THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

School of
Chemical Engineering

The University of Queensland's School of Chemical Engineering is an international leader in chemical engineering and has an excellent reputation in teaching and research, built over one hundred years.

Our School is one of the top ranked Schools in Australia and placed 33rd in the 2019 QS World University Rankings for Chemical Engineering, however, we recognise the need to grow and to provide more of the answers needed by our changing world.

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Note: BE/ME is the integrated Bachelor of Engineering/Master of Engineering program

Editor's note.

This was a very expansive interview which involved some eight Undergraduate students, all double degree with Chemical Engineering major.

The below transcript has been shaped to tease out editor identified key themes; we wish to draw attention to the key words/phrases identified as bold text.

ChemEng Evolution Transcript Summary
UQ Students interview with John McGagh

Over the past 100 years we've seen many **resources** that have been used at **unsustainable rates**. This same pattern can be seen with lithium and in particular **lithium battery recycling** has not been economically viable and so we are not using lithium sustainably. Current battery recycling practices are to remove the copper, cobalt as they are more economically viable and leave the lithium as a slag which is dumped.

Our biggest issue here for humans is human nature. We've seen it with climate change, we always wait until the last second to make changes. **Resources are finite, nothing on Earth is infinite.**

The key challenge that I want to focus on was **how we feed a population of 11 billion people** because already by 2100, so because already we've got the issue of millions of people going hungry around the world every day. But there is also significant food waste in countries like Australia, so it's going to be a major challenge.

Obviously, food production in crops and livestock has significant environmental impacts in terms of land use, water use, soil degradation and greenhouse gas emissions. So, **we can't just scale up the current food system because that's not going to be sustainable**.

A social issue: people in **developing countries** and low-income communities are more likely to experience issues with **food insecurity** and the impacts of **climate change** firsthand.

Another issue is with **water supply** as well because that'll be another **challenge** trying to manage freshwater resources and have enough **freshwater resources** to meet the needs of the population

We are aware of the environmental implications that climate change has and it's inevitable that we're going to see the **world changed drastically in the next 80 years**.

Currently it's estimated that there's a **technological difference gap of about 25 years between first world countries and developing countries** and with global climate change looming above all that is quickly becoming a reality for everyone. We can only imagine that this divide is going to increase further and slow the already lagging advancement.

The only way that we can move forward to an equal and Sustainable Global Society by 2100 is by **bridging the development gap** that we have between developing and developed countries.

It is up to the engineers of today to find the solutions for the problems of tomorrow.

From a technical point of view, and I think that the **transition of refineries to a more sustainable and circular operating model** will be an important challenge for metals and minerals such as lithium cobalt.

I think that achieving a sustainable future for these processes means **addressing the entire asset or supply chain** rather than focusing specifically on the products. This is what equitable future means.

The intense strain that we're putting other species on this planet is not only increasing year by year as the population grows consumption increases and our **finite resources are being used** up and discarded. We see this as a challenge that **undermines the very definition of global security** and the possibility to thrive over the next century.

I wanted to start our discussion today, with a bit of dreaming. So, what do we hope that 2100 is going to look like? We want global warming to be non-existent. We hope that **the global average temperature is no longer increasing every year** and that **sustainability is one of the first factors that we take into consideration every time that we start a new project**, a new process or new production. We see an **equitable world** with **equal gender pay** no matter what sector you're in and an **equitable distribution of the world resources and technologies**. This may appear idealistic.

All our other challenges we identify are linked to humanity 's impact on Earth climate and the challenge of balancing mitigation and adaptation to changing climate. The one of the major challenges that the world is going to face as we head towards 11 billion people in 2100 and the **availability of arable land on which to grow food**.

The UNESCO Institute for water education states that approximately **15,000 liters of water go into producing one kilogram of beef** in Australia.

The **transport industry** in 2010 was responsible for **23% of CO2 emissions** and obviously the projected impact of this industry only grows over the next 80 years.

Production of carbon neutral fuels is a mammoth task, with many countries pledging to achieve net zero by 2050. We fear that countries have pledged to achieve net zero by 2050 but do their leaders **don't know how much is involved to achieve this goal?**

Another challenge that material development is going to see in this area is in plastic with plastic free guidelines coming into many countries. We're going to need new materials in terms of **plastics that fully biodegrade at the end of their life cycle.**

Consider energy poverty as well as climate change, **a challenge to decrease energy poverty**. Both energy consumption and economic development have been closely linked and as a country develops, currently there's quite a disparity.

When I see the details laid out in front of me like that, I can practically feel every government representative sweating in their seat finding out **what it really means** to achieve the pledge to go **net zero by 2050**.

How do developed countries turn around, after developing and having a much higher quality of life using high-carbon energy, and say to the developing countries no, you can't do that because that because it would mean CO2 emissions and you have to stop these emissions. So, **unless developing countries receive enormous assistance from developed countries** at the same time as we're trying to limit our missions it is going to end-up badly for the Planet as a whole. I believe we have a duty to the world and ourselves to provide this assistance.

For our own **collective survival** and this is something I'm very passionate about, **is supporting the decarbonization of developing countrie**s with for instance hydrogen exports. This is something that chemical engineers can lead the way for developing countries, we do need to be a bit more benevolent.

I don't know if a lot of Chemical Engineers are aware of the importance and urgency of these issues, many courses at **University** can be **oil and gas based** because currently that's where the jobs and opportunities lie. For example, **we're not talking in our Undergraduate Courses about how recycling works or green infrastructure design,** that's a symptom of where our job opportunities lie and changing this could be a potential for helping Chemical Engineers be involved in the solution.

There needs to be **more avenues into sustainability for chemical engineering students** because this is where our new job opportunities lie and changing education gap this could be a potential for what we can do in the future. This would also be an exciting way forward as graduate engineers can be involved in solving sustainability issues.

Chemical Engineers by our nature **will try to find a solution to climate change**, since we first found out about the problem objectively. When we look at the Earth as a system and a set of subsystems the idea of a carbon negative cycle becomes a challenge. Recent examples in technology included carbon capture sequestration and carbon capture Utilization, which have entirely disrupted the carbon markets. We have examples where carbon capture sequestration injects carbon dioxide back into the earth. Electro chemical processes converts carbon dioxide into valuable chemicals such as carbon monoxide formic acid and methane inching us **closer to the idea of a circular economy**.

Economic incentives for companies to research and develop processes and specific technologies will be needed. Other alternative of options will the introduction of legislature such as the **carbon tax** to give emissions a price point and this forces companies to adopt the **green technology challenge**.

There are going to be **multifaceted solutions** to all of the challenges that we have discussed here, this is going to become a necessity in the next 80 years as we look towards the future. However, it is these big ideas and this ambitious way of thinking that will ultimately pave the way for developing nations and **inspire future generations of Chemical Engineers**.

There are two ways Chemical Engineers approach solutions to sustainability challenges, which are either from a **new process design perspective** involving changing the process to reduce or reuse waste and this will involve a shift in perspective from the entire chemical engineering design. The second way is to **retrofit circular model solutions** to existing processes.

Both approaches obviously have large economic aspects, which require **policy changes to drive the transitions.**

Heading into the future as graduate **chemical engineers** about to enter the workforce it is obvious that we carry a great deal of **social and environmental responsibility**.

The challenges and solutions that we've presented to you today are, you know, to say the least ambitious. To even get to 2100, we to get through **the next critical 10 to 15 years** and therefore we need a much stronger education of politicians and policymakers on the scale of the challenges and technological options that offer a solution if we do not do this we will continue to **spiral towards an unpredictable resource-less future.**

Chemical Engineers can play a really big role in **improving food supply and food security** in two main ways. Firstly, in terms of advancements and innovation using skills that we have in things like **processing techniques and knowledge of environmental systems**, for example, reducing food waste by making food last longer and developing alternative to animal protein (meats) that have similar taste and consistency to encourage the uptake. Secondly **leveraging Genetically Modified Crops** as an essential solution to allow us to improve the efficiencies of production but also minimize environmental impacts. GM also offers opportunities to improve the quality and reliability of food as well so for example, GMO crops can be made resistant to certain insects or viruses and food can be boosted in vitamin A which when seen as deficiency leads to blindness in developing countries, also, producing more resilient crops to manage changing weather conditions and extreme weather events.

Chemical Engineers are skilled in terms of **water supply security** such as desalinization techniques and recycling, treatment of reuse of wastewater and runoff.

During our undergraduate education the importance of having **good communication skills** is stressed, this is because we're always going to be working in teams and with stakeholders on a range of projects. It is important that we are able and willing to go out and explain science and engineering concepts to the general population in a way they can because they will be more likely to accept and be supportive of new technologies. If we are going out and **promoting awareness** and education around **sustainability** challenges and opportunities, it is important that we can address and breakdown misconceptions that people may have and provide answers to reservations. It is critical that we make it easier to **explain to the wider population** things like the social license to operate and the need for better research to ensure that these new technologies are going to be safe and effective.

The goal of sustainability not only requires new technologies to better utilize our resources, but also provide solutions for **recycling spent resources and waste** that is currently produced at preposterous levels to enable transitions to more sustainable world, hopefully we will ultimately see end of product lifestyle cycles that end up in waste tips. Chemical engineers should already be planning for this task.

Chemical engineers will be a major part of the future when it comes to the production of **sustainable and available food**, one area this has already seen a recent growth and I believe will continue in the coming decades is the production of "fake" (not animal derived) meat. Chemical engineering will be key in ensuring that these products have the correct taste and texture and that they include the necessary nutrients that people need and can decrease the bad fats that are in animal-based meat. This needs to be achieved **ensuring** that we use **less land, less water** and emit **less climate warming gasses** as we produce these products.

A range of countries are committing to **single use plastic free way of life**. The role of chemical engineers will be vital in the creation of new materials to be produced in industrial volumes that can improve sustainability of the globe and one example is the production of **fully biodegradable, plastics** that have properties that are both on par with and cost competitive with current fossil fuel-based products.

Chemical Engineers must accept **responsibility** for **influencing** the current global **throwaway culture** by creating processes that can reuse materials, rather than just use new ones.

In the transport sector we are seeing the impact of new technologies such as batteries based on Lithium-ion systems. These new batteries will reach the end of their economic life and **recycling all components, including Lithium, must be the norm**. This provides not only an economic benefit, but it's also going to be valuable for creating a sustainable world built upon a circular economy that we can all live in. Also, in transport sector we have already seen the development of **renewable fuel** technologies and **carbon neutral** options involving carbon capture and storage.

Hydrogen is a secondary energy source but an excellent fuel and transport medium so this will be important to the **Chemical Engineer of the future**, as we start to design processes **using hydrogen and other combinations of carbon neutral feedstocks.**

The changes needed to achieve a sustainable, equitable and prosperous society on a global level brings **a complexity that is almost unimaginable**. Global society will be challenged to make these changes.

It is not logical to expect the same rates of change from country to country. People living in the developing world have not had access to the "cheap" carbon-emitting resources that helped advance the developed world. Scarce renewable resources, technologies and processes will **require support and leadership from developed countries to assist developing countries** achieve their growth aspirations. Therefore, it will be necessary to create equitable, interconnected, global supply chains to support sustainable circular economies and in doing so **allow for a better world**.