

Chemical Engineers – Thriving in an Exponential World



Draft text of an address by the 77th President of the Institution of Chemical Engineers, Mr John McGagh FIChemE for delivery in Birmingham on Wednesday 10 May 2017

Prelude

Friends, colleagues, ladies and gentlemen; it is difficult to put into words how honoured I am to be addressing you today. For all of my working life I have been proud to identify myself as a Chemical Engineer, this great profession has provided me with the springboard that took me into a varied, global and extremely fulfilling career; to be asked to serve as IChemE President leaves me truly humbled.

My commitment to you is that, during my time as president of this noble institution, I will strive to do justice to our mission of *Advancing Chemical Engineering Worldwide*.

I have based my address around three core themes. First, a little bit of personal context, or what I call, 'From Scapa Flow to the world'. Then my thoughts on IChemE's governance, evolution, opportunities, strategy. And I'll conclude with some views on the future for chemical engineers and how I feel they can thrive in what I define as an 'exponential world'.

Chemical Engineering, from Scapa Flow to the world



Please allow me to introduce myself. Some of you will have picked up the echo of an accent. The more astute may be able to pick up a Yorkshire undertone overlaid with Australian and occasionally American twang; this stands testimony to my global journey.



I was born in South Yorkshire and spent most of my early life growing up in and around Doncaster, Rotherham and Sheffield

I do recall, almost to the day, when I decided to pursue a career in chemical engineering. Prior to selecting my university course I was lucky enough to secure what was essentially a vacation labouring job on the construction project of Occidental oil terminal facility taking place on the Island of Flotta in the beautiful, ancient and enchanting Orkneys.



For a young man the awe and excitement on being confronted with the scale of an oil terminal construction project against the haunting backdrop of Scapa Flow was, quite literally, life changing. I was working in the light vehicle garage servicing, and in some cases rebuilding land-rovers. The money was good and I was living a boys-own type of adventure.

One evening, when the wind wasn't blowing and the rain had stopped, I was had the opportunity to listen to a few ripping yarns, courtesy of Bechtel's construction and engineering team. One chemical engineer took me under his wing and described the workings of the terminal; from the crude stabilization and degasification process through to the dual crude and LPG export systems. I was hooked. In fact I've still got a copy of the Flotta P&I diagram somewhere!

Why was this first encounter with chemical engineering so attractive? Well, looking back, it touched upon many of my personal drivers.

- I was looking for a profession offering the potential of an exciting future.
- Chemical engineers hung out with interesting people, with interesting backgrounds, from varied and interesting places; all working together to build a fantastic facility.
- The process looked logical and elegant; and it was big (to my eyes).

- These factors attracted me. Chemical engineering appeared to open up a range of opportunities for international travel



I studied Chemical Engineering and Management Economics at the University of Bradford in the days where it offered a thin-sandwich course weighted towards the intakes of great companies such as BP and BNFL.

And the rest, as they say is history. Well my history at least.

And here is my first challenge to chemical engineers, particularly those of you who are IChemE members. When you encounter an inquisitive school age student please take the time to explain what a great profession we have. We are, by far, the best advocates for chemical engineering. I do this all the time, because notwithstanding the vagaries of business and economic cycles, the world will always need new chemical engineering talent.



So let's briefly examine where that conversation on Flotta led. I've lived in the UK, Europe, America and Australia. I've conducted business in almost every part of the globe, working out of many different locations. My career started in engineering, then commercial, through business and strategy, transitioning to global procurement and supply chain back to a role with a hard engineering and technical R&D focus.

I transitioned from the chemicals Industry to the mining Industry by way of an M&A transaction. I had the opportunity to establish and run a world scale innovation programme with an annual budget exceeding \$100M. And during this period I forged alliances with universities in London, Nottingham, Sydney and Brisbane as well as with MIT in the US, Tsinghua in Beijing and Laurentian in Canada.

It gives me pleasure to reflect that whilst I was the head of the innovation programme, we sponsored a wide range of PhD and Masters' candidates, a number of whom were chemical engineers.

Over the last decade I have been increasingly associated with advanced digital technologies. These span autonomous vehicles - first commissioned in 2008, data fusion, predictive analytics, remote operations and use of cognitive learning systems. More on this in a moment.

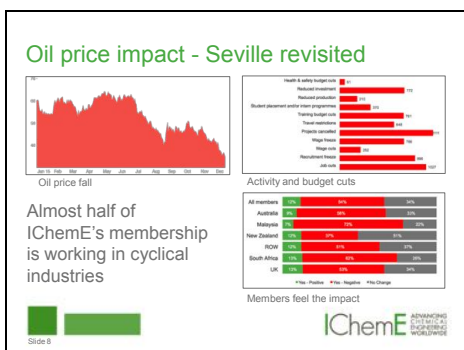
This then, is my chemical engineering journey. IChemE members will recount other journeys. Every journey is personal, sometimes very different, and very often unique. That is one of the beauties of this great profession.

So, I humbly thank chemical engineering for opening up the world to me; and I am delighted to be able to give something back to the profession that has given so much to me.

IChemE – Evolution, opportunities, strategy and governance

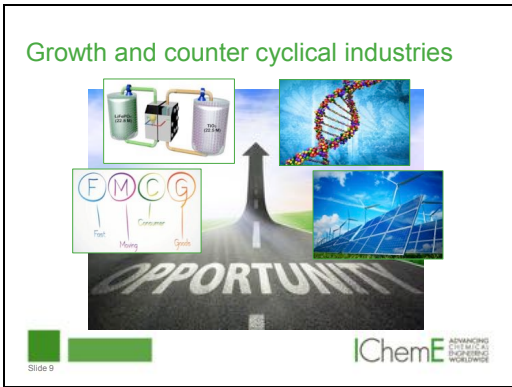


Last year, my predecessor, Professor Jonathan Seville talked about chemical engineers and our profession undergoing a process of evolution. His address raised several interesting topics.



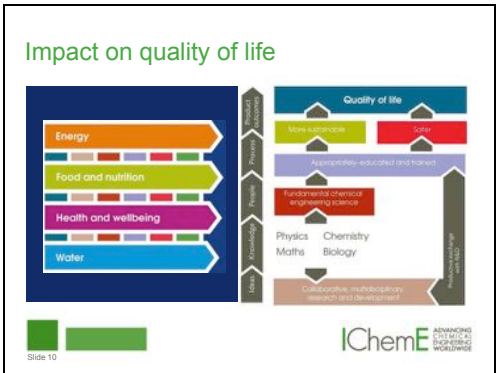
He illustrated the direct impact that oil price cycles have on the near turn on the employment prospects for chemical engineers in what is an inherently cyclical industry.

He also talked about the changing landscape our members face as new industries rise and open up a range of areas from fundamental research to the support of new and in some instances novel industrial production. Jonathan elegantly argued that the opportunities for chemical engineers to add value to society through our application of knowledge, skills, participation and ethics will continue to evolve and grow, I wholeheartedly agree with his perspective.



I personally read *The Chemical Engineer* with considerable relish. The magazine connects, and grounds, me to a community that I am deeply invested in. The breadth of interests and industries that our profession supports constantly impresses me.

When I graduated, the world of the chemical engineer, at least as it appeared to me, was very much oil and gas centric, with a big dollop of chemicals thrown in for good measure. Chemical engineers have served these industries well. And they have served our members well too. Today getting on for half of our membership works these industries. They remain a crucial part of IChemE’s present; and of its future. But they are not the only part.



Our profession operates within an industrial, and societal landscape, which is evolving at a remarkable rate. We directly impact the Quality of life, Chemical Engineering really matters. I will talk about this exponential,

digital world and how it might impact on chemical engineers shortly, but for now, I want to stay focused on IChemE.

Wicked problems - great opportunities

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We must always manage through the volatile economic cycles that impact our traditional foundation industries, but we should also bear in mind that we are surrounded by sunrise industries that are growing at a remarkable pace. This is a world of remarkable opportunity for Chemical Engineers, we have a track record of tackling wicked problems and turning them into great opportunities.

We are a community of professionals, inside and outside of our profession expectations are changing.

Opportunities for chemical engineers

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One significant shift I have seen in industry is that the people entering the workforce today are from what I have seen described as 'Generation C' – the connected generation, we must become a connected Institution.

They know nothing other than a world with instantaneous communication and 24/7 on-line access to knowledge and communities.

Throughout my working life I have taken the view that challenges can be turned into opportunities and what a range of opportunities we face.

IChemE - navigating a complex world

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IChemE

IChemE sits at the intersection of members, employers and the educational sector. We have a complex world to navigate our way through. How we shape our strategies and govern our Institution drives critical engagement within, and across diverse stakeholders.

Member engagement in this process is essential Our strategies must continue to evolve in order to take into account what is a changing and complex context, indeed we evolved our strategy in 2016 IChemE will conduct a deeper and more expansive engagement with members on the refreshed strategy.

IChemE – governing for success

Our governance framework enables and supports our strategic purpose
“Advancing Chemical Engineering Worldwide”

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IChemE

The work of implementing our strategy requires alignment of membership, council and management, this alignment takes place within a framework which we refer to as our Governance approach. I wish to touch upon the Governance of the Institution, but, what do we mean by governance, particularly in the context of a 21st Century Professional Engineering Institution like IChemE?

Governance is a complex construct. It's difficult to capture in a few short sentences; however, having been involved in governance, I think Canada's Institute on Governance offers a useful start point.

IChemE – governing for our future

The need for governance exists anytime people come together to accomplish an end...

Governance determines:

- who has power?
- who makes decisions?
- how other players make their voice heard?
- how account is rendered?

Ultimately, the application of good governance serves to realise organisational and societal goals

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IChemE ADVANCING TECHNICAL ENGINEERING WORLDWIDE

- The need for governance exists anytime a group of people come together to accomplish an end.
- Governance determines who has power, who makes decisions, how other players make their voice heard and how account is rendered.
- Ultimately, the application of good governance serves to realize organizational and societal goals.”

In parallel with the 2016 refresh of IChemE's strategy, Council requested that a separate review of governance be undertaken. The review commenced in the middle of last year and I volunteered to be the sponsor of this work.

But why focus on governance? My answer is a simple one; we must match our governance model to best enable our strategy, which for IChemE is to support, inspire and motivate our members to contribute to the greater good by “*Advancing Chemical Engineering Worldwide*”.

Yes we have a number of challenges to face, but also a range of opportunities to exploit. This is business as usual for IChemE and I suspect our predecessors would say “So what’s new?” We are a dynamic organization and I am convinced that we need dynamic governance to best support our members.

I want to share with you some of the areas that need to be considered in some depth:

- In all instances we must continue to manage our affairs in alignment with the Charities Commissions’ rules and regulations in order to deliver public benefit
- We need to think deeply about how we govern and support our Institution with an increasingly diverse global footprint, thinking through the balance and inevitable compromises that need to be made between central and distributed systems
- We must frame an understanding of what other Institutions have done as they confront the same tensions. I note with interest some have chosen to adopt a structure where fiduciary and charities commission duties are managed by a subset group releasing a more diverse council to represent and more deeply engage with diverse membership.
- We have always aspired to be a member-led Institution. This requires transparency and democracy, but these are not concepts born in the digital age, they are ageless. Digital platforms such as LinkedIn,

FaceTime, Twitter and the like are new channels that enable transparent discussion and dissemination of information; the Institution has an obligation to utilise these channels in support of our traditional member communication approaches.

The initial assessment of best practice in the governance of professional associations which was undertaken in late 2016. This uncovered a number of opportunities and also posed a range of interesting questions. We have a solid foundation for the next phase of Governance deliberations.

I recently chaired a review of the Australian PhD system sponsored by our learned academies on behalf of the Commonwealth government. This review demanded extensive consultation and systematic consideration of a wide range of views and opinions. I want to use a similar approach when engaging with our membership over the critical issue of Institution governance. Experience tells me that not all opinions can be catered for, however, all opinions must be listened to and taken into account when formulating the way forward for our Institution.

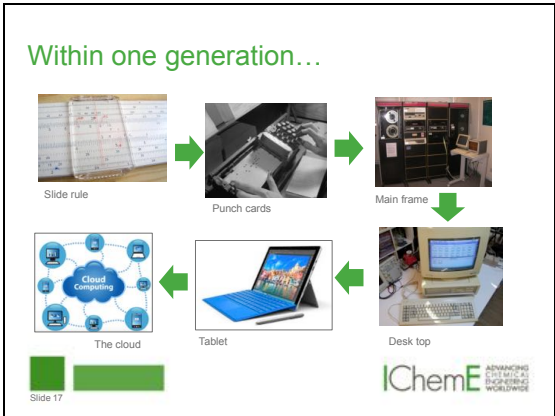
Before I hand over IChemE Presidency to my successor in 2018 your council and management team will complete this governance work. I will personally chair this review, and I will ensure that the outcome is communicated to the membership in an open and transparent manner.

Thriving in an exponential World



I want to frame a straightforward hypothesis for you today. This is a hypothesis based both on observation and also on measurement.

Simply put, digital is driving exponential changes and those changes are impacting on every facet of society. Chemical engineers can and, assuming that we adapt and evolve, will thrive in this exponential world.



Within a single generation we have gone from slide rules and log tables, through card reading mainframes to mini, then personal computers.

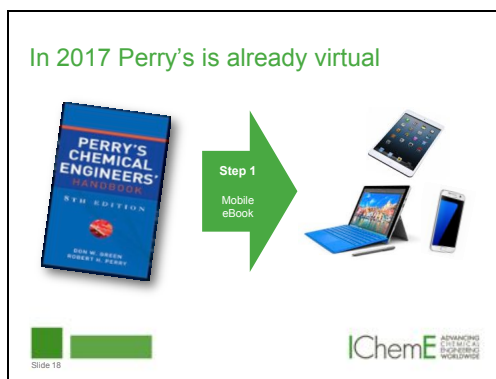
Laptops came along then smart-phones, touch pads and more recently hyper-powerful cloud-based cognitive systems.

Allow me to clarify what I mean by the last term on that list.

Cognitive computing involves self-learning systems that use data mining, pattern recognition and natural language processing to mimic the way the

human brain works. It's already here and it's changing the world in some fundamental ways. The pace of that change is getting faster, and in many areas it is truly exponential.

Most of you will be familiar with Perry's Chemical Engineer's Handbook. Perry's was first published in 1934, and like many of you here today this was the weighty tome that I carried with me wherever I went in the early years of my career.



Like me, I suspect that you too will have all enjoyed the intellectual satisfaction of successfully completing some mass transfer, heat transfer, or wicked engineering problem with Perry's close to hand. That's one of the joys of being a chemical engineer. Perry was last updated in 2007, so putting it bluntly; it's already ten years out of date

In the intervening decade we can look back on the exponential rise of computing power, massive data cloud-based management and manipulation systems, advanced analytics platforms building predictive algorithms from the base data.

Cognitive meets humans



More recently the rise of cognitive and self-learning computer systems; perhaps best recognised in popular culture as the game show winning IBM Watson program.

It's worth dwelling on Watson's 2011 game show success for a moment.

The stand-alone program had access to 4Tb (200 million pages) of structured and unstructured content including everything on Wikipedia.

Jeopardy! is one of the most popular TV game shows in America. It's also seen as one of the most difficult, in that contestants are required to frame possible questions in response to general knowledge clues given in the form of answers. Nonetheless, Watson beat two seasoned Jeopardy! contestants and 'walked off' with the \$1m prize money.

More recently, in January 2017, Libratus, a computer described as an 'AI Robot', won chips worth \$1.5m from four of the world's top poker players in a three-week challenge at a casino in Pittsburgh.

Computers are now capable of taking on, and beating, human beings in situations in situations with imperfect information.

Cognitive meets the professions

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This has huge implications for the world of business and commerce; self-learning cognitive systems are already coming into the professions.

I have personally been involved in the introduction and commissioning of completely autonomous, self-navigating, environment aware, massive haulage machines in the mining industry. Employing what was previously military technology we introduced real time data fusion of many hundreds of thousands of sensors from complex plants literally from across the globe.

Exponential forces shaping digital

Slide 21

This data was constantly scanned by semi-intelligent self-learning systems and in real time they sensed process excursions across inherently chaotic systems, intervening and eliminating the excursions and learning from the 'experience' each time they intervened. We could do this because the enabling technologies were growing at an exponential rate, that was way back in 2008. Just imagine what the next exponential decade might bring?

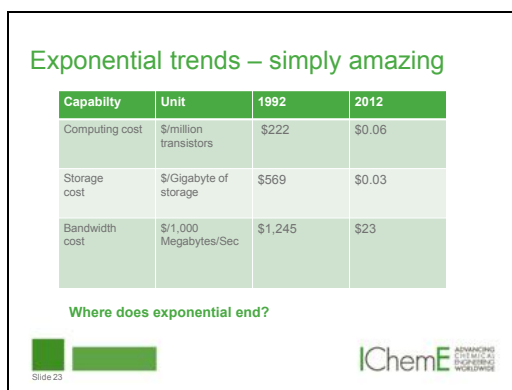
Okay; I recognise and fully accept that projecting into the future is fraught with danger and many of you will be familiar with the following quote from 1943: "I think there is a world market for maybe five computers..."

This is attributed to IBM's CEO Thomas Watson, but to be frank there is scant evidence that he ever uttered these apocryphal remarks.

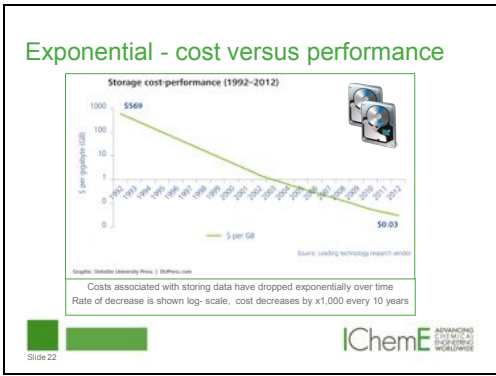
Nonetheless, as a chemical engineer, you might expect me to be a little more cautious; so here's the advice that I offer to senior business leaders to guide their thinking about possible futures.

I outline three probable-outcomes.

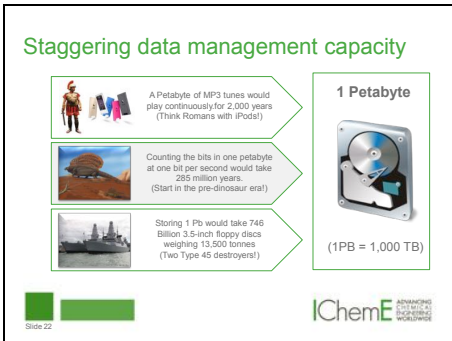
1. Within the next fifteen years a microchip will have the same number of switches as a human brain has neurons.
2. Data storage capability and associated cost compression is also following an exponential trajectory; or if it is already cheap today, it will be cheaper and more powerful tomorrow.
3. Knowledge is, and will continue to be incorporated into cognitive expert systems, in other words self-learning computer systems are coming to your profession soon.



Clear evidence that this world is moving quickly, this slide illustrates some cost per unit comparators made between 1992 and 2012 I feel sure you will find them to be enlightening.



Given exponential speed of change in these technologies today's numbers could easily be an order of magnitude lower than 2012.



Now without sounding too blasé about such things, I now throw a Petabyte of data in an out of the cloud on a whim. This slide puts a Petabyte in some sort of context!

It's the availability of this raw computing power at rapidly reducing cost that underpins the digital revolution. The phenomenon has been unleashed into the real-world in a range of new innovative ways.

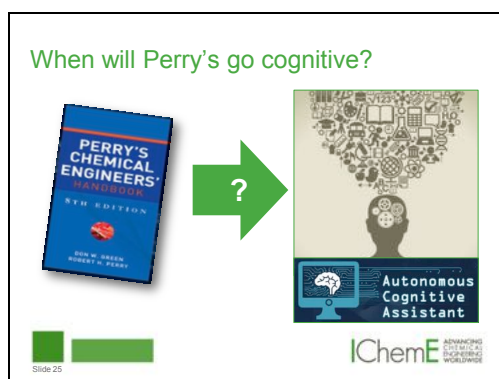
I recently read a report explaining that a typical GP would need to dedicate 160 hours per month just to keep up with their recommended professional medical reading.

But today's GP can call on the services of a 'cognitive assistant'. The assistant can do the reading for them. And in so doing, it can provide access to knowledge amassed in a context approximating to the way in

which the doctor asks a question. And, these conversations are already happening.

Cognitive systems have been trained to look at tens of millions of breast cancer scans. These systems learn from the experts that first recognise, identify and classify the cancer; and they outperform the individual human by many orders of magnitude.

So we now have massive data capabilities at negligible cost and cognitive assistants capable of digesting past and current information in a context that human beings can understand. Combine this with predictive and learning analytics and we have an exciting new frontier opening up in front of us.



What does this mean for our beloved Perry's? Perhaps in the very near future it will no longer be paper based. This transition has already begun since it is already available from Amazon as an eBook. But what lies beyond this first step to digital?

eBooks are just the start.

We are close to a world where Perry's of the future could, say, be built from a collection of expert systems that teach, problem solve and are in themselves self learning as they strive to support the chemical engineer of the (very near) future.

Perry's could possibly be just one part of the chemical engineers' cognitive assistant. A cognitive assistant providing access to a corpus of information combined with a self learning assistant that reads, consolidates sorts, understands and supports the entire world of the chemical engineer.

This corpus of information could literally combine everything we have ever know about the entire span of knowledge that is consolidated within Perry's and many more essential chemical engineering texts.

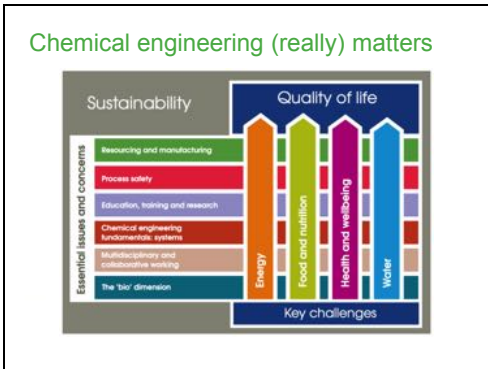
It would be accessible, instantaneously updated in real time, from all new knowledge created and capable of interacting with engineers in natural language, thereby assisting us at every step in our professional lives.

This vision of the future is exciting and at the same time, disturbing; but, I believe it is unstoppable.



Ask yourselves this question. How much more could chemical engineers achieve in a world where we have cognitive power like this at our disposal?

Because let's face it, there's a lot for us to go at.



Let me remind you of some of the pressing issues that IChemE members will be better placed to address armed with these new tools.

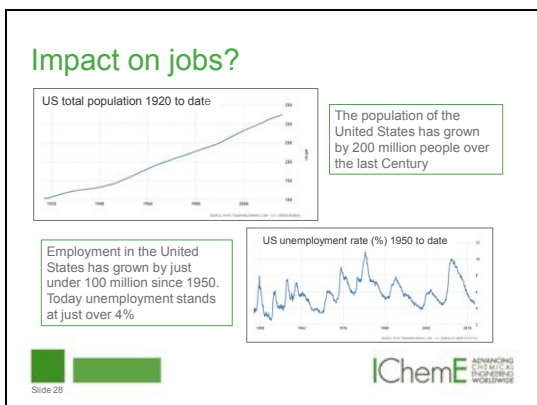
1. Confronting and helping to shape a response to challenges presented by the water-energy-food nexus and climate change
2. Contributing to a new balance between fossil fuel and renewable power generation with important contributions from improved energy efficiency, nuclear, carbon capture and energy storage
3. Supporting the biotech revolution and helping to ensure that it delivers against great promise
4. Educating and training the next generation of chemical, biochemical and process engineers, to deliver safe and sustainable solutions to these grand challenges

Plenty to go at, yes indeed and this Institution remains committed to making these things happen. I want to ensure that we maintain our position and reputation as an independent public benefit charity committed to advancing chemical engineering worldwide

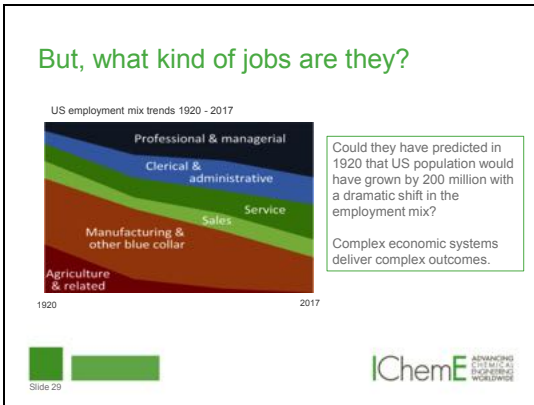
We will provide insight and opinion for the benefit of society based on the premise that IChemE membership is a sign of trustworthy professionalism and a visible commitment to a code of conduct that embraces safe, sustainable and ethical practice at its core.

I contend that we can do much more to add value to society as a whole if our members are armed with, and are masters of, these emerging systems and technologies.

This is a future to embrace and not one to fear. One reads of projections that jobs will be displaced by the penetration of digital technologies into all corners of the economy, the Oxford Martin School Report from 2013 confirmed that knowledge is being captured and digitised; systems are learning and increasingly interacting with human beings in ways we will soon struggle to discern from real human interactions. Indeed, some fear that human roles will be substantially replaced. But we've been here before.



These trends in US population and unemployment rates over the last century span a period of huge technological, economic and population change. But today, unemployment remains tolerably low and there's a reason for this.



Employment patterns change, and they will certainly change again.

However, as professional chemical engineers we must ask what moral, ethical, training and management opportunities does this new world bring?

We are in the midst of all this. And I remind you of Jonathan Seville's key question from this platform last year.

Can we remain relevant?

My answer is unquestionably 'Yes'

Yes, because we are a collection of great people with the knowledge, the experience and the competence to exploit these new and amazing tools.

The combined wisdom of 44,000 members from every corner of the process industries – ably supported by our colleagues in academia and the research communities – represents a powerful resource.

I'm glad they're on our side!

I want to finish by returning to the cognitive computing capabilities of IBM Watson. But in this instance we are not playing games.

Woodside is an Australian oil and gas company with a global presence, recognised for its world-class capabilities. They are a major employer of chemical engineers in Australia.

Woodside are already working with Watson as this short video clip illustrates



The digital train has left the station. Think about the implications of what Woodside have embarked upon. Consider again for a moment that quote, “Watson teaches us to think like a thousand engineers from a thousand different sources.”

Incredible, mind-blowing even...

But real; and happening right now and shaping our world and the world of every other profession that we interact with. With developments like this there has never been a better time for collaboration between professions. In fact it's essential that we do.

Closing observations

We are a community

- Professional
- Qualified
- Ethical

We must evolve

- Our predecessors did
- Our successors must

Society needs our solutions

- We thrive on “wicked problems”
- New amazing tools are coming

“With a feeling of deep humility I thank you for the opportunity you have given me to serve our great Institution”

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IChemE ADVANCING CHEMICAL ENGINEERING WORLDWIDE

So I will conclude with this simple message. The Institution of Chemical Engineers has a vital role to play in helping its members, and its stakeholders in industry, academia, the research community and in the regulatory sphere to seize the moment and take full advantage of the exponential world that we are living in.

We are a great community, we must evolve. And we must evolve because society needs the solutions that are within our grasp.

This is not a time of fear.

This is a time of opportunity.

And there is much work to be done.

I am humbled to be given the opportunity to serve you as your 77th President,

(~4,100 words equating to approximately 45 minutes running time)