.

In this chapter, by chemical engineering, we mean the corpus of practising chemical engineers and the societies and institutions that represent them. We are not talking about companies or industries.

2.3. *Historical contributions to the community*

The nature of chemical engineering is in using basic scientific principles to solve practical problems. In looking back over the last hundred years at how the profession has contributed to the community, it is at a practical level. The USA's National Academy of Engineering in marking the turn of the century, acknowledged what it believed to be the twenty greatest achievements of the 20th Century. Number four on their list was technologies that purify and deliver safe and abundant water, which significantly improved living standards (as an aside, lasers and fibre optics, which transformed the rate of information flow, is ranked 18th). The NAE, in determining the twenty greatest achievements, acknowledged contributions based on impact to society. Clearly, contributions with a more direct, measurable, impact are in the outcomes based stuff than the process stuff (such as fibre optics). This method of ranking also reflects where society is focused when it comes to valuing science and engineering.

Chemical engineers contribute at a practical level — the above example of safe water supply is a good one. Figure 1 shows the decrease in incidents of typhoid in the United States once open sewers in back lanes were done away with and adequate plumbing installed. There are numerous others examples of technologies developed by chemical engineers assisting to improve living standards — food processing, large-scale manufacture of medicines etc.



Source: Armstrong et al, "Trends in Infectious Disease Mortality in the United States During the 20th Century" JAMA / volume:281 (pg61-66), January 6, 1999

Fig. 1. USA: population and incidence of major water-borne diseases.

It is not just in the practical implementation of technologies that the profession contributes. More recently, chemical engineers have taken active roles in organisations such as Greenpeace and on advisory panels to governments.

In the work we do, it is vital to always consider the outcomes and implications. Sustainability is all about this, and, as such, makes a good framework for our interaction with the community. Before considering a new framework, it is necessary to look at the current modes of interactions between the chemical engineering profession and the community.

2.4. *Community interaction and the licence to operate*

Chemical engineers practise their profession within communities — there is constant interaction. But, what form does that take? There are legal requirements for environmental compliance, government regulations regarding where we can build our processing plant etc. So, at one level, the current framework for interaction is set by government and legal process. In a broader context though, as mentioned earlier, the profession also requires the general acceptance of the community in order to function. That is to say, the licence to operate is given by society.

Prescribed legislation and regulation exist for a reason. Protection for the environment is one reason, but more importantly it is for the health and safety of the individual (members of society who make up the community). Society did not sit passively by and wait for a higher authority to put that legislation in place — campaigns for safer working conditions, controls on pollution, the 8 hour day, eliminating child labour are all examples of community intervention driving change. Today, companies who choose to build their factories in countries with relaxed labour laws in order to improve their profit margins have a poor public image and are targeted by an outraged community. Our licence to operate may be regulated through legal channels, but it is given by society. It is important not to lose sight of this. It is not by chance that companies are beginning to discuss the concept of having an 'implied' contract with their communities.

Two parallel modes of interaction with the community are emerging: forced and voluntary. Forced interaction is that fixed in legislation, with clear legal requirements and defined penalties for non-compliance. Voluntary interactions are more about implied ethics and social responsibility.

2.5. *Forced interactions*

As discussed above, there are laws and regulations which dictate where and how we build and operate our process plants. These vary between countries. It is necessary to meet the legislative requirements of the country in which we operate.

Accreditation of chemical engineering courses allows those who graduate to be acknowledged as a professional and accepted into the societies and industry associations which stipulate the requirements to be a certified practising chemical engineer. Again, the requirements for accreditation and certification vary across borders.

Even though different countries have different legislative requirements, our "...right to practise... is, and must continue to be, based... upon our competency and accountability" [2]. This is over-arching, regardless of the country in which you work.

Legislation sets the framework for safe operation of our plants. There are prescriptive regulations regarding occupational health and safety, though again the exact structure and extent varies across borders. And, embodied in all of this legislation, there are clearly defined penalties for non-compliance — penalties not only directed at the companies, but also targeting the individual. A chemical engineer in a line management role is personally responsible for the safety of those that work for him/her.

2.6. *Voluntary interactions*

Not prescribed in legislation are the unwritten codes of conduct, the ethics that govern our interaction with the community. This is about doing what we see as right and appropriate, as well as what is required by legislation. It is about meeting the most stringent standards for environmental emissions when operating in a location with the most relaxed legislation. It is about going above minimum requirements for health and safety. This is becoming more important as we operate globally — across borders, and across varied levels of regulatory requirements.

The interaction of the profession with the community it seeks to serve can be seen from the perspective of a licence to operate to companies first, but less directly, to the profession itself. However, unless this is placed in an historical context, the message may appear apologetic.

An early mover in voluntary initiatives was that of Responsible Care® begun in Canada in 1987 to develop the principles on which the chemical industry could base its product development from laboratory to disposal, to improve its health, safety and environmental performance (see Table 1). That was taken up by the International Council for Chemical Associations in 1991 and now covers 87 per cent of global chemical production in 42 countries. Mainly adopted by the larger multi-nationals, the Responsible Care® concept needs to be extended to more small and medium sized enterprises [3].

2.7. *Balance between forced and voluntary interaction*

The lines between forced and voluntary interaction are becoming more blurred, with greater overlap taking place. Companies and the professions that service them are operating globally. There is a move to self-regulation but the community is being more proactive in its expectations. All these factors contribute to the overlap, but that overlap is still not fully grasped by the profession.

Table 1
Objectives of Responsible Care®

Responsible Care®
1. To seek and incorporate public input regarding our products and operations.
2. To provide chemicals that can be manufactured, transported, used and disposed of safely.
3. To make health, safety, the environment and resource conservation critical considerations for all new and existing products and processes.
4. To provide information on health or environmental risks and pursue protective measures for employees, the public and other key stakeholders.
5. To work with customers, carriers, suppliers, distributors and contractors to foster the safe use, transport and disposal of chemicals.
6. To operate our facilities in a manner that protects the environment and the health and safety of our employees and the public.
7. To support education and research on the health, safety and environmental effects of our products and processes to foster the safe use, transport and disposal of chemicals.
8. To work with others to resolve problems associated with past handling and disposal practices.
9. To lead in the development of responsible laws, regulations and standards that safeguard the community, workplace and environment.
10. To practise Responsible Care by encouraging and assisting others to adhere to these principles and practices.

The abandonment of detailed and prescribed regulation in favour of self-regulation sees the lines between forced and voluntary interaction with the community — in terms of looking after the health and safety of individuals — becoming blurred. Desired outcomes are set through codes of practice aimed to assist employers, but these are not mandatory.

In exploring dimensions of self-regulation versus prescribed regulation, a couple of key issues are evident. Respect for governments and their role in control the regulatory environment is changing (this is explored later) and there is a focus on the rules applying to individuals, rather than companies. These issues came to light in the Longford case, illustrated in Fig. 2. This is a local, Melbourne, example but there are plenty of others around the world.

There is a need for the chemical engineering profession to work with the community, rather than leave it to the government and regulatory bodies to dictate the level and extent of accountabilities. A united approach between the profession and the community is more effective. Whatever the dimensions of regulation and self-regulation, interdependence of chemical engineers with the wider community must be recognised. That interdependence is not power-based but rather one that attempts to satisfy mutual needs.

Lessons from Longford and the issue of self-regulation

On the 25 of September 1998, an explosion ripped through the Esso gas plant at Longford, Victoria, Australia. The Longford incident received a significant amount of attention from the community — not surprisingly as it left Melbourne, a city of 3 million people, without gas supply for 10 days. This is a city where the majority of residents rely on gas for heating their water and houses and for cooking. In a month where overnight temperatures averaged 8°C, us softies used to a comfortable lifestyle were not so keen on cold showers in the morning. This was a small price to pay, compared to those who lost their lives or who were seriously injured at the plant, but it got the government's attention and resulted in a royal commission.

The Royal Commission into the Longford incident ruled that 'operator error is not an adequate explanation for major accidents' and 'front-line operators must be provided with appropriate supervision and backup from technical experts' [4] — i.e. the responsibilities and accountabilities expected of the chemical engineer. The practising chemical engineers were seen as having a responsibility for the operators performance and hence the impact of plant and production on the wider community.

Fig. 2. Lessons from Longford [4].

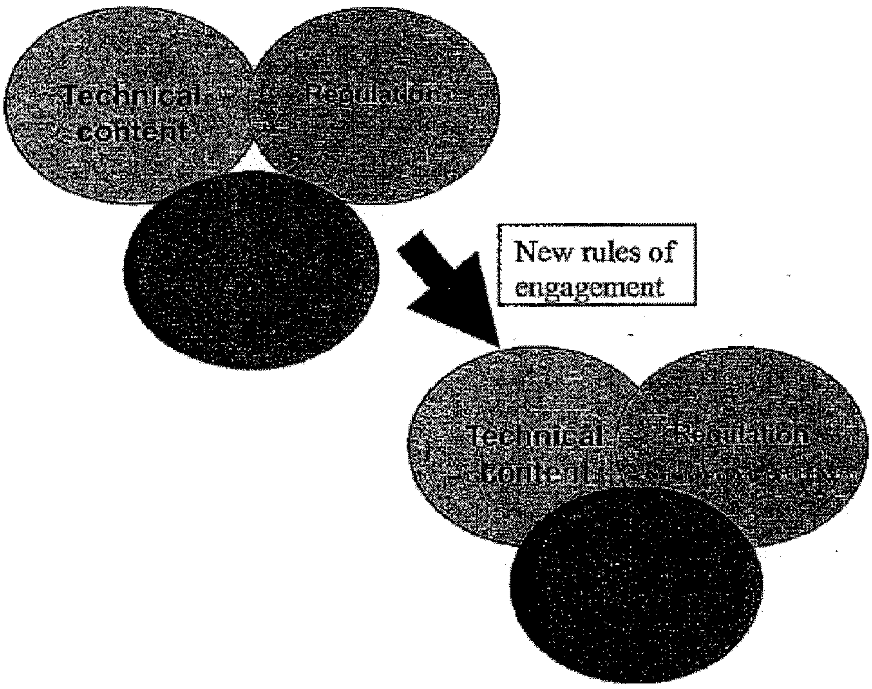


Fig. 3. The new rules of engagement.

2.8. *The pace of change driving a shift*

What was once voluntary is becoming the forced position (see Fig. 3). For the chemical engineering profession, the components of technical content, regulation and stakeholders interaction have all expanded and overlap to a greater extent than in the past.

In the past, chemical engineers have operated within a comfortable framework of technical content and prescribed legislation. On the technical side, the laws of thermodynamics, the continuity equations, McCabe-Thiele diagrams and, when you cannot quite remember the required formula off the top of your head, go to Perry/Levenspiel/Bird, Stewart and Lightfoot. On the legislative side, HAZOP analysis, classification of hazardous substances, requirements for PPE, rules for confined space entry. Nowadays, there is greater interaction with the community by individual chemical engineers, their societies and institutions and this interaction falls outside the areas of technical content and prescribed legislation with which we are comfortable.

There is a need to shift the framework, and to be proactive in doing so or society will do it for us. To step outside the old framework (with no form-guide to help us) takes the traditional chemical engineer outside their comfort zone. But, it is becoming a necessity if we wish to maintain our licence to operate. How much should societies and institutions acknowledge the shift? We pose that, in a rapidly changing society, they need to address the shift by being proactive in developing a framework for community interaction.

3. Society is changing

> Welcome to the 21st Century. You are a Netizen (a Net Citizen), and you exist as a citizen of the world thanks to the global connectivity that the Net makes possible. You consider everyone as your compatriot. You physically live in one country but you are in contact with much of the world via the global computer network. Virtually you live next door to every other single Netizen in the world. Geographical separation is replaced by existence in the same virtual space [5].

3.1. *The world is changing and society with it*

The external factors that drive and encourage community behaviour and interactions are changing at an exponential rate. Consider the pace of change in digital infrastructure. John Seely Brown illustrates this by describing Digital Power as a function of

- computing power (Moore's law — a doubling every 18 months),
- communication (fibre law (bandwidth), doubles every 9 months),
- storage (disk law, doubles every 12 months),
- content (community law, which is 2^n, where n is the number of people).

Couple this with the exponential increase in power consumption that can be attributed to the internet. In the United States alone, current estimates are that 15% of all electricity consumption is used to power the internet (from a base of 0% 9 years ago). From 0% 20 years ago, and 5% in 1992, roughly 20% of US electricity consumption is used to power computers [6]. The ability to disseminate information rapidly and globally has seen a breakdown in traditional forms of communication. With the explosive development of the internet neither companies nor professions have complete influence on, or control of, the communications process between themselves and consumers.

The internet is mandating unprecedented global transparency. Now with access to the internet and mobile phones, communities feel empowered to challenge developments that are contrary to an established agenda. They have the access to a support and information network that can, and will, assist them in this challenge. An Australian company working in Turkey spent 18 months negotiating an agreement for mining with the central government while evaluating an old mine near an established community. On reaching agreement in Ankara, the company turned its attention to developing the mine only to find that the local community had organised themselves to reject the project [7]. It is no longer possible to ignore the influence of the community as a stakeholder.

The next generation of the internet is the "evernet", where broadband, wireless protocol and the growing range of internet devices intersect. The "evernet" applies not only to the World Wide Web but also the universal connection of domestic and industrial units to the internet, such as that much written-about refrigerator that can order its own replacement food. It is an 'always on' instant internet that is rather quickly becoming a reality, able to further intensify and revolutionise the dissemination of information.

Consumers, stakeholders and employees will each be rapidly informed of company activities and performance. In addition, the community can be aware and monitor action taken. As a consequence communities across the world can be empowered to challenge developments given the support and information networks that can, and will, assist.

It is not surprising that people's approach is changing. With the traditional 'hub-and-spoke' lines of communication all but dissolved and a global communication network at their fingertips, there is a heightened sense of awareness in the community. There is a fall-off in trust in authority and hierarchical responses because information is available from other sources. The challenge for the chemical engineer is that the changing content of technology is also seeing a change in the content of the corpus of chemical engineering. An example of this is the new areas of genomics-based chemical engineering, described by Lord May in his opening address, which will see an increased emphasis on the development of processes utilising bacteria.

The community is just as vocal in traditional areas of clash with science and engineering, such as health, safety and environment. But, with the changes to the content

Table 2
DNA-free food? [8]. "Ordinary tomatoes do not contain genes but genetically modified ones do". True or false?

	True	Don't know	False
Canada	15	33	52
USA	10	45	45
Austria	44	22	34
Finland	29	27	44
France	29	39	32
Germany	44	20	36
Ireland	29	51	20
Italy	21	44	35
Netherlands	22	27	51
Spain	26	46	28
Sweden	30	24	46
UK	22	38	40

of engineering, new areas for concern are emerging. The individual chemical engineer, in his/her interaction with the community, needs a broad knowledge base while retaining a deep working knowledge of one or two particular areas. This position is important when dealing with a public who can be ignorant of scientific detail, particularly in emerging areas. The rapid advances in science and technology, particularly in the biotechnology area, are bringing about changes and potential changes that are being questioned, such as GM foods, but sometimes with little understanding of the basic science. The example in Table 2 demonstrates misconceptions relating to the existence of genetic material in plants — people know the rhetoric, but there is a lack of science literacy.

Being overwhelmed by information and conflicting arguments can lead to swings and outrage. The anti-globalisation protests around the world are an example.

3.2. *How are chemical engineers responding?*

In view of these pressures, it is important to consider how chemical engineers are responding, and why it is important that they do. The current situation is reactive and the consequences, when they come, can be extreme, resulting in drastic swings. The approach is frequently ad hoc — is this desirable?

Being reactive has a long history of landing us in the soup. Consider Love Canal.

In 1978 New York State officials began something that has long haunted America. What they did led to a Presidentially ordered, complete 'emergency' relocation of the residents of Love Canal, a small community in Niagara Falls, NY. From 1942 to 1952 some 21 000 tons of various chemical wastes were dumped in a 70 acre site. In 1953 the landfill was sealed. Subsequently an area close by was extensively developed and problems with odours and residues, first reported in the 1960s continued into the 1970s.

Worried by headlines concerning an earlier industrial waste site in the area, the residents then clamoured for government intervention. As a result of the Presidential order, some 950 families were evacuated. Laws determining how to dispose of unwanted chemicals began to be introduced. But in the post evacuation scientific inquiries, researchers did not find any evidence of an abnormal incidence of cancers or other maladies among the former residents. They did, however, find evidence of indirect psychological damage traceable to sensational media reports.

The Environment Protection Agency's Science Advisory Board, noting the presence of dioxins, advised the only human disease with a known connection to dioxin was chloracne — a skin disorder that Love Canal residents never had.

In 1980 *Science* magazine stated that while adverse physical consequences had been rare, the series of events known as 'Love Canal' had engendered "deep and abiding mistrust" of authorities.[1] Subsequently, remediation continued into the 1980s and 1990s.

Love Canal set the scene for massive intervention as well as the sheeting home of costs to all users of a site, not just the polluters. To not be proactive can prove costly, not just financially for the companies involved, but also for the reputation of the profession. Love Canal had a long history. By being proactive in looking ahead at the implications for new technologies, we can develop a strategic framework for addressing issues.

In looking to the future, consider the recent advances in stem cell research that indicate the potential to turn embryonic stem cells into blood cells, with the possibility of creating inexhaustible blood banks [9]. How might the community react to the first process plant for blood production? What is the ethical position of the chemical engineering profession with regard to synthesising blood cells from embryonic stem cells? Do we need one? Governments around the world are putting frameworks and regulations in place to address the implications of stem cell research. If the community shows outrage at large-scale synthesis of blood cells, then it is the chemical engineers who operate the plant who will be in the firing line. The societies that represent the profession need to be proactive in educating the community, addressing their concerns, and setting the ethical framework for such an activity, or the licence to operate can be withdrawn.

Doing nothing is not smart. Being proactive is effective if strategic. Other professions have been proactive. In the medical and health sciences area, Research!America, a not-for-profit membership supporting a public education and advocacy alliance, has been active for over 10 years. The mission of Research!America is to make medical and health research a much higher national priority. The organisation received a 3-year, US$ 5.5 million grant to build national support for prevention

[1] See: http://www.prioritiesfor health.com/1004/lovecanal.htm

and public health research and is quoted by The Wall Street Journal as "the driving force behind the huge 15% increase in the NIH budget".

Being proactive enables greater direction in setting the framework for interaction, ensuring it is a framework within which the profession can reasonably be expected to operate, and that it does take cost–benefit analysis into account.

3.3. *Communication, engagement and discussion*

Communication, engagement and discussion are key to any framework for interaction with the community. The ability to communicate information and ideas rapidly and to a broad audience is the common thread linking social and technical change. Network communication channels are seeing diminishing powers of governments to regulate interactions, a lack of trust in authorities and an expansion of what comprises the group of stakeholders in a given situation. These elements support the argument to be more proactive.

The engagement process for the profession and for individual engineers can be considered in the light of stakeholder theory. The theory considers the relationships between an organisation and its stakeholders in terms of a manager acting as a caring person wishing to help the myriad local organisations, in its region, in all ways. A firm and its stakeholders are now no longer considered in either terms of power or contractual relations. Rather they are related to each other as part of their very existence; a firm's relationships constitute part of the firm. The question now to be asked by the manager is "What can we do to help you prosper, to act on our caring for you?". While contracts require consideration of reciprocity, caring relationships do not. In a world of essential relationships all groups are interdependent.

The balance between forced and voluntary interactions with the community, in the light of stakeholder theory, defines our licence to operate. Nowadays, the number of stakeholders is drastically increasing. The example given below illustrates this multiplicity of interactions.

In 2000 in South Australia an announcement was made about a proposed new magnesium development. While it did not proceed, reactions in the press and on radio highlighted the views, often conflicting, of the different community sectors.

- The *local aboriginal community* indicated it had not been consulted (nor, presumably offered compensation or part of the action).
- The deposit to be mined was in a national park — *environmental groups, and the park ranger service*, opposed mining in the park as it would impact on its sensitive ecology; they suggested that there were plenty of places outside the park to mine!
- The *SA Government* welcomed the development, as it would have created much-needed jobs; it wanted to stay in office.
- The *Port Pirie Council*, where the smelter was to have been located also welcomed the development; it would have benefited employment and added wealth to a depressed area.

- The *Australian community* should have welcomed it because it would have resulted in reduction in vehicle fuel consumption as a result of lighter cars.
- The *Federal Government* would have welcomed it because of export income and potential greenhouse-friendly production.
- The *world community* would have benefited from lighter cars, reduced fuel consumption and reduced greenhouse gas emission.

In the context of a changing society, chemical engineers need to be more attuned. They need to take advantage of the networks to pick up on community concerns and then be proactive in responding. The profession has embraced 'the environment', but that was in the last decade (an old framework). With the new century, 'sustainability' is the catch cry.

3.4. *Sustainability offers a framework*

Sustainability is a framework that is being embraced, that sits well with the concerns of the community and where society is heading in the 21st century. In the profession's second century, sustainability is not just about integrating environmental considerations with the bottom line. Sustainability is about making best environmental practice, product stewardship, partnership and transparency integral to the bottom line. In this changing society, sustainability is also about people's expectations and aspirations, the framework in which they operate and their understanding of risks and rewards.

A proactive position is needed because society is changing. This position is required to prevent the chemical engineering profession being caught by extreme swings.

4. Sustainability as a framework for proactive community interaction

> We are now transforming the biosphere — depleting the oceans, poisoning the air, levelling mountains and altering the composition of the atmosphere — and we are doing it in a mere instant of geological time. In the nearly four billion years that life has existed on Earth, no species has possessed this capability for changing the biophysical makeup of the planet and thus affecting every other species on Earth. From an Australian perspective the effect of 200 years of European methods of agriculture now require us to replant 75 per cent of our now cleared agricultural land so as to ensure our cities have a continued supply of potable drinking water [10].

In Australia, European farming practices led to native vegetation being replaced with crops and grasses with shallower roots and different growth patterns. Native vegetation evolved to make the best use of available rainfall. Imposing foreign methods of agriculture has resulted in a major water imbalance in many catchments. Water is no longer used at the same rate, with the unused portion migrating to lower soil depths and causing a rise in the water table. As the water table rises, stored salts are mobilised and brought near to, or reach, the surface, leading to widespread land and environmental degradation. As well as causing problems for agriculture, with land becoming unusable for growing crops, salinity damages downstream aquatic ecosystems and biodiversity and can affect urban infrastructure due to damage to building foundations from shallow, saline water [11].

The salinity issue in Australia is the result of agricultural practices that are unsustainable. Finding ways to redress the balance and implement sustainable farming practices is a matter of necessity receiving significant attention from scientists, engineers and the wider community.

4.1. *Sustainability is on the agenda*

There is widespread interest in the elements of sustainability. It is not simply a fashion and is certainly not a Luddite reaction against new technologies. As an example, recycling is now widespread and common practice. A common feature across a number of countries, seen and supported by the community, is the recycling of waste paper, aluminium cans and household garbage. Not so visible to the wider community are the large changes that have taken place in manufacturing, such as the changes in metal forming techniques to minimise waste and the looming of copper wire in cars so that it can be easily removed in one piece when recycling vehicle components.

Sustainability itself has been adopted by some countries. In Sweden, The Natural Step Framework (discussed later in this section) has received strong support from business and political leaders and has been adopted by a number of council municipalities and corporations (such as IKEA and Electrolux).

As a strategic framework for the chemical engineering profession, sustainability builds nicely upon the traditional framework of mass and energy balances. At the most practical level, it offers concepts easily grasped by the classically trained chemical engineer. Also, sustainability and its key elements such as life cycle analysis, require teamwork and a multi-disciplined approach. Strong interaction with all stakeholders is necessary, making it a good framework for community interaction.

4.2. *Technical innovations enabling sustainability*

Technical innovations are leading us towards a more sustainable society. With today's technology we are learning to take care of much of the waste we produce. We recycle waste water, plastics and aluminium cans, re-manufacture discarded tyres and use garbage as a source of electricity. A number of organisations are seeking to develop a no-waste strategy by 2010. This is built on the increasing levels of success we have achieved in new waste reduction strategies over the last twenty years.

Most recently, 'Green Chemistry' focuses on modifying intrinsic chemical properties of substances to reduce or eliminate their hazardous nature. The implementation of green chemistry technology has potential to offer environmental benefits that propagate throughout the life cycle. Waste minimisation is at the core of a process that seeks to not only promote clean technologies and reduce the environmental impacts of the energy sector but also to stimulate ecologically conducive consumption patterns. By developing processes to assist remediate past pollution the profession can work to preserve the landscape. With redesign, investments in efficiency yield expanding rather than diminishing returns.

Taking advantage of the technical innovations that enable a move towards sustainable processing has occurred in incremental and revolutionary steps throughout the 20th century. The example of technologies that purify water (discussed earlier as example of practical contribution to the community and illustrated in Fig. 1) was a first step towards sustainability — how do you sustain an increasing population without a process for treating sewerage and providing a clean water supply?

> "Chemical engineers will be central to solving water shortages… increasing the efficiency of use, reducing demand by rethinking systems for treating and recycling water and designing and overseeing the construction of reverse osmosis plants." [12]

4.3. *The role of societies and institutions*

Societies and institutions have a key role now in setting the context for the sustainable practice of chemical engineering.

The misunderstanding regarding genes in tomatoes has been discussed earlier. Perceptions can be made with lack of understanding, but if people respond according to what information is available, then what more can we expect? Our societies and institutions have a role to educate the profession. They also represent the profession in its interactions with the community. Therefore, they also have role to educate the community with regard to profession.

Our societies and institutions have been active in the past in revamping the profession. Certified practice, and the requirements that go with it set a standard for professional behaviour. Societies have been instrumental in defining the code of conduct — particularly with regard to matters of health and safety. Certification is becoming an ever more rigorous process as the community's expectations of what engineers can deliver is rising: "Ensuring that engineering skills are practised competently is essential for safeguarding the health and prosperity of our nation. It is our competency, together with our accountability that defines us as a profession" [2].

Examples of initiatives by the professions societies with regard to sustainability include:

(a) Future Life Report by IChemE, released in 1997 [12]. The report sets out ideas on how chemical engineers might contribute to sustainability. In particular, the report addresses the following questions:

- Can we quench our thirst for water?
- Can we break the link with carbon?

- Are miniaturised factories the way forward?
- Can we reduce the amount we produce?

These are all issues that need to be addressed in order to sustain our community into the 21st century and beyond and they are issues that will require engineering solutions.

(b) More recently, IChemE has become part of a consortium of chemical industry organisations in the UK — the CRYSTAL Faraday Partnership — which has come together "to improve and develop the UK science and technology base by providing a virtual centre of excellence in low cost, sustainable ('green') manufacturing technologies and practices".

(c) Center for Waste Reduction Technologies (CWRT), established by AIChE in 1991. Technologies and management tools supporting sustainable growth, environmental stewardship, and Responsible Care® CWRT's mission: To benefit industrial sponsors and society by leveraging the resources of industry, government, and others, to identify, develop and share non-proprietary technology and management tools that measurably enhance the economic value of sponsor organizations while addressing issues of sustainability and environmental stewardship.
An example of a recent CWRT project is the use of their previously developed Sustainability Metrics to establish a methodology for determining practical minimum energy requirements for chemical processes.

There has also been commitment by individual companies, such as Alcoa who has set very clear waste reduction targets over the next 10 years:

- SO_2 — 60% reduction in emissions by 2010.
- Volatile organic compounds — 50% reduction in emissions by 2008.
- NOX — 30% reduction in emissions by 2007.
- Mercury — 80% reduction in emissions by 2008.
- Landfill waste — 50% reduction by 2007.
- Process water use and discharge — 60% reduction by 2008.
- GHG — 25% reduction by 2010 (potential to achieve 50% with use of new inert anode technology).

> "This set of goals will be milestones along the way to the ultimate vision of a company where all wastes have been eliminated, where products are designed for the environment, where the environment is fully integrated into manufacturing, where the workplace is incident free, where protecting the environment is a core value of every employee and where all stakeholders recognise Alcoa as a leader in sustainable development."

In considering sustainability as a framework for the chemical engineering profession, the London Communiqué was an ad hoc step in the right direction. The 1997 London Communiqué (Fig. 4) acknowledged the need for chemical engineers to minimise their adverse impact on the environment more so than to use the profession's

We, the representatives of 18 societies representing chemical engineers worldwide and acting here in our personal capacities, subscribe to the following statement:

THE KEY CHALLENGE FOR OUR PROFESSION IN THE TWENTY-FIRST CENTURY IS:

To use our skills to improve the quality of life: foster employment, advance economic and social development, and protect the environment.
This challenge encompasses the essence of sustainable development. We will work to make the world a better place for future generations.

SPECIFICALLY, CHEMICAL ENGINEERS WILL:

Design processes and products which are innovative, energy-efficient and cost-effective, make the best use of scarce resources and ensure that waste and adverse environmental impact are minimised.
Achieve the highest standards of safety in making and using products of all kinds.
Provide the processes and products which give the people of the world shelter, clothing, food and drink, and which keep them in good health.
Work with other disciplines to seek solutions.
Engage in honest and open dialogue with the public on the challenges presented by manufacture of the products which the public requires.
Promote research to allow the profession to respond fully to global demands.
Encourage the brightest and best young people into the profession, and promote lifelong professional development.
Therefore we must co-operate together and recognise each other's efforts in striving to meet this challenge.
We acknowledge that this challenge cannot be met by our efforts alone, but this does not lessen the responsibility to pursue it.

Fig. 4. The London Communiqué.

skills in systems design to achieve good social outcome. It cited honest and open dialogue with the public, but did not refer to a partnership between the profession and the community in which it operates.

This communiqué is a marvellous start in that it is a concerted effort by the leaders across the profession. It is a long way however from a code of practice. It is a statement of intent and an encouragement to the profession, but not a commitment.

The London Communiqué, the efforts of IChemE through the Future Life report and the CRYSTAL Faraday Partnership, the commitment of AIChE to sustainability through the CWRT Industry Alliance, the efforts of individual companies such as Alcoa, are all positive steps but they may not be proactive enough.

Proactive commitment is possible. This can happen by our societies and institutions adopting a strategic framework whereby

- Practising chemical engineers must commit to the London Communiqué in order to retain their licence to operate.
- Courses to be accredited base teaching on a strategic framework for sustainability.
- The profession (and in particular the societies and institutions) are proactive in communicating with the wider public.
- A commitment is required — implemented within a framework, supported and promoted by the societies and institutions that represent the profession.

4.4. *What are the options for a strategic framework?*

A strategic framework for chemical engineers is required, as for example suggested by The Natural Step[2] (a good example) or the Global Reporting Initiative (GRI)[3]. As a structured framework, the Natural Step is about the science, life cycle analysis (see Fig. 5).

One concern regarding The Natural Step is that the goals are too broad, with targets for chemical engineers a long way from where we are now. A better approach could be through initially targeting reduction of wastes within a set timeframe or adopt a current strategy being used. The CWRT project to determine minimum energy requirements for certain chemical processes may be a good start in specific areas of process engineering.

A further framework for consideration is the Global Reporting Initiative (GRI), which is about indicators for measuring economic, environmental and social impact — regulatory in nature, but a voluntary exercise (Fig. 6). The GRI is in the process of establishing a global presence and a credible guidelines-setting process for environmental reporting. Early in 2001 the GRI circulated its members and interested friends to engage those able to offer the resources, legitimacy, technical excellence and global standing to achieve its mission in the long term. Their aim is to establish the GRI as a permanent, independent and international institution in 2002.

The concern raised by some with regard to the GRI is that it does not offer directions on how to go about improving underlying systems and processes in order to achieve sustainability. Also, that it is not sufficiently focused on active community interaction.

Engaging in strategic initiatives such as the Global Reporting Initiative is one process. Another is to engage with the community more directly. A good example of effective direct community interaction is the recent initiative of BHP Cannington. This BHP-Billiton mine in Australia engaged the North Queensland Conservation Council (an independent community-based environmental advocacy group) to create a robust external environmental appraisal of their operation. "This innovative partnership brought together for the first time in Australia (and probably the world) both

[2]See: http://www.naturalstep.org
[3]See: http://www.globalreporting.org

The Natural Step Cyclic Principle (www.ozemail.com.au/~natstep)
Basic science and the precondition of our lives lead to the cyclic principle. This means that waste must not systematically accumulate in Nature, and that reconstitution of material quality must be at least as large as its dissipation. Consequently, all matter must be processed in cycles. This avoids a systematic shift in environmental parameters and enables the continuing diversity of Nature and human activity.
From the cyclic principle, four conditions for the maintenance of quality in the whole system can be deduced.

There should be no systematic increase of:

(1) **Concentrations of substances extracted from the Earth's crust.**
This means substituting certain minerals that are scarce in nature with others that are more abundant, using all mined materials efficiently, and systematically reducing dependence on fossil fuels.

(2) **Concentrations of substances produced by society.**
This means systematically substituting certain persistent and unnatural compounds with ones that are normally abundant or break down more easily in nature, and using all substances produced by society efficiently.

(3) **Degradation by physical means.**
This means drawing resources only from well-managed eco-systems, systematically pursuing the most productive and efficient use both of those resources and land, and exercising caution in all kinds of modification of nature.

In a sustainable society:

(4) **Human needs are met worldwide.**
This means using all of our resources efficiently, fairly and responsibly so that the needs of all people on whom we have an impact, and the future needs of people who are not yet born, stand the best chance of being met.

Fig. 5. The Natural Step.

sides of the traditional mining/environmental divide to jointly develop a sound and portable methodology for assessing sustainable development in mining operations. This project has shown the way for other such partnerships around the world."[4]

This proactive approach to community interaction is increasingly necessary when the rules of engagement change and wild swings are observed as communities seek solutions to their concerns that may border on uneconomic idealism. There is potential to shape the language of public debate through educating the community in the concepts of risk analysis — the cost–benefit trade-off in green and clean production strategies and other such processes.

[4]AMEEF — 2001 Awards, Community Award finalist, see: http://www.ameef.com.au/awards

The GRI aims to help organisations report information:

- in a way that presents a clear picture of the human and ecological impact of business, to facilitate informed decisions about investments, purchases, and partnerships;
- in a way that provides stakeholders with reliable information that is relevant to their needs and interests and that invites further stakeholder dialogue and enquiry;
- in a way that provides a management tool to help the reporting organisation evaluate and continuously improve its performance and progress;
- in accordance with well-established, widely accepted external reporting principles, applied consistently from one reporting period to the next, to promote transparency and credibility;
- in a format that is easy to understand and that facilitates comparison with reports by other organisations;
- in a way that complements, not replaces, other reporting standards, including financial; and
- in a way that illuminates the relationship among the three linked elements of sustainability — economic (including but not limited to financial information), environmental, and social.

The GRI's Sustainability Reporting Guidelines encompass the three linked elements of sustainability as they apply to an organisation:

Economic: Including, for example, wages and benefits, labour productivity, job creation, expenditures on outsourcing, expenditures on research and development, and investments in training and other forms of human capital. The economic element includes, but is not limited to, financial information.
Environmental: Including, for example, impacts of processes, products, and services on air, water, land, biodiversity, and human health.
Social: Including, for example, workplace health and safety, employee retention, labour rights, human rights, and wages and working conditions at outsourced operations.

Fig. 6. The Global Reporting Initiative (http://www.globalreporting.org/).

There is no doubt that a strategic framework for community interaction, which focuses on the elements of sustainability, is required by the chemical engineering profession. There is not currently an 'off-the-shelf' framework that is a universal good fit. We need to work on it.

4.5. *Sustainability as a framework for proactive community interaction*

Issues in sustainability that fall within the 'control' of chemical engineers include the core elements of The Natural Step and GRI — Life Cycle Analysis and criteria for monitoring performance. These core elements fit well with elements that are

- *In the teaching of the profession:*
  A greater emphasis on life cycle analysis and sustainability as the key element in all subjects. Also, training in stakeholder engagement.
- *In the activities of our professional societies:*
  Proactive in promoting sustainable practices within the profession and in communication with the wider public.
- *In the practice of the profession:*
  A commitment to the London Communiqué in order to retain a licence to operate and an understanding that proactive community interaction comes with the territory.

Fig. 7. Interacting with society — features of a framework.

the essence of chemical engineering — mass and energy balances, rate processes, HAZOP analysis. Other important factors include

- a focus on risk analysis,
- indicators for effects on the community, and
- guidelines for informing and educating stakeholders.

Such a framework would be acceptable to both the profession and the community — acceptable to the profession because it is "do-able", that is to say that it is possible to practise the profession within the framework, and acceptable to the community because the framework sits on a common ground of mutual interest in sustainability and, as such, enables a common language for dialogue.

How might such a framework be implemented? At one level, implementation should include the following steps

- Adopted into the chemical engineering curriculum.
- Included in further education and training programs.
- Guidelines stipulated by the societies and linked to certification.

This is all well and good, but at a fundamental level it is the individual chemical engineer who is most important in the process of implementation. This is because it is the totality of the actions of the individual within the profession that is the most significant part of community interaction. Therefore, encouraging proactive interaction of professional chemical engineers is necessary. In a support role, our societies and institutions have a role in education and advice to government, as spelled out above and earlier in this chapter.

In considering development and implementation of a framework, it is important also to be aware of potential road blocks to success, namely "Is the profession ready?". Is there other work that needs to be done first? Has enough of the background work been done to start implementing something that will be useful or successful over the next 3–5 years? With such a rapid pace of change, will anything conceived today have relevance tomorrow?

The fact remains that we have to do something. There is no indication that the community will lose interest in sustainability. In fact, we are more likely to see the focus intensify. It may be that a necessary factor is the need to ensure the approach we take is flexible, and not limited to today's perception of sustainability but what innovation may provide for tomorrow.

The implication of not adopting a strategic framework for sustainability, as discussed throughout this chapter, leaves the profession vulnerable. There is a need to be proactive in a structured way. A possible framework would encompass the features shown in Fig. 7. For any framework for community interaction to be successful, it must also incorporate the three key elements of trust:

- stick to the facts,
- state your intentions clearly,
- be consistent.

And, in stating the facts and your intended course of action, remain open and honest about the consequences.

5. Conclusion

We end with a proposal. In addressing the topic of chemical engineering and the community, we strongly advise the need for the profession to be more proactive in its interaction with the community. Sustainability is proposed as a strategic framework for such interaction and, indeed, as an overall framework for the profession as it moves into the 21st Century.

There is a need to be more proactive on sustainability because technology and society are changing. Without action, we run the risk of becoming less effective. It can be concluded from the success of others — e.g. Research!America — that being proactive works well, but requires a framework.

We note the likelihood of a World Council of Chemical Engineering being formed. This presents an excellent opportunity to consider potential frameworks and adopt or develop a suitable one for the profession.

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Chapter 4

The Chemical Engineer and the Community

Robin Batterham

Rio Tinto Limited, GPO Box 384D, Melbourne, Victoria 3001, Australia

1. Introduction

The pace of change is increasing at an exponential rate. In his opening address, Lord May indicates "science has expanded more in the past half-century than in the sum of all previous human history" and there is no issue more public today than science and its impact on society. Stem cell research and the debate on use of embryonic cells, potential implications of the hydrogen cell, use of nano-technology, not to mention the developments in fibre optics and computer processing capabilities are all very current issues. 15% of power consumption in the USA is used to power the internet (compared with close to zero 9 years ago). The digital power is there and people are using it — the ability to disseminate information and share knowledge is driving continuous innovation at amazing speeds. A revolution is occurring — some refer to the digital revolution (which is the process), the knowledge revolution is the outcome.

So, what does this means for society? The original, more traditional lines of communication were hierarchical in nature. People trusted companies and governments to disseminate information down through fixed channels. This can be referred to as the 'hub-and-spoke' method of communication, where information disseminates from a central core through fixed lines projected radially. Some people may have been sceptical of the news they received, but the means of questioning the information, gaining evidence to support their position, proving possible discrepancies and letting others know their concerns was not so straightforward. The new way information flows is less hierarchical, more interlinked. The mechanisms are available to easily access information on the same topic from more than one source. The framework is networks and they are reshaping the way people communicate and changing the way we live and work. Increasingly, we are relying on networks for our knowledge. And the knowledge gained is driving innovation and creating needs, which the technology network supplies. In this context, how is the chemical engineering profession adapting? And, more to the point, why is it important that they do?