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## The transition to a sustainable society

JAMES GUSTAVE SPETH

World Resources Institute, 1709 New York Avenue, NW, Suite 700, Washington, DC 20006

**ABSTRACT** Transitions in dealing with the root causes of environmental problems are advocated to achieve environmental sustainability. These transformations include (i) a demographic transition, (ii) a technology transition that includes the "green" automobile, (iii) an economic transition to one in which prices reflect full environmental costs, (iv) a transition in social equity, and (v) an institutional transition to different arrangements among governments, businesses, and peoples. Businessmen and environmentalists are urged to work together in the next decade to make the environment a personal issue, to call for government action, to recognize the environmental challenges, and to commit to accountability in order to leave a legacy of hope to the twenty-first century.

The concepts of industrial ecology and industrial metabolism offer important insights both for further academic investigations and for practical applications.

We certainly need to change course. I am convinced, after 20 years of working on environmental issues, that present approaches will not accomplish the job, because they do not focus enough on underlying problems at the root of our environmental troubles. The approaches of the 1970s have bought us time but not much more. Unless we find innovative ways to meet the challenges of the 1990s, we will lose the battle for the planet.

Why are new approaches so urgent? Consider our century's exponential growth trends. Since 1950, world population has doubled to over 5 billion. The output of the world economy has quadrupled. Economic activity on the planet today is greater by a factor of four than when I was a boy of 10. It took all of human history to build a world economy that produced about \$600 billion in output in 1900. Today, the world economy grows by this amount every 2 years.

For over a billion of us, principally those of us in the rich countries, this growth has brought material wealth unimaginable by earlier generations. But it has also brought pollution, waste, and consumption of the planet's resources on an unprecedented scale.

The buildup in the atmosphere of carbon dioxide and other gases from fossil fuel use now threatens far-reaching climate change. Seven of the hottest 10 years on record have been in the last decade. Other gases—principally the chlorofluorocarbons—are depleting Earth's ozone layer, which shields us from the sun's UV radiation. And over large areas of the globe, air pollutants are escaping urban-industrial areas and invading the countryside, seriously damaging aquatic life, forests, and crops.

Meanwhile, in the poorer countries, the legions of the poor and resource-dependent have swollen dramatically. A billion people in the developing world live in hunger and poverty, often destroying the fragile base of soils, water, forests, and

fisheries on which their future depends because no alternative is open to them. The world's deserts are advancing, while its forests, with their immense wealth of life forms, are in retreat. On average, an acre and a half of tropical forests disappears every second; four species are committed to extinction every hour.

For the first time, human numbers and impacts have grown so large that they are eroding on a global scale the natural systems that support life.

Moreover, these challenges promise to multiply in the future. World population is projected to double in the lifetimes of today's children. World economic activity is projected to be five times that of today in 60 years.

Imagine, just as a simple thought experiment, what would happen if climate-altering gases, industrial waste, and other pollutants increased proportionately with the 5-fold expansion in world economic activity projected for the middle of the next century. These increases would, indeed, occur if this growth merely replicates over and over today's prevailing technologies, products, and lifestyles. More of the same will thus not work; it will merely make difficult problems into impossible ones. Fundamental changes are needed.

At the World Resources Institute we have thought hard about what these changes should be and how we can implement them—and we have arrived at a set of essential transitions. These large-scale transitions—or transformations—are essential for human society to approach sustainability.

The transitions I will mention briefly seek to deal with the root causes of environmental problems. These transitions recognize that the solutions to *underlying* causes lie mostly *outside* the established "environmental sector." And I doubt that any of these transitions can succeed without the active support and leadership of both the technical and the business communities.

(i) The first transition will not surprise you. It is the need for a demographic transition to population stability before world population doubles again. Population pressures already exacerbate virtually every environmental challenge we face. It is hard enough to imagine a workable world with 10 billion people, mostly living in the already stressed developing world, much less a world of 14 billion people. Cutting birth rates requires making many changes that will alleviate poverty, raise the status of women, make family planning service universally available, improve health care, and provide old age support. Developing countries that set out on such a course should be able to count on help from nations and businesses that have the resources to help.

(ii) The second transition is more directly relevant to this colloquium. It is a transition in technology to a new generation of environmentally benign technologies—to technologies that sharply reduce the consumption of natural resources and the generation of residual products per unit of prosperity.

We need a worldwide environmental revolution in technology—a rapid ecological modernization of industry and agriculture. The prescription is straightforward but im-

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mentally challenging: the only way to reduce pollution and resource consumption while achieving expected economic growth is to bring about a wholesale transformation in the technologies that today dominate manufacturing, energy, transportation, and agriculture. We must rapidly abandon the twentieth century technologies that have contributed so abundantly to today's problems and replace them with twenty-first century technologies designed with environmental sustainability in mind.

Today, everyone speaks positively of "environmentally sustainable development." What this means in the context of pollution is technology transformation. It is a transformation that must be made in the decades immediately ahead and must begin today. And, for it to succeed, this transformation must have leadership from America's research and development and business communities. In several ways, the greening of technology is your job.

The needed fusion of economic and environmental objectives requires technologies that meet two criteria, both linked to the concept of industrial metabolism. First, the needed technologies must be able to transform industry and transportation from materials-intensive, "high-throughput" processes to systems that use fuel and raw materials highly efficiently, rely on inputs with low environmental costs, generate little or no waste, recycle residual products, and release only benign effluents. The need, in short, is for technological systems that are more and more environmentally "closed"—that is, detached as much as possible from natural systems.

Second, because the first criterion can't be fully met while human annual consumption of nature's land-based photosynthesis approaches 40%, technological innovations must help societies move toward living off nature's income rather than consuming nature's capital. An honest accounting of the costs of such "capital depletion" would show that few societies are doing anything of the sort today.

For any economic system—firm, industry, nation, or community of nations—environmental damage over time is in one sense a function of the consumption of inputs from environmentally unsustainable processes, the generation of pollution and postconsumption waste, and other factors. This damage won't stabilize and decline until pollution per unit of output and materials consumption per unit of output—factors that are at their core technological—decline rapidly enough to outweigh growth in economic output. "Technological transformation for environmental sustainability" is thus a process that reduces environmental damage per unit of output fast enough to greatly outpace production increases.

Bringing about this transformation will not be certain, quick, or easy. Many adverse trends in global environmental quality are evident. Nevertheless, the current moment offers special potential, in part because of technological developments in such fields as biotechnology, information services, and advanced materials. These advances could create a new technical base for long-term environmentally sustainable development.

Some of the following technologies are possible now or soon should be: manufacturing processes and motors that cut energy needs in half; gas turbines that cogenerate electricity and heat 50% more efficiently than today's power plants; solar thermal and wind systems that are producing electricity today at prices competitive with nuclear power and photovoltaic power that promises to be competitive within a decade; manufacturing processes that make detoxification possible and waste elimination profitable; new microbial and other bioengineered products that can substitute for chemical pesticides and fertilizers, help treat effluents and other waste, promote vegetation growth on impoverished soils, and increase the potential of biological sources of energy; miniaturization, microprocessors, and computer-aided design and

management that greatly improve efficient use of raw materials and reduce both waste and environmental pressures; and other computer and telecommunications applications that can strengthen satellite remote sensing, monitoring instrumentation, and environmental management through artificial intelligence.

Most important, perhaps, is producing and marketing the "green" automobile. There is probably no product that causes so much environmental damage as today's car. From an environmental point of view, we will need cars that are super-efficient users of fuel, and the day is approaching, perhaps faster than we know, when we must move beyond vehicles that operate on fossil fuels. Both hydrogen- and electric-powered vehicles are possible, and both hydrogen and electricity can be made from renewable energy sources, such as photovoltaic cells and wind power.

(iii) The third needed transition is an economic transition to a world in which prices reflect the full environmental costs. The revolution in technology just discussed will not happen unless there is a parallel revolution in pricing. Most of us live in market economies. The corrective most needed now is environmentally honest prices. Doing the right thing environmentally should be cheaper, not more expensive, as it so often is today.

It has been said that the planned economies failed because prices did not reflect economic realities. It might also be said that the market economies will fail unless prices reflect ecological realities. Getting the prices right would require, for starters, that we get rid of subsidies. Today, many countries subsidize the consumption of forest resources, automotive transport, energy, and water, and the use of pesticides, to mention a few.

Beyond subsidy elimination, we should impose environmental user fees, levying taxes on pollution and the use of virgin materials. Doing so would also raise government revenues, so pricing reform can go hand in hand with tax reform that shifts some of the tax burden away from "good" things, such as earning income and investing, and on to such "bad" things as pollution and waste.

(iv) The fourth transition is a transition in social equity to a fair sharing of economic and environmental benefits both within and among countries. Over much of the world, the greatest destroyer of the environment is poverty—because the poor have no alternative. If we want to do something about the environment, then we must do something about poverty. The developing world desperately needs both cutting-edge technology and major new financial resources dedicated to sustainable development. The business community is essential to filling both needs.

(v) None of these transitions is possible without a fifth—an institutional transition to different arrangements among governments, businesses, and peoples. These institutional arrangements are urgently needed to enlist the tremendous potential of the private sector in what must be an unprecedented cooperative effort to bring about this environmental revolution in technology.

In the past, government support of new technologies through such mechanisms as research and development funding, procurement, and research consortia has led to great strides in aerospace technology, computers, defense, and medicine. Similar mechanisms could also advance environmentally sustainable technologies while promoting U.S. competitiveness. Large areas of important "generic" research—widely applicable research that is too far removed from marketable products to garner sufficient industry support, but too "applied" to interest most academic laboratories—remain underfunded. We must all work to make environmental objectives a truly major part of U.S. discussions and actions on competitiveness, technology policy, and research and development funding.

Beyond technology cooperation, environmentalists and business leaders must make a common cause of reforming current regulatory approaches. Many environmental laws favor old technologies over new ones and prescribe cumbersome administrative procedures that impede innovation. Relying on "best available technology" standards has tended to entrench existing technologies at the expense of new ones, although that result was certainly not the original intent. Regulations often focus on only one medium (air, water, or land) rather than across the whole spectrum and tilt toward "end-of-pipe" pollution controls instead of prevention options. Regulations also fail to incorporate incentives for beating the minimum standards they set. Foremost among the policy tools needed to facilitate innovation is the greatly expanded use of performance-based standards and economic instruments. Public disclosure requirements, along the lines of the Toxic Release Inventory required under Title III of the U.S. Superfund Amendments and Reauthorization Act, can also increase public demands and corporate incentives for environmental protection.

One exciting thing to me is that these transitions give business leaders and environmentalists a common agenda—an agenda that sees technology as part of the solution and not just part of the problem, an agenda that recognizes the need to replace old stocks in the economy with ecologically modern capital equipment and consumer durables, an agenda that stresses market-based approaches and economic incentives, and an agenda that requires environmental and business leaders to move away from adversarial approaches

and forge modes of cooperation that work upstream to design a sustainable system for the future.

Let me summarize by stating what I would urge the business and technical communities to do: (i) *Make the environment a personal issue, not someone else's issue.* (ii) *Move beyond compliance to leadership*—leadership in going beyond standards and leadership in developing the technologies and products of the future. (iii) *Call for government action, rather than waiting for it.* Develop proposals for government, because governments need this leadership to support research and development for a green future, eliminate subsidies, and make prices reflect environmental costs. (iv) *Recognize and address the great environmental challenges of the day.* Today, the two biggest challenges are the need to reduce greenhouse gas emissions by shifting to sustainable energy strategies, particularly in industrial countries, and the need to reverse the deterioration of the natural resource base, particularly in the developing countries. (v) *Commit to accountability.* Bring outside environmental experts and leaders onto corporate boards and committees, make complete environmental disclosures, and have environmental accounts independently audited.

If we pursue these approaches, the 1990s can be an exciting period in which different approaches are launched, new partnerships are created, and the full power of modern technology is applied to achieving sustainable development. If that happens, we can leave a legacy of hope—our most important gift to the new century.