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Evolving Environmental Engineering for the 21st Century

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Environmental engineering is defined broadly as the design of systems and solutions where humans and the environment intersect, but the field is best characterized by the vast array of issues it has addressed in practice. Initially, environmental engineering researchers and practitioners focused on providing clean water and treating wastewater, drawing upon the field's roots in sanitation and public health. More recently, the field has expanded to address air pollution, hazardous waste, contaminated soil, emerging contaminants, green manufacturing, and sustainable urban design. The practice of environmental engineering has improved countless lives, and its achievements are a testament to its multidisciplinary, pragmatic, systems-oriented approach.

Despite a long list of breakthroughs, this progress is incomplete. Pollution and waterborne disease persist around the globe, and billions of people today continue to suffer from inadequate access to clean water, food, sanitation, and energy. As the human population continues to grow, pressures on the environment continue to mount. The challenges ahead will be of a different nature and a larger scale than those faced in the past, and they call for new thinking, perspectives and expanded roles for environmental engineers.

Environmental Engineering for the 21st Century: Addressing Grand Challenges, a consensus 108-page report of the National Academies of Sciences, Engineering, and Medicine, outlines crucial roles for environmental engineers in this period of dramatic growth and change.[1] The report was authored by 18 distinguished thought leaders (including environmental engineers, scientists, social scientists, and policy experts) to galvanize environmental engineers across the globe to address the most pressing challenges facing humanity in the 21st century.

The report identifies five grand challenges of the 21st century that environmental engineers are well-poised to help tackle:

1 Sustainably supply food, water, and energy;
2 Curb climate change and adapt to its impacts;
3 Design a future without pollution and waste;
4 Create efficient, healthy, resilient cities; and
5 Foster informed decisions and actions.

These challenges encompass traditional environmental engineering strengths, such as developing alternative water supplies and remediating hazardous pollution sources, but they also call upon the field to expand its efforts and direct the power and potential of the environmental engineering craft to the myriad of new challenges that will characterize the 21st century.

Systems thinking is a key strength that environmental engineering brings to the challenges we will face in the coming century, which are increasingly complex, interconnected, and global. Systems thinking facilitates innovative solutions that transcend technology alone and address multiple societal challenges simultaneously. For example, a holistic "farm to plate" assessment could engender processes and policies to reduce waste, pollution, energy, and water consumption associated with food production while improving access to healthy dietary choices.

Pressures posed by resource consumption, pollution, and waste will intensify as the world's population grows and standards of living increase. Environmental engineering principles will be essential to valuing ecological systems and services and replacing linear "take-make-waste" models of resource use with circular economies, where products and processes are designed to repurpose waste products from one activity into inputs for another while ameliorating adverse impacts, such as contamination of water, soil, and air.

To be sure, one of the most pressing issues of our time is climate change. Challenges posed by developing sustainable energy sources that do not adversely impact our climate will require a full and holistic understanding of potential environmental and societal benefits and impacts that environmental engineers must help address.

Engineers and scientists cannot meet challenges such as these simply by developing and implementing innovative technologies in isolation. Success will depend on the ability to proactively engage communities and stakeholders that engineering solutions are designed to serve, with a keen awareness of the needs of people historically excluded from

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environmental decision making, such as those who are socioeconomically disadvantaged, members of underrepresented groups, or otherwise marginalized. It also will require rich and robust partnerships with scholars and practitioners from different disciplines and backgrounds, including economists, policy scholars and practitioners, lawyers, and businesses and entrepreneurs. Environmental engineers are well positioned to clarify the social, environmental, and economic dimensions of our choices; connect diverse disciplines and practitioner communities; and advance solutions that are practical, sustainable, and consequential.

Implementing a new model for the field will require innovations in environmental engineering education. Course offerings should be updated to keep pace with current and anticipated global challenges and the most promising tools for developing solutions. Extracurricular and experiential programs, such as the National Academy of Engineering's Grand Challenges Scholars Program or Engineers Without Borders, can also strengthen, contextualize, and inspire the undergraduate educational experience. Yet, there are limits to how much can be included in a four year undergraduate program, and new subspecialties related to the grand challenges may need to be introduced at the undergraduate level but fully developed and delivered through graduate programs. Almost certainly, increased focus on the compelling challenges of the 21st century will help attract the best and brightest students to the field to address these vexing problems.

The grand challenges also provide impetus for evolving environmental engineering research and practice toward broader contributions and greater impact. Universities and funding agencies should help incentivize interdisciplinary research on complex social and environmental problems and foster environments where relationships and collaborations develop organically. The environmental engineering field must pay particular attention to cultivating a more diverse workforce, focusing on increased racial and ethnic diversity of the pipeline of students who enter this field.

As humanity faces mounting and diverse challenges, the field of environmental engineering must build on its strengths, inspire and implement visionary solutions, and continue to evolve in order to serve the best interests of people and the planet. The five grand challenges provide focal points for evolving environmental engineering education, research, and practice toward increased contributions and a greater impact. Although this is unquestionably an ambitious vision, it is feasible and imperative to advance a future where both humans and ecosystems thrive.

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REFERENCES

(1) National Academies of Sciences, Engineering, and Medicine. *Environmental Engineering for the 21st Century: Addressing Grand Challenges*; The National Academies Press: Washington, DC, 2019; https://doi.org/10.17226/25121.

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