

9th Annual International Colloquium on International Engineering Education
Panel on "Defining the Global Engineer"

"The Global Academic Engineer and the 2050 Challenge"

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This panel has been asked to discuss the attributes, future and present, of the global engineer. I would like to talk about the necessary attributes of the global engineer in academics; the faculty, students and staff in Colleges of Engineering worldwide.

Let's start with some context:

The US Census Bureau predicts there will be 9.4 billion people in the world by the year 2050. What does that mean?

Energy: The World Energy Council predicts a 40-70% increase in energy consumption by 2050 to an energy demand of 20-25 giga-tons of oil equivalent. Power consumption will grow to 28 TW. Energy experts in a recent National Research Council report confess that they don't have a clue as to how that power will be delivered in an environmentally acceptable way. And those are the optimistic estimates. The Energy Information Administration of the Department of Energy predicts a 70% increase in energy use by 2030 let alone 2050.

Water: The Population Information Program at the Johns Hopkins School of Public Health predicts that 4 billion people, more than 40% of the world population, will face severe water shortages in 2050. Even in the absence of world population growth, simple economic development results in greater water usage. The average citizen of Africa uses 47 liters/day, Asia 85 liters/day, the UK 334 liters/day and the US 511 liters/day. China's economic growth to US standards simple cannot be sustained with its current water policy. There simply isn't enough water. We fight wars over oil now. We'll fight wars over water in 2050.

Global Warming: Clearly an emotional and political issue. The hard evidence is that atmospheric levels of carbon dioxide, methane and nitrous oxide are at all time historic highs. The permafrost is melting and glaciers are shrinking. A report just commissioned and published by the English government predicts that hundreds of millions of people could suffer from hunger, water shortages and coastal flooding if significant changes are not made by 2050. Every coastal city in the world could be partially submerged by 2050.

Strategic Metals: A research team at Yale has predicted that we will basically run out of most of our strategic metals by 2050. Anyone who has priced copper recently can sympathize with that prediction.

With that context, the College of Engineering at Iowa State University has coined what we call the "2050 Challenge," and it goes something like this:

Put yourself in the year 2050 and ask yourself what fundamental society changing challenges must be met in order that we have functioning and prosperous societies?

- Clean water for 9 billion people

- Non-polluting energy sources
- Reversal of global warming trends
- Stable worldwide economies
- Universal access to information
- Universal access to healthcare
- Means to deal with global cataclysms such as rising ocean levels
- Sustainable infrastructure.
- Sustainable everything, from agriculture to manufacturing.

If we don't meet these challenges and solve these problems, it's not clear we will have functioning societies in 2050. It's not clear that a single country on the planet will have the quality of life we enjoy today in the US. Solving these challenges are not options. They are mandatory to insure we have functioning societies in 2050.

What is so bothersome is that there is no comprehensive plan to meet these challenges to make certain we do have functioning societies. There is no viable plan to replace petroleum. There is no viable plan to insure that 9 billion people will have clean water. There is no comprehensive national or international plan in any country that has the goal of insuring that the fundamental infrastructures of modern society will still be operational in 2050.

So whose responsibility is it to come up with "the plan" and implement that plan? And when do you start?

The when is now. If you work backwards from 2050 and ask when should we have started in earnest to meet these challenges, you come to the conclusion that we should have started decades ago.

So what is the process?

All of these problems fundamentally have technical solutions. We need practical, implementable, affordable technical solutions to will provide sustainable agriculture and manufacturing, that will provide non-polluting energy sources. This is an enormous task. We are talking about fundamentally changing how we manufacture, travel, ship, grow food, interact globally. This is probably the single greatest task ever attempted.

And for that reason, we not only need technical solutions but leadership solutions. We international partnerships that make the United Nations pale in comparison. We need leadership and partnerships able to implement those technical solutions across hundreds of countries, thousands of cultures while overcoming millions of self imposed barriers. The enormity of the task magnifies when you realize that we need to reach every corporation, every company, every business, every farm and every water system; we need to literally reach every person on earth and compel that entity or person to change their behavior for good of the whole.

This is an enormous task and the cultural aspects are perhaps the most daunting and challenging. The Green Revolution nearly failed in Asia in the 1960s because the starch content of the high yield rice developed by western scientists wasn't quite right. The rice grains didn't stick together and so the rice couldn't be eaten with chopsticks. A famine of unimaginable proportions nearly occurred because of a lack of appreciation of cultural aspects of eating utensils.

So who is going to do this? Who has the intellectual capacity and social mandate to meet the 2050 Challenge?

It probably won't be governments. It took nearly 15 years for world governments to agree upon the construction of the International Thermonuclear Energy Reactor (ITER) that will cost a mere \$10B, take a mere 10 years to build; and involve the EU, the Russian Federation and only 5 other countries. We are talking about an effort with uncalculatable costs with an unending duration involving every country on the planet. If governments had the will and foresight to tackle this problem, they would have started already.

It probably won't be businesses. Although when aggregated internationally, industry likely has the intellectual capacity to meet the 2050 Challenge, industry lacks the social mandate and the required long term perspective.

The only organizations on earth who have the intellectual capacity and social mandate to meet the 2050 Challenge are universities and, in particular, Colleges of Engineering. We have the intellect, we have the talent, we have the innovative spirit, we have the ability to optimize, perform the return on investment calculation, and we have the ability to collaborate. It is within our collective abilities as Colleges of Engineering to literally save the planet.

Pause to think about that. The intellectual capabilities and social mandates of Colleges of Engineering, aggregated internationally, have the ability to save the planet and meet the 2050 Challenge.

What is lacking? What do we need to meet this challenge?

We need the will, the organization and the leadership and fundamental changes in the way that academic engineers conduct their research and educate future engineers.

No single entity has the ability or resources to meet these challenges. They will only be bested by unprecedented international collaboration by colleges of engineering. International networks will be required to collaborate, perform cooperative research and globally educate engineers at scale never before attempted. These will be teams of students, researchers, scientists and engineers, from academics, industry and government, all working towards solving exceedingly complex problems using state of the art technologies, generating solutions that produce more, more of everything in increasingly more sustainable ways; and innovating efficiencies and conserving technologies to better use what we have. The future academic engineer will have to be sophisticated in international collaborative research in a manner that makes it second nature. The education of engineers must include internationalizing experiences as fundamental to the curriculum as is calculus and physics. This is not an option. It is a requirement.

I've taken care to say internationalizing and not international experiences. For practical reasons, not every student can travel internationally. However as we will hear at this conference, there are many ways to have internationalizing experiences without leaving the country; and we must require some such internationalizing experience of every student, if not internationally then domestically. There are areas of US cities where you can walk for a mile without seeing a sign in English. Spending a week there is far more internationalizing than a week in London.

But the technical expertise will not be enough. Leadership is also required, international leadership at an unprecedented level leadership that crosses international boundaries as though

they didn't exist, because that is what engineers will need to do to meet the 2050 Challenge. And that leadership can also come from engineers.

Engineers have aspired to and successfully filled leadership roles in corporations, but are almost absent from elected public leadership roles, at least in the US. Of 535 members of Congress, there are only 5 engineers. Think of how much further along we would be towards meeting the 2050 Challenge if there were 100 engineers in Congress; and a similar proportion in every elected governing body on the planet. Imagine governments worldwide having return on investment conversations, optimizing globally and not locally, making the tough choices, implementing long term plans and knowing when and how to invest in the proper research. These are all qualities that engineers bring to the table. Other countries are far ahead of the US in this regard.

We are doing something fundamentally wrong in the educating and mentoring of our young engineers if they self select out of public leadership roles at a rate 60-to-1 greater than the social sciences.

The academic engineer has an obligation to mentor and instill leadership skills in our young engineers so they will aspire to and fulfill international leadership roles; so that the right decisions will be made on the use of technology in public policy and in addressing the 2050 Challenge. They must become as astute in people engineering as in mechanical engineering. The best technical solutions will fail if the cultural challenges of implementing them are not as high on the agenda as optimizing the design.

This is an enormous undertaking. Where do we start? You eat an elephant one bite at a time. And the first bite is changing the mindset of academic engineers and the students they teach, advise and mentor that the international perspective is not an option but a requirement if we wish to best the 2050 Challenge. We must make the case that international collaborations are required to do no less than save the planet; and it is our unique responsibility to do so as members of Colleges of Engineering.

The College of Engineering at Iowa State University is committed to meeting the 2050 Challenge. We are hiring our new faculty in clusters, groups of faculty with common scholarship interests, that address the 2050 Challenge.

- Biosciences and Engineering
- Energy Sciences and Technology
- Engineering for Extreme Events
- Information and Decision Sciences
- Engineering for Sustainability

We are establishing international collaborations in areas of education and research. We are doing our best to birth the next generation of engineering leadership through the Engineering Leadership Program and Engineering Policy and Leadership Institute. And we will require an internationalizing experience of our students in the very near future.

So how do I define the academic global engineer? One who is dedicated to international collaboration as the only possible way for us to meet the 2050 Challenge.