Overconsumption: An Ethical Dilemma for Christian Engineers


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One of the most important and yet most difficult of the ethical challenges facing technological civilization is "excessive" consumption in the affluent nations. This includes dissipative use of raw materials and production of waste at rates higher than sources or sinks regenerate. Ethics-driven decisions about working on toxic products or in the defense industry are familiar to engineering students; but are engineers who design new products ethically compelled to resist "overconsumption"? Should engineering curricula be targeted toward avoiding overconsumption? Technical professionals may be uniquely positioned to work against some aspects of overconsumption, and it is worth inquiring into whether and how the topic might be incorporated into engineering education and practice. Christian engineers perhaps should be concerned especially if and when they determine that the products and processes they help develop and distribute will abet overconsumption. Arguing from this premise, we attempt to establish a theological foundation for Christian engineers and educators to guide their responses to the issue. The nascent field of Industrial Ecology provides a promising beginning.

We believe Industrial Ecology offers a good start at combining Christian caring, environmental stewardship, and ordinary prudence.

Do Christian engineers and others who develop and distribute new products have any special responsibilities to resist environmental degradation and other harms stemming from technological innovations? We begin to analyze this question by summarizing the case advanced by those who perceive excessive production, consumption, and waste in affluent societies. The ensuing section then considers two possible responses by Christians: an optimistic one, emphasizing human ingenuity as a boundless means of overcoming physical limits; and a pessimistic approach, perceiving the earth as irredeemable and expecting that the second coming of Christ will moot any necessity to deal with environmental and other earthly problems. Finding neither of these responses entirely reliable as a guide to prudent Christian coping with the effects of modern technologies, we then examine the promise of an emerging field known as Industrial Ecology. Although the approach has certain shortcomings, we believe it offers a good start at combining Christian caring, environmental stewardship, and ordinary prudence. Finally, we discuss some of the implications of our analysis for Christian engineers and for others interested in a spiritual approach to technological innovation and consumer society.

We are neither acscetics nor Luddites. Neither of us is willing to give up antibiotics, mosquito abatement, or the printing press. A significant portion of the research for this article was conducted on the Internet, and collaboration was carried out at opposite sides of the country, simultaneously employing word processing, e-mail, and speaker telephones. But we do believe that the Bible warns of a never-ending (until the kingdom) struggle for balance in our earthly lives.

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What is Overconsumption?

"Overconsumption" is an emotionally and politically charged term referring to types and quantities of goods and services that exceed some level perceived by the speaker as constituting "enough." The term sounds pejorative—and based on the context of usage, that often is exactly the intent of those who use it; indeed, the term hardly can be used in a meaningful way without taking a critical stance toward the activity being discussed. Overconsumption is a syndrome more than a particular act, but those who criticize the phenomenon seem to believe they know instances of it when they see it. This section describes elements of the syndrome, and briefly summarizes some of the consequences for the environment and society that appear to accompany high levels of production, distribution, use, and disposition of materials and energy.

Overconsumption sounds like a recent phenomenon, but it may actually have played a role in the sudden decline and disappearance of Sumer and other early civilizations via resource exhaustion or poisoning of the environment.[1] The term entered the English language in 1879 as part of an economic argument about the causes of recession.[2] Consumption was perceived to be a problem only if it exceeded production and thereby caused shortages of goods. For economic growth, according to Hooper's model, consumers must consume as much as industry can produce, which requires stimulation by advertising.[3] Thus by 1999, $215 billion per annum was spent in the US on advertising, and $450 billion on packaging—of which perhaps $200 billion was to make items look more appealing.[4] Estimating world expenditures at three times the US total, over $1.2 trillion is spent annually to stimulate consumption!

As the term now is used, overconsumption refers to a set of technological activities that have one or more major environmental effects. Thus, the following activities are examples of overconsumption.

- Natural resources such as fossil fuels are consumed at a rate greater than they can be replenished.[5]
- Environmental "sinks" or repositories (land, water, or atmosphere) are loaded with waste products (such as greenhouse gases) at a faster rate than they can regenerate.[6]
- Chlorinated compounds and other chemicals have toxic effects on living organisms.[7]
- Human habitation, roads, and other activities encroach on the habitats of many species, with one or more species extinguished daily.[8]

The leading consumers, North Americans, "each directly or indirectly use an average of 125 pounds of material every day, or about 23 tons per year … For every hundred pounds of product we manufacture in the United States, we create at least 3200 pounds of waste."[9] Some of this is done directly by end users, including not only households but also businesses and governments, but much of it is enabled behind the scenes by engineers, who develop designs, select materials, choose manufacturing processes, and otherwise prepare goods and services. Often it is technically feasible to design less environmentally damaging ways of doing things, as when chemical engineers create alternative synthesis pathways that produce the same final products with less hazardous waste.[10]

However important the environmental aspects of consumption, the ethical issues raised by consumer society are broader than that. As shown in Figure 1, those concerned about consumption also need to be concerned about three other categories of risks: aesthetic, social, and spiritual. These may be less tangible than environmental problems, but are no less real. Physicians, psychologists, and public health officials provide statistics demonstrating widespread and prolonged stress, coupled with too little sleep for many American adults.[11] The symptoms appear to be caused partly by overwork, necessitated by credit card debt and patterns of spending intended to keep pace with the lifestyles of the upper-middle class depicted on television. Maintaining large homes, yards, and other material possessions also requires many hours of unpaid work. The disease Juliet Schor terms "Affluenza" appears to be spreading to other parts of the world.[12] Further exploration of the social and political impacts of overconsumption is available in several recent reports.[13]

Some of the social symptoms of consumer society also show up in very personal realms, including the spiritual (broadly construed). Though some Christians have sufficient trust in God's plan for their life that they interpret whatever happens in a positive way, others fall prey to insecurity and anxiety occasioned by lack of medical insurance, layoffs and underemployment, high levels of

Figure 1. The impacts of overconsumption are more than environmental.

debt (leading to more than a million bankruptcies per year), and other factors associated in complex ways with contemporary economic life. Rates of psychological depression are high, and studies in many different affluent nations indicate that happiness has not increased with a higher standard of living in the second half of the twentieth century. In fact, it appears that there has been a worldwide *decline* in happiness in recent decades.[14] Once people are above the poverty level, increased possessions do not contribute much additional life satisfaction; yet television and other cultural cues stimulate us to try to buy happiness and we end up disappointed. (Certain job roles can help to give a more satisfying life by enhancing self-esteem, personal development, and a sense that one is valued as a person.[15])

At the heart of the over-consumption syndrome, we believe, are speed, quantity, and proliferation of variety.

Materialism has been critiqued by numerous Christian writers.[16] Most develop their insights from biblical cautions regarding dividing loyalties between God and possessions. Some also appeal to biblical teachings about distributive justice.[17] Jesus repeatedly warned that material well-being has an *inexorable propensity* to distract believers from wholehearted pursuit of God. Our search of the literature of technology and society revealed only sparse analyses of the association of materialism with technology per se, and *no* analysis specifically focused on the contributory role that engineers play. Treatments of engineering ethics have not considered materialism an ethical concern for engineers to consider.[18] We believe that materialism does present an ethical dilemma for engineers because they have become "the enablers, the agents of change, and de facto social experimenters in industrial society."[19]

The Psalmist(s) wrote of wilderness as a place of inspiration, solitude, and refreshment (Pss. 23, 65, 68, 121) where "the trees will sing for joy" at Jesus' return (Pss. 95, 96). Jesus made retreats to places of solitude a regular practice (Mk. 6:46; Lk. 22:39). Though environmental legislation has resulted in cleaner air and groundwater in the US, population growth and the individual mobility cherished by Americans have covered vast areas of open country and seacoast with homes, highways, malls, and industrial parks. Many new homes are 3500-plus square foot "McMansions." Forests are clear-cut for lumber because economic incentives favor the practice, and increasing energy consumption gives rise to strip mines and power plants whose produce must be transported to distant urban areas. New roads are carved into remote areas to provide access to "wilderness" recreation, and commercial enterprises follow—ski resorts, golf courses, vacation homes and lodges, together with the essential supporting services and infrastructure. Airplanes over-fly the parks and wilderness, bringing sightseers or commercial travelers. Each increment in development brings loss of wetlands, wilderness, and scenic vistas. The Grand Canyon is frequently veiled in a blanket of haze, and Yosemite Valley smells of vehicle exhaust.

Gradual replacement of the pastoral and peaceful countryside with "development" is nearly impossible to stop because it embodies another example of "the tragedy of the commons."[20] Each incremental development brings immediate tangible rewards to the developers (the few) while the aesthetic losses are small in proportion to the whole and are borne by the general public. Inexorably, the very peace, beauty, and solitude that drew people in the first place is disappearing. Inspiration and solitude are much harder to find today than when the Psalmist wrote and Jesus sought solitude to pray.

Of course it would be plausible to discuss individually each of these and other environmental, social, aesthetic, and spiritual issues. But we find it more instructive to look at them as facets of consumer society, as elements of the way of life characterized by high levels of production/consumption/disposal. And we find it convenient to label the syndrome as "overconsumption." One great advantage of the integrated approach is that it allows us to see more holistically—to probe for common roots to the disparate problems and to look for responses that might deal with sizeable chunks of the syndrome rather than just with pieces of it.

At the heart of the overconsumption syndrome, we believe, are speed, quantity, and proliferation of variety. Thus, the average life of a product is about three years, with even some expensive items such as computers being useful for less than five years. So unless a company frequently upgrades and replaces its line of products, competitors will

move in and the company may go out of business.[21] Innovative features provide a market advantage, but only for a time, until competitors catch up. Thus there is pressure on design teams to bring products to market ever faster. Today's features quickly become standard, a new "quality" level is sought via further design innovation, and the cycle repeats. Equally important is the huge quantity of stuff that moves from computer-aided design (CAD) to computer-aided manufacturing (CAM), then into retail channels, households, and eventually landfills. Mass production depends on engineers and other product designers doing their jobs well—in particular, designing and producing for low cost, together with making consumer items appealing via design features, packaging, and advertising.

This proliferation of designs and products has at least six problematic effects.

1. To stock a wider variety of items, "big box" Wal-Marts and other retail outlets of comparable size emerge—with construction, maintenance, lighting, heating/cooling, land use, and other requirements growing accordingly.
2. Increasing variety leads to proliferation in the number of different types of stores, such as specialty stores for electronic games.
3. Proliferation and scale greatly increase 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.
4. Businesses have a hard time keeping spare parts on hand, making it difficult for consumers to find repair parts, decreasing the likelihood of repair and indirectly leading manufacturers to put even less emphasis on serviceability.
5. Diversity of products increases the information burden on consumers, consumer watchdogs, and government regulators.
6. For many product lines, increasing variety and quantity has correlated with reduced durability.[22]

Still, not everyone would agree that the tangible and intangible problems cohere into an overall problem that deserves to be labeled "overconsumption." The real problem, some say, is maldistribution—for just as many in the world have too little as have too much—a perspective we find partly persuasive. Others believe that appropriate technological and other changes can replace natural resources in short supply, cut down on pollution, and otherwise allow much higher levels of production and consumption than now are occurring.[23] In fact, the latter is the dominant view behind most discussions of sustainability by government officials and business executives, in which the emphasis is rarely on limiting consumption. Whereas some intellectuals and environmental advocates speak of sustainability as including a reduction in consumption per capita together with population stabilization, the focus is usually limited to greater resource efficiency and less pollution per unit of production.[24] During his final month in office, President Clinton expressed his endorsement of this boundless, technocratic approach to sustainability, stating: "People are not going to be willing to give up becoming wealthier—and they shouldn't."[25]

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A contrasting view, one worthy of consideration by Christians engaged in technology-based production and consumption, is that of Bishop John Taylor of Winchester. He went so far as to say that the "blind worship of growth" in western economies is symptomatic of "second degree materialism," by which he means that we are not just hooked on *having*, but on *getting more*—i.e., the acquisition of things.[26] Thus the stock market now responds not to earnings, or even earnings growth, but to the *rate* of earnings growth! Taylor understands the biblical model as an *equipoise society*—where economic equity is combined with balance between human and natural systems. Our analysis in subsequent sections follows Taylor more than Clinton.

We close this section on overconsumption with a methodological suggestion for readers. Even those who do not find the case against overconsumption compelling may acknowledge that contemporary consumer society may be risking a variety of tangible and intangible problems, some potentially quite severe. Just as nuclear power reactors merited precautionary design even though considered acceptably safe by a majority of relevant experts, might it be sensible to protect against the "maximum credible accident" from consumption?[27] Is it an engineer's professional responsibility to contribute to such protections—perhaps especially a Christian engineer's responsibility?

Searching for an Alternative

If one accepts the two-fold premise that overconsumption is a problem and that design engineers are *enablers* of the process, how might design practitioners be motivated to take a different approach? More specifically, how might Christian engineers and other Christians respond to the risks and actualities of overconsumption and attendant

social and spiritual ills? Ethics-driven decisions about working on toxic products or in the defense industry are familiar to engineering students.[28] We now argue that a new ethical dilemma for Christian engineers arises if and when they determine that the products and processes they help develop and distribute will abet overconsumption.

In his classic *The Existential Pleasures of Engineering*, Samuel Florman proposes that "[e]ngineers derive pleasure from helping others, to the extent that the main existential pleasure of the engineer will always be to contribute to the well-being of his fellow man."[29] However, Florman also argues that "professionals have the task of meeting the expectations of their clients and employers. Professional restraints should be laws and governmental regulations rather than personal conscience."[30] Thus the concerned engineer—Christian or not—may face a dilemma because there are no laws or regulations regarding overconsumption.

For the Christian, moral reasoning bereft of a transcendent basis quickly reduces to utilitarianism or personal preference.

Ethics, except revealed ethics

The ethics literature does not provide a sufficient motive to empower a Christian designer's decision to resist overconsumption. This is because secular ethicists (not surprisingly) discount religious bases for ethics and morality, though they acknowledge that religious convictions have strong motivational qualities. According to ethicists, one's ethics are determined by one's level of moral development. Kohlberg identified three such levels: *pre-conventional*, thinking that right conduct is whatever benefits self; *conventional*, adopting the norms of family, group, or society; and *post-conventional*, acting on principles that are not reducible to self-interest or social convention.[31] Gilligan adopted Kohlberg's definition for the pre-conventional level of development but substituted self-sacrifice for the benefit of others at the conventional level, and revised Kolberg's post-conventional ethics to require balancing one's own needs with the needs of others while maintaining caring relationships.[32] For these modifications, Gilligan has been credited with developing the "ethics of care" and thereby establishing a moral foundation for environmental care.[33]

Martin and Schinzinger identified seven possible ethical models for engineering practice, as follows: (1) *Virtue ethics*, having desirable character traits; (2) *Utilitarianism*, avoiding bad consequences; (3) *Duty ethics*, self respect and self care; (4) *Rights ethics*, liberty or welfare emphasis; (5) *Ethical egoism*, maximize personal good; (6) *Ethical relativism*, acting by law or custom; and (7) *Religious or divine command*.[34] They believe that divine command ethics "has things backwards" because moral reasons are not reducible to religious matters and a morally good deity would command on the basis of moral reasons.

Consistent with Martin and Schinzinger, Haws insists that "professional codes, like religious dogma, are effective primarily at the pre-conventional level of moral development … and will restrict our students' ability to reason through their own values and select ethically appropriate courses of action."[35] To each of the foregoing authors—educators all—human moral reasoning is superior to revelation as a guide for engineering practice. But for the Christian, moral reasoning bereft of a transcendent basis quickly reduces to utilitarianism or personal preference.

Possibly cognizant of the need to establish a sufficient motivational basis for responsible design, Papanek[36] and Graedel[37] invoke a "spiritual" dimension ad hoc, carefully avoiding any recourse to transcendent values. Papanek states: "If beauty and high utility exist simultaneously and are furthermore clear expressions of the social intent of the designer, it is possible to speak of the spiritual in design."[38] For Christians this must be a point of departure because—in the absence of a God who can be known (revealed knowledge)—Papanek's concept of spiritual lacks foundation. However, his three "elements of the spiritual in design" should be acceptable to a biblical world view. They are:

1. The design releases transcendental feelings (hints of the sacred).
2. The designer intends a social good—namely, a service to our fellow humans and/or the planet.
3. The intended use of the product will nourish our soul and help it to grow. (Here Papanek introduces the term "soul" but in the absence of explanation we assume he intends for the term to be interchangable with "spirit.")

Thomas Graedel, a principal in the field of Industrial Ecology, invokes four "Grand Objectives" that he believes are required "for life on earth, its maintenance, and its enjoyment." They are:

The Ω_1 Objective: Maintaining the existence of the human species.

The Ω_2 Objective: Maintaining the capacity for sustainable development.

The Ω_3 Objective: Maintaining the diversity of living things.

The Ω_4 Objective: Maintaining the aesthetic richness of the planet.[39]

Graedel uses these Grand Objectives to derive guidelines for an environmentally conscious design. We will return to the topic of Industrial Ecology in a subsequent section. As we shall show, the Objectives can be derived from Scripture and do not need to be invoked ad hoc.

Technological optimism and the religion of technology

One way forward would be to assume that *all perennial human problems—whatever their manifestation—can be corrected with technical solutions, given enough time and resources*.[40] This is technological optimism. Technological optimists do not fret about the environmental, social, or spiritual effects of technology.[41] They remind us of Mr. Macawber, Dickens' character in *David Copperfield*, who—when the situation looked most grave—would proclaim that "something will surely turn up." Ardent technological optimists admit no limits on innovation, production of goods, or consumption of resources, and dismiss pessimists' warnings about the "Faustian bargain" of complex technologies.[42] Edward Teller, the developer of the H-bomb, wrote that "technology has opened the possibility of freedom for everyone."[43] Economist Julian Simon, a principal spokesperson for the optimistic economic view, argued that physical limits are illusory because human intellect provides an unlimited resource.[44]

In the optimism of the Enlightenment, technology assumed a high position in the secular realm, and subsequently has at times been so exalted as to become essentially a religion.[45] Certainly the Christian church has not hesitated to employ the latest technologies to help spread the message of the Gospel: airplanes, radio, computers, sound systems, movies, and television. Cautions from within the Christian church against uncritical application of technology are relatively sparse; Jacques Ellul and Donald MacKay are well-known exceptions.[46] Technology issues that have been addressed from within a biblical framework are by and large limited to environmental impact, genetic engineering, and artificial intelligence.[47] The evangelical community has been rather silent about technology, most likely as a consequence of the discontinuous eschatological view discussed below.

Technological pessimism

The optimist's hopes have some plausibility; but unfortunately, so do many pessimistic arguments. Technological pessimism is *the belief that technology is destroying human freedom, corrupting our social process, and degrading our natural environment*.[48] According to this view, in the process (of optimistically pursuing technology) "we have robbed ourselves of our freedom and authority by projecting our alleged autonomy onto our machines, methods, and systems. While wrestling nature for our freedom, we have subjugated ourselves to our *technique* (which is) the sum of technology and rational methodology."[49] Ellul has argued that technical means have become more important than the search for truth;[50] and technology has not spawned a heaven on earth, but a gulag.[51] The technological prison that surrounds and defines us, according to Ellul, is totalitarian, autonomous, demonic, and insidious in character.[52] Pessimists see technological progress leading us into a predicament like the one faced by the sorcerer's apprentice in Goethe's poem *"Der Zauberlehrling."*

Technological pessimism is typified by radical ecology groups such as Earth First or Earth Liberation Front. These groups advocate a less "developed" way of life, arguing that "[i]t is time to re-create vast areas of wilderness in all the planet's ecosystems: identify key areas, close roads, remove developments, and re-introduce extirpated wildlife."[53] From some radical ecologists' perspectives, humans either occupy no special status among the created order, or worse, are the source of earth's travails. In biblical terms, this could be interpreted to mean that the creation was pristine prior to the advent of humans and has been cursed by human activity.[54] As far as it goes, this idea is consistent with biblical exegesis; but it does not leave room for the special *imago Dei* status given to humans. And since the earth's 6.5 billion humans depend on technology for support, many could suffer or die if radical ecology were suddenly adopted, because of the reduced carrying capacity.

Technology and eschatology

A curious blend of the pessimistic and optimistic approaches is found among those emphasizing "end times" in their interpretation of biblical passages. According to the dispensationalist end-times model favored by many evangelicals, the earth's fate is complete destruction in the not-distant future. Since, in this view, destruction is God's plan and is inevitable, it is to be accepted and even anticipated; environmental, social, and spiritual consequences of technology are interpreted as precursors of the coming destruction. Truesdale refers to this model as "discontinuous eschatology."[55] One discontinuity arises when God destroys (or allows destruction of) the cosmos, then creates a new heaven and new earth. Rather than *re*-creation or *re*newal, this eschatological model has more in common with the original creation *ex nihilo*. Another discontinuity

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would occur if believers are removed from the earth during the tribulation, then returned to rule with Jesus during the millennium. The discontinuous eschatological model is usually combined with a utilitarian interpretation of Genesis 1 and 2; that is, intrinsic value of the creation is discounted relative to the value that nature can obtain through its productivity for the human race.

Because negative consequences of technology are interpreted as portents of God's plan for destruction, discontinuous eschatology provides no basis for critiquing misguided technological innovation. Discontinuous eschatology is paradoxical because while advocates expect a monotone descent into chaos and apocalypse (culminating in destruction), at the same time they maintain an eager and uncritical view of technology. Thus Christians who hold the discontinuous eschatological world view not only lack a basis for sustainable living, they are inclined lackadaisically to identify environmental degradation with the approach of the end times and, in extreme cases, actually embrace it as evidence of the trustworthiness of Scripture. Lynn White's oft-cited article castigating the Christian faith for insensitivity to environmental degradation was based primarily on evangelicals' (mis-) interpretation of the dominion mandate in Genesis 1 and 2.[56] Even though White did not address it directly, discontinuous eschatology seems especially vulnerable to his critique.

A More Satisfactory Model

None of the above approaches is absurd, given certain assumptions, but each embraces grave risks thoughtful people ought to be wary of assuming unnecessarily. What if Simon and other optimists are wrong, and crucial substitute energy sources and raw materials turn out to be grossly inadequate? For example, what if it proves impossible to grow enough biomaterial sustainably to simultaneously provide food, fuel, and feedstocks for the chemical industry as a replacement for fossil fuels? What if there is no feasible way to return to radically less technological ways of living without horrible suffering? We do not see how anyone embracing Christ's tenets could in good conscience urge consigning billions of persons— and other living creatures—to such fates.

What if discontinuous eschatology is an erroneous interpretation of end-times prophesies? An intriguing alternative to the dispensationalist model, not widely considered in the evangelical church, holds that instead of the creation's destruction and subsequent replacement by a pristine new heaven and new earth, corruption will be removed. More generally, the *whole creation* will be purified and the edenic state restored.[57] This purification eschatology is consistent with amillennialist concepts of the kingdom of God on earth; and it precludes an escape from human responsibility. Because human understanding became impaired by the fall from grace and because God has placed limits on human knowledge, is it not an act of hubris to claim that one has the definite key to interpretation of biblical prophesy? Since the time of Christ, the world has been subjected to many "concordist" identifications of current world events with particular end-times prophesies from Scripture, most of which proved false (yet the prophets were not stoned as required by Mosaic Law). To believe in one's interpretations of end-times Scriptures to the degree that one can turn his or her back on the known and certain environmental problems of today is incompatible with the teachings of Christ. This does not mean that there are no tradeoffs to be made (e.g., the primacy of evangelism over environmental activism), but to behave as if the Creator values only the human spirit among all that he created is simply unbiblical. Fortunately, a much less risky strategy appears to be available.

To overcome the difficulties with discontinuous eschatology, one might adopt a "theology of technology" that assumes technology can (and should) be employed to help relieve suffering caused by the fall from grace. Such a view apparently prevailed for the first millennium of the Christian church.[58] During the early years of the second Christian millennium, and adjunct to the millennialist movements that periodically surged through Europe, the idea gradually emerged that technology could be used to help recover the pristine conditions that Adam and Eve enjoyed in the garden.[59] Although the envisioned recovery that was to be facilitated by technology was primarily

physical, no distinct separation between physical and spiritual realms was made.

To a certain extent "environmental sustainability" is one manifestation of such a theology of technology. However, the term has been bandied about by so many people with such differing interpretations that it has almost lost its meaning. But the spirit of the term retains significance: Rearrange human consumption within sensible limits. A promising approach for doing this—and thus for addressing overconsumption as an ethical issue in engineering design—comes from the nascent field of industrial ecology (IE).[60] Advocates of IE see themselves engaged in "the engineering of sustainability," and we believe IE also can be practiced as an application of Christian engineering. It must be noted, however, that thus far IE has focused more on lessening the impacts of production and consumption than it has on reducing consumption per se.

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The first goal of IE is minimizing anthropogenic perturbations to natural cycles, especially cycles of the key elements for biological life (carbon, nitrogen, phosphorous, and sulfur). A corollary goal is to avoid releasing new substances into the environment that are not found in nature and thus, because they are unfamiliar, are not readily assimilated or broken down by nature. Such new substances tend to be toxic.

A second goal of IE is to move from linear throughput of materials in the economic system to cyclic flows—thereby reducing the need for virgin materials and also reducing quantities of waste. Progress toward cyclization, therefore, can be measured by the rates of extraction of raw materials: in a fully sustainable economy, raw materials would be extracted only to replace material lost during extraction and production, as well as from oxidation, corrosion, friction, and wear during the use phase. Environmentally concerned designers can minimize unavoidable losses through judicious materials selection; dissipative uses of scarce elements are especially to be avoided. A related way of reducing raw material use is through "dematerialization," which means accomplishing design objectives with less material, replacing scarce materials with plentiful materials, and making products last longer. It also means designing so that at the end of their functional lives, products and components can readily be refurbished, because less energy is required than to produce wholly new products. Only when refurbishment is impossible should the product be de-manufactured for recovery of materials.[61]

To achieve these objectives, the entire life cycle of a product—and its materials—must be evaluated. For example, pollution prevention in the manufacture of automobiles is desirable but clearly does not begin to address the major environmental implications of that technology system, which occur in raw materials extraction, vehicle use, and eventual disposal. For either a proposed new product or a design improvement, environmental impacts must be forecast for the entire life cycle, beginning with raw materials extraction and proceeding through primary materials production, manufacture, packaging and transport, product use, and disposition. All significant material and energy flows are inventoried at every stage, then each impact is assessed. The assessment includes secondary materials such as by-products of extraction and refining, use of solvents and lubricants during manufacture and use, packaging materials and shipping, and dissipative losses during use or disposition. Only after these steps are complete can "greenness" be determined—even in a relative sense—in a way that permits design for environment (DFE) to be incorporated into engineering design practice. Thus the discipline of IE offers the designer a methodology for assessing overall impacts of the design alternatives under consideration.

How well does IE take care of the concerns that a Christian engineer ought to have? The impact assessment phase of the life cycle analysis actually seeks to include social and political concerns regarding the materials used, including regulatory and legislative status, impacts on labor and community, "social" impacts, and significant externalities.[62] These less tangible impacts are not yet nearly as well developed, however, as the direct and familiar environmental impacts. Even if one accepts Graedel's Grand Objectives for life on earth, considerable interpretation is required to derive specific design choices from them. Thus Ω_2 might be interpreted by a technological super-optimist not as calling for energy conservation but for intensive research and development (R&D) to create substitutes to replace resources that become scarce. Might Ω_3 require returning prairies to their natural state and preserving maximum genetic diversity, or is it sufficient to maintain mixed-use wilderness areas with some protection of endangered species, or should humanity rely on genetic engineering eventually to re-create species made extinct in the current relatively backward era? Does Ω_4 refer to nature primarily, or to the art, architecture, and other aesthetics created by humans? And whatever one's interpre-

tations, how do the objectives map onto a biblical stance?

It is not possible to begin with the four Grand Objectives and reason our way to a biblical world view; however, the reverse process may prove illuminating. First, even though Ω_1 is anthropocentric as written, and consistent with materialistic naturalism, it also is consistent with the biblical *imago Dei* (Gen. 1:26–27) and the command to be fruitful and multiply (Gen. 1:22, 24, 28). Because this command was given to all the creatures, Ω_1 and Ω_3 are each derivable from Scripture. However, a biblical derivation of Ω_1 would add that the purpose of the human species is more than propagation; it is to worship God and honor him (Ps. 8).

Scriptural foundations for Ω_2 include Ps. 104:27–30; Jer. 2:7; Ez. 34:17–18; Hos. 4:1–3; Rom. 8:22; Heb. 1:3; and Rev. 11:15. In Gen. 1:11–12, God assigned to the land the "duty" to produce vegetation. Today land, water, and atmosphere are under stress from human activity; and some of the stresses are global in extent and perhaps irrecoverable. The stresses on the land have damaged its productive capacity in some areas and destroyed it in others. Spaling and Wood, in deriving a biblical ethic for land use, conclude that "Stewardly care of farmland means that humans may enjoy the fruit of the land, but they may not diminish its fruitfulness."[63] This ethic should also include the seas.

The biblical concept of limits also supports Ω_2. Limits to human endeavor is a familiar theme in Scripture, beginning with the commandment about eating from the off-limits tree (Gen. 2:16–17) and proceeding to limits for technology (Gen. 11). There are many admonitions against focusing on acquisition in the forms of greed, covetousness, aggrandizement, unjust gain (Mk. 7:22; Jer. 22:13–17; Prov. 30:15–16; Hab. 2:9–11; Col. 3:5; Ex. 20:17) and materialism (Lk. 12:15; Matt. 6:24, 19:23–24; Mk. 10:21–22; Acts 2:45); conversely, voluntary self-restraint is emphasized (reinforced in the Old Testament by rules regarding tithing, gleaning, and the Sabbath). Jeremiah asks: "Does it make you a king to have more and more cedar?"—i.e. a bigger and fancier house (Jer. 22:15). In addition to Jesus' many warnings about material things, Paul equates greed with idolatry (Col. 3:5).

The Ω_3 Objective to maintain biodiversity upholds the biblical portrayal of God cherishing the diversity of his creation (Gen. 1:22, 6:19–20, 7:7–10; Job 12:10; Hos. 2:18). In Job 39–41, God takes delight from creatures that have no apparent usefulness—thereby discrediting a purely utilitarian world view. God's intent regarding biodiversity is codified in the Noahic covenant (Gen. 9:8–10, 12–13, 16–17). Human activity that results in extinction of species is not only a biological concern for the ecosystems that support human life, it is in opposition to God's intent. The Ω_3 Objective is sufficient for a biocentric ethic,[64] but a biblical basis elevates maintenance of biodiversity to obedience to God.

The Ω_4 Objective regarding aesthetic richness can be derived from the many passages about the beauty of the creation (Pss. 8, 19:1–6, 66:4, 96:11–12; Neh. 9:6; Job 37:14–24; Isa. 55:12; Rom. 1:20). Some of these passages describe a time when the earth will be restored: mountains and hills will sing, trees will clap hands, the earth will be glad, the seas will roar, and fields will be joyful in praise of the Creator. A contravariant set of passages can be found expressing God's anger toward and punishment of those who defile the land (e.g., Jer. 2:7; Rev. 11:18). Prophesies on restoration require recovery from past departures from sustainable development. Scriptures teach that *all creation* will be reconciled (2 Cor. 5:19; Eph. 1:10; Col. 1:15–20). When we understand that God called the creation "good," maintains ownership, and loves his *entire creation*, we derive additional motivation. (Evangelicals are sometimes startled to learn that the Greek word *cosmos* translated *world* in Jn. 3:16 refers to all of nature at least, and more likely to the entire universe.)

In sum, a biblical world view holds neither technology nor nature as sacred. Neither is to be worshiped; humans must learn to operate within revealed constraints. We must maintain a distinction between creation and Creator (Rom. 1). In addition, nature (natural resources) and technology are to be used for human benefit, but usage must be constrained. Achieving sustainability requires self-assessment, the outcomes of which then are used to guide the collective self-limitation that will permit civilization to operate within constraints set forth in Scripture.

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Application

A general biblical response to overconsumption

None of the individual Grand Objectives speaks directly of overconsumption. Taken collectively, however, they are clearly consistent with biblical mandates for creation care and an equipoise society. A biblical platform is not *essential* for their derivation, because biocentric or pantheistic world views also are able to support them. However, a biblical exegesis will produce *more than* Objectives Ω_1–Ω_4; some additional conditions emerge. First, humans are to live within their means. Moreover, we are to live within our means *after* tithing and setting aside resources to help those in need.[65] The Greek word *oikonomia* can be understood as stewardship—living within our means—which requires sustaining God's creation and therefore precludes overconsumption (1 Tim. 6:6; Lk. 12:15, 23–24). Bishop Taylor draws attention to the Hebrew word *betsa*—meaning overweening greed and the hubris that underlies it (Ex. 18:21; Job 27:14–18; Prov. 30:15–16; Isa. 56:10–11, 57:17; Jer. 22:13–17; Hab. 2:9–11) and the Greek *plexonia*—meaning having in excess and still wanting more (Mk. 7:21; Col. 3:5). This mandate leads to stewardship and precludes a purely utilitarian view of nature. Taylor's vision of an *equipoise society*—requiring both equity among people *and* equilibrium between humans and nature—seems to capture much of the biblical guidance. Referring to 2 Cor. 8:13–15, Taylor explains that "God's gifts, and man's happy dependence upon them, are the grounds of the 'theology of enough.'"[66]

A Christian understanding of the meaning and place of technology in our lives would be neither pessimistic nor optimistic, but … balanced between the two extremes.

God's directive on human endeavor recorded in Genesis 1 and 2 does not preclude technology as a legitimate response to the dominion mandate. The directive is supplemented, however, by certain constraints. Chief among these, according to Psalm 148, is that the purpose of development is the glory and service of the Lord.[67] Use of technology to relieve suffering and drudgery consequent to the fall from grace is consistent with this framework, as far as it goes. A Christian understanding of the meaning and place of technology in our lives would be neither pessimistic nor optimistic, but rather—as so often turns out to be the proper biblical exegesis—balanced between the two extremes. Using Wauzzinski's definitions, a Christian approach to technology must not be *pessimistic* because through the liberating, redemptive work of Jesus Christ we gain the ability to manage the creation responsibly rather than just for our personal benefit. We are (or more precisely, we can be) freed from the grip of *technique* just as we can be freed from enslavement to other sinister forces. Neither should the Christian approach be *optimistic,* because taken to an extreme, exaltation of technology as our *savior* becomes idolatry and enslavement to a master other than Jesus Christ.

Specifics for Christian engineers in the design profession

Most of our development here applies to all believers, but some guidance is particular to engineering design practice. When underpinned with the biblical basis for the Grand Objectives, Industrial Ecology (IE) moves from a purely utilitarian methodology (or *technique*) to becoming a moral foundation for responsible engineering design. The foundation should satisfy most environmental world views, but three probably are not satisfied: (1) technological optimism; (2) radical ecology; and (3) discontinuous eschatology. One might argue that IE is in fact an optimistic technique because it looks to science and engineering to provide the tools to achieve sustainability. However, its thesis is that the present path of technological civilization is not sustainable, and deliberate technical, social, and political action must be taken to preclude catastrophic decline in population and/or quality of life. This thesis separates IE advocates from the pure technological and economic optimists, who believe that market forces will induce solutions when they are needed. Radical ecologists agree that present civilization is not sustainable, but will reject the tenants of IE simply because IE accepts technological civilization as a given and discounts radical ecology as "attempts to return to anti-technology pastoralism."[68] Discontinuous eschatology is paradoxical: it is optimistic in the sense that technology is embraced, but pessimistic in that the global outcome is expected to be environmental catastrophe.

The biblical standard of *equipoise* that we have adopted from Bishop Taylor calls for equity plus balance, and the concept applies to technology as well as to economics. Unrestrained adoption of technology that damages nature and leads to social and physical decline is excessive, or imbalanced. We absolutely do not oppose technology per se. Rather we believe that the adoption of technology has progressed with inadequate assessment, and imbalance manifested in overconsumption is the result. The most common response of the Christian church to the issue of overconsumption consists of one of the following extremes: willing, usually unexamined, complicity with the process; or opting out, i.e. separating from mainstream culture into small faith communities that seek to adopt simple lifestyles. We understand the biblical mandate as a call for Christians to live within the culture without overconsuming and to work to redirect culture toward a

different destination. This alternative might involve the Christian engineer in three endeavors.

First, using the biblical perspective we have provided, assess the risks of technology at the individual and systems levels, and then take appropriate action. Effective actions might include efforts to influence public policy by means of letter writing, speaking, teaching, and working through professional societies.[69] One of us (JS) has used the Grand Objectives as an apologetic in a senior-level engineering elective class called "Industrial Ecology and Sustainable Manufacturing." The students frequently encounter issues facing contemporary Western culture—such as globalization, energy supply, green standards, environmental impact of consumer preferences, and reducing time to market. Because the topics are value-laden and controversial, they provide opportunities for discussing biblical perspectives, in class or after class. At the very least, the class provides numerous opportunities to initiate dialog on world views. Some of the segues from IE to biblical themes are summarized in Table I. The correspondence is not surprising because, as we showed in the preceding section, Graedel's Omega Objectives are derivable from Scripture.

[Jesus] challenges [designers] to voluntarily assume risk of monetary or physical loss in the pursuit of ethical ends.

Biblical Theme	Segues from IE
Voluntary self restraint • Tithing • Gleaning • Sabbath/Jubilee • Simplicity	Constraints on society • Living sustainably • Sustainable design • Environmental justice • Free trade vs. environmental protection
Dissipation • Wasted lives • Dominion mandate to bring order from chaos	Dissipative use • Irrecoverable loss • Nonrenewable resources
Living more simply • Equipoise society • The theology of enough	Dematerialization • Materials productivity • Per capita GDP vs. quality of life
Irreducible complexity • Intelligent design	Complex systems • Emergent properties
Theism • The purposeful hand of God in history	Guided evolution of complex systems • Toward sustainability

Table 1. Segues between biblical themes and industrial ecology principles

Second, the Christian design engineer might need to search for sustainable alternatives on his or her own time while working for his or her employer on the project that has emerged from the design definition process.[70] Such action would be consistent with a biblical conviction about overconsumption or its environmental impacts. In the long term, however, if the employer remains unresponsive, the designer may have to make a decision about remaining on the payroll. This is but one example of a larger set of choices that a Christian must make in order to work out a biblical relationship to creation.

Third, every Christian should be seeking to establish "prototype kingdom communities."[71] This does not mean separation from culture, but rather living as a sub-culture that displays redeemed three-fold relationships: humans with the Creator, humans with the creation, and humans with other humans.[72] We believe that an authentic prototype kingdom community would seek to practice sustainability. The lessons learned should be made available to the rest of society.

Jesus' teaching of "extra mile lifestyle" in the Sermon on the Mount and the Parable of the Good Samaritan asks even more of Christian designers. He challenges them to voluntarily assume risk of monetary or physical loss in the pursuit of ethical ends. At first this may sound a little like *Erin Brockovich* except for the sensationalism in the movie, and it could also include "whistle blowing" or even "tree sitting." However, those illustrations are negative in the sense that they have as their goal to stop something that is perceived to be damaging. In contrast, the application to design ethics is positive in that it seeks not opposition and blockage, but redirection.[73]

Whatever actions the Christian designer chooses, one option precluded by Scripture is passive compliance. One who "sees the sword coming and fails to warn the people" fails in his or her duty as a watchkeeper (Isa. 21:11; Jer. 16:1; Ez. 6:17–19, 33:2–10). Nor would it be adequate, in our opinion, for technical professionals merely to work quietly to increase the efficiency with which industry and its products operate. Instead, taking overconsumption seriously would

lead to more fundamental reconsideration of technical professionals' work—and all of our lifestyles.

Conclusions

We have identified eight conclusions. They are:

1. There undeniably is a risk that current and projected levels of consumption may be unsustainable, and that further increases in consumption may pull the world into a deeper environmental predicament.

2. Some aspects of consumption pose threats not just to environment but also to aspects of culture, psyche, and spiritual life.

3. Engineers and other technical persons abet the extension and spread of overconsumption.

4. Christians could avoid having to deal with the overconsumption problem if they could be confident that the second coming of Christ would moot environmental and other concomitants of consumption. But absolute certainty regarding biblical end-times prophesy is impossible to achieve, and therefore cannot be used by Christians to evade responsibility.

5. Christians likewise could avoid dealing with overconsumption if they could be confident that technological improvements would bail humanity out, and that the global ecosystem would prove forgiving (as by avoiding calamitous climate changes from greenhouse gases). However, there is considerable dispute about such matters among scientists and technologists who know the most, and the balance of informed opinion is more pessimistic than optimistic about the present trajectories. So while a Christian may hope for a never-ending string of technological solutions, it would be imprudent to bet on it—and certainly unbiblical to assign to technology the role of savior.

6. Christians have special responsibilities in how they live everyday life. Considering how central consumption behaviors are in everyday life, would it not be surprising if Christians had no spiritual responsibilities in regard to consumption?

7. If that is true of Christians who function as ordinary consumers, does it not make sense that it would apply with special force to Christian engineers and others who make some of the key R&D and production decisions in the civilization's overall approach to (over)consumption?

8. The emerging field of Industrial Ecology offers an approach to environmental sustainability that seems to us to deserve thoughtful consideration as one element of a perhaps much broader Christian practice of engineering.

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