Int. J. Engng Ed. Vol. 19, No. 1, pp. 124–131, 2003
Printed in Great Britain.
0949-149X/91 $3.00+0.00

Overconsumption and Engineering Education: Confronting Endless Variety and Unlimited Quantity*

E. J. WOODHOUSE
Rensselaer Polytechnic Institute, Troy NY 12180, USA. E-mail: woodhouse@rpi.edu

Excessive consumption in affluent societies is the taproot of many environmental and social problems. Because engineers play crucial roles in design, production, and distribution of the goods and services that arguably add up to too much for too many, questions arise concerning how engineering educators might address the problem. Section I briefly summarizes some of the defining characteristics of overconsumption. Section II discusses engineers' participation in the phenomenon. Section III considers barriers and prospects for bringing greater concern with the issue into engineering classrooms.

DEFINING OVERCONSUMPTION

TOO MANY UNITS of stuff are being designed, produced, advertised, sold, and eventually discarded, according to critics who refer to this as 'overconsumption' [1–2]. US consumers lead the way, with each accounting for 125 pounds (57 kg) of (mostly pre-consumer) material daily, totaling more than 20 tons (18 metric tonnes) per capita annually. In arguing for a shift toward valuing the 'natural capital' on which we draw for 'ecosystem services', Paul Hawken points out that discarded and emitted each year in the US are [3, p. 44]:

- 3.5 billion pounds (1,575,000 tonnes) of carpet sent to landfills
- 25 billion pounds (11,250,000 tonnes) of carbon dioxide
- 6 billion pounds (2700,000 tonnes) of polystyrene
- 28 billion pounds (12,600,000 tonnes) of food
- 300 billion pounds (135,000,000 tonnes) of organic and inorganic chemicals used for manufacturing and processing
- 700 billion pounds (315,000,000 tonnes) of hazardous waste generated by chemical production.

For every hundred pounds of product we create at least 3200 pounds of waste. In a decade, we transform 500 trillion pounds of molecules into nonproductive solids, liquids, and gases.

Responses to the problem differ, of course, with some such as Juliet Schor [4] arguing for 'downshifting' to a lifestyle less geared toward wanting and getting. Others, including Paul Hawken and other advocates for 'natural capitalism', believe that clean production and other environmentally friendly redesign actually may be able to cure many of the problems while contributing to business profitability [5].

Whether one accepts that view or any other regarding overconsumption, the topic is inherently partisan—in the sense that anyone using the term has at least an implicit stance concerning what constitutes 'too much', and in the sense that no standard for 'appropriate' consumption will be uncontroversial. Indeed, discussions of (over)consumption tend to become entwined with more general views about contemporary society, and with one's ideology. Thus, David Orr, director of environmental studies at Oberlin, believes [6, p. 141]:

> The emergence of the consumer society . . . resulted from . . . a body of ideas saying that the earth is ours for the taking: the rise of modern capitalism; technological cleverness; and the extraordinary bounty of North America, where the model of mass consumption first took root. More directly, our consumptive behavior is the result of seductive advertising, entrapment by easy credit, prices that do not tell the truth about the full costs of what we consume, the breakdown of community, a disregard for the future, political corruption, and the atrophy of alternative means by which we might provision ourselves.

Some readers will take issue with some of Orr's claims, but we all can use his criticism as a springboard to consider for ourselves, in terms of our own values, whether and how to respond to the challenges of contemporary production/consumption.

Engineers' contributions to shaping consumer purchases are a significant part of the overconsumption story, because households account for about two-thirds of GDP. But business-to-business sales also account for a substantial fraction of economic activity, from production machinery and commercial buildings to data processing and business travel. Governments likewise purchase vast

* Accepted 12 September 2002.

quantities of paper, trucks, heating and lighting, and cleaning compounds. And governments stimulate consumption indirectly, by funding military, medical, and other R&D that leads to new applications ranging from aluminum cans to composite materials [7–8].

There clearly are a great many people in the world who have too little rather than too much, so why refer to economic growth as overconsumption? One answer is Hawken's: the present process is extraordinarily inefficient. A related answer is that contemporary rates of resource usage appear to be unsustainable, especially if a world population of eight to twelve billion aspires to live at US levels. There is room for dispute because, for example, prices of many minerals have fallen rather than risen as extractive techniques have improved, and substitutes can be developed for many industrial purposes [9]. For petroleum, however, the US Geological Survey estimates that 75 percent of the world's conventional petroleum reserves and 66 percent of natural gas reserves have already been discovered, and estimates that more than half the world's total supply will have been used within the next decade or two [10].

Overconsumption is indicated as well by the fact that enough pollution is being introduced into ecosystems to have destabilizing effects. A substantial majority of atmospheric, oceanographic, and other scientists now agree that climate change is occurring and that it is due at least partly to release of carbon dioxide and other greenhouse gases [11–12]. And there is a close relationship between rates of consumption and quantities of toxic substances released into air, water, and land. It may prove necessary to virtually reverse the course of the 20th-century chemical industry, phasing out most synthetic organic chemicals made with chlorine [13]. Human habitation is encroaching on most of the planet, leaving less and less wilderness. One or more species are being wiped out daily, and some considered of great value such as orangutans and pandas are among those most threatened [14–17].

Also of concern are the less tangible social and cultural problems stemming partly from consumer society, such as the overwork, debt loads, and stress which characterize a nontrivial fraction of the American public. The 'diseases' termed 'affluenza' and 'luxury fever' are spreading to other parts of the world [18–19]. And far from making people happier, innovation in recent decades correlates with a decline of happiness in market democracies worldwide [20–21]. Participation in civic and other voluntary organizations is declining, partly because people are too busy and also because of stress, individualism, and breakdown in the structure of local communities that once evoked participation [22].

A host of other sociocultural risks potentially are created or exacerbated by the rapid technological innovation on which consumer society is partly based. Inadequate time for learning gradually from experience is one of these, as is a tendency to rely too heavily on technical fixes—and to fail to invest commensurately in social R&D [23].

PROLIFERATING VARIETY AND OTHER ROLES ENGINEERS PLAY

If present consumption patterns are as problematic as the critics charge, if human health, environment, and global culture are at risk from the juggernaut of consumer society, then engineers who facilitate technology-based consumption are making ethically charged public choices every day. They are just doing their jobs, of course, but in so doing are helping shape and misshape contemporary life. Engineering ethics thus comes into play daily, not just when whistle blowing or other unusual circumstances arise.

Being a good engineer often means being a contributor to consumer society and its excesses. Many or most engineers would find it difficult to keep their jobs if they actively opposed overconsumption; indeed, they might well jeopardize their livelihoods if they merely refused to *accelerate* consumption. The formula for many workplaces is: Figure out how to manufacture something less expensively, package it more attractively, and sell more units of it. Technical professionals do such a good job of running the treadmill of production that one manufacturing engineer of my acquaintance has wondered about retitling his profession 'landfill supply'.

Proliferation of variety

Engineers (and many others) promote overconsumption partly by diversifying the *variety* of goods and services produced and sold. Variety of course is manifested in electronics, breakfast cereals, shampoos, and clothing, and manufacturing engineers certainly participate centrally in figuring out how to produce these and myriad other items. But the sheer diversity of goods and services yields consequences reaching far beyond the easily pilloried consumer products. Consider several categories of secondary and tertiary effects that stem from increasing variety.

First, to stock a wider variety of items, 'big box' WalMarts and other retail outlets of comparable size have emerged. Construction, maintenance, lighting, heating/cooling, land use, and other requirements have grown accordingly, assisted in crucial ways by architect-engineering firms and by many other types of engineers.

Increasing variety also has led to a rapid increase in the number of different *types* of stores, such as specialty stores for electronic games or cell phones. Again, anyone involved in construction participates in this process, as do civil engineers responsible for road construction to the new establishments and environmental engineers who enable wastewater treatment.

Third, the scale and number of stores bring greatly increased management and data processing tasks: point-of-sale scanning and printing, software for inventory control, and automatic teller machines help with certain tasks, and simultaneously become part of the consumption machine. They come to entail their own somewhat independent R&D trajectories as competitors vie for market share on the basis of continuous improvement—or at least change.

An indirect effect of the foregoing is that there are so many items in commerce that businesses have a hard time keeping spare parts on hand for every conceivable widget. Consumers do not know where to find parts they need, decreasing the likelihood they will seek to service and repair items that in principle could still have useful life remaining. As consumers come to expect that hair dryers and other artifacts are to be replaced rather than repaired, manufacturers are encouraged to put even less emphasis on serviceability. For many product lines, therefore, increasing variety and quantity has correlated with reduced durability—adding to the environmental burden.

Fifth, diversity of products increases the information burden on consumers, consumer watchdogs, and government regulators. Whereas *consumer reports* in their early years could cover a high percentage of products on the market, it now is not unusual to have five or more years elapse between tests of big-ticket items like snow blowers. Many products go untested altogether. And it is quite common for models to have changed substantially before test results even can be published. The US Environmental Protection Agency operates a Premanufacture Notification program intended to keep excessively risky chemicals from being manufactured and distributed. But manufacturers overwhelm the process by proposing several thousand new chemicals annually, far too many for limited EPA staff adequately to analyze.

Also worth considering as an instance of proliferating variety is the familiar story of the chlorinated chemicals that have caused such damage in the second half of the twentieth century. The chloralkali process used to produce caustic soda for pulp and paper also produced free chlorine as a byproduct, so chemical executives and their engineering employees invented new products utilizing chlorine with essentially no study of the consequences. We now know that adding chlorine to an organic molecule often makes it more toxic, less biodegradable, and otherwise more dangerous [13]. Worries about chlorinated compounds surfaced nearly half a century ago, yet neither the International Union of Pure and Applied Chemistry nor the American Institute of Chemical Engineers has mounted a serious, generic inquiry into the problem. Chemical companies have defended each chlorine-based product until confronted by massive evidence, and then have grudgingly retreated one compound at a time rather than helping lead humanity's reconsideration of the matter. Nor have there been many dissident voices among chemical professionals, although advocates for green chemical engineering now are beginning to speak out [24, 25].

Silence may be a form of unwilling acquiescence based on fear of workplace retaliation in some cases, but many engineering practitioners and educators seem blithely unaware of the relentlessly accumulating evidence calling overconsumption into question. They seem equally unaware that they play key roles in steering technological society. Major technological innovations are analogous to governmental legislation, in the sense that innovation establishes an enduring framework for everyday life [26, 27]. Technological choices help decide who gets what, how tradeoffs are made between present and future, and other inherently ethical matters. Engineers therefore can be thought of as non-elected representatives of the public, representatives who help 'legislate' concerning technology. Of course, none has the degree of authority that top elected officials wield, except perhaps when an engineer becomes CEO of a major company. What would it take for engineers to use their admittedly constrained authority more wisely?

CHANGES IN ENGINEERING EDUCATION?

One crucial step toward more socially conscious engineering practice would be for universities to foster greater awareness of the roles engineers play in proliferating variety, accelerating consumption, and governing technology more generally. Some of this can occur in humanities, social science, and management courses, but for engineering students to give credence to the matter engineering instructors probably would have to shoulder some of the task.

As many observers have pointed out, engineering faculty tend to emphasize narrow technical competence at the expense of more general preparation for thoughtful professional practice [28, 29]. One way to interpret this state of affairs would be to say that the better the job that engineering educators do in training their students under the present curriculum, the better prepared are the graduates to contribute expertly to their employers' goals—and the goal of many businesses is to accelerate the treadmill of production and consumption. How might engineering educators begin to slow down that treadmill, if they so choose?

Faculty could press for more frequent, deeper curricular revisions to teach environmental design in closer accord with the forefront of the field. Whereas the forefronts of chemistry and chemical engineering are moving toward biocatalysis, teaching remains focused disproportionately on stoichiometric synthesis. Whereas environmental compliance, avoidance of liability, and building public image are high on the agenda of most large chemical companies, many textbooks and curricula pay more attention to engineering economics than to environmentally insightful chemical engineering. And whereas R&D is central to improving both the economics and the environmental record of the chemical industry, undergraduate curricula teach a rather static sort of chemical engineering that under-prepares graduates for continuous innovation.

A very different curricular revision would import Industrial Ecology centrally into the curriculum. In order to cut down on the resources used to accomplish a given objective, industrial ecologists propose that engineers increase the 'dwell time' of materials in the economic system. Design for 'X' would come to include DFE (design for environment), design for durability/serviceability, and so forth [32]. Neither government mandates nor professional norms presently encourage such a design approach, however, and most employers in most nations place substantial obstacles in the way of engineers who would try to go beyond what law and market competition require. Schools of engineering could attempt to counteract this by giving lifecycle analysis and other concepts from industrial ecology greater prominence in the curriculum.

Such changes may be fairly easy, because clean production and green chemistry can be approached in ways that fit fairly well with conventional engineering practice, especially where innovations promise to reduce costs. In fact, most schools are gradually adding more environmental material to the curriculum. Thus, the University of Dayton's first-year design course, billed as 'a model of seamless integration of social and ethical dimensions' into engineering education, has students work on improved design for appliances such as toasters and can openers. Some thereby learn about durability and energy efficiency, and about half the students end up saying that it is 'an ethical responsibility of designers to develop products that most efficiently utilize a diminishing supply of nonrenewable energy, particularly when technologies exist to achieve this end' [32, p. 13].

Many other schools now are offering an elective called something like 'Industrial Ecology and Manufacturing,' 'Clean Production,' or 'Sustainability in Manufacturing'. Depending on the instructor and the department's culture, course materials may include newspaper and TV coverage of climate change, 'globalization' and the role of the World Trade Organization, and may deal with enduring issues such as actual or perceived trade-offs between jobs and environment. On most campuses, however, there are only one or two such classes, and they tend to be electives taken by a minority of engineering students. Still, if dealing with the excesses of consumer society only requires introducing considerations of environmental sustainability into engineering education, there is a good chance the changeover will be made. Many European universities already are ahead of the USA in this regard, and there are enough signs of progress in the USA to have a reasonable expectation of a greening of the curriculum over the next generation.

Although it would be a great step forward to introduce industrial ecology, clean production, green chemistry, and other facets of environmentally sustainable engineering throughout the curriculum, my argument has been that dealing satisfactorily with the overconsumption problem actually would require going well beyond environmental issues as these now are being defined. An additional step would be to press for more social design in the curriculum: the case of the plow for poor Mexican farmers is a well-known example, and Harvey Mudd is one of the programs where students design assistive technologies for less physically able people. The Dayton curriculum includes design of a water filtration system for use in a poor country, and is said more generally to aim at awakening students' social, cultural, ethical, and environmental responsibilities [33, p. 14].

At Rensselaer Polytechnic Institute there is a new inter-school major in Product Design and Innovation, with the program chair located in a social science department; the major is designed to blend social considerations with technical from the introductory courses to the capstone projects.

This approach might begin to interrupt the present process of engineering for overconsumption because there is an acknowledged 'general absence' in engineering curricula of broad 'professional service themes, having a focus instead on technical content and design and problem-solving processes' [30, p. 8]. The relative neglect of social content may be attributable to the traditional deference of engineering to the business sector [31]; to the impossibility of combining genuine undergraduate education with professional training in a four-year program; to self-selection of engineering undergraduates and faculty; and to a tendency to become preoccupied with problem-solving techniques (as also occurs in the statistically sophisticated sub-fields of the social sciences, particularly economics).

If one wanted to be bolder still, and wanted to get closer to the heart of engineering's arguably codependent relationship with overconsumption, it might be desirable to probe whether some aspects of engineering design as now taught perhaps do not belong at an institution of higher learning. Weaponry R&D was reduced or eliminated on many campuses in the 1960s and 1970s. If circumstances had not pretty much forced an end to the Liquid Metal Fast Breeder Reactor, many observers might adjudge it socially inappropriate and therefore out of place in engineering teaching. And hardly anyone in our era would advocate designing new persistent insecticides such as Dieldrin^{TM}. So it is by no means the case that anything goes in engineering curricula: there always are adaptations to prevailing social mores, funding arrangements, and other judgments about appropriateness. Might it be time to reconsider some current teaching that goes too far in supporting the excesses of consumer society?

This is a touchy matter, and I leave it to the reader to fill in possible examples from engineering, while I stay on safer ground by working with an analogous field of study: might there be a case for paying greater attention to what is being taught in classes on advertising? Such courses prepare students for careers devoted at least partly to playing on would-be purchasers' envy, low self-esteem, and inchoate longings; when successful, as they often are, marketers' practices certainly constitute manipulation and sometimes border on thought control. I have grave doubts about whether such an aim is consistent with the spirit of free inquiry that supposedly characterizes higher education. A curriculum committee might insist that marketing courses contain substantial material challenging dominant tendencies in contemporary marketing practice, and it seems likely that analogous material could be envisioned to partially counteract aspects of engineering that risk fostering overconsumption and its attendant social ills.

Because mechanical and manufacturing engineering are the principal sub-fields involved in design and production of consumer products, it is these curricula that arguably deserve special attention. ABET mandates attention in undergraduate study to contemporary, global, corporate contexts including social, economic, legal, ethical, and environmental issues. But the accreditation process leaves enormous discretion to each campus and department. Many faculty are in a position to mount at least a modest challenge to the status quo in preparation for the next re-accreditation process—or as part of study teams that visit institutions other than their own.

Another issue in curricular redesign is that when ethical issues are mentioned at all in engineering texts and courses, the emphasis overwhelmingly is on 'right conduct' by individual engineers. One of the most important changes I can conceive in the teaching of engineering ethics and social issues would be to shift some of the focus away from whistle-blowing engineers such as Roger Boisjoly, toward broader social processes impinging on engineering practice. Focusing on micro-level transactions puts the field in opposition to long-standing traditions in the social sciences: economists do not primarily study consumers or business executives, but focus on the economy as a complex system; social psychologists think about situational determinants of individual behavior; and sociologists map tendencies in populations, and unpack the (il)logic of collective processes. Social science, in other words, is not primarily about learning how to better understand and advise individuals. Hence, engineering educators arguably need to pay greater attention to the 'social design' of overconsumption.

There also is a practical reason for shifting to a more thoroughly social understanding of professional ethical practice: most engineers are employees who will lose their jobs if they refuse to play their assigned roles in the treadmill of consumption. To empower them to redesign toward appropriate consumption would require business executives and customers to behave differently. This would entail changes in tax laws, government purchasing, R&D, cultural mores, technological momentum, population growth, maldistribution of income, and many other factors. I worry that even the currently fashionable emphasis on participatory or 'experience-based' design involving clients—obviously laudable in many respects—takes attention away from systematic consumption patterns, and the social causes thereof [33]. Engineering educators would take an unrealistic stance in class by pretending that such constraints and tensions do not exist in the workplace; but perhaps educators take an equally inappropriate stance by assuming too readily that business practices should determine engineers' behaviors. Might there be a way to teach best practices while acknowledging that contemporary institutions rarely practice them?

Also needing attention are several issues connected closely with undergraduate engineering curricula: accreditation, professional licensing, and ongoing lifetime education. The tests and test-preparation materials in chemical engineering I have examined have radically under-responded to the emergence of green chemistry and green chemical engineering [24, 25]. And according to my inquiries at the American Institute of Chemical Engineers, professional licensing is being overseen disproportionately by retirees who serve as volunteers rather than by paid staff and high-powered educators and other engineers at the cutting edge of their fields. If such deficiencies are widespread throughout many engineering sub-fields, it might require only a comparative handful of educators and practitioners to nudge the relevant committees to more scrupulous oversight of the process.

CONCLUSION

Two of the most important facets of the overconsumption predicament, I have suggested, are the intertwining problems of variety and quantity. Together they constitute a sacred cow, partly because doing interesting new stuff is a challenge dear to engineering designers' hearts, and also because the current economic system mandates proliferation of newer and more. To challenge unlimited variety and ever-increasing quantity may seem foolhardy, but challenge I think we must.

By no means are engineers solely responsible for excessive variety and quantity, nor for overconsumption more generally, but they do play key roles in the treadmill of innovation, production, consumption, and disposal. As industrial designer Victor Papanek expressed the point three decades ago [34, ix, emphasis added]:

> There are professions more harmful than industrial design, but only a very few of them. . . Never before in history have grown men sat down and seriously designed electric hairbrushes, rhinestone-covered shoe horns, and mink carpeting for bathrooms, and then drawn up elaborate plans to make and sell these gadgets to millions of people. . . By designing criminally unsafe automobiles that kill or maim nearly one million people around the world each year, by creating whole new species of permanent garbage to clutter up the landscape, and by choosing materials and processes that pollute the air we breathe, designers have become a dangerous breed. *And the skills needed in these activities are carefully taught to young people.*

He overstates, I would say. And some fields of engineering obviously are less vulnerable to the criticisms than others. Still, there is enough merit in the claims to warrant reconsideration of how those of us in universities go about teaching the next generation of technical professionals.

One must acknowledge, of course, that many engineers now operate under significant constraints; all but the most heroic, clever, or fortunate probably are limited in what they can do until social, political, and economic changes alter the conditions under which their companies function. But everyone can face up to the dilemma, talk about it with others to raise awareness, and begin to make small changes in hopes of opening the way for larger ones. And if one must behave somewhat unethically in the workplace, s/he perhaps owes compensatory pro-social behavior at home as a consumer and citizen.

Engineering educators have less justification for neglecting the topic of overconsumption than do practicing engineers. Yet even at scholarly conferences, where most participants are tenured, discussions of engineering practice tend to nibble around the edges rather than boldly probing fundamental shortcomings while brainstorming prospects for radically more ethical conduct. Indeed, I have been in situations where it seemed impolite, almost a violation of etiquette, to raise issues such as some of those under discussion in this paper. When a panelist engages in stringent criticism of conventional business-engineering practices, considerations about business profitability tend to arise quickly from the audience. I do not mean to say that cost should not count; but there are many ways to balance the books (e.g., via increased governmental subsidies for socially desirable activities), and hasty reference to costs and other practical considerations often obscures thoughtful probing—and, sometimes seem intended to do so.

The ideas proposed here in some respects are just the newest wrinkle in longstanding criticisms and suggestions for how engineering might be socially contextualized, a debate arising episodically over most of the 20th century. Franklin Roosevelt, for example, urged the president of the Society for Professional Engineers to encourage engineering educators to activate in young engineers a sense of social responsibility for technologically rooted social problems [35, p. 64]. In another respect, however, the overconsumption issue arguably slices closer to the heart of engineering practice than did most previous criticisms/recommendations.

In sum, if the engineering profession sometimes has unintentionally colluded in promoting overconsumption and its attendant ecological and social ills, most of the rest of us have done likewise. There is no reasonable alternative except to understand that everyone works within the confines of one's era's blinders, and to forgive. But from here forward that is not an acceptable solution, in my opinion. We now know enough not to blithely endorse the boundless, technocratic approach to consumer society. Whereas former President Clinton during his final month in office averred that 'People are not going to be willing to give up becoming wealthier—and they shouldn't' [36], it seems more defensible for those in the world's upper ten percent of humanity in income and wealth to begin asking ourselves and each other, 'How much is enough?'

Because virtually every engineer in the USA, Europe, and Japan is in that upper ten percent, and because engineers are vital carriers in the spread of the affluenza disease, is it too strong to say that engineering educators have an affirmative professional as well as personal responsibility to ask themselves hard questions about reform of engineering curricula? Universities historically have been devoted partly to asking mind-expanding questions, not just to preparing young people for the world of work. Although it may be inconvenient and even monetarily risky to challenge endless proliferation of variety, quantity, and other aspects of overconsumption, is that challenge perhaps overdue? As Nigel Whitely puts the point in *Design for Society*, products and other engineered phenomena henceforth should reflect not merely technical competence but 'intelligent thought and action. Designers—and consumers—can no longer plead ignorance' [37, p. 170].

Acknowledgment—This is drawn in part from E. J. Woodhouse, Curbing overconsumption: challenge for ethically responsible engineering, *IEEE Technology and Society Magazine*, **20**(3) Fall 2001, pp. 23–30.

REFERENCES

1. Roger Rosenblatt, ed., *Consuming Desires: Consumption, Culture, and the Pursuit of Happiness*, Washington, DC: Island Press (1999).
2. Juliet B. Schor, *The Overspent American: Upscaling, Downshifting, and the New Consumer*, New York: HarperPerennial (1998).
3. Paul Hawken, Natural capitalism, in *Mother Jones*, March/April 1997, pp. 44ff.
4. Juliet B. Schor, *The Overworked American: The Unexpected Decline of Leisure*, New York: Basic Books (1992).
5. Paul Hawken, Amory Lovins, and L. Hunter Lovins, *Natural Capitalism: Creating the Next Industrial Revolution*, Boston: Little, Brown (1999).
6. David Orr, The ecology of giving and consuming, in Rosenblatt (1999), pp. 137–154.
7. Ivan Amato, *Stuff: The Materials the World is Made Of*, New York, Basic Books (1997).
8. Robert Friedel, Scarcity and promise: materials and American domestic culture during World War II, in Donald Albrecht, (ed.) *World War II and the American Dream: How Wartime Building Changed a Nation*, Cambridge, MA: MIT Press (1995).
9. Julian L. Simon, ed., *The State of Humanity*, Oxford, UK: Blackwell Publishers (1995).
10. US Geological Survey World Energy Assessment Team, *World Petroleum Assessment 2000—Description and Results*, US Geological Survey Digital Data Series—DDS-60 (2000).
11. Thomas A. Clair, *Climate Change and Ecosystem Research in Canada's North: A Report to the Northern Ecosystem Initiative Management Team*, Sackville, New Brunswick: Environmental Conservation Branch, Environment Canada-Atlantic Region (2000).
12. Merylyn McKenzie, *Climate Change: Assessing the Impacts—Identifying Responses: The First Three Years of the UK Climate Impacts Programme*, London: Department of the Environment, Transport, and the Regions (2000).
13. Joe Thornton, *Pandora's Poison: Chlorine, Health, and a New Environmental Strategy*, Cambridge, MA: MIT Press (2000).
14. Edward O. Wilson, *The Diversity of Life*, New York: W.W. Norton & Company (1992).
15. William H. Schlesinger, The Vulnerability of Biotic Diversity, in Robert Socolow *et al.* (eds) *Industrial Ecology and Global Change*, Cambridge, UK: Cambridge University Press (1994).
16. Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, National Research Council , *Upstream: Salmon and Society in the Pacific Northwest*, Washington, DC: National Academy of Sciences (1996).
17. Bryant Dirk *et al.*, *The Last Frontier Forests: Ecosystems and Economies on the Edge*, Washington, DC: World Resources Institute (1997).
18. John DeGraff, Victor Boe, and Scott Simon, *Affluenza*, Seattle, WA: KCTS Television, the Corporation for Public Broadcasting, and Bullfrog Films (1997).
19. Robert H. Frank, *Luxury Fever: Why Money Fails to Satisfy in an Era of Excess*, New York: The Free Press (1999).
20. Robert E. Lane, *The Market Experience*, London: Cambridge University Press (1991).
21. Robert E. Lane, *The Decline of Happiness in Market Democracies*, New Haven: Yale University Press (2000).
22. Robert D. Putnam, *Bowling Alone: Civic Disengagement in America*, New York: Simon and Schuster (2000).
23. J. C. Swearengen, and E .J. Woodhouse, Cultural Risks of Technological Innovation: The Case of School Violence, *IEEE Technology and Society Magazine*, **20**, Spring 2001, pp. 15–28.
24. Martyn Poliakoff and Paul Anastas, A Principled Stance, *Nature*, **413**, September 2001, p. 257.
25. David T. Allen, and David Shonnard, *Green Engineering: Environmentally Conscious Design of Chemical Processes*, Upper Saddle River, NJ: Prentice-Hall (2002).
26. Langdon Winner, *The Whale and the Reactor: The Search for Limits in an Age of High Technology*, Chicago: University of Chicago Press (1986).
27. Richard Sclove, *Democracy and Technology*, New York: Guilford Press (1995).
28. Joseph R. Herkert, Sustainable development, engineering and multinational corporations: ethical and public policy implications, *Science & Engineering Ethics*, **4**, 1998, pp. 333–346.
29. Deborah G. Johnson, ed., *Ethical Issues in Engineering*, Englewood Cliffs, NJ: Prentice-Hall (1991).
30. Kevin Hallinan, Malcolm Daniels, and Steven Safferman, Balancing Technical and Social Issues: A New First-Year Design Course, *IEEE Technology and Society Magazine*, **20**, Spring 2001, pp. 4–14.
31. Edwin T. Layton, Jr., *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession*, Cleveland: Press of Case Western Reserve University (1971).
32. Lucas Reijnders, The Factor X Debate: Setting Targets for Eco-efficiency, *J. Industrial Ecology*, **2**(1), 1998, pp. 13–22.
33. Special Issue: Current Perspectives on Participatory Design, *Human-Computer Interaction*, **11**, 1996, pp. 181–290.
34. Victor Papanek, *Design for the Real World*, London: Thames and Hudson (1971).
35. David Noble, *America By Design: Science, Technology, and the Rise of Corporate Capitalism*, New York: Knopf (1977).
36. *60 Minutes*, interview with President Clinton, December 2000.
37. Nigel Whitely, *Design for Society*, London: Reaktion Books (1993).

Edward Woodhouse, associate professor of political science, Rensselaer Polytechnic Institute. Woodhouse is a democratic theorist conceptualizing political and economic institutions for steering technologies more wisely and fairly. Present projects: underinvestment in social R&D; green (benign-by-design) chemistry; nanotechnology innovation without public consultation; and an edited book on improving decision making about design. Previous books include *The Demise of Nuclear Energy* (Yale University Press) and *The Policy-Making Process* (Prentice-Hall).