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The Responsibility of Scientists and Engineers to the Stewardship of the Earth and Its Environment

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The advances of SCIENCE and ENGINEERING are a cornerstone for the technical advancement and economic productivity of scociety.

These advances are also responsible for the environmental impacts presented to the earth.

While the scientist and engineer contribute to the productivity of the earth, so must the scientist and engineer assume a responsibility of stewardship for the earth and its environment.

In our teachings, training, and daily professional practice, environmental impacts associated with advancements in technology are neither regularly addressed nor acknowledged. One needs only to examine undergraduate curricula in science and engineering. Courses in environmental impact and assessment are not offered. The accreditation guidelines for engineering programs in the United States, for example, do not require environment topics as either integral to, or peripheral to, the standard programs.

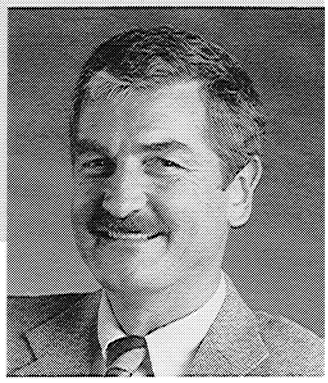
What is taught are the laws of energy conservation, and mass conservation. These are basic principles of thermodynamics that are routinely presented in undergraduate courses in physics, introductory courses in engineering, and graduate courses in both science and engineerring. In addition, while students study, practitioners daily apply these principles in design and analysis.

In contrast, the law of environmental constraint is not embraced.

The world's energy serves as one example.

The provision of the world's energy provides the electricity, propulsion, and industrial processing essential to the economic health of society. This work of science and engineering is recognized as commendable and necessary. Yet, science and engineering have relied upon combustion as the source of energy. As a result, ninety (90) percent of the world's energy is today provided by combustion. However, combustion

"Teaching and Practicing the Environmental Law of Thermodynamics: The Missing Boundary Condition"



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⟨Research Activities⟩

Dr. Samuelsen's research focuses on air quality and propulsion systems, with pioneering work in gas turbine and spray combustion, coal combustion, hazardous waste incineration, air quality assessment, and environment toxicology. His current emphasis encompasses the development and application of laser diagnostics to practical combustion systems, the development and use of model combustors with clean boundary conditions and optical access, and model liquid fuels. His work has been documented in over 150 journal articles and conference papers.

produces over ninety percent of the contamination to the atmosphere. The result: urban smog, greenhouse gases, and stratospheric ozone depleting gases.

The reasons ? The mass associated with pollutant species is negligible and, as a result, is ignored in the conservation of mass. Similarly, the energy associated with the pollutant species is negligible compared to the reactants and major products of combustion. Hence, in the energy as well as the mass equations, pollutant species can be, and are, ignored.*1

Mother nature is incredibly subtle and powerful. On the one hand, fossil fuel is provided to satisfy the energy thirst of society. On the other hand, mother nature assigns a toxicity to trace species that, through environmental impact, is a gentle reminder for restraint. Environmental impacts are today beginning to constrain (1) the quality of fossil fuels that can be used, (2) the extent to which fossil fuels can be used, and (3) the conditions under which fossil fuels can be used.

Clearly, environmental constraints invoke consideration of a boundary condition in addition to energy and mass:

The earth and its environment is a closed mass of finite dimension.

Boundary conditions are a necessary prescription in the definition of science and engineering problems. Ignored to date, mother nature is making it patently clear that the environmental boundary condition can no longer be ignored in teaching and practice.

Scientists and engineers are reacting.

For example, the current wave of public sensitivity to the environment is rooted in an evolving public awareness of environmental impacts. In a domino effect, the political arena is reacting to this public sensitivity, and the science and engineering community is reacting to the political and associated regulatory pressures.

Although significant, this response is reactive, not proactive.

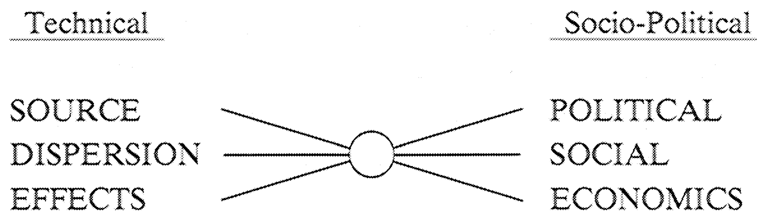
A proactive response is needed with a vigor that mirrors the intensity with which the laws of energy and mass are taught and practiced.

Consider the model for environmental pollution[*2]--

SOURCE → DISPERSION → EFFECTS

The model also aptly describes **the effect** of a proactive response. Consider yourself, for example, as **a source** for the training and teaching of the boundary condition imposed by the environment. By **the dispersion** of this basic principle, the practice of fellow scientists and engineers will be affected. If the sources for the introduction of environmental principles are undergraduate science and engineering curricula, then the dispersion will lead to a demonstrative effect on generations of future scientists and engineers.

Through this process, not only will scientists and engineers be affected, the socio-political process will, in time, be influenced as well.
How ?
As illustrated below[*2], in no other area of science and engineering is technology so interwoven with the socio-polical arena:



The natural interplay between the technical and socio-political assures that proactive leadership by scientists and engineers will impact the socio-political process. The difference between reactive and proactive is whether scientists and engineers take the lead, OR whether scientists and engineers are lead.

It is a basic responsibility of the scientist and engineer to define, teach, and apply the principles of nature. Can the boundary condition imposed by the environmental be ignored ?

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*1. Carbon dioxide (a major product of combustion that is negligible in neither energy nor mass, and plays a significant role as a greenhouse gas) is not yet defined as a pollutant, only a contaminant. The environmental effects of CO_2 are also ignored in today's curricula.

*2. AIR QUALITY IMPACT ANALYSIS (1979).
In J. Rau and D. Wooten (eds.), *Environmental Impact and Assessment Handbook*, 3-1 to 3-165, McGraw Hill

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〈要　旨〉

科学・工学の進歩は社会の技術的・経済的な発展の土台となっているが，それだけに，科学技術者は地球環境の管理に対しても責任を負わなければならない．現在アメリカの大学では，エネルギー保存の法則や，質量保存の法則などの熱力学の基本に関する教育は多くなされているが，環境の拘束力についての教育は軽視されている。

世界のエネルギーの90％が燃焼によって供給され，また大気汚染物質の90％以上が，燃焼によりもたらされているにも拘ず，従来，その量やエネルギーが熱力学的に非常に小さいからといって無視してきた．しかしながら，母なる地球は信じられないほど繊細，かつパワフルである．化石燃料はエネルギーを供給する一方で，環境に影響を与えることにより，「地球が有限の閉ざされた系である」ことをさりげなく警告している．今や，環境の境界条件に関する教育が必須の課題となっている．

現在の環境問題への高まりは，一般大衆の環境問題への関心が政治の場に作用し，そしてこの政治的圧力に作用されて科学技術者達が動くといういわばドミノ現象に起因している．いいかえれば，いずれも受身的に触発されているといえる．

環境汚染のしくみは，『Source→Dispersion→Effect』の流れとなるが，環境の境界条件を教育する場合も同様の手法が必要となる．まず，貴方自身が発生源となり同僚に波及させたり，学生の教育カリキュラムに入れることが次世代の科学技術者に影響を及ぼすことになる．また，このプロセスを通じて，科学技術者だけではなく社会・政治も同様に影響を受けることになる．科学技術者がこの流れに沿って指導力を発揮すれば，社会・政治を確実に動かすことはできる．科学技術者の責務は，自然の原理を定義し，教え，そして応用することである．

環境が課している境界条件を無視することができるだろうか？

（文責　編集部）
