The Built Environment and the Ecosphere: A Global Perspective

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The Coming Age of the 'Built Environment'

By early in the coming decade, the majority of humankind will be living in cities. For the first time in the two million year history of our species, the immediate human environment will be the 'built environment.' By all conventional accounts, we seem to be leaving nature and the countryside behind.

'Urbanization' is usually regarded as a demographic and economic phenomenon, as a transition to a somewhat higher plane of civilization. Western industrial culture tends to associate 'rural' and 'agricultural' with general underdevelopment and a presumptively inferior peasant culture. After all, it is cities that serve as the seats of government, the engines of economic growth, the centers of culture, the well-springs of new knowledge, and the repositories of cumulative learning.

Certainly it is true that our greatest cities are among the most magnificent of human achievements. But there is another side of cities and urbanization to which the modern technological eye is blind. Urbanization also represents an unprecedented transformation in human ecology. This greatest of human migrations has produced a dramatic shift in the spatial and material relationships of our species to the ecosphere. People now live and work far from the land and biophysical processes that actually support them. Cities require ever greater quantities of food, material commodities, and energy - all often shipped great distances - to sustain the increasingly consumer lifestyles of their inhabitants. High-income cities in particular impose ever greater burdens on the global commons to assimilate their metabolic wastes. Indeed, whether through commercial trade or natural flows, modern cities draw on resources and dump their garbage all over the world. This new ecological reality underscores the urgency of 'greening' the building industry.

Cities and Sustainability

Given the pace of growth the prevailing pattern of urbanization has serious negative implications for global sustainability (Girardet 1992, Rees 1992, Rees 1997, Rees and Wackernagel 1996,). On the positive side, certain characteristics of cities could be exploited to enhance humanity's future prospects. Nevertheless, and despite the two UN 'Habitat' conferences on urban prospects, cities have been given short shrift in the mainstream sustainability debate. For example, the World Conservation Strategy of 1980, which apparently first explicitly used the term "sustainable development," paid no special attention to accelerating urbanization. The Brundtland report did discuss the issue, but the main emphasis was on the "urban crisis in *developing* countries" (WCED, p.8, emphasis added).

This relative neglect of cities - particularly rich cities - is difficult to reconcile with physical reality. Up to eighty per cent of the populations of high-income countries already live in cities and, as noted, half of humanity will be urbanized early in the next century. Moreover, since the wealthiest 20% of the human population consume 80% of the world's economic output (WCED 1987), approximately 64 % of the world's economic production/consumption and pollution is associated with cities in *rich* countries. Only 12% is tied to cities in the developing world. In short, "half the people and three-quarters of the world's environmental problems reside in cities, and rich cities, mainly in the developed North, impose by far the greater load on the ecosphere and global commons" (Rees 1997).

Greening the Building Industry

These basic facts underscore the fact that urban designers and planners, architects, the makers of building materials - indeed, anyone associated with creating the built environment - have a major but as yet unrealized role to play in enhancing the sustainability of our cities in the 21st Century. The ultimate purpose of this paper, therefore, is to suggest ways by which eco-cities and "green building" can become the standard for global society. I begin, however, by elaborating two concerns that exacerbate the issue: first, most decision-makers and ordinary people alike still seriously underestimate the scale of the ecological crisis, and; second, modern industrial society has badly misconstrued the nature of the problem. The first concern helps explain why the political response so far has been so limited; the second explains why responses to date have been so ineffective. Understanding any problem is prerequisite to prescribing appropriate solutions.

Global Change: An Ecological Wake-up Call…

In the past thirty years the scale of environmental problems has shifted upward, from local and temporary to global and chronic. Atmospheric change, wobbly climate, and ozone depletion - the stuff of daily headlines - affect people everywhere. Land degradation, falling water tables, acid rain, and accelerating species losses are occurring on virtually every continent. Humankind is now the major force changing the face of the earth and few serious observers feel we have the capacity to control the direction of change. More than any other factor, humanity's capacity unwittingly to disable global life-support mechanisms is beginning to forge a novel consensus. Increasing numbers of technical analysts and informed citizens alike are coming to believe that the current global development path is fundamentally unsustainable.

Despite the growing unease, human pressure on the planet is increasing relentlessly. The world population is nearing six billion and growing by 80 million per year; by the end of the decade (and millennium), it will have almost doubled twice in this century. All these people, rich and poor alike, have rising material expectations sustained by an economic system that assumes the latter are insatiable. Little wonder that the global economy has expanded five-fold in *half* a century.

…And Yet We Slumber

Any effort to address the environmental crisis is complicated by the fact that the benefits of this economic explosion have not been unevenly distributed. While twenty percent of the world's population enjoy unprecedented material well-being, another twenty percent remain in abject poverty. However, rather than contemplate mechanisms to redistribute the world's wealth, the global community has determined to abolish material poverty through sheer economic growth. In theory, if the economic pie is big enough, even the relatively poor will enjoy adequate material well-being (thus easing political pressure for re-distributive policies). Despite the warnings of its top scientists, mainstream industrial society does not yet see "the environment" as a serious constraint on the required five- to ten-fold expansion in industrial activity. According to conventional wisdom the only limits are our stinted imaginations, inefficient institutions, and inadequate technologies (see WCED 1997).

Unfortunately, there is no indication that the growth approach will bridge the income gap any time soon. In 1960, the richest twenty percent of income earners took home "only" thirty times more than the poorest twenty percent; by 1990 this ratio had increased to 60 to one (UNDP 1992). In short, the income gap actually doubled in 30 years of continuous global growth!

Meanwhile it is precisely the continuous growth in the "throughput" of energy and material required to feed aggregate human demand that drives the so-called "environmental crisis" (Goodland 1991). Empirical evidence suggests that resource consumption already exceeds the productive capacity of certain critical biophysical systems on every continent. Waste production already breaches the assimilative capacity of many ecosystems at every scale.

Shifting Perspectives

If the physical evidence is so obvious, just how can mainstream society continue to "misconstrue" the problem? The difficulty is not so much a matter of disputed fact as it is of distorted perspective (Rees 1995a). The "Cartesian dualism" that underlies scientific industrial society effectively sets humanity apart from nature. Conventional economics, for example, treats the economy as a separate, mechanically reversible system, virtually independent of the ecosphere. Yes, there are connections - the "environment" serves the economy as a source for resources and sink for wastes - but these linkages are not critical. Indeed, it is a near doctrinaire position among neoclassical economists that technology can substitute for both resources and environmental functions. As Nobel Laureate economist Robert Solow wrote over 20 years ago: "If it is very easy to substitute other factors for natural resources, then... The world can, in effect, get along without natural resources..." (Solow 1974, 11).

Such overweening confidence in technology (i.e., freedom from environmental constraints) has convinced much of the world that the economy can grow forever. We also base our economic analyses and indicators almost entirely on money flows (e.g., GDP per capita is every country's standard measure of progress). Ironically, then, while market economics determines the allocation and transformation of material resources in society, its dominant analytic models virtually ignore the biophysical basis of economic activity. Any resultant problems can be handled by technological fixes.

Human Ecology and Thermodynamic Law

There is, of course an emerging, more holistic, alternative world-view. This human ecological perspective sees the economy not in isolation, but rather as an inextricably integrated, completely contained, and wholly dependent *subsystem* of the ecosphere (Rees 1990, Daly 1992). Moreover, it recognizes that both the economy and the ecosphere are complex self-organizing systems whose behaviour is ultimately governed not by the mechanical assumptions of mainstream analysis but by evolutionary forces, complex systems dynamics, and thermodynamic laws. Indeed, the second law of thermodynamics as applied to open far-from-equilibrium systems provides an important theoretical foundation upon which to rebuild our understanding of economy-environment interaction.

Modern formulations of the second law suggest that all highly-ordered complex systems develop and grow (increase their internal structure and order) "at the expense of increasing the disorder at higher levels in the system's hierarchy" (Schneider and Kay 1994,2). In other words, complex systems maintain their internal order and remain in a dynamic non-equilibrium state through the continuous dissipation of available energy/matter extracted from their host environments. Such self-organizing non-equilibrium systems are called dissipative structures (Nicolis and Prigogine 1977).

The human economy is one such highly-ordered, dynamic, far-from-equilibrium dissipative structure. Its internal order and complexity continuously increase as it grows and develops, particularly through the formation of manufactured capital (including the built environment) made from natural capital (resources). However, as noted, the economy is an open growing subsystem of the materially-closed non-growing ecosphere. Beyond a certain point, therefore, the increasing size and complexity of the former can be purchased only through the dissipative disordering of the latter.

The second law thus provides both a necessary condition for sustainability and a nearly sufficient explanation of the present ecological crisis. Economic activity is ecologically sustainable only so long as consumption by the economy is less than production in nature. Today's continuous population and economic growth is therefore necessarily unsustainable. A materially expanding economy by definition appropriates an ever greater share of the fixed (or declining) quantity of usable energy and matter continuously being formed by solar-driven processes in the ecosphere. In structural terms, the expanding human enterprise is positioned to consume the ecosphere from within.

Human Ecological Dysfunction

This ecological lens enables us to discern that that the so-called "environmental crisis" is really a symptom of profound human ecological dysfunction resulting from deeply-rooted cultural values. Economist Herman Daly (1991, 29) argues that this reality requires a perceptual transition from "empty-world to full-world economics," a shift which he terms "an historical turning point in economic development". Similarly, Caldwell (1990, 191) argues that "the world is passing through a (sic) historical discontinuity" requiring a reorientation of previous goals and values and a radical reconfiguration of the way people relate to the Earth. In this light, it may well be that new technology is both inevitable and necessary. However, as we shall see, it is unlikely better technology alone will prove sufficient for sustainability.

Doubling the Built Environment

There is little question that how cities develop is key to attaining a secure ecological future. The global population is currently increasing by 1.4 per cent, but the rate of urbanization can be many times higher, particularly in developing countries. From 1950 to 1990, the world's urban population increased by 200 million to about 2 billion, adding just 1.1 percent of the 1950 level each year. In the 1990s, the pace of urbanization picked up. The world's urban population is expected to have grown by about 50% in this decade to almost 3 billion by 2000. By 2025, the UN projects that about 5.1 billion people will reside in cities, an increase of 70% in the first quarter of the Century (UN 1995). This means that in the next 27 years, the urban population alone is expected to grow by the equivalent of the total human population in 1930.

In 2015, almost 17% of urban dwellers will live in large cities of over 5 million and there will be 71 such mega-cities by 2015. Most of the growth in these cities will occur in the less-developed countries. To illustrate, in 1950 the only city to exceed 10 million people (New York) was in a developed country. However, 23 of the 27 cities expected to reach this size by 2015 will be in less developed countries. Similarly, of the 44 cities of between 5 and 10 million inhabitants in 2015, some 36-39 will be in the developing world (UN 1995).

Material Considerations

Many cities in the developing world have been woefully ill-prepared to accommodate the first wave of newcomers. In the mid 1990s as many as 25% of urban dwellers in the developing world did not have access to safe potable water supplies and 50% lacked adequate sewage facilities. Even by 2000, more than 600 million urban dwellers will still lack adequate sanitation and 450 million will suffer from unsafe drinking water (NRTEE 1998). Accordingly, the World Bank estimates that developing countries alone will need to invest $US200 billion a year in basic infrastructure in the period to 2005, most of it for urban regions. Given anticipated urban population growth and material demand to 2025, "…it would be reasonable to expect the total volume of investment [in infrastructure] to reach $6 trillion by that time" (NRTEE 1998, 11).

Keep in mind that the world must construct adequate new physical plant to support an urban population *increase* in just the next 27 years equivalent to the total accumulation of people in all of history up to the 1930s! In effect, we will be doubling the 1970s' urban presence on the planet. This means millions of new dwelling units, stores and offices; thousands of new schools, hospitals, and water and waste-water treatment plants; countless square kilometers meters of new roads and parking facilities for tens of millions of additional motor vehicles; and all manner of supportive transportation, communications, and related urban infrastructure.

On the face of these data, it is little wonder that most people expect cities to be "using much more energy,[materials,] water, and land than ever before and doing so in more concentrated, land-, capital-, knowledge-, and technology-intensive ways" (NRTEE 1998, 2). What is not as readily clear is how we can reconcile the expected use of so "much more" of everything with growing evidence that global carrying capacity has already been exceeded. Increased throughput growth on the scale implied here is simply incompatible with ecological sustainability (see Goodland 1991).

Urban Ecological Footprints

In an effort to quantify this dilemma, the author and his students have developed a method to estimate the spatial dimensions of the human ecological niche. Our approach, called 'ecological footprint analysis,' starts from the premise outlined earlier, that human beings remain integral components of the ecosystems that support them (Rees and Wackernagel 1994; Rees 1996; Wackernagel and Rees 1996).

Ecological footprinting therefore explicitly builds on traditional trophic ecology. We begin by constructing what is, in effect, an elaborate 'food-web' connecting any specified human population to the rest of the ecosphere. This niche analysis involves quantifying the material and energy flows required to support that population and identifying significant sources and sinks. However, the human food-web differs significantly from those of other species. In addition to the material and energy required to satisfy the metabolic requirements of our bodies, the human food-web must also account for our industrial metabolism - the material demands of the economic process and the built environment.

Ecological footprinting is further based on the fact that many material and energy flows (resource consumption and waste production) can be converted into land- and water-area equivalents. Thus, *the ecological footprint of a specified population is the area of land/water required to produce the resources consumed, and to assimilate the wastes generated, by that population on a continuous basis, wherever on Earth that land may be located*. It therefore includes the area appropriated through commodity trade and the area needed for the referent population's share of certain free land- and water-based services of nature (e.g., waste assimilation and nutrient recycling). In other words, ecological footprinting estimates the area of productive ecosystems all over the world whose biophysical output is appropriated for the exclusive use of a defined human population.

How Big is our Ecological Footprint?

Our early estimates, accounting for just food, fibre, and fossil energy consumption, show that the ecological footprints of typical residents of high-income countries, ranges as high as five or six hectares *per capita* (Rees and Wackernagel 1996; Wackernagel and Rees 1996). More recent analyses push the upper estimate to nine or 10 hectares *per capita* (Wackernagel *et al.* 1997). By extrapolation, the ecological footprints of high-income cities is typically two to three orders of magnitude larger than geographic areas they physically occupy.

For example, assuming Vancouverites are average Canadians, the 472,000 residents of the author's home city generate an average ecological footprint of about seven hectares *per capita* to support their consumer lifestyles (Wackernagel *et al.* 1997). This means that the aggregate eco-footprint of the city proper is 3,304,000 ha, or 290 times its political-geographical area (11,400 ha). Similarly, in a more comprehensive study, Folke *et al.*(1997) estimate that the 29 largest cities of Baltic Europe appropriate for their resource consumption and waste assimilation, an area of forest, agricultural, marine, and wetland ecosystems 565-1130 times larger than the area of the cities themselves.

These data emphasize what should be obvious but which is often forgotten in a rapidly urbanizing world - that no city as presently defined can be sustainable. In ecological terms, cities and urbanized regions are intensive nodes of consumption sustained almost entirely by biophysical production and life-support processes occurring outside their political and geographic boundaries (Rees 1997; Rees and Wackernagel 1996). The resultant separation of production from consumption renders urbanites blind to the degradation that results from their consumer lifestyles and unconscious of their increasing dependence on a deteriorating resource base. Far from reflecting our assumed increasing independence from nature, the modern high-income city resembles a parasite on an increasingly global hinterland.

Ecological footprinting also reveals that in some dimensions, consumption by the present human population already exceeds the long-term productivity of the ecosphere. According to Folke *et al.* (1997), the carbon dioxide emissions of just 1.1 billion people (19% of humanity) living in 744 large cities exceed the entire sink capacity of the world's forests by 10%. Similarly, Wackernagel and Rees (1996) and Wackernagel *et al.* (1997) estimate that with prevailing technologies and average consumption levels, the present world population exceeds long-term global carrying capacity by up to one third. Contrary to prevailing international development models, so-called "first world" material lifestyles are not extendible to the entire world population along the present development path.

More Bad News About Cities

Urban regions not only appropriate an increasing share of global production but they also destroy the structure of the ecosystems that support them. Most important, cities significantly alter natural biogeochemical cycles of vital nutrients and other chemical resources. Removing people and livestock far from the land, prevents the natural recycling of phosphorus, nitrogen, other nutrients and organic matter back onto farm- and forest-land. As a consequence of urbanization, local, cyclically integrated ecological production systems have become global, horizontally disintegrated, throughput systems. For example, instead of being returned to its source, Vancouver's daily appropriation of Saskatchewan mineral nutrients goes straight out to sea. Similarly, in their classic 1978 analysis of *The Metabolism of Hong Kong*, Newcombe *et al.* found that 2.4 million tonnes of plant nutrients passed through the city's human food supply system annually (cited in Girardet 1992). This is half a tonne of vital nutrients *per capita*, most of it discharged into Hong Kong's Victoria Harbour.

As a result, agricultural soils are degraded - half the natural nutrients and organic matter from much of Canada's once rich-prairie soils have been lost in a century of mechanized export agriculture - and we are forced to substitute non-renewable artificial fertilizer for the once renewable real thing. This results in ground and surface-water pollution and consequent additional ecological damage. Clearly, there is need for much improved accounting for the hidden costs of cities and their supportive infrastructure and for a redefinition of economic efficiency to include biophysical factors.

Accepting Reality, Confronting Ourselves

There is no getting around the fact that material consumption is at the heart of the sustainability crisis - the aggregate "ecological footprint" of humanity is already larger than the Earth. The material challenge for sustainability, therefore, is how to accommodate both rising material expectations and a four billion person population increase over the next 50 years, while actually *reducing* total throughput. Researchers in various disciplines, from urban spatial planning to materials science, are exploring this conundrum.

Re-Thinking Urban Form

We have seen that modern cities unwittingly disrupt the ecosystems upon which they depend. To avoid this, should we not be reconsidering how we define city systems, both conceptually and in spatial terms? As presently conceived, cities are incomplete ecosystems, typically occupying less than 1% of the productive area upon which they draw. In whole-systems terms, 'the city' com-prises not just this tiny node of consumption, but also the complementary productive hinterland.

Whole-systems planning is, of course, some time off. In the meantime, urban regions should at least implement policies to protect the integrity and productivity of local ecosystems and reduce the ecological load imposed on distant systems. This would require rehabilitating their own natural capital stocks and promoting the use of local fisheries, forests, agricultural land, etc. For example, land use planning planners and politicians should find ways to:

- capitalize on the multifunctionality of green areas (e.g., aesthetic, carbon sink, climate modification, food production, functions) both within and outside the city;
- more specifically, integrate open space planning with other policies to increase local self-reliance in food production, forest products, water supply, carbon sinks, etc. For example, domestic waste systems should be designed to enable the recycling of compost back onto regional agricultural and forest lands;
- strive for zero-impact development. The destruction of ecosystems and related biophysical services due to urban growth in one area should be compensated for by equivalent ecosystem rehabilitation in another.

Urban Leverage: Good Ecological News About Cities

The very factors that make cities weigh so heavily the ecosphere - the concentration of population and consumption - also give cities enormous economic and technical leverage in the quest for global sustainability (Mitlan and Satterthwaite 1994, Rees and Wackernagel 1996). The advantageous economies of scale and agglomeration economies of urban settlements result in:

- lower costs *per capita* of providing piped treated water, sewer systems, waste collection, and most other forms of infrastructure and public amenities;
- a greater range of options for material recycling, re-use, re-manufacturing, and a concentration of the specialized skills and enterprises needed to make these things happen;
- high population densities which reduce the *per capita* demand for occupied land;
- greater possibilities for electricity co-generation, and the use of waste process heat from industry or power plants, to reduce the *per capita* use of fossil fuel for space-heating;
- numerous opportunities to implement the principles of low through-put 'industrial ecology' (i.e., the creation of closed-circuit industrial parks in which the waste energy or materials of some firms are the essential feed-stocks for others);
- great potential for reducing (mostly fossil) energy consumption by motor vehicles through walking, cycling, and public transit.

Walker and Rees (1997) provide a graphic illustration of the economies associated with housing type and attendant urban form. They show that the increased density and attendant energy and material savings associated with high-rise apartments, compared to single-family houses, reduces that part of the *per capita* urban ecological footprint associated with housing type and related transportation needs by about 40%. Such gains occur independent of building materials used. Similarly, Kenworthy and Laube (1996) detail how personal energy consumption associated with transportation needs is dramatically inversely related to urban density.

Technological Efficiency Gains: The "Factor-10" Ideal…

Various studies show that sustainability requires a massive reduction in materials consumption approaching 50% world-wide (e.g., Schmidt-Bleek 1993). However, the material intensity of consumption in industrial countries must be reduced by a *factor of ten* to accommodate the need for additional income growth in the developing world (Ekins and Jacobs 1994; RMNO 1994a,b). Even the Business Council for Sustainable Development has agreed that "industrial world reductions in material throughput, energy use, and environmental degradation of over 90% will be required by 2040 to meet the needs of a growing world population fairly within the planet's ecological means" (BCSD 1993). Clearly, one necessary factor in achieving sustainability must be a new "efficiency revolution" (Young and Sachs 1994).

…and a Cautionary Note

Many growth advocates assert that the market alone will produce efficiency gains capable of decoupling growth from the environment. This argument is flawed for several reasons. First, material efficiency has, in fact, increased greatly in recent decades. However, because the resultant savings can lead to higher wages and lower prices for an ever wider range of goods and services, they may actually *increase* gross consumption! The most recent studies of resource flows in a selection of high income countries found that the average citizen now requires 45-85 metric tons of natural resources (excluding air and water) *annually* - including 17 to 38 metric tons of direct material inputs - to produce his/her goods and services. Thus while these countries have seen some reduction in the ratio of resource inputs per unit GDP since 1975, there has also been "in most, a gradual rise in *per capita* natural resource use." We can only conclude that "meaningful dematerialization, in the sense of an absolute reduction in natural resource use, is not yet taking place" (WRI 1997,2).

Second, remember that in global terms, by far the bulk of material growth in the next few decades will take place in the less-developed countries. These countries account for 75% of the world's population and, since growth here starts from a much smaller base, it has further to climb. Moreover, this massive expansion is less likely to benefit from efficient technologies than is growth in the developed world.

Finally, free markets and market-based processes do not and *cannot* reflect ecological reality for a variety of theoretical and practical reasons. These range from the fact that prices reflect only short-term market supply and demand (and not true ecological scarcity) to the inability of markets to cope with lags, thresholds, and other discontinuities in the behaviour of natural systems under stress (see Rees and Wackernagel 1998). In these circumstances, the prices of raw commodities and manufactured goods alike are almost always far below the true social costs of recovering, transforming, using, and disposing of the resources involved. Free markets thus produce artificially low prices, and it is an economic axiom that under-pricing leads to overuse. Much of today's sustainability crisis derives from the fact that prices do not reflect the hidden resource depletion and pollution damage costs of economic goods and services.

Ecology and Fiscal Reform: Taxing our Way to Sustainability

In these circumstances, governments have positive role to create the necessary policy incentives to ensure that even as consumption rises, the material and energy content of that consumption falls apace. Achieving a "factor10" economy will require major changes in fiscal and taxation policy, industrial strategy, and consumer-corporate relations. However, if managed properly, the net effect of this transformation should be not only less consumption and waste but also more jobs and increased regional self-reliance (Weizsäcker and Jesinghaus 1992, Rees 1995a,b, Roodman 1997).

Most importantly, approaching the "factor-10" ideal will require replacing present subsidies by systems of resource use and depletion taxes off-set by corresponding reductions in other taxes, particularly on labour. By raising prices closer to the full social cost of goods and services, taxes on energy and resources create an incentive for industry to minimize material throughput; meanwhile, lower labour costs further increase workers' comparative advantage over capital helping to create jobs. Reducing income/payroll taxes in proportion to resource tax hikes also makes the reform package revenue neutral so there may be no increase in the average fiscal burden. Thus, unlike regulation or add-on pollution charges, ecological tax reform, properly implemented, would not jeopardize international competitiveness.

Conclusions: The Next Step

Given the massive anticipated global increase in urban physical plant, eco-cities design and green building technologies have the potential to make an enormous contribution to reducing the energy and material intensity of cities. Unfortunately, the full potential of green building is unlikely realized in the present political climate. In the past two decades, most governments have become committed to market forces and renewed global growth as the well-springs of all social value. Progressive tax reform, particularly tax increases are anathema to contemporary politicians. Canada, for example has forsworn contemplation of a 'carbon tax' (that most essential of eco-taxes) and has taken no significant steps toward achieving her Kyoto commitment of a 6% reduction in CO_2 emissions over the next decade.

As suggested above, this is both dumb ecology and perverse economics. It may also prove to be bad business. In countries without the strong pseudo-market incentive of eco-taxes to stimulate the creative process, new "dematerialized" building materials, methods, and technologies will be slow to appear. The under-pricing of conventional energy and materials will inhibit their development and the domestic building industry will have little to offer the world as the sustainability imperative gains momentum. Conversely, those countries and firms that act first to develop new energy/material-efficient technologies and processes will gain the upper hand in marketing these products and services in a global market of enormous potential demand.

If they don't wish to be left behind, all players in creating the build environment of the future would be well-advised to lobby their respective governments to formulate the necessary tax reforms without delay. Significantly, in the 1990s, at least five European countries "have taken the seminal step of combining environmental tax hikes with income or payroll tax cuts (Roodman 1997, 8). The world waits to see whether this is also a tentative first step toward producing the deep-green construction materials and methods needed for a doubling of the built environment in the 21st Century while ensuring the ecological sustainability of global society.

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