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# The Power of an Idea: The International Impacts of the Grand Challenges for Engineering

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Since the dawn of civilization, advances in the fields of engineering, science, and technology have played an indispensable role in shaping humans' social and economic development. Now people face a host of global challenges that must be addressed through long-term and innovative education, research, and engineering solutions. Recognizing the growing importance of these problems, a select group of experts in 2008 identified the Grand Challenges for Engineering. The idea of naming the specific problems to be addressed for global benefit caught on immediately and has been picking up speed ever since. Among other initiatives, two very successful Global Grand Challenges Summits have been jointly convened by the US National Academy of Engineering (NAE), UK Royal Academy of Engineering (RAE), and Chinese Academy of Engineering (CAE). Rarely has an idea captured the imagination of a profession, policymakers, and the general public as rapidly and forcefully as the Grand Challenges for Engineering.

## 1. Major challenges confronting the world

Since the beginning of the 21st century, the world has become a multipolar system characterized by increasing economic globalization, cultural diversification, and global communications, which have reduced distances and barriers between nations and people. Accompanying these changes are significant challenges to the survival and continued development of the world as we know it.

Sustainable growth is essential to modernization. Since the Industrial Revolution, the booming development of science and technology has significantly enhanced people's material goods, wealth, and standards of living. But the world's ever-growing population is consuming the Earth's resources at a pace that cannot be sustained if humanity is to survive. For example, the rapid exploitation and consumption of traditional energy sources such as coal, oil, and gas have undermined global energy security. And the conventional development model, characterized by widespread mass production, consumption, and waste, has led to severe environmental problems and climate changes.

All people want a healthy life and basic standard of living. At the United Nations Sustainable Development Summit 2015, it was pointed out more than 800 million people are still living on less than $1.25 USD a day, and we also need to make efforts to feed the current 800 million population and the additional 2 billion population expected by 2050.

Globalization has made it easier for people to cross borders and travel great distances. But this has given rise to and exacerbated a host of public health challenges, dramatically changing the global disease spectrum. Influenza, malaria, AIDS, SARS, and other varieties of new and old infectious diseases, like the current Zika virus, pose significant threats to human health. Antibiotic tolerance and other emerging public health challenges mount in a seemingly relentless tide of epidemics and public health crises. Clear commitment and ongoing efforts are needed to counter these dangers.

Urban renovation and reinvention pose complex challenges for engineers in the 21st century. The rapid expansion of cities—in terms of geographic area, population, industrial capacity, and transportation systems—has given rise to a host of "urban diseases" such as traffic congestion, environmental deterioration, housing shortages, unemployment, severely strained infrastructure, and degrading quality of life.

Systemic risks and globalized hazards in nontraditional security fields faced by policymakers are becoming more intense, diverse, and intricate. Terrorism, economic and financial instability, evolving cybersecurity challenges, and extreme weather events all pose transnational threats.

## 2. The idea of the Grand Challenges for Engineering

Identified in 2008 by a committee of 18 distinguished engineers, scientists, entrepreneurs, and visionaries, the Grand Challenges present 14 goals to ensure that human life as we know it can continue on this planet. Substantial effort went into selecting the Grand Challenges. The committee received the counsel of thousands from around the world, and more than 50 subject matter experts reviewed its report. Yet the challenges can be stated simply:

- Make solar energy economical.
- Provide energy from fusion.
- Develop carbon sequestration.
- Manage the nitrogen cycle.
- Provide access to clean water.
- Improve urban infrastructure.
- Advance health informatics.

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- Engineer better medicines.
- Reverse-engineer the brain.
- Prevent nuclear terror.
- Secure cyberspace.
- Enhance virtual reality.
- Advance personalized learning.
- Engineer the tools of scientific discovery.

The premise of the Grand Challenges is straightforward but essential: How can a high quality of life and security be maintained and extended worldwide in the 21st century? This is not a national idea, a business idea, or a government idea. It is an idea that encompasses everyone on the planet.

When proposed, the Grand Challenges were not ranked in importance or likelihood of finding a solution, nor was any implementation plan proposed for solving them. Rather, they were set forth as a way to inspire the engineering profession, young people, and the public at large to seek solutions. The Grand Challenges are a call to action, and they have created a growing, global, grass-roots movement that is changing how people think about the future and about the responsibility of engineering in creating that future.

The Grand Challenges have drawn attention to the need to promote the engineering that will achieve their solution. What the public knows and learns about engineering from the media is often wrong by omission or misrepresentation. For example, the construction of the Large Hadron Collider near Geneva, which explores the fundamental constituents of nature and discovered the "God particle" (the Higgs boson), was one of the great engineering feats of modern times. Yet publicity about the collider has essentially been silent about the engineering that created it.

The Grand Challenges also have called attention to the need to stop using the word "technology" when "engineering" is meant. Technology is an outcome; it is not engineering. If the public hears nothing about engineering, how can people develop a correct understanding about engineering and what engineers do?

Solving the Grand Challenges will require contributions from many professions in addition to engineering because the Grand Challenges are engineering *system* problems. Public policy, law, medicine, international relations, and science (including the social sciences and culture) and all of humanity must be engaged if solutions to these challenges are to be created and implemented. But engineering will play a leading role in their solutions.

## 3. The Global Grand Challenges Summits

The most visible indicators of the global nature of the Grand Challenges have been two major international summits, with planning for a third under way, to identify opportunities for global cooperation on engineering innovation and education. Jointly sponsored by the Chinese Academy of Engineering (CAE), UK Royal Academy of Engineering (RAE), and US National Academy of Engineering (NAE), the first Global Grand Challenges Summit was held in London in 2013, the second in Beijing in 2015, and a third will take place in Washington, DC in 2017.

The Beijing summit brought together more than 800 participants from around the world, including prominent engineers, entrepreneurs, and societal leaders. Webcast globally, it also served as an online classroom for hundreds of students who attended virtually. Designed to accelerate global engagement on the Grand Challenges, the summit led to international collaborations, friendships, and a renewed sense of what engineering does for people and society.

The Global Grand Challenges Summits have several potential outcomes. They inspire more students into engineering careers. They remind both students and experienced practicing engineers of the excitement, impacts, and importance of their profession and of their responsibility to the planet and generations to come. And they communicate to policymakers and the public that a prosperous, sustainable, and secure future for the planet depends on engineers and their collaborative efforts all over the world.

Given all these possible outcomes, the most effective approach to the summits has been to select talented engineers from all over the world who are doing exciting work that could have a profound impact on the planet's future and let them tell their stories. At the summit in Beijing, speakers discussed sustainability, urban infrastructure, health, energy, education, security, and resilience, as well as a topic that seems distant from engineering but is actually central to many engineering endeavors: the joy of living. As Robert Socolow, professor emeritus of mechanical and aerospace engineering at Princeton University, remarked, "Electronics delivers us music with marvelous fidelity. Air travel brings us access to the extraordinary variety of human cultures and natural settings. Electronics nurtures our curiosity by providing incredible access to information. Engineering in its many forms enables discoveries about our universe and the history of life, which we then share." It also creates our future.

Several essential messages emerged from these stories. The first is that many of the most exciting and potentially game-changing innovations develop across the boundaries of traditional disciplines. At the Beijing summit, Guang-Zhong Yang, director of the Hamlyn Centre at Imperial College, described wearable devices and smart implants that may lead to broadly accessible and personalized health care, thus exploiting informatics for public health needs. Jack Cohen, at the University of Warwick, outlined the potential use of virtual reality to prepare individuals to engage with the various systems in our societies.

The second message is that bringing together practitioners in engineering, the social sciences, and the arts to build excellent teams, make breakthroughs, and tackle global issues, such as sustainable energy and climate change, is a mandatory step, not merely a gesture toward inclusivity.

The third message was best expressed by Microsoft founder Bill Gates during his keynote address at the first summit, in London in 2013. "The market is a tremendously powerful driver of innovation," he said, "but it has its blind spots." He pointed out that more research money was being spent on a cure for male pattern baldness than on a cure for malaria. In cases of market failure, challenge-based approaches, whether they come from government, foundations, or communities, are critical to effecting change.

The summits have produced dialogue, debate, and collaboration among their participants, from students to academy members to industry leaders to policymakers. The international gatherings have demonstrated that an international community of engineers who take cross-disciplinary, challenge-based approaches to their practice may change the world. Initiatives are already emerging that capitalize on the energy and commitment of the gatherings, such as the joint call between the research councils of the United States and the United Kingdom to pursue the challenge of clean water for all[†].

The UK Engineering and Physical Sciences Research Council, which was a partner in delivering the London summit, followed up in 2014 with its own major Engineering Grand Challenges research call. In 2016, inspired by the Grand Challenges agenda, the

[†] The collaboration was announced by the US National Science Foundation Directorate for Engineering on April 3, 2013. Available from: www.nsf.gov/pubs/2013/nsf13082/nsf13082.jsp.