“Thinking outside the pipe: unlocking potential, delivering chemical engineering futures”

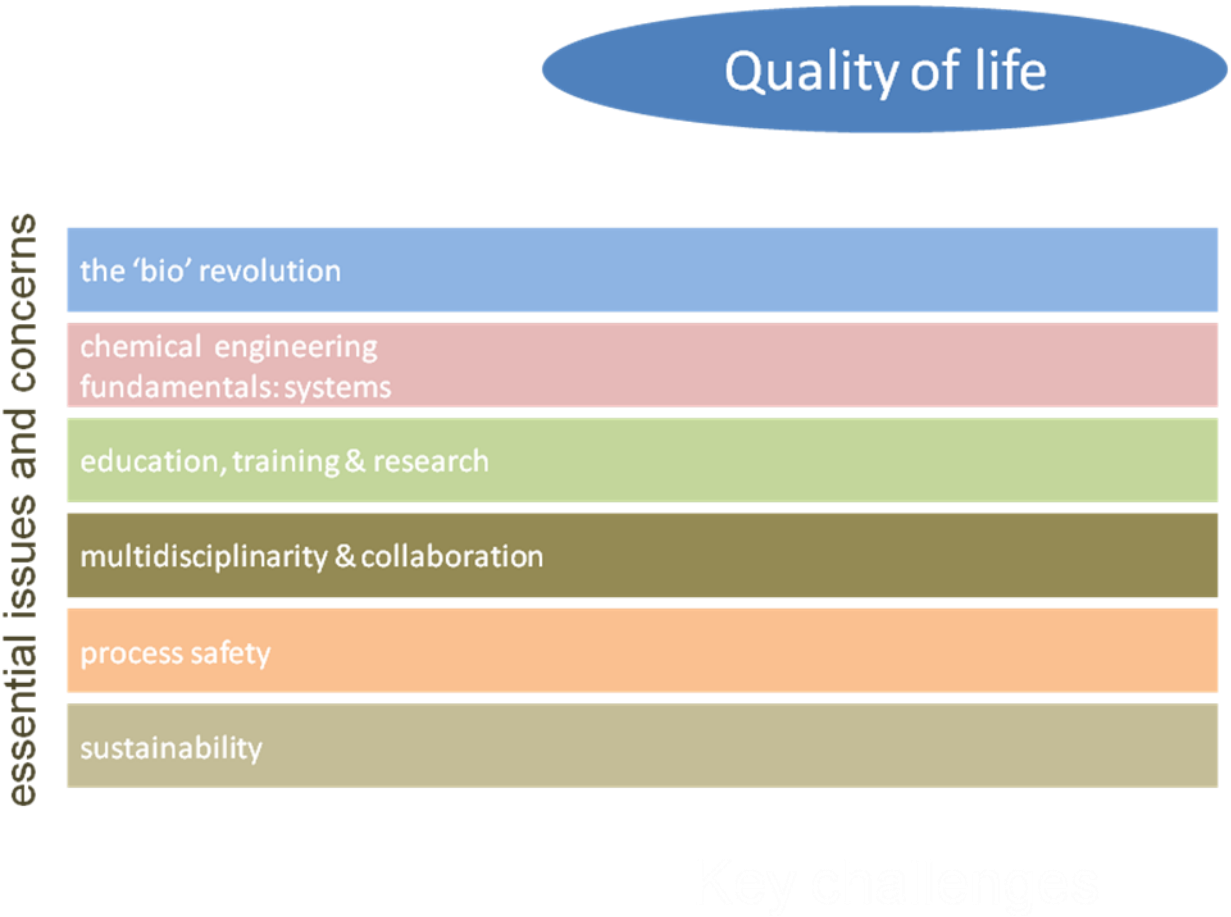
Presidential Address delivered by Sir William Wakeham FREng

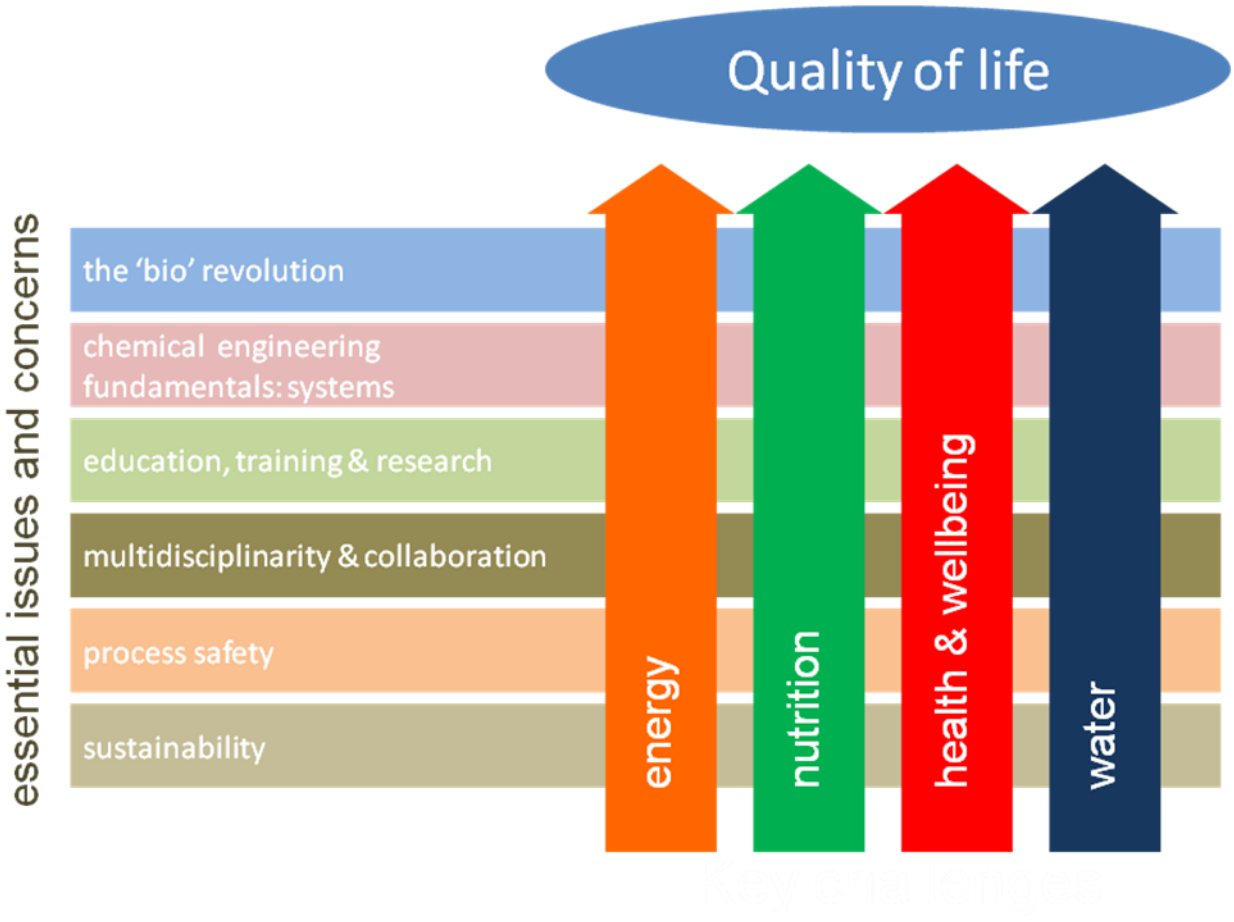
Monday 23 May 2011

My Lords, Ladies & Gentlemen

It’s a very great pleasure and an honour for me to be standing in front of you as the President of the Institution of Chemical Engineers; it is also somewhat of a surprise. My relationship with the Institution goes back 40 years and to say the least has been interesting and this is perhaps the most interesting moment. But I will say something more about that later on.

I wanted to begin by talking about the IChemE coat of arms because it describes in the way only the College of Arms can do, chemical engineering as it was seen when devised in 1964 and I will just point out a few of the things. This is a cascade of which all chemical engineering processes were assumed to include, the salamander on the bottom left is the symbol and the name for crucible in chemistry and fire associated with it is an obvious reference to heat transfer and heating, and then finally, and perhaps most importantly in a way, this is a mill rind which is associated first of all with milling corn which it is argued was the first continuous process. Now you can believe all those things if you like but I think the most fascinating one are these two integral signs at the top which are associating the discipline of chemical engineering with mathematics which is of course a very strong and continuing association. So if that was the view in 1964 I think you have to think now it is quite different and that's what I want to talk about, not the differences so much in what is happening in the world that chemical engineering serves but actually its consequences for the Institution. I want to pay tribute to Des King my immediate predecessor for his splendid leadership of the Institution over the last year and to many people before that. They have most recently concentrated on the development of the Institution's remit, the recognition of new aspects of chemical engineering both in the UK and more importantly perhaps in the whole world. What I want to focus on is to build on that but talk about how the Institution needs to respond. And I believe there are a significant number of changes and challenges for the Institution because of those developments.


Quality of life
essential issues and concerns
the 'bio' revolution
chemical engineering fundamentals: systems
education, training & research
multidisciplinarity & collaboration
process safety
sustainability
Key challenges



The challenges for engineering in general, you could even say for humanity, are often cast in these four terms and particularly in the Roadmap for Chemical Engineering Futures those are identified as four key challenges. And then there are a series of issues and concerns for chemical engineering that we need to consider.

And of course everywhere there is a node in this diagram there is something to be done; something quite substantial to be done. Among these concerns I think we obviously recognise that we want to do everything we can that is safe, sustainable but I want to pull out two words from this; one is 'multi-disciplinarity collaboration' - one phrase, and the other one is systems and particularly the systems approach that characterises much of modern chemical engineering. That I think is a unique feature of chemical engineering and it is essentially my

basic proposition that chemical engineers are among the most promiscuous, the most catholic in their interest in working with other people and solving these problems compared with any other discipline. They spread themselves widely; the discipline has spread itself over the world in a very effective manner, but each step has caused the Institution some new challenges and I think I want to express most of those challenges in terms of balances between various competing forces and I'll try and do that as I go through what I have to say.

I think I should probably give you my own personal perspective first and I want to do that by talking about the pipeline through which the traditional chemical engineer, beginning as a 1st degree entrant, perhaps these days through being interested through a lot of activities that are joint across all of engineering , and indeed more generally across all of science, - the Big Bang, E4E, particularly around chem. eng *whynotchemeng,* the OnCampus activity, Get Chartered and so on - all of which bring more students into chemical engineering and I think we recognise that chemical engineering undergraduate courses in UK at least are now roughly at saturation; there are very few places which can still absorb more students. So I think a very successful beginning to the pipeline and on the way through people go through these various stages of membership of the Institution, perhaps eventually ending up as Chartered Members and Fellows. What I am though is one of these people on the outside of the pipeline. It is somewhat ironic that the Institution was forced to move its venue for this activity from the Institution of Chemical Engineers to the Institute of Physics where I have been a Fellow for rather longer than I have been a Fellow of chemical engineering having begun life as a physicist. I am no more popular here of course because I have done a number of reviews of physics that have got me into trouble with a whole series of people, particularly those in particle physics and astronomy; but no more of that here. But my journey is therefore not

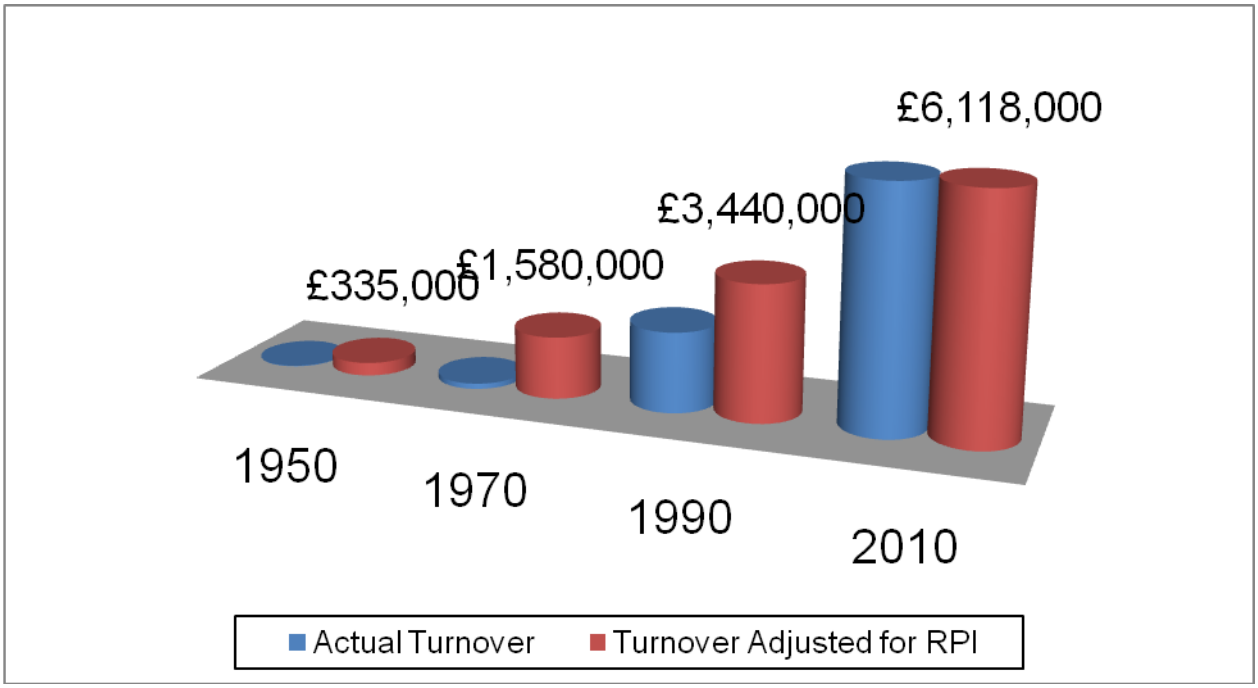
straight down this pipeline, I somehow crept across the border of this pipeline and of course we should also speak about people who escape from this pipeline - they begin on this route but transition outwards. If you teach inside a university, at least it has been my belief, you do not mind that. The process of educating people in a university is about educating them for a transient activity which will change dramatically through the 40 years of their working lifetime. They may start off as one thing but by the time they have finished 40 years of work they will have done many other things. They re-invent themselves, and what a university education is about, supported by institutions, will be around training for that journey through life which may not be down this single pipeline. We also though as an Institution need to care about these people who perhaps contribute to the evolving nature of chemical engineering as a discipline and its activities but haven't always found it easy to transition into the discipline.

So here's my journey very quickly; I began as a physicist worried about the forces between the simplest possible molecules, in fact even argon was quite complicated for us, and after training in this country I went to the United States and I met engineers for the first time and decided, or discovered, that what I was doing could be useful - and that was a bit of a shock as a physicist, in fact somewhat depressing. But nevertheless this step of designing instruments to measure the properties of fluids was a key step. It was a key step in two ways: first of all it enabled us to go backwards to these properties but it turned out - and this I had not recognised - that these properties were of interest to chemical engineers in the design of plants like this. The viscosity, conductivity, thermodynamic properties all of interest. So when I came back to the UK it was perhaps reasonable to join chemical engineering at Imperial and soon afterwards was my first interaction with the Institution of Chemical Engineers through a thing that was then called Physical Properties Data Service operated by

IChemE and subsequently operated in conjunction with National Engineering Laboratory. At Imperial College we were much engaged in this and I began to understand the totality of the chemical engineering activity that represented for me the use of what I was doing. Now there was a pure coincidence behind the fact that EPSRC, or SERC as it was at the time, stopped funding work into this because we'd solved that problem and they were rather more interested in doing this. So this is my route into chemical engineering. It was a research-based route originally but of course at the same time I was teaching and I was slowly allowed by Roger Sargent, who was then Head of Department, and Henry Sawistowski to teach chemical engineering - at least in the first two years I couldn't really do much damage there, could I? And I ended up because of the design of these instruments I did know a little bit about fluid mechanics - although Stephen Richardson who's here might disagree – and tried to implement some of those things. So that's my route. A very strange route you might think but I think not so uncommon now. In the 1970s it would have been quite an unusual route but I think its becoming increasingly common and I want to explore why that is and the consequences for the Institution.

So in many diagrams you will see this pivot with a balance of different kinds of people because the Institution is responsible for servicing what I think is a growing number of people, a greater membership, of ever increasing diversity. Diversity in what they do and where they come from. And it's my belief that that poses significant challenges for the Institution because the last thing that we would want to happen is that some people fall out of our Institution because we cannot contain them within a broad enough church. And for me that's quite a significant challenge. You can think of many areas where that might happen, where there could be a fragmentation of the totality of what chemical engineering now embraces.

Because the membership is growing very rapidly – I'll say something about its characteristics later on – but you see it has now reached 32,000 worldwide and the growth is increasingly rapid.



At the same time its turnover is increasing even more rapidly because of course the Institution is much more than merely servicing its membership; it is about organising conferences, organising events, continuing professional development and servicing a corporate and individual membership base. So quite a significant operation again growing very quickly, doubling in the last 20 years roughly speaking.

The breadth of chemical engineering, as has been explained in several Presidential Addresses in recent years, is ever more increasing. It is a feature I think of chemical engineering that it bridges engineering and science rather more effectively than any other engineering disciplines. It is also able I think to contribute to many of the improved qualities of life and we saw in the earlier Roadmap just how that operates across the sorts of things chemical

engineering does. And here I want to draw out another word which is 'process' to add to the systems approach, because I think it is really the chemical engineering ethic of understanding processes that is dominant in modern chemical engineering and also allows the modern chemical engineer to apply their expertise to processes other than chemical engineering and to illustrate that you will see here what people think and state their employment is now compared with how it was in the past.

The changing feedstock

New corporate members by stated occupation

Description	1940-45	1946-56	1963-64	1973-74	1983-84	1993-94	2011
Chemical Engineer	23%	35%	24%	17%	7%	8%	2%
Process Engineer	0%	0%	10%	8%	26%	19%	57%
Chemist	39%	15%	9%	6%	4%	2%	0%
Engineer	4%	14%	15%	19%	19%	19%	14%
Manager	23%	25%	30%	22%	34%	41%	19%
Consultant	3%	1%	2%	0%	1%	8%	3%
Educator	1%	4%	6%	7%	2%	0%	5%
Technologist	4%	6%	4%	19%	6%	3%	0%
Metallurgist	1%	1%	0%	0%	0%	0%	0%
Sales Representative	1%	0%	1%	2%	1%	1%	0%

So if you look at the top line you see the description 'chemical engineer' has decayed dramatically from 23% of people describing them that way to 2% now over 50 or 60 years, whereas 'process engineer' has gone the other way dramatically. So many more people now either think of themselves or are employed as process engineers and not chemical engineers. An interesting other side light is the third line here – 'chemists' – I think you should interpret this probably as industrial chemists not necessarily any other kind of chemist, where that was

a common title in the 1940s and 1950s but now has decayed to zero; rather few people responding to this survey described themselves as industrial chemists and that's a big change, and finally just because it is somewhat amusing you see the rise and fall of people describing themselves as 'managers' – I probably shouldn't make any comment about that. All other things stay roughly constant here, particularly consultants and educators and so on and perhaps that's not too much of a surprise.

So there's something about the change in the make up. But of course chemical engineers are immensely successful but not necessarily in chemical engineering. Here are examples of a few people – Ambani is the head of a very large chemical operation in India; Jerzy Buzek here is the President of the European Parliament, he is a chemical engineer; Mohammed Al-Mady is the head of SABIC which has taken over much of the activity of ICI in some parts of this country and is a very big chemical company, he is trained in the US; Maxwell Richards is the

President of Trinidad and Tobago and he did a Masters Degree at Manchester and has gone back to his company and then onwards into politics; and finally but perhaps most significantly this is the current Vice President of China and likely to be, if you believe political pundits, the future President, and he is also a chemical engineer. So it is obviously a profession that leads to the top in many areas and I do believe that to reflect the nature of the educational process that chemical engineers enjoy.

Chemical engineers in Hollywood!

Steve McQueen in his most famous role as USAAF Captain Virgil Hilts – The 'Cooler King'

There is one more person. Now you might think that Steve McQueen is not really a chemical engineer – and indeed that's true. But this is a clip from a very well-known film called the Great Escape and for those of you who remember it the first time Hilts gets thrown into the cooler he is throwing a baseball against the wall and his small neighbour next door asks him what he did at university was it physical education and Hilts response was 'no, it was chemical

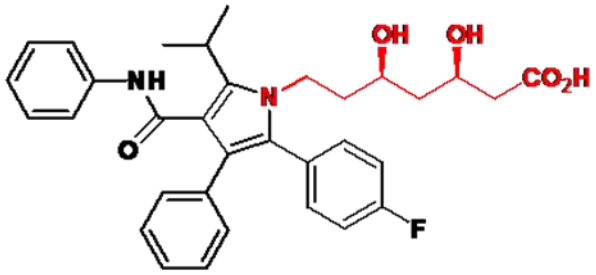
engineering'. I think as a profession we haven't exploited that single phrase quite as much as we might have done.

But aside from the people who have used their training of chemical engineering, I want to emphasise the breadth of the discipline because the bio domain is becoming increasingly important to the discipline. I will show you a little conflict later on between that and the way people are reporting themselves and where the Institution sits but I think we sitting here probably all believe that the bio domain, in various forms, various colours of biotechnology – meaning related to health, related to energy, all those different forms of bio activity – could be very, very important in the future and will broaden the discipline very considerably. It will be important for example in biofuels, biorefining, industrial biotechnology, and the size of the market is of course enormous. This particular drug, on which I am dependent along with many other people I suspect, is Lipitor and it has a very significant sale as one of the statins at the moment, and is of course the product of biotechnology. That's one dimension.

Making an impact

Growth of the 'Biodomain'

- Biofuels and biorefining
- 'Multicoloured' biotechnology
- Industrial biotechnology:
- £150bn - £360bn market by 2025?
- UK: £4bn - £12bn?



Lipitor (Atorvastatin): 2008 sales = $10 billion

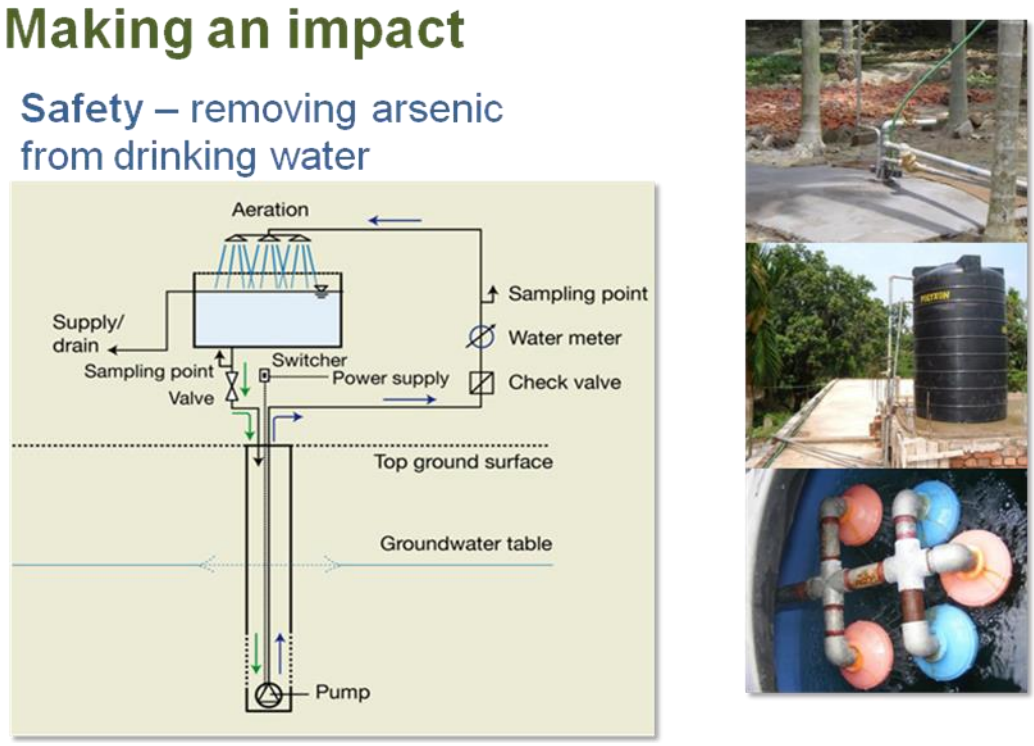
But within that you can look at very significant new developments; for example the second and third generations of biofuels will be significant. I along with Ron Oxburgh, who I am delighted to see here, were most upset by the failure to understand thermodynamics in the first generation of biofuels but by now people do seem to understand it a little bit and there is some hope now, particularly this example from British Sugar, which involves of course many chemical engineers, producing significant amounts of bioethanol by fermentation and distillation, the life cycle analysis is all there, the complete thermodynamic analysis, and of course if you combine it with the production of sugar then you can significantly reduce greenhouse gas emissions compared with the generation of an equivalent amount of fossil fuels, petrol particularly.

Making an impact

EBRI - Biothermal Valorisation of Biomass

- Consuming 300,000 t/a of biogenic waste and residue material – no conflict with food
- Delivers 580 GWh (CHP) with 15 applications required to make the council green
- Hydrogen grid with up to 60 t/d and biochar for fertilization as well as carbon sequestration

And here's the sort of thing that is going to be used 300,000 tonnes per year of waste material thus not conflicting with food – it will deliver combined heat and power of 580Gwh and several applications including this hydrogen grid, and then finally the bio chart produced in this system can be used as a means of carbon sequestration into the soil. That's a system for me and it is a prime example of how individual components are involving chemical engineering but also the complete system.



And I want to choose one more example because this is very interesting example to me. It won a prize at last year's Awards ceremony, it's developed in India by people from Queens Belfast and talks about removing arsenic from the ground water in India without any chemical intervention; the trick is to use a lot of air here to produce aerated water and thus drive the bacteria that make it unsafe because they're reducing bacteria in the ground as they stand to make them oxygenating and oxidising bacteria and thus remediate the ground water. And of course that means this system needs essentially no maintenance and is continuous in its operation. Now all those things are very different from the traditional view of chemical engineering based on an oil activity and I think that is going to be the future of the discipline. It will be an increasing component.

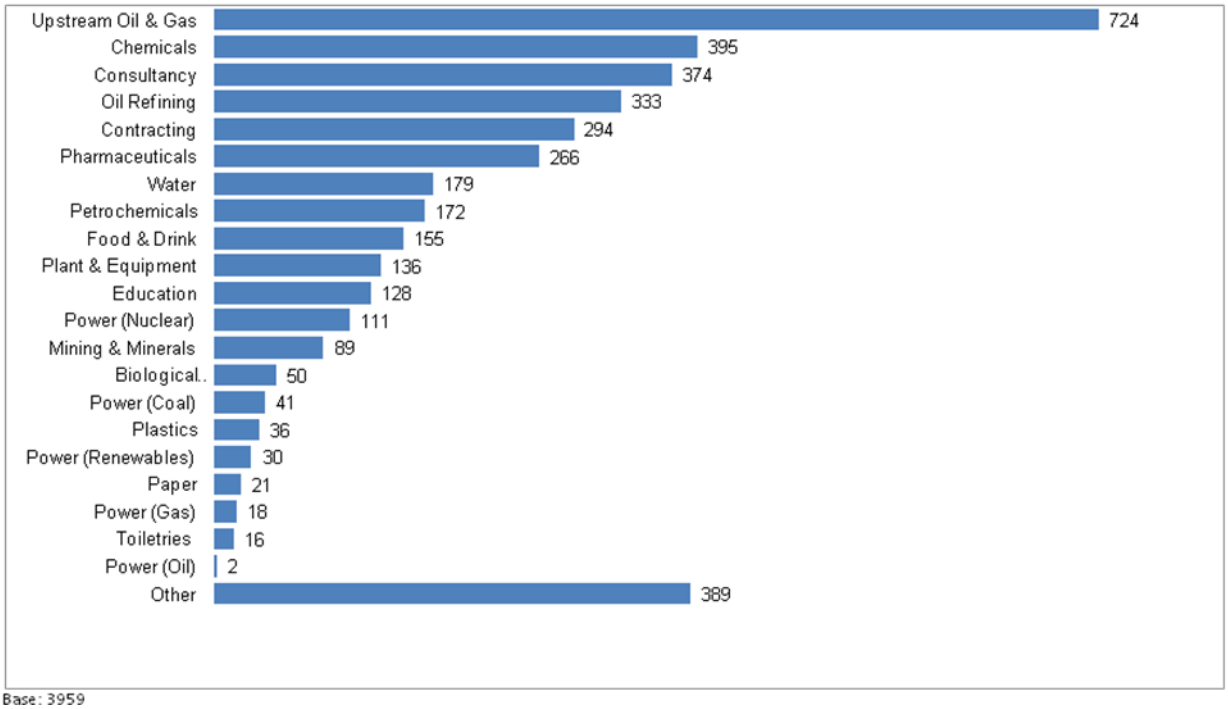
But it'll be one example of a balance to balance that new activity against the traditional. I'll show you later that the traditional activities are still dominating employment in the sector and yet we know we have this growing piece coming at us.

Many of those new pieces will involve disciplines not chemical engineering so particularly you will have biologists, materials scientists, mechanical engineers, all of whom will be engaged in the chemical engineering endeavour over the whole system, so we need to work well with them and embrace them and there are interesting questions about how you might do that.

Now actually what does the profession look like at the moment? Well, we have asked in a recent survey last year where people are still employed and if you look carefully at this and you look back 10 years it looks absolutely identical to 10 years ago – no change. The dominant element is still oil and gas, chemicals, consultancy, oil refining, and you see how many of these activities relate to the oil business. Not surprising and of course the nature of the oil business is changing to make it more sustainable, less carbon-generating and so on, but that is still the dominant place of employment. And yet we as the Institution know that we are going to face a changing balance in the future so we've got to be ready to respond to that. You see it's not until we get down here that you get to pharmaceuticals, you then have water, but still petrochemicals, food and drink and so on. The power industry which is becoming ever more important I think, is still a small employer of our membership at the moment. But I expect that to change dramatically and the Institution will need to change to absorb it.

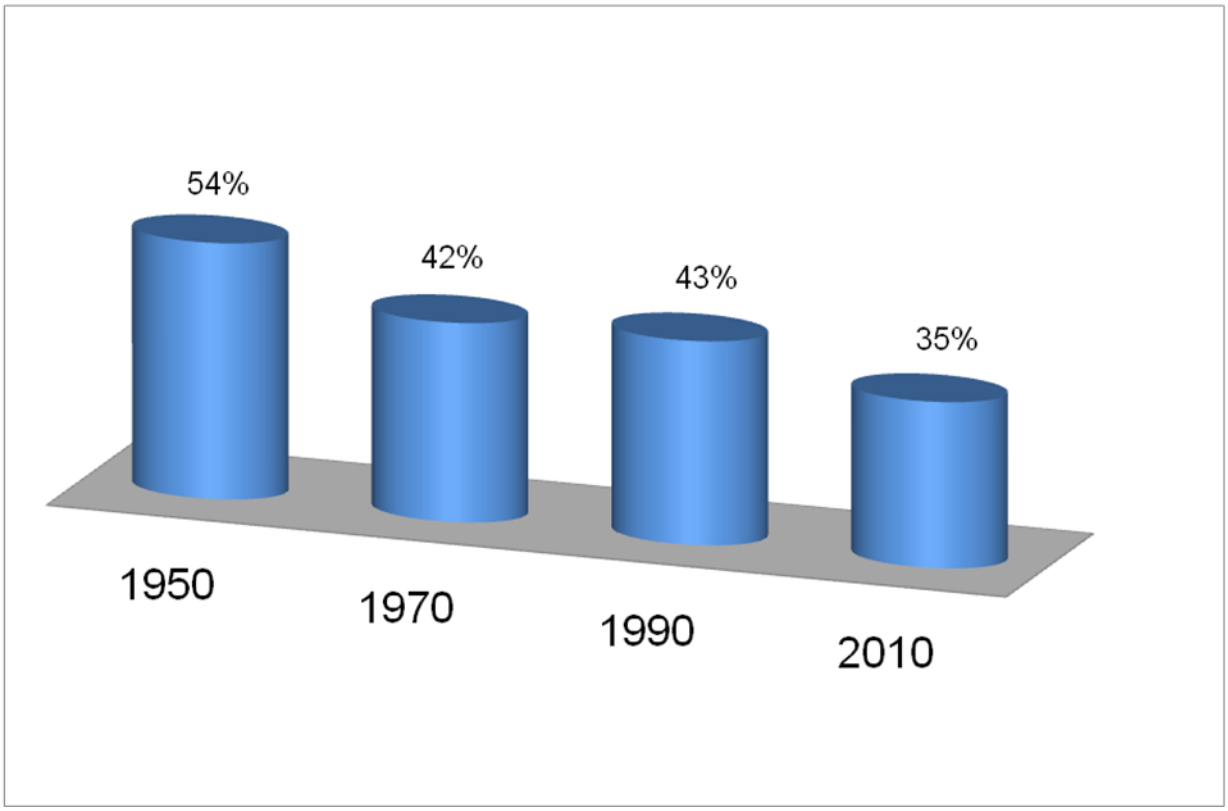
What does our IChemE look like?

Respondents to 2010 Value Proposition survey by industry sector



The other change that is taking place is that not everybody that enters this pipeline is now seeking to end up with Chartered status. You will see that the population of Chartered members as a fraction of the whole membership, which is itself growing, is declining. That speaks to an increasing number of people who are doing different activities than would lead to Chartered Engineering status. So another change in the pattern of our membership.

The population of chartered members within IChemE membership is declining



It wouldn't be reasonable of me to admit another changing pattern and that is the gender profile. At When I joined Imperial College in 1971 I think there were only two female students. Two began and I think only one finished.

How is that looking now? Well in about 1990 we at Imperial College celebrated having 25% of the intake female. That was for us a tremendous achievement. It was a significant milestone for us.

What does it look like now? Well this is just a part of the Imperial College intake of 2006 and you see a significant change in the diversity. First of all around gender of course, and secondly around ethnic origins, but the other thing is I can only show you here part of it and

that's because the number of the intake now is nearly double what it was in 1970. Perhaps even more. And that's a very significant growth in the activity. But most especially the diversity of the course reflects the diversity of chemical engineering both in ethnic origins and gender.

It wouldn't be right either if I didn't say a little bit about the balances struggled with by academia, not just in chemical engineering but perhaps especially in chemical engineering. Since I know Lesley Thompson is here from EPSRC and I have been a Council member of EPSRC,I can say that the Research Council has been driving ever more towards rather more strategically based research and rather less bottom-up driven research. However, that has to be balanced. You cannot go all the way one way or the other and I think that's a rather important balance for the academic community.

But it poses significant problems because of course the immediate benefits to industry on the bottom right here, through pilot plants or actually the research laboratory or the teaching, are all balances with which the academic community have struggled with forever. Continue to struggle. It is increasingly difficult I think in the research dimension because of the way the Funding Council behaves and the behaviour of the Research Assessment Exercise. That drives particular behaviour at the expense of other pieces of behaviour. And I think that's rather unfortunate and I think, I hope, the new Research Evaluation Framework will do something about it but I'm not supremely optimistic about it, I have to say.

The other balance I think for academia is around the balancing of the teaching activity and the periphery of where I think much of research in chemical engineering particularly now is.

If you look at the balance between those two things – the typical core syllabus for chemical engineering would look pretty familiar to all of you – heat transfer, separation, fluid mechanics, thermodynamics, all the things with which you are familiar. But the research agenda often looks quite different and I could choose individual institutions and give you examples of that. There is a relationship between these. However, if you wish to do well in a research model of the UK particularly, then you need to concentrate on things like this which will bring peer review praise, and indeed RAE money, and that maybe recruiting people who are stars in these areas. Are they also able to teach effectively in these areas is a slightly different problem and I think therefore for academic departments there will be a problem of balancing a growth in research at the periphery with the need to teach the core materials upon which the discipline depends.

And the last balance I think is around the globalisation of the world which of course in chemical engineering has been especially profound and continues. This gives you an example of how it continues this is taken from the last 3 months. The left hand side shows you announcements of new projects, numbers of new projects, and you see most of them are taking place in the Asian Pacific region, rather few in Europe, even in North America, whereas on the right you have the amount of plant shutdowns, for reasons other than maintenance, and you see there it's rather the other way round; a rather large number in Europe and a rather small number in Asia Pacific and other parts of the world. So the heartland, the core of chemical engineering activity as it was known, as it was exemplified in the shield perhaps, is moving out of Western Europe elsewhere in the world. And IChemE properly stimulated by Presidents before me in the Institution, has responded to that, but it doesn't come without some cost, and it doesn't come without some challenge either.

As you've heard the Institution is positioned globally, it has offices and activities in all of these cities – London and Rugby in this country, Singapore, Shanghai, KL, Melbourne and Wellington - it is active in all those areas, it has members in all those areas.

And I just wanted to look at a bit of history here at the 25th Annual Associate Membership Examination, at the time in 1950 there was just one candidate from Australia, 12 from Holland, 5 from New Zealand and one from Trinidad, and out of the 118 candidates 77 satisfied the conditions and just 16% of candidates for membership, Corporate membership, were outside the UK. Now in applications 27% are domiciled outside the UK and of the total

membership 40% are now outside the UK. That's a very significant shift and a very big challenge for the Institution to which it has been responding and will respond.

The times they are a changing...

1950 – Dudley Newitt: "Technology and the State" Owing to the length of time occupied by the EGM at which proposed subscription increases were approved, the presidential address was not delivered. It was later sent out by post!

1990 – Geoff Hewitt: "Chemical Engineering in the British Isles"

2006 - Greg Lewin: "The Boundaryless Profession"

I thought these were quite amusing recollections from the past. Dudley Newitt in 1950 - in contrast to today the Annual General Meeting and the Extra General Meeting lasted so long that it was possible, and indeed deemed appropriate, to send out the Presidential Address by post. I have to say we are being videoed now, it is going to be streamed on the web as we speak and henceforth and that's quite different. And that's just about acceptable to do that.

Another example of the internationalisation – Geoff Hewitt's talk in 1990 was entitled "Chemical Engineering in the British Isles", to the Institution". 20 years later I think that would be an unacceptable title.

More recently, Greg Lewin has talked about the 'boundaryless profession'. I think this has a double meaning as boundaryless in its discipline-base and boundaryless in terms of where it is done. And it is that that I believe causes a challenge. To communicate across the world to seven different countries where we have members, all of whom feel they need to be involved, and properly should feel they want to be involved, is really difficult.

So I think that's the challenge I want to set myself over the next year, to understand that, because it's my view that this rapid change we've seen is actually with us forever, it will continue, there will be no diminution. The discipline is growing totally, absorbing new things, getting broader and that very success which that is poses a challenge. So the institution, both its members and its officers, have to be flexible and adaptable. I think it is no longer acceptable, and I think the Institution fully understands this, to have people such as myself standing outside the pipeline unable to get in. The institution has responded to that extremely well but will need to continue to do so, and I would argue in order to do that most effectively we have to be exceedingly close to our membership. They are what it's all about; they see it happening day to day, and at the moment I don't see mechanisms either in this Institution or indeed any other I am associated with of a similar kind, of involving the membership in a big enough way to be sure of that. The Councils of such organisations need somehow to connect better to their membership and I'm determined that we should find a way of doing that but I don't say it is easy because I think our members are the life blood of the Institution.

How do we connect to them globally? Is electronic means adequate, should we have some other means? What is the governance of an Institution that is based in many different countries, there are many difficult issues around that. So I'm going to try and listen to as many members as possible by finding ways of doing that, that I hope will set us up for the future. Because I think if I can succeed in that, if we can succeed collectively, then I do believe, just going back to the title of my talk, we will be able to unlock the potential that is locked up in chemical engineering and has not yet been delivered, and deliver what the Institution has set out for itself, the chemical engineering futures.

Thanks very much.