The Responsibility of being a Chemical Engineer

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It is a great personal honour to be asked to present the fourth Kennedy-Wunsch Lecture, particularly since I am following such eminent chemical engineers as Professor Miles Kennedy, Dr Kevin Marshall and Graeme Robertson. I am also doubly honoured since I am the first graduate of Chemical & Materials (C&M) engineering at Auckland University to be asked, and that it was possible for the lecture this year to actually be held at my alma mater.

Donald Sandys Wunsch

I am going to speak about the importance of Professor Miles Kennedy in my life later, but I am sure that many of you here tonight, and others reading this material will have no idea who Donald Sandys Wunsch was. So, I will give you a very quick summary of his life and why he is honoured and remembered annually through this lecture. He was born in 1887 near Manchester in England. His academic record includes an MA in chemistry and distinction in mineralogy (from Oxford University) and a BSc (from McGill University, Canada). In 1923 he was a founding member of the Institution of Chemical Engineers, London. After working in UK and Nigeria he arrived in New Zealand in 1929 to manage the New Zealand Sugar of Milk and Casein Company factory at Edendale in Southland. He spent the rest of his working life in the lactose industry. Recognising the need for chemical engineers in that industry he encouraged the founding of the chemical engineering department at Canterbury University College in 1944. He was a member of the Council of the Department of Scientific and Industrial research from 1943 to 1958 and its chairman from 1955 to 1958. In 1957 he was made an OBE for his services to science. Sandys Wunsch died in August 1973, but is remembered as one of the pioneers of chemical engineering in New Zealand.

My University Years (1966 – 1976)

Since I was a graduate of Chemical & Materials Engineering from Auckland University, the question is, how did Miles Kennedy, the Head of the Chemical Engineering Department at Canterbury University play such a critical role in my life? To answer that I will go back even further to try and explain how I came be interested in chemical engineering in the first place and how I ended up at Auckland University. I am still unsure exactly how or when my interest in chemical engineering arose, but in retrospect I know that my best exam marks were always in chemistry and mathematics and as a child and teenager, I was always pulling things apart to try and understand how they worked, and sometimes I was successful at putting them back together again! So chemistry and engineering seemed like a starting point, but I think that I was heading towards a chemistry degree with the aim of being an industrial chemist until my father introduced me to the chief chemist at the factory where he worked. I suddenly realised that a life with test tubes and routine chemical analysis was not for me, and this profession called chemical engineering would be worth a try. Having made that decision, much to my surprise I found in early 1966 that my marks in the University Entrance Scholarship exams were good enough to get me direct entry into chemical engineering. But that would have meant going to Canterbury University since the 1st Professional year of Chemical & Materials Engineering at Auckland did not start until 1967. I was totally unprepared for the Canterbury option, so I settled back to do my Intermediate year in Auckland. And a great year of under-indulgence in study and over-indulgence in everything else it was!

So in 1967, along with nine other colleagues I started 1st Professional Chemical & Materials engineering at Auckland University. However it was not in Auckland, or at least not on the Auckland campus, but at the engineering school at Ardmore (very close to the Ardmore Airport). This has always been a very close-knit group, bonded by the dubious honour of being the only Ardmore Chemical & Materials engineers!

In 1968, there were 11 of us, when Rod McDonald joined us as a direct entry into our 2nd Professional year, and by then there were some facilities (for instance, chemical and materials laboratories) in Symonds St. That meant that we lived in town and I estimate that we spent 40% of our time at Ardmore, 40% of our time on the Symonds St campus and 20% of our time travelling backwards and forwards between the city and Ardmore. At the end of 1968, the Ardmore engineering school was closed, so that in 1969 all engineering courses were being presented at the Symonds St campus. At the end of that year, we finished the course, with four 1st-class honours and three 2nd-

class honours from the 11 in the class. Professor Alan Titchener, who at that time was Head of Department, had always said that he wanted only a very small and high-achieving first C&M class, and the results certainly reflected that. One of the more interesting aspects of my four years as an undergraduate is that I was probably a B+ student until in May 1969 (one third the way through my final year), when I got married to Julie. Obviously Julie's influence or the stability of married life was such that my final year marks were high enough to drag me up into First Class Honours.

So what to do then? It was not necessarily the best time to look for a job, so with a University Postgraduate Scholarship under my arm and my wife stuck in Auckland since she was still only part way through nursing training, in early 1970 I started my PhD. Klaus Moller, Geoff Tegg, Bob Andrew and Murray Sargisson also came back to do postgraduate studies. After two years full time research, Geoff Tegg and I were appointed part-time Junior Lecturers in 1972. While much of our work was to assist in laboratories and tutorials, the two of us did lecture half each of Thermodynamics 1 during that year. To this day I do not think that I have ever fully understood thermodynamics, so I have probably tainted some of those 1972, 1st Professional year students forever.

By early 1973 I had finished all my practical work and had started to write up my thesis, but with a young baby at home I needed a job. So in April 1973 I started working for the Department of Health as an Air Pollution Control Officer under the newly-passed Clean Air Act 1972. My monetary issues were eased, but my biggest problem was that my PhD thesis had not been completed, and it took me until early 1976 to complete and submit it. In the meantime my esteemed colleagues, Klaus Moller and Geoff Tegg had submitted their theses and both had left for Scandinavia having been awarded their PhDs.

The story has been long, but at last Miles Kennedy becomes part of it, since my examiners were; my supervisor, Peter Spedding, and two externals, one of whom was Miles Kennedy. The initial decision regarding my thesis was not good; Peter Spedding recommended pass, Miles Kennedy wanted some level of re-writing and the other overseas examiner rated it a fail. I remember vividly a meeting that I was asked to attend between Alan Titchener and Miles Kennedy. They agreed that the three of us could get the thesis across the line, and after, what I understand was degree of persuasion; they convinced the third examiner and the university that my thesis could be lifted to a pass level. After a couple of months of re-writing including lots of input from both Alan and Miles, I re-submitted the thesis and was awarded my PhD. Obviously I therefore owe both the late Alan Titchener and Miles Kennedy an eternal debt of gratitude for their personal intervention in helping to get me across the PhD line.

The Technical Years (1973 to present)

For over 20 years between April 1973 and August 1993 I worked for the New Zealand Government. As I mentioned above, my first job was as an Air Pollution Control Officer in the Department of Health. The recently enacted Clean Air Act 1972 required that all large and polluting industry be given licences by the Department of Health, and I was part of a team of chemists, chemical engineers and other scientists who had to visit each of the prescribed industries, negotiate licence conditions on behalf of the Department of Health and finally issue licences for all these "polluting" operations. This was an extremely interesting role, particularly for a raw graduate whose only experience was research for a partly finished PhD. Even though I was based in Auckland, I spent extended periods in Christchurch and Dunedin, clambering over industries in Canterbury, Otago and Southland. This was a great job for a young chemical engineer, since I was exposed to so many different chemical, mechanical and other processes, some of which were well-designed and operated through to others that were both poorly-designed and poorly-operated.

My first substantial chemical engineering project arose in 1975 and 1976. Following a series of environmental incidents at sulphuric acid plants around New Zealand, I was asked to carry out an in-depth safety and hazard survey of all the plants in New Zealand. Due to fertiliser subsidies that were in place at that time, I think that there were about 15 plants in the country, all of which were Simon Carves designs except for the Lurgi plant in Wanganui. The outcome of this work was a major report to the industry and an overall raising of design, process control and operational standards.

I spent most of 1977 and part of 1978 in the UK on a Confederation of British Industry (CBI) Overseas Scholarship working for Sim Chem Ltd and BP Chemicals Ltd (but more about that later).

On my return to New Zealand I recommenced working for the Air Pollution Group of Department of Health, but in a different role; a role that continued with minor changes until the Clean Air Act was replaced by the Resource Management Act in 1991. I was now not part of the licensing and enforcement team, but I led a group that provided engineering, chemistry and other scientific back-up services to the Air Pollution Group. As well as managing various groups of staff over this period, I also got heavily involved in the science behind air quality and air pollution. Examples of the types of work that I got involved in over those years include -

- I pulled together all the air quality monitoring data that I could find that had been collected in New Zealand, set up a location, pollutant and monitoring method system, wrote large parts of the database software that would ultimately hold all this data and then finally coordinated the data entry of all the available data.
- I wrote some of the first atmospheric dispersion models, such as GASDIS and DUSDIS and ran those models to predict pollutant levels downwind of many polluting and large industries. When overseas models became available in the late 1970s, such as from the US EPA, it was my role to get the models running and provide a dispersion modelling service to the enforcement team.
- I provided back-up and engineering support to the enforcement team as and when required.
- I carried out most of the post-event analysis regarding the spread of effects after the fire at the ICI factory in Mt Wellington in December 1984, using a number of the basic tools that had been developed after the February 1973 Parnell fumes incident, and more recent incident and fire models.
- I carried out or co-ordinated the Department of Health response, including science and engineering to such major projects as the aluminium smelter that was proposed for Aramoana in the late 1970s and into developing standards for the spray disposal of secondary and tertiary treated municipal liquid wastes.

Obviously there was not a lot of pure chemical engineering in this work, but by the late 1980s I realised that I had been involved in or spent time on nearly every industrial plant in New Zealand that did or could emit air pollutants. This meant that I considered myself armed with enough knowledge of New Zealand industry, air quality, air pollution abatement, meteorology, atmospheric dispersion modelling, etc to be able to work as an air pollution consultant. I think that my first truly non-Department of Health consulting job was for Rob Fisher at what is now known as the Bombay Quarry, owned by Holcim Aggregates Ltd. Soon after that I did all the air quality studies on the landfill that was proposed for the Winstone Mt Wellington quarry. I mention that project since all members of the consulting team were provided with training in evidence presentation and cross examination that has been invaluable to me as a consultant over the last 20 plus years.

After a period of relative stability in my work-life, by the late 1980s there were a number of changes occurring within the Department of Health. The National Environmental Chemistry and Acoustics Laboratory (NECAL) which I was now in charge of, was moved into DSIR Chemistry, and then a few years later become part of the Crown Research Institute (CRI) known as the Institute of Environmental Health and Forensic Sciences (IEHFS) Ltd (now ESR Ltd). I continued carrying out some consulting projects from within the public service during this period, but by mid-1993 I was very frustrated with working for the government and more particularly with the CRI environment. Even though I was within part of the New Zealand Government that should have facilitated my working as a consultant, I found the various constraints of management, public-contestable funding and private consulting just too difficult. So after lots of talking to Rob Burden (the CEO) and Jim Hodges (one of the Senior Principals), I was persuaded to join Woodward-Clyde (NZ) Ltd in August 1993 as a Principal Engineer. I had three extremely enjoyable years in this role, working with Terry Brady (an excellent chemist who should have been a chemical engineer), Louise Wickham, Kirsten Lawrence (nee Arthur) and Andrew Curtis (all Auckland C&M graduates). These were the early years after the introduction of the Resource Management Act 1991, and we were extremely busy working for most of the industrial concerns in New Zealand. For me it was very similar to the first five years or so after introduction of the Clean Air Act 1972, when the opportunity arose to climb all over and get to understand so much about New Zealand industry. It also meant that I was able to hopefully add value to the consents that were needed by colleagues, such as Murray Sargisson (a fellow 1969 graduate) at Danco (NZ) Ltd.

From 1996, when I became New Zealand Manager for Woodward Clyde, my capacity to carry out consulting was reduced. The constraints of management became more obvious following my move to Sydney in early 2000 and even more comprehensively after my appointment as Asia Pacific Manager for URS. But I have still carried out some significant projects, more often-than-not in a peer review and expert witness role, for instance -

- Hampton Downs (Waikato) and Kate Valley (North Canterbury) landfills
- Gold mines at Fosterville and Bendigo (Victoria)
- Long term containment facility for hazardous wastes, for Major Projects Victoria (near Mildura)
- Cement plant for Holcim New Zealand Ltd at Weston (Otago)

Looking forward, I guess that as I wind down some of my governance roles, I will keep my hand in as a part-time consultant through my new consultancy, Delaney Jones Gillett & Associates Ltd.

Management, Leadership and Governance (1978 to present)

I always set out to be an engineer, and even though I have some reputation as a consulting engineer, I guess most of those people who have come into contact with me over the last 20 to 30 years would recognise me as a manager or company director, rather than as an engineer. On looking back I find it quite amazing how, when one works for an organisation such as the New Zealand Government, and the system perceives that you have some management and leadership capability, who and what groups one can end up managing.

My first foray into looking after staff was when I was made Section Leader at the Department of Health's Environmental Laboratory in Auckland in March 1978. My staff at that time included 2 physicists, a combustion engineer, a mechanical technician and 7 electronics technicians. When the Director of the Environmental Laboratory (Norm Thom) became more involved in Department of Health Head Office functions in the mid-1980s, I became Section Leader (Scientific Services), effectively Deputy Director, controlling all the scientific and technical staff at the Environmental Laboratory and the National Acoustics Centre (which by then was called the National Environmental and Acoustics Laboratory, NECAL), which varied from about 15 to 25 in number.

On Norm Thom's retirement, I took over control of NECAL in October 1988 and managed its transfer from the Department of Health to DSIR Chemistry, which took effect on 1 April 1989. Once the whole laboratory had been transferred to DSIR I was appointed the Environmental Services Manager (Auckland) and Government Analyst based at what was then known as DSIR Chemistry's NECAL Laboratory in Mt Eden. I also managed all the Environmental Health Group staff in Auckland, which included the Food Safety Group situated at the Mt Albert DSIR Campus. I always thought it highly ironic that a chemical engineer had ended up with the title of Government Analyst. As far as I am aware, I am the only chemical engineer to have "worn" that legislated title.

In 1992, the New Zealand Government corporatized the government-owned research organisations (primarily DSIR) into ten Crown Research Institutes (CRI). I was appointed the Northern Regional Manager for the CRI that dealt with forensic services (primarily to the New Zealand Police), public health (primarily to the Department of Health), and a wide range of other environmental health research areas. It was originally known as the Institute of Environmental Health and Forensic Sciences (IEHFS), but is now known as ESR Ltd. I had about 100 staff in Auckland, and I reported to the IEHFS Managing Director who was based in Wellington.

So by the time I had left the New Zealand Government in August 1993, I had managed physicists, electronics technicians, chemists and chemical technicians, combustion and chemical engineers, acoustics scientists and engineers, audiologists (I forgot to mention them earlier), food and water scientists, illegal drug analysts and forensic scientists. I did not know at the time how such diverse management and leadership training was going to lead me into much larger and more complicated roles.

At the same time, when I joined Woodward-Clyde (NZ) Ltd in August 1993, I had no management, leadership or governance aspirations. I simply wanted to work as a consultant engineer. So for three years, I steered clear of any management type roles, until in August 1996, the New Zealand Woodward-Clyde manager resigned relatively unexpectedly, and due to my past experience I was asked to manage the New Zealand operations. I did that for a

little over three years, during which time Woodward-Clyde had been sold to URS Corporation (NSE: URS) and then URS bought Dames & Moore in mid-1999. It was the latter acquisition that took me to Australia. URS (because it owned Woodward-Clyde) and Dames & Moore were fierce competitors, particularly in Australia. So when the acquisition of Dames & Moore occurred, there was a terrible clash of cultures and lots of staff unrest and departures. The NSW manager had resigned as part of the upheaval that occurred in the Sydney office, so in January 2000 I was asked to spend six to nine months in Sydney attempting to calm the office down and find a permanent manager. I found my NSW replacement but before I could return to New Zealand I was offered the role of Asia Pacific Manager for URS, based in Sydney.

My Asia Pacific role was not only to manage all the URS offices and staff from China, through SE Asia, the Philippines, Indonesia, Australia and New Zealand, but also to grow the company from what was predominantly an environmental engineering operation, to a mixed infrastructure and environmental company, with a significant overseas aid component. This was a major task for a chemical engineer from New Zealand, with primarily an environmental background. The key, as it always had been, was to find key players in the area of focus, e.g. roading or dams, and then built teams around them. This period, until I left URS at the end of 2007 was a period of great learning for me. I had offices to close down, new offices to establish, acquisitions to consider and bring to fruition, project risks to continuously be determined and legal issues to fight, all at the same time as grow the business and keep making profits! When I left URS at the end of 2007, I left behind an operation with offices in China, Singapore, Australia and New Zealand, with about 1,500 staff and turning over about A$200m.

My main decision then was; did I want to take on another CEO role, go back to consulting or look at other opportunities? I choose a combination of the last two, with a focus on developing my governance roles. I will not go through a long-winded sequence of the last six years, except to note the following summary –

- I am currently Chairman of publicly-listed Orbital Corporation (ASX: OEC). Orbital is a leader in specialised engine and vehicle systems and is based in Perth. I have been a non-executive director of Orbital since April 2008 and Chairman since September 2013.
- Since March 2008 I have been Managing Director of Bermand Pty Ltd, which offers some technical consulting services and is the company through which I contract some of my governance roles.
- I have been Chairman of Christchurch-based SciTOX Ltd (a private technology company developing a rapid BOD and toxicity measuring system) since December 2008.
- Non-executive director of Kimbriki Environmental Enterprises Ltd (KEE) since July 2011. KEE is an independent waste management company owned by four Sydney local authorities.
- Chairman of Bencallaur Pty Ltd (a private integrated 3rd generation crude biofuels and renewable chemicals company based in Sydney) since October 2011.
- Managing Director of Delaney Jones Gillett & Associates since March 2013. DJG & Associates is an independent business and project services organisation meeting the needs of clients in planning, initiating and executing projects in Australia.
- Non-executive director of Pacific Environmental Ltd (ASX: PEH) from July 2009 to June 2012 and Chairman from February 2010 to May 2012. Pacific Environment is an environmental services and technology company based in Sydney.
- I was a member of the Advisory Board of the Consulting Group within Downer EDI Ltd from August 2008 to April 2011.

It is the unusual mix of technical, leadership, management and governance roles that I am lucky enough to have been involved in over the last 40 years that put me in a position where I feel that I can comment (or is that, pontificate) about the roles and responsibilities of chemical engineers.

But before I get on to that, I want to talk about the chemical engineering profession and what it has meant to me and why I am so passionate about it.

The Profession

I am unsure as to when and why I became interested in becoming a professional or chartered engineer; maybe it was Mike Allen, since I cannot remember any of our other lecturers at that time being heavily involved in IChemE, or it might have been my first boss at the Department of Health, R.T. (Terry) Douglas. All I know is that in 1976 I first made enquiries to the Institution of Chemical Engineers, UK, about becoming a Member. I was less-than-impressed when I realised how hard gaining membership was going to be, particular since I was in the midst of my PhD difficulties at that time. The difficulties were based on the fact that the C&M course at Auckland was not accredited during my time there, and was not first accredited until 1974 (for graduates of that year). My only options for membership were therefore through additional practical/design experience or via a further examination route, and I was certainly over studying and examinations by that time.

To try and overcome this difficulty my boss at that time, Terry Douglas and I decided that I should apply for a Confederation of British Industry (CBI) Overseas Scholarship which would enable me to work as a chemical engineer in the UK for a period of between one and two years. So after applications being filed and interviews undertaken, in early 1977 I was awarded a CBI Overseas Scholarship and was given overseas study leave from the Department of Health. I spent six months working for Sim Chem Ltd which was the process engineering division of Simon Carves Engineering Ltd (a large UK engineering contractor, who had designed and built most of the sulphuric acid plants that I had surveyed in New Zealand during 1975 and 1976), four months with BP Chemicals Ltd at Baglan Bay in South Wales and a couple of months on shorter assignments and visits.

This experience, plus my PhD (which I had finally got by then) meant that when I did formally apply for membership it was granted in April 1979 at my first attempt. In 1996, Mike Allen reminded me that I should apply to be a Fellow, which I did, and I have been a Fellow of IChemE since July 1996.

I have always been a strong believer that if a professional body has given me a qualification then I should get more involved than simply gaze at my certificate on the wall. To that end, I first sat on the New Zealand national committee of what was then the Society for Chemical Engineering in New Zealand (SCENZ) in the mid-1970s, at a time when Dr Basil Walker was the Chair and eminent chemical engineers such as Drs Dick and Mary Earle were on the committee. I only resigned from the national committee when I left New Zealand to take up my CBI Overseas Scholarship. On my return to New Zealand, I served in a number of roles on the Auckland Branch committee of SCENZ from 1978 to 1993. Since March 2009, I have been the IChemE NSW Branch Chair, and also therefore sit on the Board of IChemE in Australia.

One of the professional roles that I have thoroughly enjoyed is being a member of the IChemE University Accreditation Panel. This is a group of academics and industrial or consulting engineers who have been through IChemE training and who carry out accreditation or re-accreditation of university chemical engineering courses. As it happened the first re-accreditation that I was involved in was at the University of Canterbury. The whole accreditation process is set up to enable the panel to understand in great depth how a course is structured, how the courses are taught and in particular how final year projects and design are managed. I was supposed to carry out a re-accreditation in Sri Lanka this year, but I understand that funding has slowed that process down. At this stage I am booked in to be part of the re-accreditation team for one of the Melbourne universities in mid-2014.

I was also fortunate in 2009 to be asked by IChemE to carry out a survey of the 13 accredited universities in Australia and New Zealand to see how Industry Advisory Committees operated at each chemical engineering department. The aim was to see if aspects of “best practice” could be observed, and through that process, provide advice to those departments where such committees were not operating as well as might be expected.

My involvement in the chemical engineering profession has been a significant part of my life. I can see some of my roles decreasing over the next few years, but I cannot see a time when I am not involved in the profession.

The Responsibility of being a Chemical Engineer

Since this is the title of this lecture, it is probably about time that I focussed upon this subject. There are two main areas that I will discuss –

1. The responsibility that chemical engineers need to have for the work that they get involved in.
2. The responsibility of experienced engineers, whether they be chemical, materials, or from any other branch of engineering, to get involved in passing their wealth of experience back to students and younger professionals, whether that be through our teaching institutions, the profession or via formal or informal mentoring

Responsibility for the work we do.

I quite like the simple definition that says - chemical engineers are the link between science and societal needs. Chemical engineers have been significantly involved in the raising of living standards and the wealth of the developed countries over the last century. Petrochemicals and plastics, pharmaceuticals, acids and alkalis, fertiliser, specialised coatings, etc have all become part of our daily lives through the research often by chemists and materials scientists, but have been put into production through the design capabilities and plant operation expertise of chemical engineers. It can be argued that we could quite easily do without some of these products of chemical processes, but that is not my premise today.

Therefore chemical engineers are responsible for the economical, safe, and environmentally benign production of useful quantities of vital materials. I am not going to give a full dissertation on "responsible chemical engineering", since there are far more learned papers and books on this subject. But in simplistic terms, I believe that our responsibility to society rests within the following questions –

- From a range of raw materials, have we used the most sustainable?
- Having chosen our raw materials, are we are going to use them in the most sustainable way?
- Is the process the best available to efficiently and sustainability produce the desired products?
- Has utility use, including water, fuel, other energy sources, etc been reduced as far as possible?
- What is happening to by-products? Is their re-use being maximised by options such as plant interdependency?
- What are the societal impacts, and can any actual or potentially adverse effects be minimised or removed?
- Have environmental impacts been assessed relative to world's best practice, local best practice and regulatory requirements?

It is interesting how important the word "sustainable" has become for all engineers and for chemical engineers in particular. I may be wrong, and I apologise to our lecturers if I am, but I doubt if the term sustainability was ever used during our studies from 1967 to 1969. I remember in 2004, when I was hosting in Sydney the President of a very large US company, he asked me to explain sustainable in the engineering context since it was not a term that he was familiar with in the US. I know that has changed in that country in the last 10 years, but it is still an example of how sustainability in engineering and contracting is not as well ensconced in our world as we might at times think.

When looking at the sustainability of process plant, I like the concept of industrial ecology where the system boundary extends well beyond any individual plant but also takes account of the "whole" process including the mining or pre-processing of raw materials and the downstream product and by-product use, recycling and disposal. Often the proponents of new plant and the owners of existing processes have little or no concern about such issues outside the plant boundaries. I believe that as chemical engineers we have a responsibility to at least raise these issues as far as is possible within the constraints of our positions.

These design and operational issues are also relevant to someone like me who mainly works as an advisory consultant. I remember many times when I explained to some of my greener friends or colleagues what I did as a consultant, they would respond by asking – "as an engineer with an understanding of the environment, how can you work for such a dirty industry?" The simple and egotistical answer is that – "if society wants the products of that dirty industry then it needs the best engineering and environmental consultants to ensure that it operates sustainably and with least impact on the environment". As a consultant I have worked for companies where profit is the only thing that matters, sustainability would never have been considered and where environmental responsibility was to do the bare minimum to keep away from the regulator's clutches. As any environmental consultant will know, these are very hard companies to work for, but when confronted with such a situation, the consultant has to follow the regulatory requirements and their own ethical and moral code. I would hope that companies like this that I have worked for have improved their operational and environmental processes through my input.

It is a long time since I have worked as a design engineer but my involvement with IChemE and my heavy involvement in health and safety issues as both a manager and company director means that plant design and plant operation have never been far from the top of my list of concerns. I find it fascinating the level of interest that currently exists with LOPA (Layer of Protection Analysis). LOPA courses are the most popular courses run by IChemE in Australia. They are frequently over-subscribed and additional courses have been added to the annual programme. As a manager or company director who is ultimately responsible for plant safety, I have some concerns that LOPA has both become the latest fad and the latest solution to plant safety. We only need to be reminded that at Bhopal there were five layers of protection and all failed, and the sixth layer of protection, a community response plan did not exist! Maybe I am old-school but I am more inclined to lean towards Trevor Kletz's view (first expressed in 1978) that the chemical industry should re-direct its efforts towards elimination of hazards where feasible – by minimisation, material substitution, alternative reaction routes, modified storage arrangements ("what you don't have cant' leak") and energy limitation – rather than devoting extensive resources on safety systems and procedures to manage the risks associated with the hazards[1].

One important area that chemical engineers do get involved in are ethical dilemmas, with most decisions being made based upon the individual's personal ethical standards, quite often unknowingly. But there are times when ethics can become a significant issue for engineers. A New Zealand engineering colleague of mine took an ethical stand when the company he was working for acquired a US company that was heavily involved in the US military. He believed on a personal level that the company he worked for and his personal engineering work did not fit with the new entity so he resigned.

The military connection is one that affects a large proportion of engineers during their career. URS had significant military operations, but as a company it also did large projects for the military in such areas as site remediation and weapon destruction that most people would consider ethically positive. I took the position that while countries have defence personal and weaponry, I could not take an ethical stand about working for any organisation that worked with or for the military.

However, there are many shades of grey in this ethical area. What happens when a company (publically-listed) that works in the clean tech space is asked to produce a significant quantity of highly engineered products for the military? Suddenly this is beyond the capability of the company's engineers, management or even the board to make a simple ethical decision, based upon personal ethical standards. This is what happened at Orbital Corporation. Orbital has always worked for the military; since it builds engines or engine parts that are or could be used in military vehicles. But what about engines for Small Unmanned Aircraft Systems (SUAS), otherwise known in the press as drones? Orbital was very proactive when it became obvious that there were ethical questions about current and more importantly future contracts in this space. The company decided to use Patrick McClure AO, who at that time was Ethics Fellow at the St James Ethics Centre in Sydney. In conjunction with the Board, management and senior engineers, he developed a simple decision-tree approach to making ethical decisions, which has been very successful in aiding management and the Board in ethical contract decisions. In this case it

[1] T.A Kletz, "What Went Wrong? Case Studies of Process Plant Disasters", 4th ed., Gulf Professional Publishing, 1998.

was the responsibility of the engineers, management and board to determine an ethical decision-making process and to be transparent in the use of that process.

Responsibility to the profession.

As I mentioned above, I have always been a strong advocate for getting involved in the profession. I have spent time on the Auckland and New Zealand national committees of what was then the Society for Chemical Engineering in New Zealand (SCENZ) and I have been the IChemE NSW Branch Chair and a board member of IChemE in Australia for the last five years. These are roles that I have enjoyed immensely, but due to other commitments both inside and outside the profession it is nearly time for me to pass the NSW Branch Chair and board membership of IChemE in Australia to someone with a bit more time and energy. If there is anyone here tonight who feels adequately invigorated by this lecture to put up their hand for NSW Chair, please wave frantically now.

I enjoy being involved in the University Accreditation Panel, and I see myself carrying out a few more re-accreditations for IChemE. This is an area where anyone who has a strong interest in both the education of students and the interaction between the university, industry, consultancies, etc and the profession should consider getting involved in this important process.

Now one area that I have not spent any time on so far in this lecture is one of my favourite pastimes, namely mentoring. It is not necessarily part of the "profession" but it is all about passing on knowledge and wisdom. Mentoring is one of those HR areas that gets both good and bad press. The worst mentoring situations are when an organisation decides that it is going to have a formal mentoring programme, and everyone is going to be involved, either as a mentor or a mentoree! I have been in, or seen as an external observer a number of situations where this has been attempted. I am sure there have been successful across-organisation mentoring programmes, but I would guess that they are few and far between. Every instance of successful mentoring that I have been involved in has either been when someone more junior than me has asked me to be their mentor, or when one of my peers or colleagues has asked me personally to mentor someone they consider would develop by working with me. As far as I can ascertain, informal mentoring programmes such as between junior staff and more experienced staff or between developing managers and company leaders seem to occur in a widespread way across vibrant and growing organisations. As a manager of staff for the last 35 years, I have mentored a number of engineers and managers who I considered would develop by being involved in a mentoring relationship.

I currently "officially" mentor two NSW Branch Managers, one Sydney-based Operations Manager, one New Zealand CEO and two mid-level engineers based in Melbourne. I get an enormous amount of pleasure from each of these mentoring situations, firstly though the learning experience that mentoring provides me, but mainly through what I believe that I am able to give in return. Anyone who has gained a few grey hairs and has learnt from life and work experiences can add value to others through mentoring. It is fun and I therefore suggest that you try it. There are so many younger engineers out there who are really wanting to grow through a mentoring arrangement.

As I head towards the conclusion of this lecture I need to return to the chemical engineering profession. It is certainly a profession where learning continues through one's working life. It is a profession where the mix of academic learning and reading has to be mixed fully with practical experience to make the rounded professional engineer. In my opinion, it is important that mix of academic and practical learning is passed on as far as possible to students and engineers during their working life. Without any actual or implied criticism of the excellent staff of some university departments of chemical engineering, the lack of industrial and practical experience within some departments is of great concern. On one re-accreditation visit that I made to a large chemical engineering department, I struggled to find any significant level of industrial experience amongst the staff. Having said that, I know that at times IChemE accreditation assessors can forget to look beyond their academic view of the world, when design in my opinion can really only be taught by staff who have spent some time in industry or in a design environment.

When I went through university, the practical experiences of Mike Allen were invaluable to our class. Just the very simplest of things that have stayed with me all my working life, such as “normal” gas and liquid velocities in pipes, came from Mike Allen. I know that at least two of my classmates, Warren Thomas and Bob Andrew have both spent time back at Auckland University relaying their knowledge and practical experience to undergraduate students. Dr Rob Kirkpatrick (C&M 1972) is another professional with a large amount of design, contracting and operational experience who is currently giving Auckland students the benefit of his wide experience.

So finally, I urge all older chemical engineers (I can use that term since I am one) who have worked as chemical engineers to look at how they can get involved in passing their wealth of experience back to students and younger professionals, whether that be through our teaching institutions, the profession or via formal or informal mentoring.

In conclusion, I would like to thank the staff of Chemical & Materials Engineering at the University of Auckland, firstly for the time and effort that you put into hammering unit operations, process control, materials science, etc into that first class of chemical & materials engineers, and for the work all the lecturers, tutors and technicians have put into the students who have passed through this school during the last 44 years. To my fellow “Ardmore” chemical & materials engineers and Rod, thank you for turning up tonight. I know that this is an honour for me to have given this lecture, but it is also an honour for the group of students who pioneered chemical & materials engineering at Auckland. Finally I’ll conclude with a thought for Ted Sutherland, the only one of that original class who has passed away.