Ethics, Engineering, and Sustainable Development

Mark Manion

The term 'sustainable development' dates back to the early 1970s when certain business and government leaders began to argue that exponential growth —in human populations and industrialization — simply cannot continue indefinitely. One such group of leaders, the Club of Rome, issued a report, *Limits to Growth***,** now recognized as a cornerstone piece of literature for the movement. In a tone somewhat reminiscent of the pessimism of 19th century Malthusianism, *Limits* warned of impending ecological disaster should nothing be done immediately to halt resource depletion, excessive energy consumption, population growth, too much pollution and waste, inappropriate technology transfer, and related problems.

The author is with Drexel University, Department of Humanities and Communications, MacAlister Hall 9-5040, Philadelphia, PA 19104.

The response to reports like *Limits to Growth* was mixed. Some critics tried to ignore the message, simply sticking to the old but entrenched belief that nature possesses inexhaustible resources, permitting it to bounce back from even the most severe depletion and contamination. Proponents of sustainable development, on the other hand, campaigned vigorously to limit growth at local, national, and global levels.

Sustainable development gained momentum and worldwide familiarity thanks to the Bruntland Commission's 1987 report, *Our Common Future*, sponsored by the World Council on Economic Development (WCED). This breakthrough report demonstrated that economic development and environmental protection are not necessarily in conflict. Instead, the potentially synergistic tension between economics and the environment is nicely captured in the Commission's celebrated definition of 'sus-

0278-0079/02/$17.00©2002IEEE

tainable development' as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs."

Whereas critics during the 1970s simply tried to dismiss the notion of sustainable development, in the 1980s and 1990s critics took a more scientific approach — they charged that the term was non-operational because of ineliminable scientific uncertainties surrounding risks from pollution and resource depletion. In addition, they deemed the concept of sustainable development as invariably vague, because it had no universally accepted definition. Hence, it became available for any interest group to exploit. Many feared that sustainable development would become an ideological slogan rather than a crucial public policy tool through which nations could influence their common future. For example, one compendium lists no less than 30 definitions for 'sustainable development.' This conceptual ambiguity, combined with the lack of scientific certainty in trying to calculate whether, when, how, and why entire ecosystems could be irreparably damaged, created stumbling blocks implementing the concept through effective business and engineering practices.

Some defenders of sustainable development have since begun to answer the critics by developing strategies to make the term operational. Many large firms and governments, with guidance from the scientific and technical communities, have developed methods for measuring environmental impacts. Proponents call these activities "ecological footprint theory," a theory which includes such strategies as environmental management, resource accounting, and ecological impact assessments, to name just a few. Using interdisciplinary approaches from ecology, demographics, chaos theory and economics, experts believe that we can at least get a rough idea of development's impact. They measure the "stocks" of nature's resources such as forests, topsoil, atmosphere, fossil fuels, water, minerals, and the like. More importantly, such theorists claim to measure the "flows" of such resources — the growth of new forests, the natural absorption of pollution — as they are affected by technological, economic, political, regulatory, and social factors. With these measurements, experts can derive some convincing scientific data on the "ecological footprints" of various technologies and practices, while still admitting lack of absolutely certain data.

Other proponents of sustainable development understand it as more of a philosophical ideal than a scientifically operational concept. They think of a sustainable development not as a scientific concept to be operationalized, but as a philosophical ideal to be valued and explored. Most proponents of sustainable development, however, advocate putting into practice the "precautionary principle," which states: "When an activity raises threats of harm to human health and the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically." According to this principle, lacking scientific certainty about damage to the environment caused by some technological process or system does not give one the right to ignore any possible negative consequences, and hence do nothing to prevent them.

The high-profile United Nations Conference on Environment and Development (UNCED), the so-called Earth Summit held in Rio de Janeiro in 1992, communicated the idea that sustainable development is both a scientific concept and a philosophical ideal. The Conference produced an influential document, Agenda 21, hailed by 178 participating governments as a "blueprint for action for global sustainable development into the 21st century." Among the various principles drafted as part of Agenda 21 were Principle #3, which states that "the right to development must be fulfilled so as to equitably meet development and environmental needs of present and future generations," and Principle #4, which states: "in order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it." Agenda 21 expresses an ambitious host of unifying goals, such as population stabilization, appropriate technology transfer, efficient use of natural resources, waste reduction, pollution prevention, and integrated environmental systems management. In addition, Agenda 21 promotes human rights development, global social equity, environmental justice, and the elimination of world poverty.

In addition to questions of ecological and economic sustainability, Agenda 21 raises questions about social sustainability. Serious questions about the distribution of "goods" (such as wealth, natural resources, food, housing, technology, etc.) and "bads" (such as pollution, resource depletion, poverty, industrial disease, etc) certainly raise issues major issues about justice, equity, human rights, and opportunity for health and prosperity. It would be difficult to expect constructive cooperation towards sustained development if more and more people are denied healthy and secure lives, while a small elite fight to protect its surplus. In other words, social disenfranchisement will do nothing but fuel destructive social conflicts. Hence, according to the new philosophy, for a community to be truly sustainable, it must adopt a three-pronged approach that considers both economic and environmental issues as well as ethical and political issues.

ENGINEERING PROFESSION'S PUBLIC POLICY TOWARD SUSTAINABLE DEVELOPMENT

The engineering community has responded to the problem of sustainable development in two major ways: through public policy statements recognizing the gravity of the problem and publicly pledging to direct engineering in ways to increase sustainable technology and to avoid the production of nonsustainable technology. The other major way the engineering community has responded to the imperative of sustainable development is through technological innovation and invention.

Engineering public policy directives are derived from at least three sources: 1) professional engineering societies through their codes of ethics; 2) engineering organizations, and 3) pedagogy requirements set forth by leading engineering and technology accreditation institutions and their affiliates.

Through their codes of ethics, professional engineering societies have made important, albeit preliminary, commitments to the environment. The Institute of Electrical and Electronics Engineers (IEEE) Code of Ethics was one of the first to make such a commitment. Its first injunction to its members is to:

> "Accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment."

An even stronger commitment appears in Code of Ethics of the American Society of Civil Engineers (ASCE), which entreats its members to maintain responsibility towards sustainable development. Canon 1 of the ASCE code states:

> "Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties."

ASCE policy statement 418, "The Role of the Civil Engineer in Sustainable Development," adopted in 2001, further entreats its members to be civic as well as technical leaders in the creation of sustainable communities through sustainable engineering practices.

In addition to professional societies such as the ASCE and IEEE, the American Association of Engineering Societies (AAES) has taken an active role in advocating sustainable engineering. The AAES is presently involved in an active joint venture with the World Engineering Partnership for Sustainable Development (WEPSD), a global coalition of engineering organizations committed to fostering sustainable development in the long term. The WEPSD vision statement is as follows:

> "Engineers will translate the dreams of humanity, traditional knowledge, and the concepts of science into action through the creative application of technology to achieve sustainable development. The ethics, education, and practices of the engineering profession will shape a sustainable future for all generations. To achieve this vision, the leadership of the world engineering community will join together in an integrated partnership to actively engage with all disciplines and decision makers to provide advice, leadership, and facilitation for our shared and sustainable world" [3, p. 7].

Collectively, the WEPSD represents 12 million engineers worldwide. The WEPSD is committed to the following critical issues:

- The need to unify the global engineering community, particularly around the issue of sustainability;
- The belief that the world engineering community has a responsibility to apply its technical expertise towards the implementation of sustainable development at the individual, corporate, and institutional levels;
- The need to cultivate and unify key relationships in the global environment and development community with sustainability serving as the central bridge linking various organizations and resources [3, pp. 8-9].

Other such engineering and science organizations committed to the goals and values of sustainable development include: American Engineers for Social Responsibility, Physicians for Social Responsibility, Scientists for Global Responsibility, Computer Professionals for Social Responsibility, International Center for Technology Assessment, the Center for Alternative Technology, the Union of Concerned Scientists, and the International Network of Engineers and Scientists for Global Responsibility (INES). INES, for example, is an independent non-profit organization built into a worldwide network of over 80 member organizations in over 50 countries.

Perhaps the most important response from the engineering community is the policy commitment of major institutions of engineering education, namely the Accreditation Board for Engineering and Technology (ABET) and the American Society of Engineering Education (ASEE). Criterion 3 of the ABET 2000 criteria dictates that engineering students demonstrate: a) an understanding of professional and ethical responsibility; and b) an understanding of the impact of engineering in a global and societal context. Criterion 4 places an emphasis on the larger, social impacts of engineering by requiring that "a major design experience… must include… the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political."

The importance ABET places on educating engineers about sustainable development is mirrored in the "ASEE Statement on Sustainable Development Education." The statement reads:

> "Engineering students should learn about sustainable development and sustainability in the general education component of the curriculum as they are preparing for the major design experience. For example, studies of economics and ethics are necessary to understand the need to use sustainable engineering techniques, including improved clean technologies. In teaching sustainable design, faculty should ask their students to consider the impacts of design upon U.S. society, and upon other nations and cultures. Engineering faculty should use systems approaches, including interdisciplinary teams, to teach pollution prevention techniques, life cycle analysis, industrial ecology, and other sustainable engineering concepts…"
>
> "ASEE believes that engineering graduates must be prepared by their education to use sustainable engineering techniques in the practice of their profession and to take leadership roles in facilitating sustainable development in their communities (ASEE Statement on Sustainable Development Education, 1999)."

If one looks at the practice of engineering over the last 150 years, it is evident that engineers have embraced the goal of public safety as an implicit goal in all engineering projects. The hope is that sustainability will be integrated into engineering so that an engineer would no more design an unsustainable system or artifact than an unsafe one.

Engineering design that respects the call to "reduce, reuse, and recycle" is a perfect example of how engineers can take the lead in developing sustainable engineering. The inclusion of recycled wood products, metals, glass, plastics, concrete, etc. can benefit society and the environment in three ways. First, recyclables reduce waste and the growing problem of its storage and disposal. Second, recyclables contribute to the conservation of raw materials and resources that then do not have to be taken from the environment. Third, recycling pays!

Specific examples of this kind of practice abound. The recycling of already contaminated metals is projected to save the U.S. Department of Energy (DOE) and the nuclear industry two million tons of new metal resources. This recycling greatly reduces the overall poisoning of the environment because two million tons less toxic waste will enter the environment. Or take the example of the Texas Department of Transportation (DOT), which has begun to use styrene and carbon black from used printer and copier cartridges as an asphalt additive. This additive improves pavement high temperature performance, and keeps lots of waste out of already overcrowded landfills. This practice is part of the Texas DOT plan to use recyclables such as glass, shingles, and shredded brush in their roads and parking lots, instead of further clogging up the state's dumps. Other examples include the development of new construction methods using fiber-reinforced wood, wood composite products, and polystyrene, in various types of structures, from homes to office buildings to skyscrapers. Such sustainable engineering construction practices have reportedly helped Dow-Europe cut overall fuel costs by 30 percent and the cost of raw materials by 40 percent in all building projects.

The American Business Establishment and Sustainable Development

The 1992 Rio Earth Summit came as a wake-up call for American corporations and government officials. The Summit highlighted the potential risks to the environment and long-term economic and social development created by current patterns of industrialization, population growth, and social inequality and human rights violations. The American government responded to Agenda 21 by creating the President's Council on Sustainable Development (PCSD), which was established by President Clinton through Executive Order No. 12852 on June 29, 1993. Since its inception, the PCSD has produced numerous task forces, and generated recommendations thorough workshops, demonstration projects, case studies, regional round tables, public comment, published reports, as well as through other courses of action.

The response to the ecological challenge by the international community has been a flurry of international law treaties. In 1987, with the Montreal Protocol on Substances that Deplete the Ozone Layer, 37 signatory nations agreed to cut, by half, their release of chlorofluorocarbons (CFCs) into the environment by the year 2000. The Montreal Protocol was further amended and expanded in 1990

(London), 1992 (Copenhagen), 1994 (Paris), and 1997 (Beijing). In 1990, the U.S. Congress amended the Clean Air Act of 1970 to implement the Montreal Protocol. Since then, dozens of federal legislative acts — such as the National Greenhouse Gas Emissions Inventory Act of 2001, the Emissions Reductions Incentive Act of 2001, the Climate Change Risk Management Act of 2001 and the Clean Power Plant and Modernization Act of 2001 — have been debated in the U.S. Congress. In 1997 over 150 countries negotiated to form the Kyoto Protocol, which requires nations to cut their emissions of carbon dioxide and other greenhouse gases (GHGs) substantially in the coming years. Just how substantial is indicated by the fact that had the U.S. adopted it, the Kyoto Protocol would have required that the U.S. cut its CO_2 emissions by 35 percent by 2010.

Important advances like the 1992 Rio Earth Summit, the 1987 Montreal Protocol and its numerous amendments, and the 1997 Kyoto Protocol, are beginning to have substantial effects on American business. The message for companies doing nothing to meet CO_2, GHG, and other toxic substances reductions is critical: they must respond with action. The message to companies already taking the environment seriously is to do more and to pay greater attention to the issue of sustainable development and sustainable engineering. In 1990 DuPont's then CEO, Edgar Woolrad, identified the developing trend toward incorporating ecological sustainability into an already growing "Total Quality Management" (TQM) movement:

> "The green economies and lifestyles of the twenty-first century may be conceptualized by environmental thinkers, but they can only be actualized by industrial corporations. Industry has a next-century vision of integrated environmental performance. Not every company is there yet, but most are trying. Those that aren't trying won't be a problem long-term, simply because they won't be around long-term. This is the new competitive reality" (quoted in [2, p. 1]).

The words of Woolrad are reflected in the words of Maurice Strong, Secretary General of the UNSED Earth Summit, who remarked:

> "Efficient enterprises are at the head of the movement to sustainable development. Corporations that are on the leading edge of a new generation of opportunities created by the transition to sustainable development will be the most successful in terms of profits and the interests of their shareholders. Businesses that are defensive, fighting yesterday's battles will fall by the wayside and will be caught in the backwash of the wave of the future" (quoted in [8, p. 2]).

Indeed, it is becoming more and more evident to corporate leaders that environmental responsibility is the next step in total quality management — some call it total quality environment management (TQEM) — a step that is becoming increasingly necessary in order to ensure their companies' continued competitiveness and profitability. More and more, government and business leaders are moving away from "end-of-pipe" environmental policies and adopting the "precautionary principle." In the pursuit of TQEM, businesses and industry in the United States and around the world are noticeably becoming more environmentally responsible. They are, in effect, "going green." In a survey conducted in 1991 by a major polling firm, 75 percent of the Fortune 200 firms surveyed recognized the environment as a central strategic issue. In numerous companies, pollution prevention, sustainability, full-life-cycle packaging, green marketing, and measurement of environmental performance are presently all sectors of intense focus and investment. Environmental performance helps to determine a company's reputation, among employees, customers, and other stakeholders. A poor environmental reputation can harm recruitment and morale, damage sales; it can even threaten a company's license to operate.

The reality is, businesses are not only going green, but improving their competitive positions by going green. Sustainable manufacturing also pays, as examples from the chemical industry have shown. Two well-cited examples are 3M Corporation's "3P" program ("Pollution Prevention Pays"), reported to have saved the company hundreds of millions of dollars, and Dow Chemical's "Waste Reduction Always Pays" program. Other Fortune 500 success stories dramatize that economic development need not conflict with environmental concerns.

The greening of business and industry is happening fast and it is happening globally. The global characteristic of the movement appears clearly in the growth of international environmental business networks. One example is the World Business Council for Sustainable Development (WBCSD), mentioned above. In addition, other international business NGOs include the Coalition of Environmentally Responsible Economies, the Management Institute for Environment & Business, the International Institute for Sustainable Development, and Business for Social Responsibility. Presently, it is no longer a question of whether companies will heed the call to sustainable development, but how, and how fast!

In sum, the legal and social pressures placed on corporations by environmentalism and the philosophy of sustainable development have created a great demand for more environmentally sound and human friendly technological systems, artifacts, and products.

Quarrel Between Engineering and Business Management

Engineers of all disciplines are in a unique position to lead by example. They can design alternative fabrication processes that produce only small amounts of waste, or cost effective and environmentally sound energy sources such as solar power, environmentally sound materials for construction, or other designs. In light of the trend towards clean engineering design and the philosophy of sustainable development, engineering could become one of most the sought-after professions. As one expert put it: "The environmental challenge will be one of the central issues of the 21st century." Moreover, engineering, perhaps more than any other profession, has an opportunity to contribute to the nuts and bolts of sustainable development. To meet these challenges, whole new dimensions of engineering theory and practice are emerging. Terms that point toward these new forms of engineering are: alternative technology, preventive engineering, sustainable engineering, design for environment, and green design. My point is that the engineering profession surely does not want to miss this opportunity to exert its influence in business and economics. According to many, however, the American engineering profession will be able to meet the challenge only if they are able to reconcile their long-term quarrels with corporate management and government officials over who gets to make the major decisions about what technology gets funded, designed, manufactured, and sold.

Many critics claim that engineers working in large corporations are subjected to various organizational and legal constraints which do not permit the necessary decision-making autonomy required in order to hold engineers responsible for the societal and environmental risks of technology. Engineers are not the only ones responsible for decisions concerning technological development or policy—managers, corporate executives, government regulators, legislators, consumers, and others must all play their part. Hence, even if fulfilling such ultimate values as expressed in the various public policy statements of engineers were possible, engineers would still be severely hampered in their ability to honor them. The variety of harassment, firings, black-listings, etc., that constantly confronts whistleblowers underscores the organizational constraints often imposed on engineers who speak out in the public interest.

The "received view," as Michael Davis [1] calls it, sees the engineer, who lacks the full autonomy necessary to be a responsible and ethical engineer, in constant conflict with corporate management, who often ends up overriding engineering judgment concerning technological designs because of their incessant pursuit of the bottom line. Lack of professional autonomy leaves scant room for moral choice for most engineers. As a result, it is often argued that:

> "Engineers are a 'captive profession' in a highly compartmentalized environment. Managers choose what to do, divide work into small jobs, and assign each job to one engineer or small group. Communication between engineers is kept to a minimum to assure management control. An engineer may need permission from his boss even to discuss a project with an engineer in another department or working group. Engineers identify options, test them, and report the results to managers. Managers combine these reports with business information they alone have. Managers decide. Engineers merely advise" [1, p. 42].

According to such accounts, engineers working in large corporations are all too often used as mere "hired-hands" who develop technology with the sole purpose of advancing the economic demands of the corporate client. This "received view" goes far back to the origins of the American engineering profession as Edwin Layton's influential book, *The Revolt of the Engineers* demonstrates, and it is also reflected in the history of the Canadian Engineering profession. As Millard puts it:

> "Engineers were not independent professionals. Most of them were employees of large corporations and governments. This was the most important factor affecting their professional life. Emerging from the canal- and railway-building enterprises of the nineteenth century, the engineer was a creature of large bureaucratic organizations—the original 'organization man'" [11, p. 41].

However, researchers such as Davis himself have in fact recently challenged the claim that modern engineers lack any decision-making authority in the corporate workplace. After an empirical investigation involving interviews and surveys of 60 engineering and management employees in 10 companies, Davis concludes that:

> "Instead of the rigid hierarchical and compartmentalized decision making process of the received view, we found a highly fluid process depend-

ing heavily on meetings and less formal exchange of information across even departmental boundaries. Managers seemed to have little control over what information would reach their engineers. Indeed, they seemed anxious to get their engineers to hook up with others on their own" [1, p. 51].

The greening of American business and technology policy may be, however, the solution to the seemingly intractable dilemmas the ethical engineer confronts when trying to reconcile business interests with the public interest. Perhaps for the first time, such changing conditions in corporate American culture provide the opportunity for engineers to exercise what Stephen Unger calls one's "right to be an ethical engineer" [12].

Some point out that policy statements and professional codes have an important role to play in establishing a "social contract" between the engineering profession and society at large. In other words, the injunctions of the codes to protect the safety, health and welfare of society and the environment could be interpreted as a "promissory note" to society, made by the engineering profession, to uphold their part of the contract. In other words, the roots of the engineering profession's duties and responsibilities to society can be said to be derived from a "social contract" that holds, at least implicitly, between the engineering profession and society. In order to uphold their part of the contract, society provides engineers, through the tax base, with educational opportunities, and through legislation, with the means for licensing and regulating themselves. In addition, professionals are given a place of honor and are usually compensated with higher-than-average salaries. In return, engineers in their professional practice have a responsibility to protect the public's safety and well-being.

An important point of my thesis is that we need a revised social contract between the engineering community and society. So far, the engineering community has demonstrated that it is ready, willing, and able to contribute to ecological and economic sustainability through technological innovation and its various public policy statements. In turn, society has a responsibility to fulfill its side of the contract by providing funding, state-of-the-art research facilities, and appropriate career opportunities conducive to sustainable engineering practices and innovations, as well as providing opportunities for engineers to inform and participate in the decision-making process regarding technology policy. If such developments proceed, then we will see the emergence of a new social contract between the engineering and scientific communities and society in which ethical dimensions play a central, guiding role.

A new social contract between engineers and society could finally permit engineers to practice their "right" to ethical engineering and hence may help engineers avoid narrow technocratic goals that often result in rigid requirements when only the "bottom-line" is at issue. If such a new social contract were forged between the engineering profession and society, sustainable engineering practice might not become "co-opted and corrupted by those who would ignore [their] ethical implications and focus on the sustainability of markets to the neglect of environmental and human considerations" [5, p. 48]. The fear is that, "despite proclamations that engineers have an ethical responsibility to endorse the principles of sustainable development, questions of just distribution and other questions of equity (such as risk distribution) are often ignored when engineers consider sustainable development policies" [5, p. 49]. My thesis is that a philosophy of engineering ethics, grounded a non-utilitarian ethic would go far to avoid such problems.

Two Philosophies of Engineering Ethics

There are at least two viable ethical philosophies which engineers often follow when considering their social responsibilities towards sustainable development. One is utilitarian in nature, one more duty-based. An example of a utilitarian ethic is the widespread and almost exclusive use of risk-cost-benefit-analysis (RCBA) in all major technology assessment strategies used by engineers. I would like to argue that an exclusively utilitarian ethic cannot support a philosophy of engineering ethics based on sustainable development due to the numerous ethical deficiencies associated with RCBA methodologies, two of which are especially pertinent here. They are 1) the value-of-life problem, and 2) problems of distributive, social, intergenerational, and ecological justice.

Of all the difficulties that surround the attempt to calculate the economic value of a human life, a necessary component in RCBA, one of the most problematic is a moral one — when and how, if ever, is it ethical to place a price on a human life? There are, of course, certain practices used by insurance agencies, economists, and risk assessors which demonstrate that society does place some implicit monetary value on human lives. As one ethicist put it, "If it is permissible to forego life-saving treatment due to its cost, life has a monetary price." On the other hand, there is a long and venerable tradition in our philosophical attitudes toward the value-of-life problem, perhaps best put by the Enlightenment philosopher Immanuel Kant when he wrote:

> "In the realm of ends everything has either a price or a dignity. Whatever has a price can be replaced by something else as its equivalent;

> on the other hand, whatever is above all price, and therefore admits of no equivalent, has a dignity" [7,].

Of course for Kant, human persons are such creatures that exemplify "dignity." Such a sentiment is reflected in a sign that Albert Einstein is reported to have had hanging in his office. The sign read: "Not everything that counts can be counted, and not everything that can be counted, counts."

The second set of problems that beset RCBA methodologies are the well-known criticisms that RCBA fails to adequately address issues of fairness and justice associated with the equitable distribution of risks and harms. For one thing, RCBA, consistent with its utilitarian foundations, places exclusive focus on the total aggregate benefits and harms of a proposed technology, and not on how those benefits and harms are distributed. For example, although the net benefit of a technological innovation may be positive overall, the distribution of goods and harms may not be fair. This is because, although the principle of beneficence — to create greater good — is satisfied, the principle of justice is all too often overlooked. And, since RCBA is primarily geared toward favoring short-range exploitation of opportunities and resources, it tends to be inadequately concerned about issues of intergenerational justice. In other words, RCBA fails to address questions about the duties, obligations, and responsibilities one generation has to the next. Given recent concern over questions of sustainability, resource depletion, toxic and hazardous wastes, and so on, this constitutes a major flaw in the ethical foundations of RCBA. RCBA also tends to ignore considerations of ecological justice. Pressing concerns that RCBA fails to address include the scarcity of nonrenewable resources, irreversible habitat and land destruction, the extinction of endangered species, depletion of the ozone layer, global warming, and the like.

The moral soundness of RCBA is no better than the utilitarian ethic that provides its moral foundations. However, utilitarianism's blindness to questions of distributive, intergenerational, and ecological justice proves that we should formulate a new engineering ethic to meet the needs of sustainable engineering. This means that engineers need to reconsider the validity of their typically utilitarian way of responding to questions about technology. Such moral deficiencies have led some to advocate a philosophy of engineering ethics grounded in a doctrine of informed consent, and not just "utility maximization."

Some theorists argue that, since no engineering project is ever totally free from risk, most engineering projects can and should be interpreted as "experiments." On this model, an engineering project can be understood as an "experiment" — a potentially risky undertaking — on a social scale. Such theorists characterize engineering as social experimentation and, on the analogy with medical experimentation, they argue that the doctrine of informed consent must be recognized and honored between the experimenters (engineers and their corporations) and their subjects (the general public) [10].

Inasmuch as people will be affected by engineering "experiments," their voice should be considered in the undertaking of engineering projects and other technological developments. In other words, the public must be informed of all the risks as well as benefits from a proposed technological innovation, and must somehow give consent. From this it follows that the moral relationships existing between engineers and the public should be grounded along the lines of an ethic of informed consent. The social experimentation model, with its corollary doctrine of informed consent, is not without its problems. It does suggest, however, a viable alternative to the generally accepted utilitarianism of much of engineering thinking that could better ground the social responsibilities of engineers and their commitment to the ideals and practices of sustainable development.

The unprecedented level of negative impacts due to turbo-industrialization has forced engineers to confront the necessities of sustainable development. This confrontation has, in turn, forced engineers to recognize the limitations of traditional ethical systems (utilitarianism, social welfarism, traditional deontology, etc.) and has stimulated the development of an alternative ethics that can help engineers understand how to articulate their duties, obligations, and responsibilities for the 21st century. Consider, for example, the following principles:

> "Act so that the effects of your action are compatible with the permanence of genuine life,"
>
> "Act so that the effects of your action are not destructive of the future possibility of such life,"
>
> "Do not compromise the conditions for an indefinite continuation of humanity on earth,"
>
> "In your present choices, include the future wholeness of Humanity among the objects of your will."[1]

The philosophical ideals expressed in such imperatives are indeed very general and need explicit formulations, which,

[1]These formulations are from the philosopher of technology Hans Jonas [6], who develops them in a somewhat different context.

unfortunately, cannot be developed here. However, they at least provide one possible foundation for a philosophy of engineering ethics that goes beyond the traditional utilitarian ethics of many practitioners, professors, and students of engineering. One could argue, for example, that such broad ethical proclamations, although perhaps articulating conditions necessary for a new philosophy of engineering ethics, are not sufficient to create such a philosophy. Much more work and thought are needed.

NEW VALUES AND ATTITUDES FOR ENGINEERS AND BUSINESSPEOPLE

Such radical changes in management theory and business practices require a new type of engineer, with new skills, attitudes, and personal qualities. In other words, the requirements of sustainable development dictate that engineers and businesspeople do nothing short of developing a new set of values and attitudes. Technical knowledge is not enough. The new engineer must be educated about the social and ethical impact of engineering and technology. This is because the philosophy of sustainable development requires that engineers and businesspeople value the environment alongside economic development; value future as well as current generations; value social equity as well as material growth; value the poor along with the rich. Thus, sustainable development relies on a change in corporate culture, supported by an amended economic system with newly defined market values, and sustained by appropriately developed technology. It is this last requirement for successful sustainable engineering, the development of appropriate or "clean" technology, which should concern the engineering profession.

In effect, the shift toward sustainable economics and business has created the perfect opportunity for the engineering profession to finally end its quarrels with business and industry over the question of autonomy and control over decisions about technological design and development. Under such advantageous conditions, managers are now "all ears." They are willing and eager to learn everything they can from engineers about how to design, develop, and deploy "clean" technologies, often praising and rewarding engineers if and when they design such technologies. Whether it be the design of more efficient energy sources through conservation measures and switching to renewable sources, or waste minimization through greater recycling and reuse of materials, more "green" production, including full product lifecycle analyses, or more comprehensive technology assessment and better management of risk and resources, engineers are beginning to play leadership roles. Inadvertently or not, they are at the forefront of the sustainable development revolution.

The cultural attitude toward the environment has been changing, and the engineer can play an active role in this transformation. In the changing climate of the greening of American business and government regulation, corporate management and political leaders will have to rely on the engineer more than ever to invent the visionary technologies that will be required to fulfill the promise of sustainable development. Therefore, the move toward sustainable development is a prime opportunity for engineers to gain full autonomy over decision making concerning technology. In order to help sustain development, the engineer must be able to reconcile the goals of engineering as a business as well as a profession. As one researcher put it:

> "If we [engineers] do not meet this challenge [of sustainable development], then we will be left behind in the decision making process that will influence the shape of this world. Engineering for a sustainable future will require engineers to engage more actively in political, economic, technical, and social discussion and processes to help set a new direction for the world and its development" (Statement of the American Association of Engineering Societies, 1994).

In their new role, engineers could become true counselors to both corporate executives and to the citizenry in general. To corporate executives, they could play leadership roles in the corporate cultural paradigm shift toward sustainable development. To the public, they could play leadership roles in enhancing public perception and understanding of risk, as well as helping to improve the quality of technology-intensive choices in public policy, particularly when it comes to developing sustainable technology. Engineers have traditionally seen themselves serving three "clients": their clients or employers; society at large; and their profession. If engineers can truly integrate principles of sustainable development into their designs as well as their attitudes, they can actually fulfill their duties to all these parties concerned.

In integrating such sustainable engineering techniques as full-life-cycle production, reduced pollution, energy efficient manufacturing, and the like, they can help their corporate clients to prosper and stay competitive. Consequently, by practicing such environmentally sound and humane engineering, they can regain the coveted trust and respect of the public at large, attitudes so important to professional success, but on the wane in recent decades. Finally, in following the principles of sustainable development, engineers will be upholding the ideals of their profession. Moreover, by following green engineering, they will be fulfilling their obligations to "self" in that each individual engineer can be proud that they are doing well by society and the environment. If such ideals are accomplished, then everyone will be a winner.

This essay has attempted to provide the rationale for a philosophy of engineering ethics grounded in the notion of sustainable development. This essay has not, however, attempted to demonstrate what the content of a program in engineering ethics grounded in such ideals would be like. I have covered this in other places [4], [9]. It is central to my present thesis, however, that this new philosophy of engineering ethics can be best inculcated into the culture of engineering through engineering education — experience and intuition are not enough.

Engineering ethicists must work more closely with engineering scientists to ensure that all facets of sustainable technology become a practical reality. While professors of engineering science can increase awareness by stimulating engineering students to build sustainable ideas into their designs, professors of engineering ethics might work to complement this by helping to transform the attitudes, values, and philosophies of the "new engineer."

If the engineering profession can accomplish this grand challenge through engineering ethics education, and train future engineers to become leaders in business and social policy, as well as counselors to corporate executives and citizens alike, they can finally fulfill their professional ideal as benefactor of humankind, and no longer be cast as obedient servants to corporatism.

References

[1] M. Davis, "Technical designs: time to rethink the engineers responsibilities?," *Business and Professional Ethics J.*, vol. 11, no. 3, pp. 41-55, 1992.

[2] L. DeSimone and F. Popoff, *Eco-efficiency: The Business Link to Sustainable Development.* Cambridge, MA: M.I.T. Press, 1998

[3] M. Ellis, Ed., *The Role of Engineering in Sustainable Development: Selected readings and references for the profession.* Washington, DC: The American Association of Engineering Societies,1994.

[4] W.M. Evan and M. Manion, *Minding The Machines: Preventing Technological Disasters.* Upper Saddle River, NJ: Prentice Hall, 2002.

[5] J. Herkert, "Sustainable development: ethical and policy implications," *CHEMTECH* , pp. 47-53, Nov. 1998.

[6] H. Johas, "Technology and responsibility: Reflections on the new task of ethics," *Social Research*, vol. 40, no. 1, pp. 31-54, 1973.

[7] I. Kant, *Groundwork for the Metaphysics of Morals*, 1795; tr. by James Ellington, Indianapolis, IN: Hackett, 1981.

[8] D. Kinlaw, *Competitive and Green: Sustainable Performance in the Environmental Age.* Amsterdam, the Netherlands: Pfeiffer, 1993.

[9] M. Manion, "Engineering ethics at Drexel University: Meeting the challenges of the ABET 2000 criteria," in *Proc. Amer. Society of Engineering Education (ASEE) 2000*, St. Louis, MO, June 18-20, 2000.

[10] M. Martin and R. Schinzinger, *Ethics in Engineering.* New York, NY: McGraw Hill, 1996.

[11] R. Millard, *The Master Spirit of the Age: Canadian Engineers and the Politics of Professionalism 1887-1922.* Toronto, Canada: Univ. of Toronto Press, 1988.

[12] S. Unger, *Controlling Technology: Ethics and the Responsible Engineer,* 2nd ed. New York, NY: Wiley, 1994.

Opinion *(Continued from page 3)*

In this way, one can attempt to respect the wishes of those who do not want to know, or who do not want others (insurance companies, employers) to know their genetic status, but who are genetically related to someone who does want to have this information gathered and recorded. Thus, if one records the information in as individualized a manner as possible, one will render the information recorded as individual as the consent that legitimates the gathering and recordation. To the extent to which the information is rendered individualized, the discrepancy between the group-import of genetic information and the individualized character of consent can be reduced and rendered less legally and ethically problematic. This is the principle of information individualization, or the PII. In accordance with the PII, one would not, for example, create a database of genetic and genealogical information without the consent of all. For in such a case, there would be too great a gap between the individualized character of consent and the group-character of the information recorded.

To balance out the greater value accorded by the Act to individuals' claims to know their genetic status over the claims of others whose status will be revealed and who do not want information gathered and recorded, one should have access to genetic information bearing upon oneself, regardless of the source of that information. That is, if one's sibling may without one's consent have genetic information gathered and recorded that bears upon oneself, then one should be granted access to any information that is linked to one's own record, regardless of the fact that another was the sample source. This will also help insure that the PII is followed. If it is not, the individual will at least know that it has been breached. Thus, if one's sibling has a genetic test, one has no claim to know the results, as long as those results, in accordance with the PII, never are linked with one's own information.

Moreover, the Act must explicitly recognize that consent is essentially individualized; that is, one can consent only for oneself (or as a surrogate for the incompetent.) One may not consent to give genetic information from oneself to determine the genetic status of a competent non-consenting genetically related individual. The Act must explicitly rule out such cases.