Proceedings of the Second Annual UNU World Congress on Zero Emissions

Chattanooga, Tennessee
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Organized by the UNU Zero Emissions Research Initiative

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Introduction

Before introducing the Second Annual UNU World Congress on Zero Emissions , I must first briefly introduce ZERI itself.

The Zero Emissions Research Initiative (ZERI) was launched by the United Nations University in 1994, as a global strategy to achieve sustainable development. Since then, the UNU / ZERI, gradually became well known world-wide for its practical solutions to current pollutant industrial processes and wasteful use of natural resources. Because of its problem-solving approach and positive outlook, it became attractive to business, governments and scientists. Today is recognized as one of the most innovative initiatives after Rio 92.

ZERI advocates a shift away from the traditional linear industrial model, in which wastes are considered a normal side-effect of industrial production, towards an integrated system in which everything has its use. All industrial inputs are converted into final products of a given manufacturing plant, or what is treated as waste is converted into value added inputs in another chain of production. At the end, the manufacturing line becomes a series of production cycles and recycling system, as it is in Nature. In this way, industries may be organized into clusters within one single corporation, or in interdependent sets of industries, such that the whole discharges no waste in the air, soil or water. This represents the maximum utilization of natural resources, on top of total quality management.

To achieve such a goal, a new industrial revolution is required. This is a stimulating perspective, as an array of opportunities are open to scientists for innovative technologies and breakthroughs, to governments for new industrial policies, to business for redesigning industrial production and for winning new markets and societal support. In total, present generation's welfare, and the survival of mankind are dependent on the survival of the global life support systems. ZERI advocates an industrial revolution in which industry mimics nature's sustainable cycles and one where mankind, instead of expecting the earth to produce more, learns to do more with what the earth produces. Its goal is a far reaching ideal, but it serves as a motto for raising awareness and mobilizing forces.

UNU / ZERI fosters the ideal into action. In two years, many countries, governments, industries, universities, foundations, local communities started to adhere and are putting in practice the idea. In Japan, zero emissions ideal is triggering a large movement rooted in local communities, but also penetrating universities, media and government. Pilot projects have been set up in Japan, Fiji, Indonesia, Namibia, Brazil, Colombia, Mexico, and Sweden. A few large chemical companies in America, the automobile industry in Sweden and cement and machinery manufacturing groups in Japan, are committed to "the goal is zero". Scientific journals started to pay serious attention to the conditions or feasibility for achieving zero emissions. Media, particularly in Japan, showed an immediate interest for the idea, and has being covering it in many languages.

The results of these initiatives, and the experience gained by the various countries, institutions and industrial groups were brought to the Second Annual UNU World Congress on Zero Emissions held in Chattanooga, from 29 - 31 May 1996. Here is their account.

Tarcisio G. Della Senta
Director UNU / IAS

Preface

The objective of the congress on Zero Emissions is to provide a common platform to academia, executives, and government officials for the exchange of ideas on how to attain a higher level of productivity, generate more jobs, and alleviate pressing environmental problems while recognizing that the demand for food, water, shelter, energy and health care will continue to rise in the years to come.

This Second Annual UNU World Congress on Zero Emissions provided a major breakthrough in terms of dialogue and content. The first world congress, held in Tokyo in April 1995, offered a group of executives and scientists a change to state their concerns, and share their willingness to develop a theory and methodology for Zero Emissions. In contrast, the Chattanooga meeting demonstrated that results can be achieved.

The depth and content of the congress surprised many, not the least of whom was the Japanese delegation chaired by Dr. Keizo Yamaji and coordinated by the Nikkei. Executives from Asia, America, and Europe shared their views on how the concept of zero emissions can actually change their businesses. Researchers from the USA, Latin American, and Europe were in the forefront, blending technologies and drafting research agendas.

The congress participants recognized the leadership of Mr. Sarwono Kusumaatmadja, the Indonesian Federal Minister for the Environment, for introducing the PROPER classification system, which grades the environmental performance of corporations in Indonesia according to a simple color system. Black stands for hazard, which means the company should be closed. Red means dangerous, orange is used when the company does not meet the minimum standards set by law. Green means the company meets the legal standards, and gold stands for zero emissions. The recipient of the 1995 Leadership Award on Zero Emissions, Mr. Edgar Woolard of DuPont, also attended the event in person and delivered a keynote address.

During the congress, Prof. Emer. Dr. Carl-Göran Heden stepped aside to offer Prof. Dr. Keto Mshigeni the chairmanship of the UNU/ZERI Scientific Advisory Committee. Prof. Mshigeni, a renowned botanist, asked the audience to reserve special attention to the opportunities for implementing Zero Emissions in Africa.

The concluding session was a memorable one with nearly twenty contributions from participants in the audience. The quality of the first world Internet connections realized during the first world congress in Japan was not matched in this second edition. The link-up to Sweden (Volvo and the Swedish Academy of Sciences) and Tokyo (Tokyo University and the Kagoshima Prefectural Government), though difficult, demonstrated that use of the latest technologies can be a major input in policy making and corporate strategy.

The Third Annual UNU World Congress on Zero Emissions will be held in Jakarta, bringing the ideas to the developing world. It is hoped that by that time the interest from both governments and business will have strengthened considerably. It is up to the Zero Emissions team to make up the difference.

This event in Chattanooga was the result of many efforts. While realizing that not everyone can be mentioned, the focus is on three individuals: City Councilman David Crockett of Chattanooga actually brought to fruition the idea of organizing the world congress in his home city ; David White gave the congress its very best and without whom the congress may very well not have happened; and Masako Unoura, who took it as a personal challenge to secure that the content and organization of the congress were never far apart. Prof. Heitor Gurgulino de Souza, Rector of the UNU, and Prof. Tarcisio Della Senta, Director of the newly established Institute of Advanced Studies, are both thanked for their steady and unconditional support.

It was most enriching to have had the opportunity to chair the event on the first day with such distinguished individuals as Prof. Dr. Richard Florida, and on the second day with the Hon. J. Hugh Faulkner. I will always remain most thankful to the generous citizens of Tennessee who make me feel so welcome, even when the ideas were so new interest was low, their open doors make this event possible. Scottie Probasco is certainly among these citizens I wish to thank. Finally we all wish to thank the Lyndhurst Foundation, which supported the ideas from the very beginning and which provided the seed funding for the congress. If all those involved will only be able to see what comes of ZERI in its third year!

Gunter Pauli
Co-chair of the Congress.

Opening Session

May 29, 1996

Who Speaks for the Biosphere? The UNU, ZERI and the Environment

Dr. Heitor Gurgulino de Souza
Rector, United Nations University

Your Excellencies,
Distinguished Participants,
Ladies and Gentlemen,

I. Introduction

I am delighted to be here in Chattanooga to help launch this Second World Congress on Zero Emissions. On behalf of the United Nations University, I want to express our gratitude to our Co-sponsors, the Oak Ridge National Laboratories, the County of Hamilton and the City of Chattanooga. We are also deeply appreciative of the support of the US Department of Energy and the Lyndhurst Foundation, which pioneered the involvement of the UNU early in 1995. A great many people have worked hard to make this possible, and those of us who have come here from Tokyo, Africa, Asia, Europe and Latin America are very grateful for all they have done. The broad range of support speaks to the growing international consensus on environment.

It is particularly fitting that a conference focused on wiser use of the Earth's finite resources should be meeting here in Chattanooga, at the very core of the region where the Tennessee Valley Authority was launched over six decades ago. Today, the TVA's dams, stilled waters, reforested hills and revitalized land set an example in wise land use for the world. When Franklin D. Roosevelt proposed the creation of TVA, he said in his April 1933 Message to Congress: "It touches and gives life to all forms of human concern." I think we will find our discussions here this week equally encompassing of the range of human experience.

The costs of environmental degradation are spread widely across all levels of society, and touch the farthest corners of the globe. But despite its pervasiveness, it has been all too easy for governments and legislators to dismiss either the long-term benefits of ecological sanity or the costs of environmental recklessness. When one nation's pollution impinges on another's soil, air or water, the usual political calculus--domestic costs versus domestic benefits--often does not apply. Governments everywhere have a nearly irresistible temptation to let the costs fall on that ultimate unorganized interest group -- the generations yet unborn. As Garrett Hardin has observed, this spirit of a limitless world view is deftly captured in the airline advertisement: "Fly now, pay later"! (Or -- It is a bit like the famous Woody Allen line: "It's not that I'm afraid to die. I just don't want to be there when it happens.")

II. A Voice for the Biosphere

More succinctly and eloquently, Erik Eckholm, in **Down to Earth**, wonders: In such cases, who speaks for the biosphere?

The UNU's Zero Emissions Research Initiative (UNU/ZERI), I believe, is one voice speaking loudly and clearly for the biosphere. It is, if you will, a responsible voice that understands that we are only borrowing the Earth from our children-- and our children's children. Its basic hypothesis is that industry is an essential partner in the achievement of sustainable development: growth and equity which honors the needs both of the future and of today.

You will be hearing a good deal of detail over the next few days about UNU/ZERI's specific projects and protocols. Let me try, in a few minutes here, to set this unique research endeavor within the context of the United Nations University, the organization I have headed for nearly a decade now.

UNU/ZERI constitutes a long-term commitment on the part of the UN University to trying to ensure that productive forces in the world can have access to the best minds to enable the manufacturing of goods without upsetting the critical balance of the ecosystem. We firmly believe that the research carried out by this initiative will contribute to some of the major environmental concerns of the modern world; including the reduction of CO2 exhaust and of the danger of global warming, to the substitution of non-renewable materials by renewable ones, to the elimination of highly toxic substances from the environment, and to vital steps toward social development and the eradication of poverty.

While we clearly target the increased productivity and competitiveness of corporations, we have agreed to take on such an ambitious effort only because industrial production processes have become a very important element in understanding the global environmental equation. Whether in the affluent North or the developing South, industry has the resources to advance or destroy humanity's hopes for environmental sanity in the 21st century. We believe that corporations which see this as the trend for the future will be the winners. Those who ignore it -- or join the race too late -- will be the losers.

III. UNU: The Binding Glue

The United Nations University has been described as part of the glue that holds the ZERI network together. Others have likened its role to that of intellectual traffic cop. Whatever -- it clearly occupies a central position in the UNU/ZERI scientific constellation.

The University stands at the intersection of the global academic society and the many different actors in the international development community. It is well positioned to play a special role in the worldwide mobilization of scholars and intellectuals. As on organ of the United Nations but enjoying full academic freedom, it can both draw upon and feed into policy-making processes without being an institutional captive or restricted by short-term political realities.

The University's Charter gives it a broad canvas: the "pressing global problems of human survival, development and welfare." Energy is obviously a vital part of the equation. The UNU is a place where the results of its own research, conducted by its fellow UN agencies, with knowledge generated by others on the international scene, can be weighed and tested in the crucible of international, interdisciplinary dialogue. It is a place to which the global community can turn when it is time to consider the controversial, encourage the unconventional, and ponder together the many tangled threads of human existence.

IV. Environment: Too Big for One Country

From the outset, the UNU agenda has been occupied with the sorts of problems that are simply too big or too far-reaching to be the domain of any one nation, even one with the resources and outreach of the United States. The environment, habitat and provider of all living things, is obviously one such candidate. Pollution, acid rain and desertification are no respecters of national borders-- nor would global climate warming be. These are all global problems, and the responsibility of all of us.

The linkage between the environment and human development was dramatically highlighted in the mid-1980s with the landmark Brundtland Commission report, which defined sustainable development as a process which "meets the needs of the present without compromising the ability of future generations to meet their own needs." At UNU we have taken that as a working definition for our research and training efforts.

The Rio Earth Summit in 1992 was a response to the challenge of sustainable development. It reinforced the urgency of a new kind of global compact to harmonize the needs of humanity and nature. The resolutions adopted in Rio-- including most prominently Agenda 21-- were seen as starting points for policy changes to be backed by concrete implementations. Agenda 21 was a kind of road map, a set of marching orders for humankind.

The all encompassing nature of environmental threat is why the UNU so readily took up the challenge of the Rio Earth Summit and its Agenda 21. We helped to bring scientific perspective to a number of the problems explored at the Earth Summit. The UNU conceived its role in the Agenda 21 as a kind of catalyst to a global intellectual mobilization, helping to direct scientific expertise to where it could do the most good.

V. Agenda 21: Eco-restructuring

Agenda 21 defines many desirable ecological steps. Essentially, however, most can be summed up in one central requirement: altering human behavior in ways that will ultimately make possible more rational reliance on the environment.

It is clear, for example, that if development is to be truly sustainable, there must be a major shift in present international consumer patterns. We also need improved

monitoring of the globe's life support systems and their resilience to human interference. Finally, we must develop more realistic forms of environmental management and governance. The UNU has been developing research efforts in all three of these areas: eco-restructuring, eco-monitoring, eco-governance.

The scale of environmental management, for example, needs to become global in order to catch up with the actual interdependence that modern communications have in fact inaugurated. The computer, the cellular telephone, and the Internet are penetrating everywhere, altering prevailing patterns of conduct, expectation and behavior. These all have vital implications for durable and acceptable growth scenarios.

The call for sustainable development parallels the growing recognition that the most worrisome ecological threats arise from human actions. The pressure of population growth particularly is working to alter the face of the earth to suit human needs. Everywhere, as the extent of environmental ravage is measured, the track of man can be seen as he uses new and even more powerful technologies to cut down forests, divert waterways, plant fields, dig mines and in a host of other ways disrupt the ecological life support systems on the planet. Even the computer, we now know, is an environmental villain, in its use of electric power and the toxic chemical wastes it returns to the soils in Silicon Valley and elsewhere.

VI. The Cost of Waste

The wastes left behind are some of humanity's worst ecological sins-- to say nothing of economic costs. In this country alone, waste-water and sewage services cost about $43.5 billion a year. It is the single largest expenditure local governments face, according to the U.S. Conference of Mayors. And at a time when Congress is already scaling back on funding, the Environmental Protection Agency has estimated that at least $100 billion will be needed to meet new environmental standards in the decade ahead.

Thus in focusing on questions of industrial waste, the Zero Emissions Research Initiative responds to a very immediate and very large problem, and a very large headache to city budget planners in cities like Chattanooga. UNU/ZERI contends that industries the world over must learn to maximize the use of available raw materials and utilize their own wastes and by-products to the fullest extent possible. It aims at technological breakthroughs which will facilitate manufacturing without any form of waste-- in the waters, air and soils of our common home, the Earth.

VII. The UNU/ZERI Perspective

UNU/ZERI offers a much needed new perspective to industries that must face two seemingly competing challenges at the same time: the need to compete globally; and the need to assume their social responsibilities. I leave it to others to go into the details of the research either already underway or in the planning stage. I would only observe that, from the first, I have personally been intrigued by the range of ecological

creativities that come under the UNU/ZERI umbrella -- from hard-headed steps like feeding chicken and fish with brewer's mash and recycling television sets, to combating iodine deficiency with iodine-rich seaweed abundant in local seas. It even proposes, to explore the brilliant plumage of birds for what it can tell us about industrial color production that now generates toxic chemical dyes.

Last month, the Commission on Sustainable Development-- an important agency created at the Rio Summit-- met for several weeks at UN headquarters in New York. The good news is that, as the Commission heard, hundreds of municipalities have written plans of action since Rio, bringing the concept of environmental protection to urban neighborhoods and the grass roots.

The bad news is that environmental platforms are often subject to compromises that must give way to other, seemingly more pressing needs. But this, in the long run, may too prove to be good news. My colleague, Nitin Desai, the UN Undersecretary General for Policy Coordination and Sustainable Development, says this should lead the environmental movement to broaden its scope, to get its issues on others' agendas. It is time, he comments, "to focus on agriculture policy, energy policy, transport policy-- all the economic policies that affect the environment."

Many environmental writers have worried about humanity's profligate habits, but one who has nicely caught the essence of the problem is Tennessee's own Vice President Al Gore in his book, **Earth in the Balance**:

"We have to change our production process and dramatically reduce the amount of waste we create in the first place and ensure that we consider thoroughly, ahead of time, just how we intend to recycle or isolate that which unavoidably returns."

To my mind, that is one of the most succinct and appropriate statements for UNU/ZERI. It argues the importance of seeing the problem of waste and pollution from many aspects--considering it thoroughly from all points of view.

Which says, in effect, to see the problem of the environment in the round--with all its many causes and effects. This is the fundamental approach of the United Nations University in all of its work. It is a philosophy which underlies the work of UNU/ZERI. Implications of UNU/ZERI research ripple out to areas like public health and the alleviation of jobs, efforts to improve water, fuel and food supply, health care and housing. These are all problems of poverty, which as Indira Gandhi once remarked, is the greatest pollution of all.

Our goals here in Chattanooga are similar. We are seeking this week to move forward in identifying new technological breakthroughs needed to further the vision of zero emissions. We want to share the experiences already gathered in the first pilot research projects, and thus facilitate the creation of an effective ZERI network worldwide. We hope these will highlight opportunities for city and regional

development schemes, and help to offer policy makers a set of policy options that will target the creation of new jobs, new industries and a higher quality of life.

The man who has done so much to bring UNU/ZERI into being, Gunter Pauli, has cogently expressed his view of how the drive toward zero emissions could offer a new vision for poverty alleviation and economic development using the best and most appropriate technologies:

"The time has come, " he says, "for humankind not the expect the earth to produce more--but rather to do more with what the earth already produces. This could give new future to all our hopes."

I most heartily support both his view of the challenge and the size of his dream.

I very much hope that all of you will share in this challenge and this dream, and I call upon all of you at the Congress here in Chattanooga, as well as those of you who are participation through the Internet, to come forward with realistic proposals and plans to help bring the vision of zero emissions into concrete reality.

Thank you very much.

Zero Emissions : a young initiative - a bold proposal

Gunter Pauli
Founder and director of
UNU Zero Emissions Research Initiative

Welcome to the Second Annual World Congress on Zero Emissions. It is a great pleasure indeed to be able to receive, meet, discuss and plan for concrete projects and initiatives related to the zero emissions concept with international delegates from 16 countries, from 4 continents.

A young initiative

Zero Emissions is a very young initiative. It started only two years ago, and has a long way to go. Sometimes we run faster than we can, sometimes we feel we are moving too slow. One thing is certain, that the past two years have motivated us to go on for years and to accept the challenge that could change industry, that industry can be more competitive, that society needs breakthroughs. Last year we somehow succeeded in getting a consensus among the participants in the first world congress on zero emissions that the present system of production is not bad at all. It is the best we have, but we all agreed, there can be better and it is needed badly. We are here not so much to talk about it, but to come to an understanding of how to move from the concept and idea stage, to the implementation. Yes indeed, at ZERI, we have a bias toward action.

Why Chattanooga?

But before getting into the content, let me share with you WHY we are meeting here in Chattanooga. It was only two and a half years ago that Mr. Dave Crockett motivated me to fly from Hawaii to Portland, Oregon, passing by Chattanooga, Tennessee. And when I arrived here on that Sunday evening in January 1994, it was raining. It actually rained the next 4 visits and each time when Pauli was arriving, raincoats and umbrellas were dug up.

Chattanooga intrigued me. The guidance I received from Bill McDonough in understanding the process of how Chattanooga transformed from the most polluted city in the 1960s to America's environmental city as awarded by President Clinton earlier this year is an exceptional performance. It is therefore no surprise that the Mayor of Chattanooga is not here among us, but actually is already at the HABITAT II conference in Istanbul presenting his case. The encouragements from Scottie Probasco have been most instrumental.

Chattanooga at first looks like any town. But after numerous meetings with its citizens, it became clear that this is not just any town. This is truly a living laboratory. Here ideas are made to work, here new concepts find their roots, and are tested and tried. It implies that some succeed and some fail, but so much has been done and so

much more is in the making that it is no surprise that the Zero Emissions concept found very fertile ground here. Chattanooga welcomes frontline thinking.

There are few places in the world, perhaps with the exception of Japan, thanks to the leadership of people like Dr. Keizo Yamaji, Chairman of EBARA Fujimura and editor Mitsuhashi, where so much discussion has been held on Zero Emissions. As usual, you have ardent partisans, as usual in a minority, and you have the traditional opponents, usually in the majority. The two leading newspapers, the Chattanooga Times and the Free Press have both reserved their editorial space for Zero Emissions and listening to the City Council, the County Commissioners, the Chamber of Commerce, the University, few places in the world have contributed so much to the debate of what Zero Emissions really means.

Here Zero Emissions could one day crystallize in the first Zero Emissions industrial park, or it may never be. But one thing is certain, that the vision of the industries of the future here in America will never be the same thanks to the fine debate that has ensued over zero emissions at the community level.

If this debate were undertaken in the numerous other American cities of the size and shape of Chattanooga, industry not only would look different, society would be transformed into that sustainable community so many are looking for. I for one look at the world through the eyes of my two children, and that world looks so different when I imagine the world my two boys will be adults in.

That is why this second annual congress was to take place here, here and now at this place and time. The fact that Chattanooga is located in this technology corridor with Oak Ridge and TVA, George Tech, and Vanderbilt just around the corner certainly is a unique plus. But it would never have come to fruition if it were not for a few individuals who hung in there against all odds, because they believe that this congress would be one of the drops in the bucket that would move their community towards that first sustainable society in America. And David White certainly deserves up front mention for keeping that spirit alive. Thank you my friend.

Who is here?

When people talk about a congress, the debate is often one on size or content. The Zero Emissions congress only involves those who are involved, or about to be involved in concrete projects, be it research, be it training, be it education. No one here is here by mere coincidence. We all do have a plan.

Last year when the first congress was held, we had a clear view of the concept, we merely had our theory outlined, the methodology was about to be tested and we summarized our ideas in a book published by the UNU. That is all.

From theory to practice

Today, we have a solid theory, based on insights in physics, biology, chemistry, engineering sciences and management. The Zero Emissions concept does violate the second law of thermodynamics, but respects the practice of nature where nothing gets lost. The human species, the intelligent one on earth, is the only one capable of producing things no one wants. And as such we violate as industry the first axiom of marketing which prescribes that you produce what the client wants. Who wants toxic waste? Who wants dioxin?

Today we have a methodology which has been tested, in our pilot research and a methodology which permits us to apply the zero emissions concept to any industry. Today, the production of leather, basalt, sugar, palm oil, sisal fiber, beer, ceramics, cement, wax has all been subjected to the zero emissions methodology and opened the eyes of engineers and executives. And perhaps more important for our keynote speaker from business this morning, Mr. Curt Nicolin, the dean of business in Europe, indeed we now know that zero emissions stimulates entrepreneurship. It offers a new vision of the great opportunities that are obvious, but still go by unnoticed by so many in industry.

Industry can move to that next level of productivity. Productivity of labor, do more with less people, productivity of capital, get more return with less risk and now productivity of raw materials. Here at this congress we have the pilot cases to submit to you for review, for inspiration, demonstrating that we are on the verge of the second green revolution. It is what Africa needs, it is offering perspective for growth like we have not been able to imagine before. We will do much more with what the earth produces! Thank you Keto Mshigeni and George Chan for making that proof possible in Africa and the Pacific, against all odds.

Countries joining

I am delighted that the second series of countries where we are to initiate our pilot projects- Tanzania, Sweden, Japan, Brazil, Malaysia and Indonesia- are all here as well. Yes, Chattanooga was the first to debate the zero emissions industrial zone, but here at the congress we will learn about the commitment from the islands of Gotland and Kagoshima on how they are planning to implement it. The world is moving on indeed.

The Rector of the UNU, to whom I am very grateful for his confidence and support, even at the times when the odds were not clearly in our favor, shares with me the enthusiasm that the next congress will have an even broader platform of projects all aiming to create these industries of the future where growth and development go hand in hand with higher productivity, better returns and more jobs.

ZERI has entered into this third year and is dedicating a lot of time and effort to capacity building. This year ZERI holds ten 20 hour courses on zero emissions and this has already lead to the creation of the Institute ZERI para America Latina with initiatives in Costa Rica, Colombia, Brazil and Jamaica. We hope to cover all the

Americas soon. The capacity building is a priority and will be the building blocks on which we depend. From the vocational training at the Montfort Boys Town in Suva, Fiji, to the post graduate training at PUC in Porto Alegre, the open program at the IAS in Japan, the University of Indonesia and Namibia, we are dedicated.

After all, Zero Emissions will evolve in a highly decentralized manner, as the chairman and my friend and mentor Carl-Göran Hedén has advised me to do from the beginning. ZERI will operate like the immune system, highly decentralized, responsible, action oriented and driven by a desire to keep the body healthy so that the mind can imagine.

The zero emissions research initiative will graduate from being just research, and may evolve into a concept for industry and society. We will forge new partnership and Hugh Faulkner and Anders Wijkman will help make that happen. We will have to invent new mechanisms for funding, we need a broad agenda for ideas and action. That is the vision summarized in my new book "Breakthroughs" which has already been published in Spanish, and of which an advance copy in English is available here today and which will be available in Japanese in the summer under the title "towards a zero emissions society".

What do we wish to achieve here?

Let me be brief as I have sufficiently exploited the privilege of the chair to talk too long without anyone having the chance to interrupt me.

We wish to have by Friday late afternoon an ACTION PLAN for the next three years. We need to understand what the industries of the future are looking like, what are the communities of the future, and what are the missing links about which WE CAN DO SOMETHING ourselves.

By Friday afternoon we hope that all our participants have their agenda and that we jointly can make the initiatives happen. We will be here in Chattanooga and we will communicate with distant parts of the globe via a series of computer links. We tried that the first time last year, we are trying again this year. We will need your patience with the systems, using the Internet to communicate across the world is still very much in a pioneering stage. We continue to learn and may have to reschedule one or the other speaker according to the state of the computer links.

At the Zero Emissions Research Initiative we do not pretend to have all the answers, but we do have a lot of questions. Zero emissions can only succeed when we avoid the preaching, and focus putting forward the right questions. We have to learn through asking questions. And we have to be prepared taking risks. Chattanooga as a living lab offers the platform, you are participants and the agents of change, and let us learn from each other by asking a lot of questions. This is Socrates, this is the wisdom of listening with the only difference that we have to put Socrates Online.

Thanks to the 4,600 researchers that ZERI has been able to work with, many anonymous, we have succeeded in advancing the ideas into concrete projects. Please do judge us by our enthusiasm to move forward and our capability to bother people. Indeed, as the French philosopher Rene Char said "those who come to the world to cause no problems, do not deserve any patience nor appreciation." I thank you for your patience and look forward to get on with our agenda.

Unesco and Zero Emissions

Dr. Federico Mayor Zaragoza
Director General, UNESCO

It is with pleasure that I address this message to participants in the Second World Congress on Zero Emissions. In doing so, I should like to congratulate the United Nations University and its Rector, Professor Hector Gurgulino de Souza, on the initiative of holding a major meeting on the subject of increasing the productive use of biomass, something that can best be summarized by the phrase: "Man can no longer expect the Earth to produce more; the time has come for us to do more with what the Earth produces."

In the more developed areas of the world, agriculture is more "productive," but only because it is driven by costly non-sustainable inputs coming from expensive chemical pesticides and fertilizers, improved irrigation and drainage methods, and the use of fossil fuels in highly-mechanized farm management practices. By contrast agricultural practice in the developing countries has been largely characterized by sweat and by a total lack of subsidy. However, thanks to the "gene" revolution through reassessed microbial intervention, agriculture in the Third World has taken on a new look. Once barren lands and empty food stockades are being converted into arable fertile fields and granaries of chemically non-polluted and nutritionally improved food crops.

The more efficient use of agricultural crops through the involvement of the microbial labor force is certainly an attractive one, because it is based on processes that have been proven in practice and through more recent scientific experience.

The use of beneficial nitrogen-fixing micro-organisms has been valuable, for example, in the low-cost production of rhizobial and algal innoculants that are easily accessible to farmers (particularly in less developed countries) who do not have the means to buy the more expensive petroleum-derived fertilizers that increase production but pollute the environment in varying ways. A major global program in biological nitrogen-fixation is being supported by the United Nations agencies. Today, in these times of economic recession and reassessment, many developing countries-for example, Brazil, Kenya, Philippines, Thailand and Senegal-are turning to the production and the use of biofertilizers to reduce, either partially or completely, dependence on the chemically derived products.

Non-polluting in its technology and feeding upon renewable resources, the bioconversion of biodegradable, organic and agricultural residues-a striking feature of the Zero Emissions Research Initiative of the UN University-is appealing since it contributes to energy production, reduces deterioration of the environment, facilitates waste management, enhances rural development and generates self-employment opportunities.

The cornerstone of any strategy designed for poverty eradication and poverty alleviation in developing countries and communities is self-reliance, since this focuses on the integration of indigenous technology with appropriate practices brought from the outside. This approach, often encountered in rural-based biosystems, is that of "walking on many legs", in other words the mixing of the rural and the urban, the small and large-scale, and traditional household skills with the technically sophisticated.

Integrated biological systems, such as the Chinese Xinbu "biovillage" system or the initiative established under ZERI, intrinsically involve the interactive linkage of humankind with its physical and biochemical environments in pursuit of basic human needs such as food, water and shelter. Cultural values and norms influence the routine societal consumption of available bioresources and consequently the assessment of such use from an environmental perspective.

Integrated biosystems of livelihood and development are in essence learning societies that disseminate information in the use of high-quality low-cost technologies. They emphasize and interactive approach in the communal application of science and technology for responding to daily basic human needs; they also generate and support research in the context of social learning; and, above all, emphasize that it is the sharing of bioresources that is underdeveloped world-wide.

Preliminary studies like the ZERI are showing that the technology and the will to apply and implement such biotechnologies exists. Yet in moving from the laboratory and field scale operations to the community stage, all-important social and cultural factors come into play and need to be addressed. Here, the challenge lies in determining how individuals, communities and societies at large relate to resource and biomaterial availability and flows. This in essence implies mobilizing the resources of universities and research institutions to improve our understanding of the causes of poverty and their solutions, the effectiveness of anti-poverty strategies and programs. It also calls for strengthening the capacity for social science research in developing countries and integrating as appropriate the results of research into societal decision-making processes involving the planning and promotion of education, research and development on farming systems, small-holder cultivation and animal husbandry techniques. The potential benefits of local knowledge and traditional practices of sustainable agriculture are particularly marked.

We need to take account of these needs in the preparation of a Blueprint for Poverty Alleviation. And we need to do this now, for tomorrow may well be too late.

The European Union and Zero Emissions

Ritt Bjerregaard
Member of the Commission of the European Union in charge of Environment

Mr. President, Ladies and Gentlemen, I would like to thank the organizers for giving me the opportunity to participate in this important international meeting. I am sorry that the pressure of my other engagements has prevented me from partaking in your discussions directly but, nevertheless, I am happy to contribute via this message.

It has become clear over the last decade that our planet is facing a number of serious problems of pollution of the environment and depletion of our natural resources. These issues pose our society the major challenge of finding ways of reconciling our lifestyle with our responsibility to future generations. The commitment expressed by Agenda 21 at the Rio Summit has defined this challenge as the search for a sustainable pattern of development a pattern of development which protects the environment and maintains our resource base for the use of future generations.

I see the search for a zero emission basis for both industry and settlements as being an integral part of the achievement of sustainable development- a response to the double objective of eliminating both pollution and waste. To achieve this, we need to find ways of introducing the same efficiency of reuse and recycling of materials into our industrial systems as we find in nature.

However to obtain this objective may seem, it must surely be our target, a target which will require us to harness the ingenuity of our scientists and technologists not so much in the search of new ways to consume resources, but towards new ways of conserving and reusing them. The protection of the environment should not be seen as a movement which is opposed to development but as an argument for a new pattern of development. This pattern is already emerging; in the last years we have seen the rapid growth of environmental technologies which are responding to the pressure to prevent pollution and reuse resources. This is a process which we need to encourage in a number of ways.

The first important line will be the encouragement of research in environmental technology. In this area, the Community is showing an important lead by seeking to direct its future research support in a more targeted manner. Significant new initiatives are currently being launched in respect to the car, train and aircraft of tomorrow. All of these recognize the necessity of significantly reducing the impact of transport on the environment.

A further main theme of research support is a variety of clean technology and energy conservation programs which support the search for less polluting industrial processes. Support is also given via the Community LIFE Program for pilot applications of new clean technologies.

The second important line of action must be to ensure that the results of such research are actively applied. This will require a number of approaches, within which legislation will have its part to play, ensuring, where appropriate, that industry is required to use the technological solutions available.

It will be equally important to apply mechanisms which influence consumers, ensuring that we increasingly make choices which benefit the environment. There is little doubt that many consumers wish to make a sounder choice but are doubtful of the multiple claims of producers of the ecological virtues of their products. Consumer information and product labeling based on sound science will clearly have a role to play. The other critical factor in our choice is, without question, price. And yet all too often our current pricing systems encourage consumption patterns which deplete our natural resources. Some countries have already started to address this issue by economic and fiscal measures aimed at redressing these imbalances, and we certainly need to explore this approach further. The Commission, in its White Paper on Growth, Competitiveness and Employment, has promoted the concept of a new model of development emphasizing the idea that switching the tax burden from labor to resources addresses both the current wasting of human resources in unemployment and the continuing waste of our natural resources. Such an approach could well provide the key to unlocking the enormous potential of green technologies to both solve environmental problems and generate new jobs.

What is certain is that the global nature of so many of the problems we are facing, the greenhouse effect, acid rain, loss of biodiversity, are such that international cooperation is an essential element in their solution.

Your Congress, and the enormous commitment behind it to research and cooperation towards the target of zero emissions, has a not insignificant contribution to make in ensuring that this much needed international collaboration becomes a reality. I wish you both success in this meeting and in your continuing endeavors.

Keynote Opening Address

HE Sarwono Kusumaatmadja
State Minister of Environment of the Republic of Indonesia
Chairman of the UN Biodiversity Convention 1996-1997

Rector of the United Nations University, Dr. de Souza, Director of ZERI, Mr. Gunther Pauli, City Council Chairman of Chattanooga, Mr. Yousef Hakeen, distinguished participants, it is indeed an honor and a source of great pleasure for me to be present here among such a gathering at the second world congress on Zero Emissions.

For my country, the conceptual breakthroughs now being researched by the United Nations University may have great future implications. To explain why, let me first give a brief introduction to Indonesia, a country that deserves to be better known. Indonesia is a large equatorial nation of no less than 17,000 islands, the fourth biggest country in the world in terms of population, which now stands at 200 million. It is richly endowed with natural resources, terrestrial as well as marine. It has the third largest tropical rain forest in the world, after Brazil and Zaire, the largest and the richest expanse of coral reefs, at 2 million acres, with a variability of ecosystems, ranging from permanently snow capped mountains to tropical mangrove swamps. It is also industrializing rapidly, like the rest of the Asia Pacific region. Economic growth last year was an impressive 8 percent. We are also culturally rich, with hundreds of distinct languages, my wife says that Indonesians speak 700 distinct languages. And yet, we also have a national language, the Indonesian language, spoken by at least 70 percent of our people, corresponding to the number of our people enjoying at least primary education.

Indonesia is committed to the environment, and its commitment is grounded in its rich indigenous cultures, reflected by the policies of the government, as well as demonstrated by the communities, NGO's, and of late, especially notably by the private sector. Indonesia is a signatory of all international conventions on the environment, and we had the honor to host the second conference of the parties to the UN Biodiversity convention last year. The high rate of economic growth, being achieved consistently during the first 20 years of our national development, has born positive results in the increasingly better standard of living of the Indonesian people. The present generation of Indonesians can expect to live longer compared to their parents, are more literate, and are also rapidly urbanizing. We are proud of our achievements, but there are also increasing and well grounded concerns that the present path may not be sustainable. For our economic progress is accompanied by serious resources depletion, as well as environmental damage and pollution of all sorts.

The Ministry of Environment, since its establishment in 1978, has worked hard to implement a mixed policy tool approach to embark on what essentially can be described as a program driven approach to environment management. Some of these policy tools are uniquely Indonesian, such as Proper Prokasih, which is a rating system

that we apply to measure the environmental compliance of our priority industries. By the way, the top rating in this system is reserved for an industry that has shown commitment and practice in Zero Emissions, and up to now, the top rating is still vacant. We are now adding to the various policies in place, capacity building and institutional development.

So environmental management is indeed a heavy task, and skeptics are now saying that Indonesia is now engaged in an uphill battle against environmental disasters in the coming years. It is now time to confound these skeptics, it is now up to us gathered in this room to demonstrate that it is possible for humankind to achieve excellent quality of life in harmony with the environment and nature. It is my belief that the future of humankind depends on the vision, leadership, resourcefulness, as well as the inventiveness of the world's industry, scientific community, and committed individuals. Indonesia is now shaping its vision of its future path towards industrial development, and as such, we are now susceptible to bold and unorthodox ideas, relentlessly driven by people from all walks of life. Hopefully it is such a gathering of people which we are now finding at the second congress on Zero Emissions. My hopes are well placed, for the ideas espoused by ZERI and the UN University provide the basic conceptual thinking that is at present absent in the mainstream of development, as well as in environmental thought. Therefore, my commitment is also firm, and I'd like to take this opportunity to offer to facilitate the holding of the third congress on Zero Emissions in my country next year. Also, with your support, I would like to extend a challenge to establish a Zero Emissions separation technologies pilot plant in Indonesia next year, coinciding with the five year celebration of the Rio Summit. Thank you.

On freedom, democracy and zero emissions

Dr. Econ. Techn. Jur. h.c. Curt Nicolin
Honorary chairman of ASEA AB

The Swedish Bishop Tomas, who lived in the 16th century, once expressed in the form of a proverb: “Freedom is the best of all things that we may look for all around the world, but only for those who freedom can handle”.

Freedom does not mean that everybody can do whatever he/she likes. Let me quote the philosopher Immanuel Kant: “We must strive for a constitution that achieves the greatest possible freedom by framing the laws in such a way that the freedom for each can co-exist with the freedom for all.”

Recently a book was published with the title “Economic Freedom of the World”. Eleven organizations have studied economic freedom in 102 countries. Much effort has been spent to define economic freedom and how to measure it.

I will only show one graph (Figure 1) out of the book, that clearly illustrates the correlation between economic freedom and growth rate. In my humble view this is a very sincere attempt to correctly measure economic freedom around the world. The authors are: James Gwartney, Robert Lawson and Walter Block.

Figure 1

The Nobel Prize winner Douglass North concluded that a market economy can only develop in societies that have a legal structure. Legal structure does not only mean laws, it is further indispensable that governments enforce the laws.

Economic freedom is indispensable for a market economy. The essential economic freedoms are:

*Freedom for private ownership of property
*Freedom to establish and operate business
*Freedom for individuals and organizations to make agreements
*Freedom to compete
*Freedom to trade, also with other countries
*Freedom to travel, transport and communicate
*Freedom for capital and labor to move over borders

In additional to economic freedom, democracy requires political freedom and personal freedom. Consequently, a market economy is a prerequisite for democracy, but not vice versa.

Free competition forces operators in the market to continuously improve their efficiency in order to survive and to make necessary profits to develop and thereby serve society and its citizens. This way they promote growth of the total economy. Some will make more money and expand, others may fail and end their operation. It resembles the law of nature: survival for the fittest.

Let me show three examples of countries that developed into market economies.

England was first, and liberalized its economy successively during the 1770's (Figure 2). England ten-folded GDP per capita in roughly 200 years.

Figure 2

Sweden on the other side turned around very quickly on the decision by Parliament in 1846 to eliminate the guilds' monopolies to operate business and further allowed free trade in the whole country, not only in the cities (Figure 3).

Figure 3

My third example is Japan, showing two steps in increasing economic freedom and growth (Figure 4). The first step followed upon the opening of trade with the outside world in the late 1850's, the second in 1950 upon the introduction of the remaining freedoms of a market economy.

Figure 4

Common to these examples is, that they illustrate how market economies promoted higher growth.

Productivity rests on three pillars:
*Knowledge
*Capital
*Labor and its competence

The rapid growth improvement could not have lasted for very long, if knowledge had not increased faster than it did before. It is difficult to measure knowledge, but I think my conclusion is defendable.

The Japanese high growth after 1950, in addition to being based on the introduction of a market economy, was also due to the enormous growth of knowledge in the world in the preceding hundred years, which was largely available to Japan at very low cost. Lately we see much less growth in Japan, and even if it is early to judge, it seems reasonable to me, that Japan is now approaching the front of new knowledge creation.

An additional factor for Japan was that the Japanese lost face in the second world war. They could not win a war, but they were eager to win the peace. As an indication: for many years their savings were 35 percent of GNP. The market economy has only recently reached the developing world. Many of them have not organized a legal structure as defined by Douglass North.

On the other hand, some of those countries, particularly in Asia, had the prerequisite of legal structure but obviously did not understand the potential of economic freedom until recently. But now they are coming with full speed.

Let me show four examples of the effect of the introduction of a market economy on the population growth in four developing countries.

Figure 5 illustrates the development in Thailand. The changes are measured in net reproduction rate parallel to the annual rise in GDP per capita year between 1950 and 1980. You see there are rather large variations but this gives a rough idea of the situation. To explain the meaning to the reproduction rate, if this index is 1, then it means that on average each woman gives birth to two children. If the index is two, it means each woman gives birth to 4 children. As you can see, as the per capita income went up, the reproduction rate fell quite sharply. This is an enormous development.

And now on to the case of Malaysia, shown in Figure 6. We also see also a steady reduction in net reproductive rate. The growth was reasonably high, about 4 percent, over the 40 years shown.

Figure 5

Figure 6

We see the same story for Indonesia, shown in Figure 7. We see a slightly growing income per capita and the net reproductive rate comes down very fast. It's still fairly high, but on the other hand it was much higher in the past.

Figure 7

And the last one on this nature, Japan, shown in Figure 8. As I showed before, Japan had an early increased growth for 90 years, from the mid 19th century, and now I show the growth from 1950 to 1992. You see the net reproductive rate didn't come down so fast, but later it came down to almost 1.0, which is no population growth.

Figure 8

Zero emissions is a far reaching target for all our efforts to preserve natural values. There is a rather general agreement that the population explosion is the greatest threat to mankind on this globe. And Zero Emissions is perhaps the most far reaching target for full success. Market economy does not by itself reach zero emissions, but it is a very

big step in the right direction, particularly when we think that our globe as limited both in area and in potential to support the increasing numbers of human beings. Market economy is in this respect a big contribution, but on the other hand, does increase growth, which has a two sided effect. It means a growth in human production and human consumption, which in itself provides problems in reaching zero emissions. It provides however, resources, not the least increased knowledge, that supports efforts to realize zero emissions.

The experience around the world that environment protection is a fairly recent issue, but it has been for some time a more important issue in the developing countries than in the rest of the world. And not the least is that true for the socialist countries

The great challenge is to achieve zero emissions and increased growth simultaneously. Increased knowledge and very strong ambitions are indispensable to achieve this. China has tried to stop population growth by laws, with a meager result. India has tried sterilization of men and various other ways to limit growth of population, but with limited success. One of the states in India had some success by introducing a lot of education among women. My conclusion is that the great thing about the control of population growth achieved by a market economy that it is achieved by increased freedom, not by increased force, as all the others are.

Increase in average length of life due to increased in living standards and general knowledge adds to the population growth over and above the net reproductive rate. More or less, all of the countries of the world have a population where the next generation lives longer than the former generation did. This is particularly pronounced in countries that have recently become market economies.

Whether we look back in history or if we compare rich and poor countries today, we find that inside countries, the difference between rich and poor is larger in poor countries than it is in rich countries. Figure 9 illustrates the distribution of wealth in developed and developing countries. The populations have been split into 5 groups according to wealth. Developing countries have more than 50% of the Gross National Product distributed over 20% of the population, and less than 15% of the wealth is distributed over the 20% poorest. If we look at the market economies, we find that it is an appreciably more even distribution of income than in the developing counties. It means I believe, that in the market the income of individuals is tested against the performance every day, and of course this is not theoretically correct in every decision, but overall it gives a general change.

I would like to mention one thing more. It is said, at least in Europe, that the income spread in the US is alarmingly high. So I thought it was interesting to illustrate, that if we compare the distribution of wealth in the USA and Europe, the distributions are very close, and in fact the US distribution is slightly more even.

Figure 9

The introduction of a market economy into developing countries further reduces the span between rich and poor countries. The gross national product growth is generally higher in new market economies than in the old ones, as I illustrated with Japan and Sweden. There is however no country that applies the principles of market 100 percent. Experience tells us that the welfare systems that cater for people who by accident or otherwise really need help do not destroy the positive effects of market economy. But if the welfare policy additionally wants to materially equalize income, the effects of market economy will successively fade. A country with a trend towards economic equality has only one trend of income and freedom, and that is downwards.

With this presentation, I tried to illustrate that market economy has many fruits to bring to everybody on this globe. On the other side, it is easy to see how these fruits can be destroyed by misuse of market economy principles. We see many examples in the industrialized world that the market economy is maltreated. For instance, reductions in free competition by introduction of monopolies or cartels. A defacto monopoly can be achieved for some time by excellent performance but that does not hinder somebody else from breaking that monopoly by being more clever. The only acceptable monopoly that I can see is patents, which stimulates the development of new ideas to solve problems, and they only last for a certain time. They are based on laws that regulate that. Other monopolies and cartels reduce the growth, they are like cancer

for business. Unions and employers federations are in principle cartels. An interesting development is found in New Zealand, where negotiations are recently made to principally take place in individual corporations. Governments further give subsidies to business and industry, which give arbitrary and often unfair distribution of tax money, reducing free competition. Like narcotics, it gives pleasure for the moment, but destroys the body in the long run. For long term research clearly beyond normal business horizons, it can principally be argued that government should however give support, in spite of my firm statement against it. Change is necessary in any business society, and subsidies hinder this process. Import duties is another limitation for free competition. Governments further operate a lot of business outside of the rules of market economy. Governments should study the principles of market economy and learn what it really means to be a market economy and what it can bring to the population. We who work in the private business should spread the ideas of market economy so that we get a unanimous appreciation of the market economy in our countries. Free trade has made progress in the last decades. For a market economy we see a mixed picture however. While liberalization of economies and introduction of market economy is taking place in the Far East and South America, we see a decay in market economies in most of Europe. It is my opinion that unless this trend in Europe is reversed, our continent will fall back and lose position in world development. The relative decay is a risk for Europe.

At the same time we have a historical opportunity to help the developing nations convert to market economies and hereby avert the population explosion from destroying our globe as a home for a happy humanity. And further we have the opportunity to increase the quality of life in these countries. We should teach the developing countries market economy and assist them to establish, so that they can be proud that they have created a happy future for themselves, not by us in the industrialized world. Companies in the industrialized countries should make joint ventures with the corporations in developing countries to accelerate their development. Governments should keep the borders open for their products, as long as they are of acceptable quality. Increasing trade stimulates economic growth and in turn stimulates the growth of trade. Market economy is a prerequisite for democracy. No true democracy has ever declared war on another democracy. Peace is best supported by free and international trade and the spread of democracy. Freedom and peace will reach a new dimension by zero emissions. Let's all work for the realization of such of a world.

The New Drive Towards Competitiveness

Dr. Keizo Yamaji
Chairman of Nihon Tetra Pak

Thank you for the wonderful introduction, Mr. Pauli. I would like express appreciation for the hospitality extended by the Chattanooga organizers. I would also like to thank the rector of the UNU for giving me the opportunity to speak on this occasion. I will be speaking on the theme “The New Drive Towards Competitiveness “.

1. The cultures of the world's industrialized nations have reached the apex of their development. These cultures were built up on the premise that the Earth was an unlimited provider of resources and an unlimited assimilator of waste, a concept which resulted in a major burden on the natural environment. This type of economic development is known as a "non-sustainable civilization (NSC)". The solutions to the problems associated with NSC are now being implemented, but they are still insufficient. In the future, advanced industrialized countries must strive ever harder to repair the damage caused by NSC.

In the manufacturing industry we should change our management attitude drastically. That leads us to great changes in the product and business planning which form the foundation of manufacturing companies' activities.

Three key phrases for shifting product planning are:

1. From best-seller to long-seller
2. From user needs to human needs
3. From benefit-series to eco-series

Rather than a best-seller which only sells for a short period of time like a fireworks display, we aim at a long-seller that will steadily sell for a long period of time. The reason being that long selling products require less investment for the manufacturing facility, the manufacturing can be conducted in a stable way, and the sales can be stabilized. There will be no need to manufacture products that eventually will become an inventory and a target for a write-off.

On the subject of human needs: Customers are, before being users, human beings. There are fundamental requirements for humans to live in this world. Customers, as human beings, have the will to maintain the beautiful earth and the natural environment, being critical about wasteful use of natural resources. It is not sufficient to regard the customers as those who only enjoy the benefit of machines. Future products need to satisfy both of these two faces the customers have.

Now we can conclude that the existing products should be replaced with an eco-series which puts more value on the environment, natural resources and comfort of use, rather than the customers' benefit or the ease of use. The new product does not use toxic materials nor produce toxic emissions. It replaces the current product with a more energy and materials saving one. The replacing products will use recycled materials and / or be recyclable themselves.

On business planning, we have two key phrases:

1. Undersupply rather than oversupply
2. Optimum share rather than maximum share

In business planning, as well an in product planning, some self-restraint is needed. For example, we should choose "underproduction", not "overproduction". We are more concerned with overproduction resulting in inventory increase which at the end becomes a write-off, rather than underproduction which might miss a great sales opportunity.

On market share, we seek optimum market share rather than maximum market share. It is indeed one of the most important strategies for a corporation to improve market share. However, this action should be kept just under the point that would stimulate a competitor. This means to maintain optimum market share. If one exceeds this point, the competitor will feel threatened and an endless price reduction war may start between the two. This could damage the market and the business itself.

2. On the other hand, if the populations of the developing countries (which are already seven times those of developed countries) continue to grow and seek to improve the standards of living to match those of developed countries by adopting the NSC model, environmental ruin and resource depletion are inevitable.

The time has come for developed and developing nations to join hands and propose new ideas to create a new "Sustainable Civilization (SC)". A joint study to create SC which combines the needs of developing countries and the technology of developed nations must be undertaken as soon as possible.

A most important subject is how to create the infrastructure of SC. Let us give you some examples:

Regarding transportation systems,

1. Railroad and electric cars are the most desirable means of transport.
2. Long-distance train systems across the country should be constructed before super-express lines.

Regarding telecommunications systems;

1. Key ideas such as wireless, both-directional and multi-media are desirable.

Regarding energy systems,

1. In developing countries in low latitude territories near the equator, which are very rich in solar energy, the main energy resource should be renewable solar energy instead of fossil energy.
2. In such areas power generation must be decentralized to each location where electricity needs exist.

It is desirable for the industry of the future to centralize factories in low latitude areas while locating software and service industries to middle and high latitude areas.

3. In either case, it is obvious that the Zero Emissions Research Initiative (ZERI) will play a central role in activities aimed an creating SC. It is heartening to know that ZERI, advocated and promoted by the United Nations University, has been widely accepted by both advanced industrialized nations and developing nations to the point where active research to realize this idea is already underway.

To commercialize the results obtained by ZERI and to realize SC, it is essential that all businesses start to move in earnest in this direction. The issues of the environment and resources will not wait for our slow progress. We should start right now, we should hurry up. There will not be enough time to study it as so-called philanthropy, mecenat or as volunteer action. Nor do we have time to spare for drawing consumers' attention with great promotional expenses. It is time for us to fix the deadline in order of priority or the importance of each issue and to solve it within the suggested time limit. We need to make it our main business. Top management needs to have a sense of mission for this activity.

However, the primary moving force behind current economic development is the "market principle". There exists complications between the two, this sense of mission and the market principle. Therefore, for business to actively participate in the creation of SC by making the necessary contributions and investments, I have been advocating a SC which is consistent with market principles.

4. The challenge now is to make ZERI consistent with market principles. First, ZERI itself must not only find a way to make zero emissions (ZE) technically feasible, but must also prove the economic advantages of ZE (for example, by making recycled materials cheaper than virgin materials, and by making the cost of recycling lower than the cost of waste processing). Secondly, businesses leading the way in ZE research should show that they have marketed ideas which are ahead of the competition, establish new technology and knowledge, and lead the race for patents in order to capture a major market share and otherwise surpass businesses than lag behind.

5. Meeting the following four conditions are necessary if ZERI is to actively apply market principles. These conditions are basically the guarantees that:

(1) A large, growing market will be created;
(2) Fair competition will take place in that market;
(3) The infrastructure required by the market will be created;
(4) A substantial will to make purchases will be fostered in the market.

Furthermore, if some sort of public assistance is made available, then the willingness of businesses to make investments will likely increase further. Moreover, I must emphasize that "inducement through an industrial taxation policy" and "the

establishment of environmental standards" are necessary to fulfill the conditions I have mentioned.

6. The basic industrial measures I am speaking of include environmental regulations, environmental taxation systems, adopting ecology-conscious purchasing rules, and supporting developing nations' move towards the creation of SC.

The first measure involves the creation of environmental regulations. Therefore, the first requirement is the early development and publication of an environmental regulation system and its schedule for implementation. In this way, ideal conditions for ZE can be created and a systematic, step-by-step approach of gradually heightening regulatory standards can be implemented. Disclosing the process (including the information schedule) to the public (the market, customers, and all others concerned) in a way that is easy to understand is a part of this process as well. On that occasion, it will be imperative to make regulations that clearly state that the responsibility for environmental preservation will lie squarely with the polluter, in keeping with the polluter-pays-principle (PPP). First of all, such regulations will create a new market for environmentally friendly products. Former polluters will
aim to provide products resulting from the cooperative research and development efforts of the business and scientific communities, thus invigorating overall R&D. Second, by virtue of the fact that remedying the burdens placed on the environment will be the task not only of leading businesses, but also of all other market competitors, the successful businesses will be those which optimize the whole process of research, development, and production, thereby creating a truly fair field of competition based entirely on market principles.

Now you can conclude that the purpose of an environmental regulation system is not to have an offender pay penalty for breaking the rule. This aim is to provide us with the guide and the schedule for achieving our joint goal. We have already taken appropriate measures against air pollutions and automobile exhaust gases. Now we should do these actions extensively and systematically.

7. The second item on the environmental regulations agenda is to apply these principles to businesses expanding overseas. This would mean, for instance, placing the onus of responsibility for environmental regulation enforcement on local infrastructures, for example, the infrastructure that accompanies corporate overseas expansion, such as thermal electrical generation plants and industrial waste-processing plants. This would also mean the necessary creation of environmentally friendly facilities in host countries similar to those found in developed countries. This will not only help alleviate and remedy the environmental problems of those countries, but will also promote the expansion of the environmental industry.

8. Next, I will address the second issue of industrial policy, that is the environmental tax system. This is a system whereby taxes are imposed on a product, based on the

environmental burden created by the product throughout its life-cycle. If a producer makes a product with a smaller environmental burden, then the tax would be correspondingly low. Furthermore, if a product's environmental burden is below a certain level, a lower consumption/value added tax would promote the creation of a major market for eco-products. Additionally, this type of tax system would follow market principles in that it would be fair to business and reward its efforts.

9. The third measure involves adopting an ecology-conscious purchasing rule. The initial implementation of the system would involve public organizations institutionalizing the purchase of products which have environmental benefits that are below a certain level. Doing this would extend the momentum behind the purchase of eco-friendly products, and ultimately attract general consumers. Furthermore, by lowering consumption tax rates on such products, a new market for eco-products would be created, with businesses competing to research, develop, and produce products for that market.

10. The fourth measure behind this industrial policy involves assisting "developing nations' move toward the creation of SC," which was the first things I talked about today. Effective steps toward realizing this goal would involve Official Development Assistance (ODA) and other types of assistance which promote joint research and production by advanced industrialized nations and developing nations.

11. Finally, to establish a system of environmental regulations, it would be necessary to anchor the soon-to-be-established International Standards Organization (ISO) 14000 series as a basic market infrastructure. Measures to facilitate this would include the establishment of an environmental strategy for each industry through a screening and registry system. Also, through the use of "eco-labels", information on a product or business's environmental burden or resource/energy consumption level could be publicized. A system which would evaluate this type of information could also be established. Moreover, education could be provided to make consumers more environmentally aware. All of these factors could then be integrated into the environmental market infrastructure, providing a good foundation for the aforementioned industrial policies.

12. These are the particulars of what I have been advocating. Fortunately, Japan has already shown some initiative -- specifically in preparing for the ISO 14000, and deliberating on starting the use of eco-regulations and "green purchasing" on a trial basis. However, I believe such activities should not be conducted separately. Rather, it is necessary to comprehensively and boldly implement effective measure under the flag of "following market principles".

As a result, I have high hopes that the activities of ZERI will become a new driving force behind industrial competition.

The Growing Wave of Zero-Emissions

Tadahiro Mitsuhashi
Deputy Chief Editorial Writer of the Nihon Keizai Shimbun

Today, I am very delighted to see all the participants here and for us to have the opportunity to be able to frankly exchange ideas with one another about how we may be able to lessen the impact of humanity on the global environment during the twenty-first century. And I think that it is wonderful that Chattanooga, which has been transformed from a very polluted town into one of the most environmentally healthy towns in the United States, is hosting this Second Zero-Emission International Conference.

Last year at the Conference, the word "zero-emission" proposed by the United Nations University was not familiar to many Japanese people, and the majority had the reaction "what is aero-emission"?. However, it has been a year since the first Conference, and I think "Zero-emission" is now well understood by many Japanese people.

I believe that Nihon Keizai Shimbun, for whom I work, has contributed much towards promoting zero-emission awareness in Japan and I am proud of it. Nihon Keizai Shimbun has a daily subscription of about three million copies, and its main readers are those with a level of education like corporate managers, business people, economists, bureaucrats and politicians. It has more influence on policy making in Japan that any other newspaper.

Our newspaper has a great interest in the idea of zero-emission and believes that those corporations that succeed in attaining zero-emission will become forerunners in business activities in the twenty-first century. This is why we have promoted a zero-emission campaign. Last year, we had a series of 31 editorials titled "Proposals for the Century of the Environment". We also host the International conference for Global Environmental Economists, which facilitates the exchange of ideas on environmental issues. Moreover, Nihon Keizai Shimbun organized the trip for the Japanese participants who are present at this Conference.

Of course, the main reason why the Japanese people have increasingly recognized the idea of "zero emission" comes from a different root. Having been poorly endowed with natural resources like oil and metallic resources, the Japanese people traditionally utilized scarce resources wisely, an attitude known as "Mottainai-seishin" in Japanese. This attitude used to flow deeply in the heart of the Japanese people. We used to have a comprehensive education which emphasized restraining from the careless disposal of products, utilizing goods for as long as possible and reusing resources.

However, after the Second World War, Japan adopted the economic system of mass production and mass consumption from the United States. Although this brought about very rapid economic growth for Japan, in the meantime many younger people

got accustomed to a lifestyle of wasting resources and the unwise use of goods. This consequently brought about massive waste and accelerated the process of environmental destruction.

But many people in Japan are trying to discard the “throw-away culture” and recover “Mottainai-seishin”, an attitude which calls for the effective utilization of resources. In particular, “Mottainai-seishin”, which is forgotten in Tokyo, is gradually spreading in the countryside, where a high proportion of the population is elderly. In this sense, it may be the rural regions rather than the mega cities that propel the zero-emission movement.

Zero-emission is no more than recovering the “Mottainai-seishin” which used to flow deep in the heart of the Japanese. One residential construction firm in Hokkaido has developed a technology which is able to make composite timber by utilizing timber that was discarded because it was curved or too thin. They build houses which last for more than one hundred years and run a successful business. Yakushima, an island just off the southern coast of Kyushu, is participating in this Conference through the Internet. Yakushima, with a population of nearly fourteen thousand, is doing away with fossil fuels and establishing waste recycling, with the ultimate objective of developing a closed metabolic economic system. This development will be discussed later in the Conference.

This year in Japan there is a movement to organize discussion groups at the district level to enhance the communication between local villages, towns and districts. Also from this year, the Department of Environments White Paper has a section on the evaluation of zero-emission.

Given the past experience of Japan and the resurgence of interest in Mottainai-seishin, I believe that Japan is able to take a leading role in the realization of global zero-emission. I am confident that this Second Conference will make a significant contribution to our collective understanding of the global environment and I hope that we can alleviate the impact of human activity on it.

Thank you very much.

Plenary Session I:
Industries of the Future

May 30, 1996

Lean and Green: The Move to Environmentally Conscious Manufacturing

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ABSTRACT: This paper advances the hypothesis that the adoption of advanced manufacturing practices creates substantial opportunity for the adoption of environmentally-conscious production strategies. The paper presents the results of a national survey of environmental manufacturing practices and of phone interviews and filed research consisting of site visits and personal interviews at manufacturing plants. The findings confirm the central hypothesis: Efforts by firms to improve manufacturing processes and increase productivity create substantial opportunities for environmental improvement. The adoption of manufacturing process innovations provides incentives for the adoption of environmentally-conscious manufacturing strategies. We also find that close relationships across the production chain, between end-users and suppliers in particular, facilitate the adoption of this related bundle of environmental and industrial innovations. We are led to conclude that firms and plants that are R&D intensive and manufacturing innovators possess the capacity to both improve productivity and reduce environmental costs and risks. The research thus suggests a convergence of zero defects, zero inventory, and zero emission approaches to manufacturing.

Key words: advanced manufacturing, environmental manufacturing, green production

INTRODUCTION

Can corporate efforts to innovate and to adopt advanced technological and organizational approaches to manufacturing be used to achieve simultaneous gains in industrial and environmental performance?

The past few years have seen increasing interest in this question from a number of quarters. A growing number of environmental studies have identified the use of environmentally-conscious manufacturing practices by American industry (Frosch 1992, 1994; Richards and Frosch 1994; Office of Technology Assessment 1994; Frosch and Gallapoulos 1992; Ausubel and Sladovich 1989; Ayres 1989; Allenby And Richards 1994; Wallace 1995). Research from the literature on organizational and industrial transformation has documented the shift to new and innovative manufacturing systems among U.S. firms (Womack, Roos and Jones 1990; Kenney and Florida 1993; Osterman 1994). A small but growing number of studies have probed the relationship between industrial and environmental performance more directly. An MIT study suggests a relationship between lean production and innovative environmental manufacturing practices (Maxwell, Rothenberg and Schenck 1993). A study by Hart and Ahuja (1994) found that efforts to prevent pollution and reduce emissions had a positive effect on industrial performance.

This paper examines the relationship between advanced production practices and innovative approaches to environmentally-conscious manufacturing. It advances the hypothesis that adoption of advanced manufacturing systems creates substantial opportunity for adoption of green design and production strategies. Simply put, this

hypothesis suggests that firms that are innovators in manufacturing draw upon the same underlying principles - a dedication to productivity improvement, quality, cost reduction, continuous improvement, and technological innovation - that underlie innovation in addressing environmental costs and risks. This paper thus suggests the convergence of zero defect (quality), zero inventory (just-in-time), zero emission approaches to manufacturing.

These hypotheses are informed by an evolutionary theory of the firm which suggests that firms develop their strategies in an evolutionary way cope with both external constraints and limited information and knowledge. Firms adapt, innovate, and learn. As Schumpeter (1947) argued, firms possess the capacity for *creative* as well as *adaptive* responses to situations. That is, a firm can over time create organizational and institutional environments suited to their needs - not just adapt to given conditions (see Florida and Kenney 1991). Organizational change is both a product of economic conditions and alters those economic conditions. In this context, we argue that firms operating in a highly competitive environment pursue strategies to increase profits by reducing cost, improving productivity, and reducing waste. Among the most effective strategies are ones that conform to Schumpeter's (1947) class of *creative responses*, that is strategies which transform the very nature of competition by overcoming traditional tradeoffs. A good example of such responses is the use of total quality management to improve quality and productivity at the same time. In this paper, we focus on the emergence of creative responses with regard to the industry-environment nexus, in particular the rise of innovative manufacturing systems which overcome the traditional *cost of environment quality* approach by improving industrial performance while simultaneously minimizing the costs associated with environmental compliance.

To shed light on these issues, this paper reports the results from a national survey of U.S. manufacturing firms, phone interviews, and field research consisting of site visits and personal interviews at manufacturing plants.

RETHINKING THE INDUSTRY-ENVIRONMENT NEXUS

It has sometimes been argued that the relationship between industrial and environmental performance takes the form of a trade-off, environmental quality coming at the expense of industrial competitiveness. Firms have typically invested in end-of-the-pipe treatment and control technology to reduce the toxic content of environmental emission and wastes. Public policy has sought to use a combination of regulatory standards and penalties to limit the environmental byproducts of their production processes, frequently by mandating the use of so-called "best-available" control technology.

A number of studies have recently argued that efforts to lower the costs of waste management and disposal and reduce waste and emissions need not negatively effect corporate performance, and at times may actually improve it (Clarke 1994; Office of

Technology Assessment 1994; Porter and van der Linde 1944, 1995; Schmidheiny 1992; Smart 1992a, 1992b; see Walley and Whitehead 1994 for a dissenting view). While the logic underlying this so-called *win-win* argument is somewhat compelling, research to date has been mainly comprised of case studies and thus is insufficient to support its claims. Furthermore, the literature has tended to focus on the *success stories.* As a result, these studies provide little more than *existence proofs*, but virtually no evidence on the extent of penetration of advanced practices across the industrial landscape and of the factors that influenced their adoption and diffusion. The win-win perspective of Porter and others also tend to overstate its claims by setting up traditional environmental economics as something of a straw-man (this literature has tended to set up neoclassical environmental economics a something of a straw-man. While the neoclassical perspective suggests that there is a trade-off between environmental improvement and productivity improvement at any given point in time, firms can and typically do improve both their environmental and industrial performance over time. For neoclassical economics, improvements in productivity and environmental performance are both driven by the same competitive pressure on firms to economize on inputs through technological change. I am indebted to one of the referees of helping to clarify this important point).

The view advanced here is different from the *win-win* perspective.

This paper advances the rather straightforward hypothesis that firms which are innovative and adopt advanced manufacturing practices can realize simultaneously improvements in productivity and environmental performance. In other words, it is argued that environmental improvements to some extent flow from broader corporate efforts to innovate and implement new and more efficient manufacturing systems and practices. There is some anecdotal evidence to support this hypothesis. A number of studies have provided some evidence that manufacturing establishments are changing their environmental strategies from traditional end-of-the-pipe control to new technologies such as pollution prevention, production process modernization, material substitution, and waste minimization which lead to more general productivity improvement (see U.S. Office of Technology Assessment 1994). The data on pollution control and abatement expenditures by U.S. manufacturers compiled by the U.S. government indicate a shift in the share of expenditures from control technology to production process improvements. Pollution abatement and control expenditures (PACE) for U.S. industrial firms totaled $7.2 billion in 1993; of this, nearly 45 percent ($3.2 billion) was spent on production process enhancements.

There is a considerable literature documenting the shift to new and innovative manufacturing systems among firms, referred to variously as *lean production*, *agile manufacturing,* and *high-performance production* (Womack, Roos and Jones 1990; Kenney and Florida 1993; Osterman 1994; Florida 1995; Jenkins 1995). These advanced manufacturing systems are distinguished by a blend of technological and organizational changes inside the factory (e.g. self-directed work teams, worker rotation and continuous process improvement) and by close and co-dependent relationships across the production chain, particularly between end-users and suppliers. An influential MIT study (Womack, Jones and Roos 1990) documented the transition from mass production to lean production in the automotive industry. A

survey of the U.S. manufacturing establishment by Osterman (1994) found evidence of significant adoption of innovative work organization in a large and representative sample of U.S. plants. A survey by Florida and Jenkins (Florida 1995; Jenkins 1995) found a significant rate of adoption of innovative manufacturing practices by Japanese transplant manufacturers in United States. Other studies document performance and productivity gains associated with advanced manufacturing systems. A study by MacDuffie (1994) identified performance gains associated with adoption of lean production in a large international sample of automotive assembly plants, while research by Ichniowski et al. (1993) found significant performance gains associated with the adoption of a bundle of innovative manufacturing and work organization practices in the steel finishing sector (While there are reasons to expect that innovative approaches to manufacturing may spill-over into firms' environmental strategies, there may be factors which may make it difficult for manufacturing plants to link their environmental and overall production strategies. In most manufacturing plants, the responsibility for environmental compliance is a specialized function outside the purview of production and operations management. Furthermore, there tends to be a natural division between environmental management and production and operation management. For example, production and operations management is typically responsible for optimizing the production process, while environmental management focuses on ensuring that the environmental byproducts of this process comply with government standards. Simply put, the responsibilities of environmental management tend to pick up where those of production management end).

A number of studies emerging over the past several years have begun to probe the relationship between environmentally-conscious manufacturing and efforts to improve manufacturing productivity and performance. Porter and van der Linde (1995) provide limited and largely anecdotal evidence to support their interesting contention that firms are responding to a new competitive environment by developing strategies to maximize resource productivity by pursuing strategies that enhance industrial and environmental performance. The findings of a group of MIT researchers (Maxwell, Rothenberg and Schenck 1993) who pose the question: "Does lean mean green?" suggest that there is some relationship between lean production and innovative environmental practices. In a comparative examination of environmental policy in Europe, the United States and Japan, Wallace (1995) concluded that the pursuit of both radical technological innovation and continuous incremental improvements in products and processes (e.g. kaizen) create substantial opportunities for pollution prevention and waste and emissions reduction. A statistical study by Hart and Ahuja (1994) found that efforts to prevent pollution and reduce emissions had a positive effect on industrial performance. This study also found that the biggest benefits accrue to large polluters, noting that the closer a firm gets to zero emissions the more expensive it becomes to further reduce pollution or realize efficiency or performance gains from such reductions.

As noted above, this paper argues that firms that are innovative and adopt advanced manufacturing practices can increase productivity and improve environmental performance simultaneously. In other words, adoption of manufacturing process innovations create incentives for adoption of environmentally-conscious manufacturing strategies. That is not to say they are part of the same cloth, or that there is no

separation between the two; but it is to say that they are interrelated. To put it yet another way, we hypothesize that firms that are innovative in terms of their manufacturing process are likely to be more imaginative in addressing environmental costs and risks. Furthermore, we suggest that suggest that close relationships across the production chain and between end-users and suppliers facilitate the adoption of this related bundle of environmental and industrial innovations.

RESEARCH DESIGN

The research effort included a combination of survey research, phone interviews, and field research consisting of factory visits and on-site personal interviews. It was designed to collect original data on the relationship between advanced manufacturing systems and innovative approaches to environmentally-conscious manufacturing across the production chain, including: pollution prevention, industrial recycling, closed loop industrial systems, zero emission manufacturing, total quality environmental management, green design, and supply chain management.

Survey research: A survey was used to obtain information on the adoption and use of a range of environmental manufacturing practices for a broad and representative sample of U.S. manufacturing firms. This survey was administered to a stratified random sample of 450 manufacturing firms and included 250 larger firms from the S&P 500 Index, 100 mid-size firms from the S&P Midcap 400 Index, and 100 small firms from the S&P Smallcap 600 Index. The survey instrument contained question on: the level of pollution prevention expenditures, the main components of pollution prevention efforts, manufacturing process improvements for pollution prevention, the role of pollution prevention in corporate performance, zero emission manufacturing, total quality environmental management, emission reductions, role of managers, engineers, workers, and suppliers in pollution prevention efforts, and the economic, political and other factors affecting the adoption of environmentally-conscious manufacturing strategies. To maximize response rate, the survey was designed as a short user-friendly instrument and administered via facsimile, resulting in successful contacts to 423 of the 450 firms in the original sample. Of this number, accurate and completed surveys were returned by 256 firms, for an adjusted response rate of 60.5 percent.

In addition, this paper draws from a survey of 1,500 Japanese-affiliated manufacturing establishments, or so-called *transplants* (see Florida 1995; Jenkins 1995). The survey examined the adoption of innovative manufacturing and work organization practices by Japanese transplants across industrial sectors (n=1,195) and a control group of U.S. suppliers to the automotive transplants (n=338). The survey collected detailed information on plant-level characteristics and products, work organization, manufacturing process innovation, and end-user/supplier relations. It was administered through a combination mail and telephone contacts and resulted in an unadjusted response rate of 40 percent (the results of the Japanese transplants survey were compared on an industry basis to those of a survey of U.S. manufacturing plants conducted by

Osterman (1994) who made his database available to us). While the main purpose of the survey was to examine the factors affecting the adoption of innovative manufacturing and work organization in the manufacturing plants, the survey included a question of the integration of environmental considerations in the design of products, which all mail survey respondents (n=316) answered (the survey question specifically asked: "Have environmental considerations had significant impact on the design of the products produced by the plant?"). These survey data were used to examine the relationship between green design and other aspects of advanced manufacturing.

Phone interviews and field research: Phone interviews and field research at factory sites were used to collect more detailed and comprehensive information on the relationship between environmentally-conscious manufacturing practices and manufacturing practices and manufacturing innovations more generally. We used a modified Delphi methodology to identify candidate firms, contacting trade associations, environmental agencies, and pollution prevention agencies to identify potential candidates. More than 50 organizations and experts were contacted, and they provided a list of 39 candidate firms including large firms such as 3M, General Electric, Motorola, TRW, Steelcase, Sony, and Honda, and a wide range of small and medium size companies. These firms were contacted by facsimile and 18 provided information of their environmental manufacturing efforts and indicated that they were willing to participate in phone interviews or site visits. As a cross-check, we examined the toxic chemical reduction records available from the U.S. Environmental Protection Agency (EPA) for a group of roughly 50 manufacturing companies that are recognized as manufacturing innovators. While coverage of these companies in the EPA data was spotty, toxic chemical reduction data was available for a number of firms, and we were able to identify a number of large reducers in the sample (since the purpose of the phone interviews and field research was to explore the relationships between zero defects, zero inventory, and zero emission strategies, this aspect of the research effort focused on manufacturing plants that were either recognized as manufacturing or environmental leaders. While this strategy was efficient in developing useful contacts, it must be taken into account when interpreting the findings outlined below).

Phone interviews were conducted with 12 manufacturing firms in a variety of industrial sectors including: advanced electronics (Motorola), computer disk drives (IBM), televisions (Sony), automotive components (TRW, Toyota, Johnson Controls), batteries (Ray-o-Vac), chemicals (Safety Kleen), plastics (Amko Plastics, Tuscarora Plastics), aerosol cans (Crown, Cork and Seal), paper (Scott Paper), and printing (Quad/Graphics). These interviews focused on corporate and plant-level environmental manufacturing initiatives, the relationship between environmental strategies and manufacturing innovation, and the role of the supply chain in the adoption and diffusion of advanced manufacturing practices. A site visit to Sony's Westmoreland plant and a number of its suppliers was conducted to obtain more detailed information on these issues, particularly the degree and level of interaction between end-users and suppliers.

NEW MANUFACTURING TECHNOLOGY AND POLLUTION PREVENTION

The adoption of pollution prevention and, in particular, the modernization of production processes to prevent pollution, is an important indicator of the shift to advanced manufacturing systems which simultaneously improve industrial and environmental performance. The survey provides a range of data and information with which to examine the adoption and use of pollution prevention strategies by U.S. manufacturing firms.

Pollution Prevention and Corporate Performance: The survey asked firms to indicate to what degree pollution prevention is important to their overall corporate performance. As Figure 1 shows, more than three-quarters of survey respondents indicated that pollution prevention was important to overall corporate performance with 35.4 percent of respondents indicating that it is very important and an additional 41.5 percent of respondents indicating that it is important. Just one-fifth (20.4 percent) of respondents reported that pollution prevention was only somewhat important to corporate performance, and less than 2 percent (1.9 percent) indicated that pollution prevention was not important to corporate performance. The survey results further indicate that pollution prevention is an important component of firms' environmental strategies. Nearly nine in ten (87.7 percent) respondents indicate that pollution prevention is an important element of their overall environmental compliance strategy.

Zero Emission Manufacturing: Zero emission strategies emphasize the elimination of all environmentally damaging byproducts from the production process. Such strategies are a strong indicator of the move to environmentally-conscious manufacturing. The survey asked firms whether they were currently pursuing zero emission strategies or strategies to reduce emissions. The survey data indicate that a significant fraction of respondents, roughly 16 percent, indicate that they are actively pursuing zero emission manufacturing. Nearly 85 percent of respondents are pursuing reduce emissions strategies.

It is important, however, to distinguish between zero emission as a goal as opposed to an objectively achievable criteria. The findings from the phone interviews and site visits shed additional light on this issue. The majority of firms reported that zero emission manufacturing is in its early stages of development, and that at this point it functions as a goal or target rather than as an adopted practice or standard. These firms noted that such targets are useful to motivate ongoing improvement efforts even though it may currently be impossible to achieve zero emissions in practice. Here, number of firms drew a parallel to zero defect approaches to quality, noting that although it is virtually impossible to achieve zero defects in practice, such ambitious goals performed an important function in motivating and focusing quality improvement efforts.

Pollution Prevention Expenditures: While soliciting the subjective preferences of firms on issues such as pollution prevention and emission reduction is useful and illuminating, the survey also obtained a variety of more direct and to some extent objective measures of pollution prevention effort. Of particular relevance, the survey collected data on the share of capital expenditures firms devote specially to pollution prevention. Here, the survey results indicate that pollution prevention expenditures are a significant component of overall capital expenditures. As Figure 2 shows, the overwhelming majority of respondents devote between 1 and 10 percent of their total capital expenditures to pollution prevention, with more than eight in ten (84.6 percent) of respondents reporting pollution prevention expenditures in this range. A significant share of respondents do, however, devote a greater share of their capital expenditures to pollution prevention. According to the survey data, one in six respondents devote greater than 10 percent of their total capital expenditure to pollution prevention. Furthermore, only a minuscule fraction of respondents (0.6 percent) reported that they do not devote any capital expenditures to pollution prevention.

Adoption of Technology: The relationship between innovation in environmentally-conscious manufacturing and advanced manufacturing in general turns upon the particular strategies firms use to prevent pollution. As noted above, the use of treatment and end-of-the-pipe control technology typically comes at the expense of other manufacturing improvements. The implementation of new technologies and/or production process improvements is an important indicator of efforts to upgrade manufacturing systems in ways that simultaneously achieve improvements in industrial and environmental outcomes. The survey asked respondents to discriminate among different approaches to pollution prevention, such as production process improvements, source reduction, recycling, end-of-the-pipe control, and treatment.

The survey results indicate that manufacturing firms are adopting new technologies and manufacturing systems to achieve joint improvements in environmental and industrial performance. The survey respondents strongly favor source reduction, recycling, and production process improvement over treatment and end-of-the-pipe control technology (see Figure 3). In terms of production process improvements, a large fraction of respondents indicate that they utilize source reduction (89.6 percent), recycling (85.8 percent), and production process improvements (77.8 percent) as main elements of their pollution prevention strategies. Significantly smaller percentages report the use of control technology as a main element of their pollution prevention efforts, with 36 percent reporting treatment and 25 percent reporting end-of-the-pipe technology as main elements of their pollution prevention strategy. In addition, the

survey asked respondents the degree to which they address environmental outcomes by reducing the size of their manufacturing operations through facility downsizing. Just 7 percent of respondents reported that downsizing was a main element of their pollution prevention efforts. We also looked at the use of various pollution prevention and environmental control

practices in combination. More than 30 percent (32.5 percent) of respondents utilized an innovative bundle of production process improvements, source reduction and recycling in combination.

The implementation of new technologies in the form of production process improvements are a central factor in the developments of joint improvements in environmental and manufacturing methods. The survey asked respondents to identify the specific types of production process improvements they have undertaken to reduce pollution and improve environmental performance. Here again, the survey results indicate that firms favor recycling and the direct introduction of new manufacturing process technology. As Figure 4 indicates, more than three-quarters (76.9 percent) of survey respondents used recycling, and roughly two-thirds of respondents upgraded their existing process technologies (63.2 percent). In addition, nearly half (48.6 percent) of respondents introduced new product design and product technology, and the same percentage introduced closed loop production systems utilizing waste from one stage of production process as inputs to other stages of production. Overall, the survey responses indicate that instead simply treating wastes with end-of-the-pipe technology,

firms are investing in new manufacturing process technology which simultaneously prevents pollution and increases productivity.

The survey asked respondents to report the level of emission reduction they have achieved by undertaking efforts to reduce waste and prevent pollution. As Figure 5 indicates, these efforts have resulted in considerable emission reductions at sample firms. Nearly two-thirds of respondents reported emission reductions of greater than 10 percent over the previous year, with 40 percent achieving reductions in the range of 11 to 25 percent, 12 percent reporting 26 to 50 percent reductions, and 7 percent reporting that they achieved no emission reductions at all.

Factors Affecting the Relationship between Industrial and Environmental Strategy:

The survey asked firms to identify the factors in the broad economic and policy environment which affect their environmental manufacturing strategies. These included: environmental regulations, corporate citizenship, new technologies, productivity improvement, competitors, customers, markets for green products, and environmental groups. The survey asked firms to rank the effect of each of these factors on their corporate environmental strategies and activities on a 1 to 4 scale, where 1 was not important and 4 was very important.

The survey results indicate that while environmental regulations and corporate citizenship remain key factors in corporate environmental strategy, a series of factors associated with industrial performance are important as well. As Figure 6 shows, the survey respondents listed the traditional considerations of environmental regulations (3.3) and corporate citizenship (3.3) as the two highest-ranked factors. However, the respondents also gave high ratings to a cluster of related factors which bear directly on industrial performance and competitiveness-technology (3.0), serving key customers (3.0). These results suggest that improving overall industrial performance and productivity are almost as important as responding to environmental regulations as a driver of environmentally-conscious manufacturing efforts. They thus reinforce the conjecture that there is an association between efforts to improve environmental performance and those to enhance manufacturing performance more generally.

ORGANIZATIONAL INNOVATIONS IN ENVIRONMENTAL MANUFACTURING

Thus far, we have considered the adoption of new technologies and manufacturing systems which can simultaneously improve environmental and industrial performance, and have found that firms are indeed adopting such technology. But, as numerous studies have pointed out, advanced manufacturing systems are distinguished by range of organizational and managerial practices, such as total quality management, worker involvement in continuous improvement activities, and more effective approaches to supply chain management which complement and enhance the performance of new manufacturing technologies (Womack, Roos and Jones 1990; Kenney and Florida 1993; Osterman 1994; Florida 1995; Jenkins 1995). This *soft-side* of advanced manufacturing systems is often seen to be as important, if not more important, than the introduction of manufacturing process technologies. We now turn our attention to the array of such organization and managerial innovations.

Total Quality Environmental Management: Total quality management is a frequently cited feature of advanced manufacturing systems, particularly among U.S. manufacturers (Osterman 1994; Florida 1995; Jenkins 1995). Total quality management is essentially a method for involving production workers in the improvement of product quality through incremental improvements in both products and processes (President's Commission on Environmental Quality 1993). Total quality environmental management (TQEM) extends the principles of quality management to include manufacturing practices and processes that affect environmental quality. According to the survey data, 43 percent of respondents employ a TQEM program.

The development of international quality standards, in particular the ISO series of standards for quality manufacturing, reflects the growing trend toward integrating industrial and environmental outcomes within a quality framework. While the ISO standards are strictly voluntary, many manufacturing firms have used ISO standards to motivate change and to ensure their operations meet recognized quality standards. Environmental quality has been adopted as a central component of the new series of ISO standards. The phone interviews indicates that a number of manufacturing firms

are migrating from the traditional ISO 9000 standards to the new ISP 14000 standards. Ray-o-Vac reported that it was already operating at 95 percent of ISO 14000 standards. Safety Kleen reported that its Elks Grove, Illinois plant was in the process of moving from ISO 9000 to ISO 14000 standards. Sony Corporation also reported that it was shifting from ISO 9000 to ISO 14000 standards for its North American and worldwide manufacturing operations.

Worker Involvement in Pollution Prevention: Employee involvement in continuous manufacturing improvement is a central element of advanced manufacturing systems. Recent research reports that a large and growing percentage of both U.S. manufacturing plants (Osterman 1994) and Japanese-affiliated manufacturing transplants (Florida 1995; Jenkins 1995) make use of employee involvement in continuous improvement to improve productivity and manufacturing performance.

As Figure 7 shows, roughly two-thirds of responding firms (64.6 percent) involve production workers in their pollution prevention efforts. Responding firms indicated that only two other groups - top management (81.1 percent) and engineers (75.0 percent) - were more important than production workers to their pollution prevention efforts. Furthermore, the magnitude of the difference between these three groups is sufficiently small, reinforcing the conjecture that production workers are an important component of pollution prevention efforts. The phone interviews and field research lend additional support to this view, indicating that manufacturers increasingly use a team approach where production workers, engineers, and managers combine their efforts to generate productivity-enhancing environmental outcomes. Responding firms reported that production workers were more important to their pollution prevention efforts than research and development staff (55.2 percent), suppliers (49.1 percent), customers (37.7 percent), or consultants (28.3 percent).

The result of the phone interviews reinforce these findings. Quad/Graphics utilized employee teams to significantly reduce hazardous waste (the firm reported that as a result of these measures it reduced hazardous waste by 27 percent and non-hazardous liquid waste by 47 percent over two years in its Wisconsin plants, with estimated cost savings in excess of $600,000). Furthermore, the company reported that employee involvement was a cost-effective way to improve environmental outcomes and reduce costs, involving incremental changes in existing processes and products as opposed to major changes in technology and large capital expenditures. IBM's disk drive plant involved workers, engineers, and R&D scientists in a plant wide effort to reduce CFCs. Safety-Kleen used teams of workers and engineers to reduce solvents, minimize waste, and redesign equipment for increased resource efficiency and pollution prevention. Crown Cork and Seal's Minnesota plant involved production workers as the centerpiece of its efforts to eliminate waste and reduce toxins, forming teams of production workers to focus on environmental issues: for example, a Recycling Team whose objective focused on an environmental problem, and the Color Cats Team whose main effort was quality improvement but whose work had considerable impact on hazardous waste generation. As a result of these efforts, the plant achieved a 60 percent reduction in use of its primary solvents between 1991 and 1993, a 36 percent reduction of air emissions in 1993, and a two-thirds reduction in solid waste disposal from an annual level 300 tons to 100 tons that same year.

In short, firms are adopting a series of internal organizational changes in their manufacturing operations such as TQEM programs and worker involvement in continuous environmental improvement, as well as new production technologies, which are the source of simultaneous improvements in environmental and industrial performance. These organizational innovations both complement and reinforce investments in new manufacturing technologies identified above.

SUPPLY CHAIN MANAGEMENT AND ENVIRONMENTAL PERFORMANCE

Up to this point, we have considered the adoption of new technological and organizational innovations within the firm. A considerable body of literature has noted the emergence of new and more effective systems of supply chain management as a distinguishing feature of advanced manufacturing systems (see Robertson and Langlois 1995). Generally speaking, this work suggests that firms are increasing their reliance on outside suppliers and developing new and more interactive approaches to supply chain management. Recent studies also suggest that supply chains constitute potentially powerful mechanisms for the diffusion of advanced manufacturing practices. Research by Florida and Jenkins (see Florida 1995; Jenkins 1995) found that end-user/supplier relations were ***the key determinant*** of adoption and diffusion of innovative manufacturing practices among Japanese transplant manufacturers. Supplier relations and supply chain management can affect industrial and

environmental performance in two different ways. On the one hand, manufacturers have at times used their suppliers as a vehicle for improving their own environmental records by out-scoring toxic elements of the production processes, essentially pushing waste and toxins down the supply chain. On the other hand, new models of supplier relationships and supply chain management create opportunities for joint approaches to improve productivity and prevent pollution. For example, the emphasis on just-in-time delivery seeks to reduce both inventory and waste. Pressures for continuous cost reduction quality improvement create additional incentives for waste reduction and cost savings. Increasing co-involvement in product development between end-users and suppliers provides opportunities for the design of new products and processes that are both more efficient and environmentally benign. The emergence of mutually dependent relationships between end-users and suppliers have opened up new pathways for the diffusion of innovative approaches to waste reduction, pollution prevention, and productivity enhancement, particularly as end-user firms actively assist their supplier in the adoption of new methods.

The results of the survey research, phone interviews, and field research indicate that manufacturing firms are involving suppliers in efforts to improve environmental outcomes and increase productivity. As noted above, the survey of environmental manufacturing practices asked firms to identify the key players in their pollution prevention strategies (see Figure 7). Nearly half (49.1 percent) of respondents identified suppliers as a key player. In addition, more than one-third of respondents (37.7 percent) identified customers as a key player in pollution prevention efforts.

The phone interviews provide more detailed data on the various ways that suppliers relations are utilized to simultaneously achieve improved environmental quality and industrial performance. The results of these interviews suggest that a supplier relations create considerable opportunities for joint environmental and productivity improvement. In particular, environmental improvements were seen to result from ongoing efforts to improve productivity and implement advanced manufacturing practices, as well as from more directed efforts to transfer pollution prevention strategies and technologies.

While the majority of respondents indicated that environmental improvements are frequently unintended consequences of broader efforts improve industrial performance, a number of respondents noted that they pursue more directed efforts with suppliers to reduce waste and prevent pollution. These firms noted that they develop supplier specifications which include environmental objectives, work with suppliers to develop new products and specifications, and hold meetings with their suppliers to relate their pollution prevention strategies. For example, Motorola noted that it pro actively pursues pollution programs with its suppliers. IBM's disk drive factory worked closely with circuit-card suppliers to jointly develop a water-based alternative to a CFC-based chemical. Scott Paper and Safety-Kleen worked closely with suppliers to eliminate toxic chemical and reduce waste through recycling and process changes. Amko Plastics formed *action teams* with suppliers to develop new materials

and processes to convert to water-based inks for printing plastic films (The company noted that: "In addition to those programs which we have initiated, we have been invited by suppliers of our plastic raw materials, color concentrates, printing inks, extrusion equipment, printing plate processing equipment, printing presses, and specialty films additives to work jointly with them in the development of new technologies and products which enhance product quality and generate environmental benefits at the same time"). Ray-o-Vac established an environmental audit and ranking system for its suppliers and worked closely with its first tier of suppliers to encourage the diffusion of pollution prevention practices through the supply chain (Ray-o-Vac indicated that "poor environmental performance can disqualify a supplier, while strong environmental performance can qualify a vendor for bonus contracts."). TRW was in the process of adding an environmental component to its existing supplier assessment program.

Our field research on Sony's Westmoreland, Pennsylvania television plant and its suppliers reinforces the finding that environmental improvements tend to flow from ongoing joint efforts to improve productivity, eliminate defects, and reduce costs, rather that from direct efforts to transfer pollution prevention technology or organizational strategies designed expressly to eliminate toxins or prevent pollution. For example, as part of its effort to reduce costs and waste, the Sony plant worked with its suppliers of plastics, metals, solder, and other materials to completely recycle all of the scraps and other products of the production process. Sony worked closely with one of its suppliers, Tuscarora Plastics, to redesign its packaging to be less costly - a design which also used less material and generated less waste. The Sony plant also collaborated with a major paint supplier to reduce the cost of paint by switching to a water-based substitute which was also more environmentally sensitive than chemical-based paints.

In short, the findings support the conjecture that end-user/supplier relationships facilitate the adoption and diffusion of environmentally-conscious manufacturing practices. Furthermore, the findings indicate that end-user/supplier relations operate by opening up opportunities for adoption and implementation of innovative approaches to both environmental and productivity improvement.

ADOPTION OF CLUSTERS OF ENVIRONMENTAL MANUFACTURING PRACTICES

An increasingly important stream of literature on advanced manufacturing systems suggests that firms tend to adopt related bundles of advanced technologies and organizational practices, and further that such technologies and practices are more effective when they are adopted and utilized as a system (see Jenkins and Florida 1996; also see Ichniowski et al. 1989; MacDuffie 1994). We used cluster analysis to explore the adoption of such bundles of related environmental manufacturing practices by firms in the survey. The cluster analysis included key measures from the survey as well as data on firm size, age, sales, and industry obtained from Dun and Bradstreet. The cluster solution that was most appropriate for these data generated four distinct clusters of advanced-environmental practices. Table 1 summarizes the relevant findings of the cluster analysis.

The firms in Cluster 1 rate pollution performance as very important to corporate performance and exhibit high rates of adoption of both technological and organizational innovations related to environmentally-conscious manufacturing. Firms in this cluster can thus be considered to represent a *best-practice* approach to environmental and industrial performance. This cluster contains the largest number of sample firms (n=6) - 35 percent of the entire sample. Firms in this cluster are relatively large, with 48 percent having sales of more than $2 billion and just 15 percent in the under $500 million category. As noted above, these firms consider pollution prevention very important to corporate performance and exhibit high rates of adoption of virtually the entire gamut of technological and organizational innovations related to environmental-industrial performance, including source reduction, recycling, production process technology, TQEM, and worker involvement in continuous environmental improvement. Firms in this cluster tend to integrate their pollution prevention efforts across the entire industrial chain, and to rate productivity and technology as key drivers of their environmental manufacturing strategy. These firms devote a relatively high level of capital expenditures to pollution prevention to achieve high levels of emission reduction.

Firms in Cluster 2 rate pollution prevention as relatively important to overall corporate performance. However, the percentage of firms responding very important to this question is significantly less than for Cluster 1 - 35 percent versus 49 percent. Firms in

Cluster 2 devote a relatively high level of capital expenditures to pollution prevention and report a relatively high level of emission reduction. However, these firms report very low levels of technology adoption related to pollution prevention, and are also less likely than firms in Cluster 1 to adopt organizational innovations such as TQM or the involvement of workers in continuous environmental improvement. These firms also exhibit a low level of integration of pollution prevention efforts across the supply chain. One potential explanation for this pattern is that Cluster 2 firms may generate types of pollution (e.g. solid rather than hazardous waste) that can be prevented by relatively straightforward methods, such as recycling and source reduction, rather than requiring high levels of technological and organizational innovation. It is also worth noting that this cluster is distinguished by a heavy concentration of consumer and personal care products firms for which brand name recognition and corporate reputation are important, and thus may pursue pollution prevention to enhance their overall corporate image.

Firms in Cluster 3 rate pollution prevention as of moderate importance to corporate performance. These firms exhibit relatively high rates of adoption of new production process technology, recycling and source reduction. These firms, however, exhibit only moderate levels of adoption of organizational innovations such as TQEM and worker involvement. They also show only a moderate level of integration of pollution prevention efforts across the supply chain. Moreover, Cluster 3 firms do not rate either productivity improvement or new technology as significant drivers of their environmental strategies. These firms devote a moderate level of capital expenditure to pollution prevention and realize a low level of emission reduction from their efforts. This leads us to surmise that the pollution prevention efforts of these firms may be a consequence of unrelated corporate efforts to improve quality, reduce cost, and/or increase performance rather than from a directed and strategic effort to achieve joint gains in industrial and environmental performance.

Firms in Cluster 4 rate pollution prevention as relatively unimportant to corporate performance and engage in low levels of technological and organizational innovations related to environmental manufacturing. This cluster has a disproportionate concentration of smaller firms, with more than 40 percent having under $500 million in sales. These firms devote a moderate level of capital expenditures to pollution prevention and achieve a low level of emission reduction. Firms in this cluster show little evidence of adoption of organizational or technological innovations related to environmentally-conscious manufacturing, and can thus be considered traditional in their approach to this issue.

The results of the cluster analysis indicate that firms differ considerably in terms of the level of effort and strategies used to achieve industrial and environmental performance. Perhaps most importantly, the cluster analysis findings indicate that a significant fraction of sample firms - more than one third of all respondents - are actively pursuing a related bundle of advanced technological and organizational innovation associated with advanced and environmentally-conscious manufacturing systems. These firms

can be considered leaders in the adoption of advanced manufacturing technologies which generate simultaneous improvements in industrial and environmental performance. It should also be remembered, however, that a smaller but still considerable fraction of firms show much lower rates of adoption of such practices and that there is little evidence of their moving to adopt technological and organizational innovations that offer joint industrial and environmental performance gains. At bottom, the findings of the cluster analysis indicate that there is a class of firms which are able to implement a related bundle of technological and organizational innovations associated with advanced, environmentally-conscious manufacturing and which are able to realize considerable emission reduction while enhancing productivity as a result.

ADVANCED MANUFACTURING SYSTEMS, R&D, AND GREEN DESIGN

To shed additional light on the relationship between innovations in environmental manufacturing and the adoption of advanced manufacturing systems in general, we utilized the detailed establishment-level data collected by the survey of Japanese manufacturing transplants (Florida 1995; Jenkins 1995; Jenkins and Florida 1995). As noted previously, these data enabled us to examine the relationship between the adoption of green design and other aspects of advanced manufacturing and innovative work organization. This was done in two ways.

First, the survey data were utilized to identify those plant characteristics which are associated with the adoption of green design. The results of this analysis are summarized in Table 2. In short, the findings here reinforce the hypothesis that

plants which practice green design are also those that are involved in advanced manufacturing more generally. The green design plants tended to be larger, more R&D intensive, introduce greater numbers of products and product designs, and involve workers in continuous improvement. The green design plants were twice as large, on average, in terms of employees and sales than those which did not engage in environmentally-sensitive product design. Moreover, there was a strong relationship between R&D intensity and green design, suggesting that environmental innovation is associated with innovative effort and activity more generally. Plants which practice green design spent on average ten times as much on R&D as those which did not. The green design plants also introduced roughly twice the number of new products and new product designs than those which did not engage in green design. Furthermore, the green design plants were more likely to be involved in total quality management, utilize statistical process control, and have lower levels of inventory. Consequently, we are led to conclude that firms that are innovative and engaged in continuous improvement of and frequent changes to their products and product designs have a greater opportunity and incentive to take environmental considerations into account, because they are already engaged in product design changes and thus are better able to absorb the fixed costs associated with such changes.

Second, in related research, Jenkins (1995; Jenkins and Florida 1995) used factor and cluster analysis to identify three groups or clusters of manufacturing establishments: taylorist, traditional, and advanced. As Table 10 shows, plants in the advanced regime were found to adopt a related bundle of advanced manufacturing practices including total quality management, quality-oriented product design, just-in-time inventory control, a flat organizational hierarchy (e.g. a low ratio of managers to production workers), high levels of employment security, cooperative supplier relations, and electronic data interchange as well as green design (according to this analysis, transitional plants were found to be large, unionized plants which used heavy investments in training as a means of transitioning workers toward more advanced production systems. Taylorist plants were found to have a very traditional approach to work organization both inside and outside the plant. They did not use work teams, have large numbers of job classifications and so forth). The results of this analysis indicate that green design is one of a bundle of practices associated with advanced manufacturing systems. They thus lend considerable support to the hypothesis that adoption of innovative environmental practices is an element of a more general strategy of productivity-enhancing manufacturing process improvement on the part of firms.

SUMMARY AND CONCLUSIONS

We started from the hypothesis that there are joint productivity and environmental gains associated with the adoption of new manufacturing technologies and organizational innovations and with the use of advanced manufacturing systems more generally. The combined results of the survey research, phone interviews, and field research provide considerable support for this view. These results can be summarized in terms of four key points.

First, firms are leveraging their environmental improvement and industrial modernization strategies. Firms strongly favor source reduction, recycling, and production process improvement over treatment and end-of-the-pipe control technology. The large majority of survey respondents see pollution prevention as important to overall corporate performance and indicate that it is the central element of their overall environmental compliance strategy. Moreover, the results of the cluster analysis indicate that firms which adopt related bundles of technological and organizational innovation related to advanced, environmentally-conscious manufacturing are able to considerably reduce emissions in ways that simultaneously enhance their productivity.

Second, and related to this, a close relationship was found between green design and R&D spending, product innovation, and a range of advanced manufacturing practices

including employee involvement in continuous manufacturing process improvement and close supplier relations. These findings suggest that green design is one of a bundle of practices associated with innovative manufacturing systems.

Third, while environmental regulations and corporate citizenship remain key elements of corporate environmental strategy, series of factors associated with industrial performance are also important. The survey respondents rated technological improvements, customer demands, and productivity improvement as important drivers of environmental manufacturing strategies, providing a clear indication of the connection between environmental and industrial strategy and performance.

Fourth, close relationships across the production chain, and between end-users and suppliers in particular, facilitate the adoption of advanced manufacturing practices, creating new opportunities for joint improvements in productivity improvement and environmental outcomes. Generally speaking, environmental improvements flow from ongoing joint efforts to improve productivity, eliminate defects, and reduce costs, rather than from direct efforts to transfer pollution prevention technology or organizational strategies designed expressly to eliminate toxins or prevent pollution.

Taken together, these findings suggest that the efforts of firms to improve manufacturing processes and increase productivity create substantial opportunities for environmental improvement. The adoption of manufacturing process innovation provides incentives for the adoption of environmentally-conscious manufacturing strategies. We are led to conclude that firms and plants that are R&D intensive and manufacturing innovators possess the capacity to both improve productivity and reduce environmental costs and risks. Furthermore, the emergence of productivity-enhancing environmental strategies is a product of evolving *creative response* on the part of firms to transform the traditional industry-environment trade-off, and optimize their manufacturing processes in ways that simultaneously improve environmental and industrial performance. In other words, the pursuit of zero defect and zero inventory manufacturing strategies by firms produces spill-over benefits to the environment and creates the context for innovative approaches to emission reduction and pollution prevention, leading in turn toward zero emission manufacturing strategies. It is in this sense that we can speak of the convergence of zero defect, inventory, and emission approaches to manufacturing, and the emergence of new and more efficient approaches to manufacturing which integrate environmental improvement as part of ongoing, broader efforts to enhance productivity, performance, and profit.

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Sustainable Manufacturing in the 21st Century

Prof. Dr. Hiroyuki Yoshikawa
President, Tokyo University

(live via the Internet from Tokyo)

A concrete methodology taking the environment and post mass production into consideration has started to emerge for the development of manufactured goods in the twenty-first century. It does this by organizing the "inverse manufacturing" project of the University of Tokyo.

The concept of the Inverse Manufacturing

Our research is advancing a step beyond concepts in the engineering field that have supported manufacturing academically. It is research concerned with how to realize technological support to bring to fruition manufacturing that deals with global environmental problems. Our real job has basically been to promote manufacturing-meaning that, if anything, we have been in charge of work that is apt to destroy the environment. But now our research is delving into how to make manufacturing friendly to the global environment possible.

A factory exists; artifacts are conceived, developed, and designed, and through that design, an object actually gets manufactured, which then enters homes and society primarily via the market. When the artifacts are used, the users gain convenience. Furthermore, through maintenance of those artifacts, such convenience will continue to be enjoyed for a long time.

Nevertheless, every artifact definitely has a life span as a product. When its life span has ended, it is thrown away and becomes an abandoned artifact. Human beings have conspicuously strengthened the efficiency of activities such as development, design, and manufacturing, and have consequently ended up with causing artifacts to keep on flooding the land.

Naturally once those are thrown away, the amount of such scrapped artifacts gets to be extremely vast. If they flow into the natural environment in that state, the self-cleaning operations of mother nature will stop functioning, and various problems will arise.

Well, what should be done then? Let us here propose the concept of the "inverse manufacturing ", i.e. reassembling the parts and materials of artifacts.

When the discussion gets to whether the "inverse manufacturing" means to recycle and reuse, the answer is that it is actually not so. The Ecofactory projects of MITI aimed at such goals: robots were developed that automated the dismantling of scrap products. The subject of our research is different from such directions that are limited to reusing and recycling. One of our perspectives is to develop methods serving toward creating

designs with thought given from a very early stage to reuse and recycling. The other perspective, which is one step further, is to improve the functions of a product along with prolonging its product life through use and maintenance and also to lower the amount of abandoned artifacts.

For instance, a refrigerator could be made of a modular design and then its capacity increased by rearranging the modules. In the case of a personal computer, its functions can be upgraded freely through replacing the CPU. What would the design support system for making all that feasible be like?

The "inverse manufacturing" is a project that began in a recycling and reusing style. However, we noticed that various modifications can actually be made in the pre-manufacturing processes. It thus became obvious to us that rather than them striving hard at the recycling and reusing stage, the problems might be solved more efficiently if we link up our wisdom of the pre-manufacturing process.

Tools to support the "Green Design"

The greatest distinguishing feature of global environment problems is that we all have a stake in them. How we will come to share information and raise the level of knowledge concerning the environment will be indispensable in solving the problems. The term "Earth-friendly product," which is bandied about in the streets, is occasionally employed by a corporation to raise its image, but the basis for using the term remains unclear.

In order to clarify socially what is an Earth-friendly product in the true sense of the words, corporations will have to take the initiative to present information concerning global environment problems to consumers. We regard the Internet as the environment for carrying such information. So at present research is under way on how to arrange a computer environment in which companies, consumers, governments, universities, the mass media, etc. can share information on the Internet.

For example, an automobile is beneficial to us. Over the Internet consumers will also be able to grasp easily what sort of burdens it leaves on the environment during its life cycle.

Twenty-first century product development will mean to make a database out of knowledge assembled from existing industries, then render it possible for consumers to access that information over the Internet, all the while working consumers' reactions into it all the same time. This is a reflection of sustainable manufacturing in the twenty-first century.

This "green design" involves how to arrange design and development information, leading to the formation of an artifact system symbiotic with the environment. We

believe that the new artifacts born out of this sort of methodology will have considerable effect in creating the new industries of the future.

Making the Manufacturing Industry into a Service Industry

When we consider global environment problems, we should recognize the need for manufacturing in the twenty-first century to move away from mass production. Will corporations be able to maintain profits by halving the amount made in manufacturing, and will they be capable of undertaking a type of development not causing unemployment problems? For that to become possible, it is believed that the manufacturing industry will turn into a service industry.

The possibility exists that reuse and maintenance will help turn the manufacturing industry into a service industry. This means that the manufacturing industry becomes like the construction industry. In the case of the construction industry, one-third of the expenses entailed by a house are those that went into constructing it; the remaining two-thirds are maintenance costs that arise continuously while someone is living there.

In this way, the construction industry is a hardware industry, which builds homes. At the same time it is also a service industry carrying the function of continuously maintaining the residence in a state fit for habitation by human beings. Research to enable the manufacturing industry to be reborn into such an industrial type is currently proceeding in reality.

At present, the number of manufactured products that are required by law to undergo regular maintenance is surprisingly large and includes items like jet engines and elevators. The costs of regular maintenance can eventually grow higher than those entailed in manufacturing.

The longstanding common sense has been that a product's number one function has been manifested in good form when the item is initially made but goes bad with the passing of time. However, information technology has progressed, and the manifestation of functions is controlled by the software. We are aiming to develop artifacts bearing the possibility of expanding functions even farther in the future. We hope to give consideration not to functions when they are added on to artifacts but to positive maintenance that causes further upgraded functions to be manifested.

By actively thinking of maintenance, the manufacturing industry will indeed turn into a service industry. The artifacts produced in that process will quantitatively decrease by half. But they will, instead, have along life and give rise to higher added values; and the manufacturing industry will become sustainable.

Conclusion

Sustainable manufacturing in the 21st century can be achieved by two approaches. One is to develop methods serving toward the creation of designs with thought given to reuse and recycling from the very early stage. The other is to improve the functions of artifacts, while decreasing the production volume but maintaining the level of economic activities. This is feasible through redefining the manufacturing industry as a service industry to take wider life cycle issues into consideration.

While possessing a tangible vision about what sort of manufacturing system should exist, we have been creating a base of knowledge and information sharing using the Internet.

The Future of Motor Vehicles: Contributions from Volvo

Sören Gyll
Chairman and President, Volvo AB

(live via the Internet from Sweden)

The car has given modern man a mobility which earlier generations couldn't dream of. It has increased our freedom, it has improved the quality of life and it has impacted on our social structure like no other product. Transportation by means of commercial vehicles such as trucks and buses have had a decisive influence on social development and welfare, and the demand for transport will continue to increase. Over 70 percent of all goods are now moved by road and this figure is increasing continuously, so let's not forget the positive contribution to society coming from transport. We can't regard cars, trucks and buses only as problems. They are also solutions in meeting today's demand for cost effective and flexible transport. But to avoid any misunderstanding, let me add, the vehicles of today are not the solution to tomorrow's needs, which is why we are here today.

The negative impact on the environment is a serious and an urgent matter. The transport sector as a whole accounts for about 40 percent of the world's oil consumption. It is also one of the main sources of emissions of harmful substances such as nitrogen oxides, hydrocarbons, and carbon dioxide. But it is important that we remember two things: firstly, that the motor vehicle of today has a considerable lower negative impact than those made twenty years ago; and secondly, that there is still room for improvement even in the future.

The modern internal combustion car emits only one-tenth of the harmful exhaust gases the 1975 engine did, and during the same period, emissions of greenhouse gases have fallen by almost half. So the auto industry has done a lot and it's continuing to do so even in the future, but we can't do it alone. We need to deepen the cooperation across boundaries, national politicians, fuel suppliers, car producers, manufacturers, transport companies in a common effort to secure long-term sustainability. It is a huge task which we can all accomplish through technology and infrastructure, development of new energy sources and harmonized legislation.

Volvo's aim is to become one of the world's leading automotive companies in the environmental pursuit. To achieve this goal, it is essential to have a holistic view of how our corporation and products are impacting the environment. Every single employee must be involved in the effort to translate words into action. By 1997, more than 17,000 of Volvo's employees, suppliers, and sales personnel will have undertaken environmental training.

The Volvo environmental management system is being introduced in stages in order to control our activities in production plants. The life-cycle assessment, commonly known as LCA, is being adopted by our design engineers. LCA enables us

to evaluate the environmental impact of our products and production processes at every stage of the product life cycle: from selection of the raw materials through manufacture and use to disposal and waste management.

We know that 80 to 90 percent of the total environmental impact of a vehicle is generated during its useful life. Therefore, the development of cleaner fuels, more fuel-effective vehicles, new engine technologies and systems, and technical aids to the development of more efficient transports are of the highest priorities. The replacement of fossil fuels by other energy sources will be necessary to cut emissions of carbon dioxide and other greenhouse gases in the long term. Several alternative fuels with environmental advantages and disadvantages are available today and will gain in importance. The choice will have to be based on which problem is the most urgent to solve at the local and global environment level and of course on a number of practical aspects such as cost, distribution, storage method, management, and last but not least, availability.

Volvo is continuously evaluating alternative fuels when developing and testing new engines and propulsion systems. In addition to conventional vehicles, our products include buses and cars which can burn methyl, producing very low emissions of exhaust gases, and the methyl used is biogas produced by organic waste. The net additional carbon dioxide going into the environment is close to zero -- it is more or less eliminated. Since the potential availability of biogas is relatively high, it may well become an important complement to the conventional fuels. In Sweden, estimates show that sufficient biogas to fuel at least 500,000 cars could be available from only this source.

We at Volvo believe in electric hybrid technology and are beginning to develop that technology for the future. The great advantage of the pure electric vehicle is, of course, that it can operate at the zero emission level. The drawback, however, is from the energy storage capacity of the battery. Unlike other fuels of technology, there's little cause for optimism in this area. The basic technology of the battery hasn't changed since the turn of the century in spite of urgent, long, and significant research. For this reason, it is Volvo's opinion that pure electric operation is an option only for small cars for short trips.

Electric hybrid technology is a better option for large cars and also for trucks. This makes it possible to build vehicles that perform as well as our current products, but that can also operate with zero emission over a short distance. Volvo has developed a complete series of concept vehicles--the environmental concept car, the environmental concept truck, and also the environmental concept bus--to demonstrate and test electric hybrid technology. In our view, the alternative power source is a gas turbine (inaudible) internal high-speed generator. Basically the gas turbine can be fueled with any liquid or gas, including biofuels. The gas turbine produces less than a tenth of the nitrogen oxide emissions produced by the modern diesel engine. The vehicle is actually driven by an electric motor mounted on the rear axle for buses and

trucks and on the front axle for cars. The batteries are charged while driven and are used as a power source for the short trip in sensitive urban areas.

But we must draw and design the whole picture. The electric vehicles can have an adverse effect on the environment depending on how it's produced, for example, in fossil-fuel-powered stations or in nuclear power plants. The development of hybrid vehicles is ongoing at Volvo, and at present we are working to develop further series of vehicles for testing on a wider scale than we have done up to today. Further attention must naturally focus on developing vehicles for dense urban areas in which problems of traffic congestion, air pollution, and noise are the worst.

The need for more efficient and less harmful systems of transporting people and goods is obvious. In those areas there is enormous potential for reducing environmental impact by becoming more efficient. Less than half of the payload capacity is used in the typical delivery truck. We can reduce the environmental impact considerably just by using these existing vehicles more efficiently. This reduction could increase even further by replacing numbers of small trucks with fewer but larger vehicles. Communication systems for improving logistics through information on vehicle position, route planning and integration are essential if we are to reduce the number of deliveries without affecting the quality of service. Volvo's environmental concept truck illustrates the type of solution which may be adopted to meet this need.

Volvo also participates in several joint projects in order to develop more efficient transport systems. They are also involved in the development of transport management and integration equipment. In the field of passenger transport there is an acute need to take measures in order to eliminate congestion and reduce air pollution. We believe that the bus best meets the combined demands of environmental care, efficiency, flexibility, and economy in the future. The trend of building new satellite towns on the outskirts of our cities means that the former pattern of travel between city centers and suburbs will be replaced by community movements of a more disparate nature. This in turn means that the public transport must become more flexible in terms of routes and capacity in order to fulfill the purpose. The need for efficient public transport is even more urgent in places where rapid urbanization combined with inadequate infrastructural development has created large-scale environmental problems in acceptable standards of mobility.

The delegates to this conference include a representative from the city of Curitiba in Brazil, a city which provides a perfect example of what the bus can do in a properly planned transport system. In Curitiba, public transport is provided by buses in a system which has the same capacity as a railbound system but at a capital cost considerably lower. Since 75 percent of Curitiba's community use the buses on weekdays, the city's total oil consumption is 30 percent less than other comparable cities in Brazil.

This concept presents a major step forward in the development of sustainable transport. As more and cleaner fuels and engines are developed, the competitiveness of the bus will increase even more. Although most of the negative impact of our products takes place in their useful life, the feasibility of recovering and recycling used vehicles is also important. Already between 75 and 90 percent by weight of the materials and components in the cars and trucks can be recovered and recycled, and these figures will further grow.

Recycling, however, must be based on a holistic approach if it is to fulfill the purpose. For example, the environmental benefits of reducing (inaudible) fuel usage by recycling may be lost if the recycling process itself is energy intensive. Efficient systems must be developed to make recycling as effective as possible. One step in this direction is the ECRIS Research plant in Sweden which is owned by Volvo and a number of other Swedish companies. Here the most efficient recycling of cars is developed with the aid of life-cycle assessment.

In summary, the automotive industry has made major progress in the environmental field in the recent decades. The conventional emissions have been reduced significantly, especially through the introduction of the catalytic converter and the purification technologies. Fuel consumption has been reduced, cutting emissions of carbon dioxide. At the same time the number of vehicles has increased at a rate which threatens to wipe out advances achieved. Our vision of the vehicles of the future must be based on realistic assumptions.

We believe that there will be no revolutionary leaps which will solve all the problems at the single stroke. I think we will see a diversification of the fuel market, the introduction of extremely tough local regulations in a number of cities, and a series of progressive improvements in vehicle technology. I believe that in the long perspective, we can solve the emission problem and create a zero emission car, but doing that, we must be wary not to create elsewhere emission of cars.

In the nearer future, it is wise to explore the possibilities to reduce the negative effect by using the technologies already available or currently used, by improving the infrastructure to the best of our ability, and gain from experience already made in creating efficient transport systems. This is important and must start immediately, but we must spend more time and speed up the process, not leaving any party without responsibility. We are together, we will come up with the solutions together because we have to and because we want to.

Thank you for your attention.

Internet Discussion between the Congress and a panel at the Royal Academy of Sciences in Stockholm Sweden

Coordinated by Prof. Dr. Carl-Göran Hedén and Christer Salen

SALEN: Hello Chattanooga, here is Stockholm with a second input from Sweden after Mr. Gyll's talk from Gothenburg. Here, at a studio in Stockholm, kindly provided by Tele-2, a group of some 20 people are now looking forward to a brief little panel discussion. The topic is the future of industrial practices and settlement patterns if greenhouse gases will indeed deteriorate our climate - - as many scientists and the insurance industry now seem to agree. The transport sector is then often regarded as the main villain, so it was reassuring to hear Mr. Gyll's summary of the technical potential of the car industry when it comes to adjusting its products to increasingly stringent environmental demands and new research challenges.

In preparation for this panel discussion an international computer conference has been operated for a couple of months, so I would like to ask its moderator, professor Carl-Göran Hedén, who is now in Chattanooga, to provide a brief summary.

HEDÉN: The task of summarizing the computer conference is both simple and difficult. It is simple because I can refer you to a cub-link on the ZERI home page. There you will find the inputs from many of the 70 transdisciplinary experts who participated in this "electronic zooming" effort. On the other hand summarizing the conference is very difficult because of the wealth of the information provided.

The conference started with an emphasis on energy saving measures (replacing megawatts by "negawatts") and continued with general remarks on integrated systems and on biogas technology in perspective of development policy. It then concentrated on the three focal areas: 1. Physical removal of carbon dioxide 2. Photosynthetic storage and 3. biological sequestering of carbon.

As suggested from Alberta, concentrated carbon dioxide from power plants that burn fossil fuels can be economically disposed of at the tune of 50,000 tons per day. This would be done by pushing the gas down into oil and gas bearing strata in Western Canada Deep sea storage. This is a possibility that could be considered for other unique locations, but photosynthetic storage is certainly a more generally available opportunity. However, it must then be seen in the life-cycle perspective of products like buildings and furniture.

The carbon-sink aspects of increased industrial use of timber and other lignocellulosic construction materials will be mentioned tomorrow, so I will instead refer to some of the messages which concern efforts to use reforestation in order to offset possible climate effects. They concern the trading of emission rights and they are interesting for two reasons.

The first is that the trading approach has worked well in the U.S. when used to counteract acid rain by limiting the sulfur dioxide emissions from power plants that burn fossil fuels. Here the EPA fixes the emission limits and issues permits in such a way that it serves as incentives for technical improvements (Financial Times, May 6th 1996).

The second reason, elaborated in a Japanese contribution, is that internationally agreed levels would give developing countries a surplus that would spur their economic development, at the same time permitting them to join the fight against global warming. The industrialized world would start out with a deficit that would stimulate the development of technologies aimed at reducing emissions.

Even those of us who love the vision of the small bicycle city, with full multimedia service, find it hard to visualize how poor countries can side step the motorcycle, bus, car, and lorry phases for growth. The challenge for the industrialized world is then to help them use the best available technologies. And perhaps the trading of emissions rights might offer a win-win opportunity for people like Mr. Gyll if he decided to push for Zero-emission vehicles which are not only safe but also small, very light, and energy efficient. In a message from Toyota it was mentioned that the company is developing special trees as roadside sinks, and driving in from the airport I noticed that Chattanooga plants small trees between the traffic lines. Perhaps we will one day drive along highways with multipurpose short rotation forestry plantation between the lanes (serving as a bioenergy source, a biofilter, a protection against glare from meeting traffic and as a soft cushion when you drive off the road.

In the U.S. the EPA Green Lights program has estimated that every 10,000 kwh of electricity saved is like planting 2,9 acres of trees or taking 1,4 cars off the road. This is of course no small amount, so a conference participant noted that other plants might have economic advantages that would qualify them as carbon sinks particularly in arid zones like coastal deserts. It was also noted that a novel type of “cold water agriculture” might help to stimulate coastal development.

In such situations it is of course not only the plant material above ground which is important but also the production of soil. This is a more important carbon sink than most people normally realize. A note from the International Lignin Institute, for instance, noted that the carbon in soil humus is about 1.5 trillion tons, i.e. 3 times more than the carbon in the plant biomass and two times more than in the atmosphere.

From the conference I quote the following which concerns a salt-tolerant oil producer (Salicornia): “After accounting for carbon emitted from roots and the machines used in growing, there could be a net storage of some 4 tons of carbon per ha per year. If we assume a cost of 2500 U.S. dollars to develop a hectare of halophytes we estimate that an investment of about 700 dollars would build enough farm to offset the carbon dioxide of one medium size car. There is enough suitable coastal desert land to

offset about 300 million cars which should be equal to about the world car population if you assume a 10 year average life.

Soil is a resource that we are losing very rapidly as illustrated by the fact that in Sweden, where we try to keep track of such changes (P. Barnevik: "What gets measured gets done"), 20 Mton of carbon has disappeared from agricultural land since 1950; (=7 tons C per hectare). The loss of humus is actually a substantial component of my country's environmental debt. It does not require much imagination to understand how much new industry that would be generated from a commitment to the greening of coastal deserts.

SALEN: Since I have been involved in the Salicornia work I would now have liked to be able to call on Prof. Carl Hodges to revise some recent developments, but he is attending his sons marriage in Mexico, so I instead call on his associate, Mr. Platt, whom I have spotted in Chattanooga, to comment on the map now shown.

PLATT: Until this generation, technology has been able to keep up with food production, matching the population growth of the world. But that is no longer possible, it is no longer feasible to bring good land and good water into production at a rate to match the growing world's population and a new approach has to be taken. To achieve this, the Planetary Design Corporation is involved in halophyte farming. This is not taking traditional crops and making them grow in salty water, it is developing non-traditional crops that are able to grow in sea water. We are using the plant Salicornia, that Dr. Heden mentioned, as an oil seed producing crop and it provides an opportunity to bring economic growth and wealth to areas of the world which are only able to offer bad land and bad water. These are the coastal lands of so much of the developing world. In addition, this develops the ability to sequester carbon.

SALEN: Just to underline that halophytes work is not only a "high tech" road to coastal development I just want show a few pictures which form a link to professor Mshigeni's report from Africa.

I would now like to close this input from Stockholm by asking the president of the Innovation Institute, Mr. Sam Nilsson, to say a few words about the direct return of waste carbon to the soil.

NILSSON: Given the time constraints, I have to refer you to my input to the computer conference where I summarize how we have developed a slow release fertilizer by pelletization of co-composted household waste and sludge. The technique presupposes careful quality control and an efficient drying process. In the latter field we are now exploring further integration steps including solar heat from a greenhouse structure and a novel combustion technique (BAL) for the plastic residues (picture).

SALEN: With thanks for a stimulating exchange I now give the floor to Prof. Mshigeni

HEDÉN: Session Introduction

I want to start this discussion with a diagram from the ZERI Feasibility Study . It reflects the fact that all exponential growth curves, including those which are driven by competition, must one day reach a phase of "negative acceleration", Innovations then start to play a key role. Besides social innovations like Total Quality management (Zero defects), Just-In-Time (Zero Inventory), Comprehensive Maintenance (Zero failures) and Environmental Stewardship (Zero Emissions), we must then also keep an eye on the consequences of various enabling technologies.

First the microprocessor gave birth to the PC, and then came cheap lasers which gave us a dramatically increased capacity to store and transmit information. In the midst of downsizing, re-engineering and out-sourcing, we now hear of a new family of inventions (piezo-electric devices and micro mechanics) banging on the factory doors. They offer to give both our robots and our VR-control facilities a sensory system. No wonder that our politicians have every reason to look at structural unemployment as a specter which can upset even the best planning systems.

So, what can we then say about the next level of Zero Emissions? After having read the recent book "Limits to Competition" from the Gulbenkian Foundation, I am prepared to stick my neck out by suggesting that it will be "Zero Conflicts". There are many reasons for this, but I will pick out five factors:

1. Transaction costs become excessive.
2. Vulnerability increases and transport costs go up due to size.
3. Flexible mini plants appear close to culturally sophisticated markets.
4. A new generation of decision makers, including more women, enter corridors of power.
5. "Nature-oriented technologies" become adopted as a management strategy.,

If I am right in the prediction, a new growth factor (human resource management) enters the exponential growth curve. This will stimulate the appearance of life-long education centers that will help companies to become "competence magnets". By that I mean companies which manage to combine their obligations to the shareholders with care for their stakeholders. The latter are their employees and their families. I hope that this session will give some thought to the combination of social and technical innovations which such companies need in their function as generators of pride.

ZERI in Africa: Review of Concrete Results From Zero Emissions Research

Prof. Dr. Keto Mshigeni
Chairman, United Nations University's
Zero Emissions Advisory Council 1996-1998

Mr. Chairman,
Distinguished Delegates, Colleagues,
Ladies and Gentlemen:

1) First and foremost, I wish to express our sincere gratitude and appreciation to the visionary Rector of UNU, Prof. Heitor Gurgulino de Souza, and to the Founder and Director of ZERI, Gunter Pauli, for their commitment to include Africa as a partner in the ZERO Emissions Program from the very beginning. I believe that ZERI has a great deal to offer for the development of Africa.

2) The ZERI Africa pilot program has started in three countries. First Mauritius is fortunate to have Prof. George Chan, a graduate of Imperial College, London who has had considerable hands-on, down-to-earth experience in over 70 countries of the world. Secondly, Namibia, a country which became politically independent only about five years ago, whose President, H.E. Dr. Sam Nujoma, made a public statement in support of ZERI. Thirdly Tanzania, whose ZERI activities are effectively being coordinated by the Tanzania Commission for Science and Technology (COSTECH).

3) Interest on ZERI has also been expressed by Zambia, and by the Executive Secretary of the Southern African Development Community (SADC), based in Gaborone, Botswana.

4) Since the conception of the ZERI vision, we have identified a number of ZERI project activities in Africa. We are fortunate and grateful that the United Nations University has kindly agreed to support our efforts in Africa, and has facilitated our use of the vast experience of Prof. George Chan, who is playing the role of a catalyst and consultant in our various ZERI Africa activities.

5) I am proud to say that the Tanzania Sisal Authority has decided to go the ZERI way. Mr. Francis Nkuba, of the Sisal Authority, is with us in this Congress to share with you his vision on ZERI. I am also proud to say that Prof. Mohammed Sheya of the Tanzania Commission for Science and Technology is also with us in this Congress, to help you understand the ZERI coordination mechanisms in Tanzania.

6) In Namibia, as stated yesterday, we have one of the most exciting, unique stories to tell. The Namibian Breweries, a private company, has signed a cooperation agreement with the University of Namibia, to work as partners toward the establishment of a ZERI Sorghum Brewery plant in Tsumeb, Northern Namibia. And

the company has committed financial resources to implement this vision. I am delighted to report that UNU, through ZERI, has secured some supplementary funds for the implementation of this project. Yes, we are moving forward, in the ZERI way.

7) ZERI in Namibia came at the right time. It came as we were planning to develop a new faculty of Agriculture and Natural Resources at the University of Namibia. And we have declared the new faculty to be a ZERI faculty. The extension work of the faculty will go the ZERI way.

8) Also in Namibia, as stated yesterday, we have ZERI activities, which will help us promote sustainable development of Namibia's coastal resources. A project write-up on the realisation of this vision has been undertaken. This project will look into the possibility of fog-harvesting, promoting aquaculture and sustainable utilization of Namibia's seaweed resources. In some localities in Namibia, 20 to 30% of the people suffer from goiter and related iodine deficiency disorders, which include cretinism. Through ZERI, we shall promote community education and let the people know that a preventive cure lies right there in their marine waters. As many of you know, seaweeds are very rich in iodine. Currently Africa spends millions of dollars on imported iodized salt. I need not repeat here the immense support and encouragement we are continuing to receive from the Namibian Government, UNDP, UNU and UNESCO, towards the implementation of these implementation of these research projects.

9) As stated yesterday, the ZERI Africa program has shown big signs of hope and success, as my colleagues from the continent, and especially Prof. George Chan, will later elaborate. We already have project write-ups on:

i) What we are trying to do with sisal;
ii) What we are trying to do with bamboo;
iii) What we are trying to do with sugar cane;
iv) What we are trying to do with seaweed;
v) What we are trying to do with our various Brewery Companies; and
vi) What we are trying to do with water hyacinth, in the context of ZERI.

10) Ladies and Gentlemen,

In his talk yesterday, Prof. Hedén made exciting and encouraging remarks about Salicornia: a vascular plant whose seeds contain oil with very valuable, polyunsaturated fatty acids, which can be cultivated through irrigation of seawater, and which we plan to introduce as a new cash crop along the coastal deserts of Africa. Actually, we have Salicornia in Africa, still growing in the wild. In January of this year, when George Chan and I were in Tanzania's Tanga region, we identified two species of Salicornia: one growing erect, and the other prostrate. I have a few slides of these.

11) I therefore wish to conclude by saying, once again, that Africa offers great opportunities for industrial entrepreneurship.

THANK YOU.

ZERI: Perspectives from the American Scientific Community

Dr. Alvin Trivelpiece
Director, Oak Ridge National Laboratories

Thank you, and good morning, everyone. It is flattering to be asked to make these remarks, but I'm not really sure that I'm entitled to make observations from the U.S. scientific community on the subject of the industries of the future. In the first place, of course, the U.S. scientific and engineering community are seldom of a single mind on any subject, let alone this one. In the second place, I'm not sure that I would be elected to represent the scientific community of the United States even if I were nominated to do so.

Even so, this is a good occasion and gives me an opportunity to comment on some of the problems that have to be solved if industries of the future are to be more sustainable and perhaps less polluting. I'm going to comment on some of the tools that we have at our disposal to work on these problems. In particular, I'm going to focus on one tool with which I am most familiar, namely, the Department of Energy's Oak Ridge National Laboratory. On any scale, sustainable development is an enormous problem. It's going to require a great deal of work on many fronts for some time to make effective progress, but we do have many of the tools and we certainly have the need to apply them to improve the world in which we and our grandchildren are going to live.

However, before turning to some of these problems, I'm going to set the stage by reminding you of some of the fundamentals, like the three laws of thermodynamics. Now, don't say, Oh, no, he's going to give a technical talk; let's go out and get some coffee. Let me explain. The three laws of thermodynamics are a little bit like the games such as roulette or poker. The first law says you can't win, the second law you can't even break even, and the third law says unfortunately you can't get out of the game.

Now, these laws are the principal means by which scientists and engineers avoid having to explain to their next-door neighbor or good friend why his or her particular approach to a perpetual motion machine is not likely to be patentable. This approach avoids having to figure out exactly where in the process your neighbor has cleverly introduced some outside energy source, sometimes even without realizing it themselves.

On the other hand, laws of thermodynamics don't say that you can't do better than you're presently doing. Just because you can't win and make a perpetual motion machine doesn't mean that you are prevented from trying to get your machine to run as long as possible on the least amount of energy. That is, you are really entitled to try to improve your efficiency. Well, what prevents your machine from running longer? Friction? failure? wear? corrosion? supply of energy? Of course, I'm just talking about my problems now as I'm getting older and I try to run when I do some exercise.

I suspect that humans probably did not sit around the campfire and worry about the three laws of thermodynamics. Even if it did govern their existence, they burned wood without regard to how long it was going to last, they hunted game to extinction and they moved on, or they became extinct themselves. Climates changed, natural disasters occurred, but whatever they did, they did not have a big influence on their environment, and sustainable development was probably not part of their daily concerns.

But occasionally when times were good, they probably did sit around the fire in the cave and perhaps discuss the fundamental properties of matter. Of course, they only had four elements to deal with--earth, air, fire, and water--so their discussions probably didn't last too long or become too theoretical. Now, the four-element theory worked well through the stone age, but with the bronze age and iron age, it was recognized that you could heat certain kinds of rocks and produce materials that had certain desirable properties, but even these materials were subject to wear, corrosion, and failure.

Now, a broken sword or spear was probably more than a minor nuisance, it could mean death, so there probably was a great effort to improve materials right from the very beginning. This created the need to have an improved understanding of the properties of materials and the science that governed them. The efforts to understand the physical world eventually led Democratus, a Greek philosopher around 400 B.C., to propose that matter was composed of minute individual particles that cannot be divided, even though they differ in shape and arrangement and position. The supply of atoms in the world today is roughly the same as for Democratus, apart from a few meteors that have hit the earth since then and some elements produced since the dawn of the nuclear age.

The early efforts to concentrate elements led to more organized mining and manufacturing. There is in fact today lingering evidence of the effects of the ancient Greek and Roman smelters on the environment. Lead has been found in Sweden and Greenland in amounts rivaling gasoline as a top lead pollutant. This is a legacy of smelting of some 2500 years ago. Since then, of course, science has made various advances. The dream of alchemists to turn lead into gold has been realized but only at great expense and with the use of machines that were certainly beyond the imagination of ancient civilizations. The atoms that we concentrate and refine today may be the pollution of tomorrow if we're not careful.

Not so very far from here in the state of Tennessee, copper was discovered about 1843, and within a very short time, mining towns and camps emerged with names like Ducktown and Copper Hill. The towns are still there, but much of the local vegetation was destroyed from the mining process and has never returned. The present view of this area is one that is hauntingly beautiful. The yellow and red hills devoid of vegetation are scattered among the green reforestation efforts of the last half century. These same atoms of lead or other materials emitted during processes of thousands of

years ago are still around today. The pollution in ancient times had an intense effect on fauna and flora, perhaps even more than what is emitted today. The industrial processes of the past have not been environmentally benign.

As each generation has grown, it has developed its own awareness of what is important. Its goals are not those of its predecessors just like the goals of our children will not be the same as ours. Clearly, what was acceptable to the ancient Greeks and Romans is not acceptable today. We're not going to solve the problems of pollution by simply moving our pollution from one physical location to another. We will not solve the problems of pollution by stopping the march of progress. We will not solve the problems of pollution by refusing to create the body of knowledge that would help us advance the state of the art in various areas of science and technology.

What if we could make parts that did not fail or corrode? What would that mean to the United States alone? The National Association of Corrosion Engineers has estimated that corrosion costs $300 billion per year in the United States alone. This represents about four percent of our nation's gross national product. They also estimate that about 100 billion of that loss could be prevented by simply applying the anticorrosion technologies that are available today. It's also estimated that the failure of parts costs another 200 billion. If we could eliminate wear, failure, and corrosion, we would not have to make as many parts.

Can we do this? Well, of course not. The laws of thermodynamics tell us that, but as I said earlier, they also tell us we can do better. We can reduce wear, failure, and corrosion primarily through a better understanding of science and technology. To do this, we need to have collaborative efforts that involve universities, national laboratories, and industry working together to achieve these scientific and technological goals.

Speaking now not for the entire U.S. science community but for just one national laboratory, let me tell you about one example of how basic and applied research can lead to better materials. The laws of thermodynamics also tell us that if you want to improve the efficiency of heat engines, you must operate them at higher temperatures, but then, of course, the problem is that materials fail easier, wear out faster, and corrode quicker at higher temperatures. Well, some years ago, since ORNL is an Energy laboratory, Department of Energy laboratory, began a program to try to better understand the properties of materials at higher temperature. It was decided to focus on metals and ceramics. This effort led to the establishment of the High Temperature Materials Laboratory at ORNL. It is widely called the HTML, and I know that some of you here in the audience had the opportunity to visit this facility earlier this week.

One of the benefits that grew out of creating this facility was that people came to visit from time to time, and one of the visitors was a former employee of the Oak Ridge National Laboratory. He happened to have with him a small bottle of burned risols. That's interesting. He and a colleague of his at the laboratory, HTML, mixed these

burned risols with some clay, aluminum oxide, and fired them to make a ceramic. Turned out this material was surprisingly hard and tough, and because the laboratory was there, there were the tools to make that measurement and there was also some theoreticians who were prepared to try to understand what caused it to become tough.

Well, the first question you might ask is: Why did this individual have with him a bottle of burned risols? Well, the southern part of the United States produces a lot of rice. The milling of rice produces risols as a waste product. The visitor to the laboratory was just trying to see what he could do with a waste stream that might be useful. The second question you might ask is why does mixing burned risols with the same raw material from which delicate china is made produce such a tough material? To answer this, let me remind you that concrete is very strong in compression but very weak in tension. To make it strong in tension, tension iron bars are buried in it. Turns out that burned risols are filled with microscopic silicon carbide fibers, and they do the same thing for ceramic that the reinforcing bars do for concrete.

This Edisonian discovery at the lab was perfected, and today many high-strength materials made of ceramic parts using the so-called whisker-toughened ceramic are common. Now, Henry Ford dreamed of building a car with materials derived from vegetables. I think Mr. Ford would probably have liked ORNL's high-tech structural ceramics. The whiskers are now chemically synthesized, so the original scheme to use burned risols was a failure, but the outcome was otherwise a great success.

Parts now made from ceramic composites are lightweight and very strong. Detroit Diesel Corporation, for example, expects its silicon nitride engine valves to last some 300,000 miles. Advanced ceramic composites based on the ORNL work are also being used to make diesel piston rings, fuel injectors, push rods, cam roller followers, and high-performance turbocharger rotors. They're used in jet engines, and many of the fastest machine tools, such as cutting tools for lathes and milling machines, are made from this whisker-toughened ceramics, and if the uncooled gas turbine engine ever begins to replace the internal combustion engine, it will be built of ceramics. That's the only material that can hope to withstand the 1400-degree C. temperatures. This will improve efficiency, reduce pollution, and increase the time between when parts have to be replaced.

Perhaps one of the most interesting uses of the whisker-toughened ceramic is in the manufacturing of aluminum cans by Coors and other companies. The ceramics are used to form a ring around the inside of the die through which the aluminum sheet is driven to form a can. It's very important to have the right characteristics on the surface of this die so that you avoid making scratches in the can, particularly when you're making millions of them every day. I understand that Coors has to make three million cans before it makes its first nickel of profit. The die with the whisker-toughened ceramic insert in it weighs less, so less energy is used to punch the can. The ceramic material requires less lubricating oil, so there is less oil to dispose of in the process. The

ceramic die produces better cans with less wastage so less aluminum scrap is produced; all in all, a rather interesting benefit.

I could go on with a lot of other examples from ORNL or other DOE national laboratories or from university research programs or from industrial programs, but my point is not to give you an extensive list but rather to illustrate the process by which progress has been made and the key roles that various institutions must play to bring about this progress. It's my opinion that the DOE national laboratories play a unique role in this national science and technology infrastructure. Their ability to conduct large-scale, long-term, integrated research projects has produced a remarkable set of contributions that range from fundamental scientific discoveries to commercial products that have improved national security, economic productivity, human health, and environmental conditions.

The success of the national laboratories in applying science and technology to national challenges derives in part from the special organizational structure that supports long-term, high-risk, problem-focused research and development, particularly on a scale larger than most universities have been traditionally used to managing. Secretary of Energy Hazel O'Leary, who will be our luncheon speaker today, established a task force on alternative futures for the Department of Energy's national laboratories. The report of this task force, which was delivered a year ago, said, "One of the great strengths of the multiprogram laboratories derives from the diversity of technical expertise that can be brought to bear from within these laboratories on specific scientific and technical challenges."

Well, part of this success depends in part on being able to team with members of industry and universities. A decade ago, there was very little teaming with the DOE national laboratories. Today, over 4,000 guest scientists and engineers, one-third of whom are from industry, come to the Oak Ridge National Laboratory as guest scientists/engineers to work on research programs. We are also increasing our international interactions and now more than 800 scientists and engineers from 80 countries spend significant time at the Oak Ridge National Laboratory.

In closing, I want to stress that ORNL is only one of the institutions that are needed to make progress in achieving goals that will result in reduced emissions of pollutants. Universities, industry, and national laboratories in the United States and their counterparts around the world need to address the problems that are the focus of this conference and to use cities like Chattanooga as living laboratories to achieve reductions in pollutants and greatly improve the quality of life for everyone.

General Motors and the car industry

Dr. Robert Williams

Chairman, Design and Manufacture for the Future General Motors Corporation

Good morning to you all. It is certainly a pleasure to represent General Motors and the auto industry in telling more of our story to, I think, bring to light some of the progress we're making to achieve the goals that this conference is all about. I may have the same difficulty that Richard had in speaking too rapidly, and I will try to keep my presentation as carefully thought-out as I can.

Let me start out by saying that the presentation that I will give is an attempt to mesh together the programs and initiatives that we have initiated at General Motors with the network of our supply community and the associated companies that work with us to carry out a very extensive collective effort at improving our industry and moving toward zero emissions. I will talk about several eco-efficiency items that General Motors has initiatives and programs in, touch on energy and even on sustainable communities' involvement that we have, and then turn to cooperative efforts across the industry, highlighting vehicle recycling and making mention of life cycle assessment and environmental management systems. And I believe all of these issues have been touched on by other speakers, and it is perhaps most important that I share the specifics of the auto industry.

The intent of these initiatives and programs is to promote sustainable business practices, to conduct open discussions on policy issues, and we certainly have changed in that fashion in our company, to develop industrial ecology in vehicle manufacturing, and to move from pollution prevention towards zero wastes and zero emissions across the product life of our automobile products.

For example, in the case of energy, we see the need to rapidly bring to stabilization and then reduction the production of CO2. We as a company are carefully monitoring all electric power usage in our manufacturing facilities worldwide. Our Opel unit in Germany has volunteered a 10 percent reduction over ten years in CO2 emissions. In terms of vehicle emissions in the U.S., we see our regulations really at a point of diminishing returns, and perhaps more importantly, to propagate those low emission levels across the world requires significant attention to fuel quality and the infrastructure needs in developing countries.

Across transportation system design, we think it's really critical to apply full cost accounting to the users of transport modes. Whether you flew here, drove here by car or walked, there are certain costs that need to be applied to the mode of transportation that you use, and it's the comprehensive costing which will really give us the best ways to make decisions.

In the area of alternative fuels, we as a company have been involved in a vast variety of alternative fuel exploration studies. We conclude that ultimately electricity will be the primary power source and very likely in a hybrid combination as the Volvo

speaker indicated. Energy efficiency really has to cross our entire business, including the initiation of new processes and equipment to increase the efficiency and reduce the energy consumption, but we also see a need for a strong U.S. national energy policy, one that would be related to supporting the cost-of-service pricing and to deregulate in those areas that still are too tightly controlled.

Some eco-efficiency issues are really brought out by the range of stakeholders that we must report to: our stockholders, our board of directors, our customers. We begin by employing strong education programs with our own employees through the total quality program that we call Quality Network, doing extensive training in pollution prevention at the plant level. Our GM Environmental Report, our annual report which is our report card of progress in reducing emissions and wastes, is publicly available as one of the conditions for the mutual endorsement of the CERES principles. That is another means of full public disclosure of our environmental record. We have a number of collaborative efforts and I'll touch on a couple of them: the U.S. Council for Automotive Research, U.S. CAR; the National Center for Manufacturing Sciences; the Program for a New Generation of Vehicles; the President's Council for Sustainable Development; the CERES Principle; and the Nature Conservancy, these are all cooperative efforts to bring focus to the issues and to begin to apply them.

Across this, we really see the need to open up the issues on a life cycle management basis, to make the vehicle development process an instrument by which we enhance the environmental properties of our products, and we have in place a series of environmental statements of work in the design of new vehicles and approval gates which assure that each new product rises to ever higher levels of environmental value.

I would like get to an issue that I think we've touched on in the conference, and that is the one of looking across the entire product life cycle in considering wastes and emissions and to understand that there are strong interactions among these separate phases; that what we do and decide in design dictates the processes and materials that we use in production; that the products we build have a long lifetime and create wastes and emissions during their use as well as an increased concern for end-of-life vehicles, end of product life; and the connection between the materials which are available at the end of life and the manufacturing needs for production.

It's important to emphasize, I think, the current success in vehicle recycling as was mentioned from Sweden, that currently 75 percent of the mass of all vehicles is indeed recycled, returned as raw materials. The recovery of end-of-life vehicles is rather impressive at greater than 94 percent. This far exceeds the recovery of other consumer products such as aluminum cans, paper, glass, and plastic. The reason for the high recovery rate is the economic value. Parts can be removed from end-of-life vehicles and resold. In the U.S., this is about a $3 billion per year business. After parts are removed, the body or hulk of the vehicle can be crushed to increase the load-carrying capacity of the transports which haul them to the reclamation facilities, the large shredder operations which can quickly reduce the mass of a vehicle into fist-sized

shreds of metal for easy recycling and the generation of a corresponding pile of nonrecyclable material.

The mass of waste material from both the U.S. total municipal solid waste as well as the fluff or automotive shredder residue waste is in the millions of tons, which we can look at as both big numbers and small numbers depending on the perspective. We're talking about one million tons per year of automotive plastic which currently is being landfilled. We can look at the automobile from front to back in terms of the materials that are recycled. Certainly the ferrous metals and nonferrous metals have a great value in returning to the manufacturing facilities, and then the automotive shredder residue which is currently being landfilled and is the target of much of the research worldwide to increase the recyclability of vehicles.

The reason that we got into this issue of having components and materials on board which are not recyclable is illustrated here. If one looks at the energy consumption by the production of materials and their implications in use on a vehicle, we can see that steel is rather low in energy content in the manufacturing stage, but since it is heavy, it increases the energy use as we travel around in those vehicles. On the bottom, aluminum is illustrated. Aluminum is very energy intensive in manufacture but is a lightweight material. What we've done then is to sum, in a life-cycle-type summation, the manufacturing and the use phase, energy consumption, and we see that plastics, the RIM, the SMC, GTX, are the lowest energy users overall, and this has driven the industry to use plastic and composite materials.

This is the beginning of it, a 1955 Corvette, and an illustration I guess that we did and still do build products which can last a long time. This has led to the ever-increasing use of plastics and composite materials in vehicles, surpassing 10 percent of the vehicle weight just last year. This is the Saturn vehicle built in Spring Hill, Tennessee, with all the vertical panels made of composite materials.

As we look at the life cycle management of automotive polymeric materials, we have the opportunity to reduce resource uses and energy conservation by the very fact of their low mass. We find that their reuse and repair is superior to metal parts. The recycling depends on grinding up that used plastic and remolding it or reclaiming the carbon content of the plastics for fuel and for fillers. One of the favored means for doing this energy recovery is pyrolysis by which organic materials are decomposed at high temperature in the absence of oxygen. This is a self-sustaining system being heated by the pyrolysis gas produced and generating an excess of gas and oil that can be recovered and used. The issue is not a technical one. It is feasible to pyrolyze plastic and recover fuels and oils, but is it ecologically, economically, and environmentally acceptable and superior to other means of recovery?

We are interdependent in our industry, as I pointed out at the beginning. The original equipment manufacturers must satisfy the customers' needs. We also must work with suppliers to make our products possible. We must close the loop at the end

of life of our products when the customer no longer has use for them, returning them to a dismantler who can profitably remove parts and recover materials, returning the mass of materials through the shredders back to the manufacturing system.

In order to enhance our capability in this area, we have formed a number of research partnerships under the banner of U.S. CAR, the Council for Automotive Research, in particular the Vehicle Recycling Partnership, which is a joint effort by Chrysler, Ford and General Motors. The research activities of this group is housed in a Chrysler facility in which materials are looked at very carefully so that we understand the issues involved with the further recycling of vehicles; to interact, to open up the interactions with the other entities involved in profitable recycling; to conduct research and development; to recycle materials and components from scrap vehicles; and then the last bullet, perhaps the most important, to develop guidelines for the design and material selection that we use in future vehicles.

And this is a simple but common story in industrial circles in the U.S., but one that must be told and retold. Here, for example, the folks are looking at polyurethane foam recovered from seats and put back into new vehicles. In the area of fluids recovery and removal, we have researched and gathered equipment worldwide to determine the most efficient means to recover the fluids from the vehicle at the end of life, not only the engine oil but the radiator coolant, the windshield washer solvent, the brake fluid, so that none of these fluids are returned or included with the landfill material but instead are recovered and reused. Even the carpeting in the vehicle, and this is an opportunity that we hope to continue pursuing, the carpet material can be recovered and reused as protective material on the backing for future products.

I want to point out that this vehicle recycling issue is indeed an international one. The Second, or the Third International Workshop on Car Recycling will be held next week in Detroit. We will have representatives of all of the major vehicle manufacturers around the world to generate some written papers: first to finalize a common concepts paper, which is an understanding of the means to achieve increased recyclability in vehicles around the world; and secondly, to recognize some significant regional differences between the Americas, Europe, and the Pacific, such that we formulate a plan to promote the recycling of vehicles, to do so in recognition of the global nature of many of the vehicle manufacturers, and at the same time recognizing the regional differences which stem from regulatory, economic, and social differences in the major regions of the world.

So we feel we are on track, making progress, and I'm catching the enthusiasm, even more as the hours go by, about the feasibility and the reality of ultimately achieving zero emissions.

The Metal Industries

Kaichiro Ogihara
Director, Ogihara Corporation

My name is Kaichiro Ogihara. I am one of the board members of Ogihara Ecology. It is a great honor for me to make a presentation on behalf of T. J. Ogihara at this World Congress hosted by the United Nations University and the City of Chattanooga.

Ogihara Ecology Corporation was established in 1995 by T. J. Ogihara who is my father and also the Executive Vice President of Ogihara Corporation. Ogihara Corporation is our parent company, located in Ota City, Japan, and is well known as the world's largest independent tool and die company for automobile body panels. Through tool and die and automobile related business experience, T. J. Ogihara has been thinking and investigating how to eliminate and reduce waste and recycle many of the items which are being used for automobiles.

T.J. Ogihara's and our goal is to strive to contribute to "ZERI" (Zero Emission Research Initiative) of the United Nations University so that "ZERI" principles are practiced all over the world through green technology such as:

1. Vacuum Evaporation and Recovery Technology (Vacuum Furnace)
2. Water treatment (Suikai Balancer)
3. Pyroligneous acid (wood Vinegar Extraction)
4. Waste treatment (Municipal Waste Treatment Technology)
5. Recycling (Can Recycling Technology).

At this moment, I would like to present an introductory video of Ogihara Ecology.

"Video Proceeding" 8 min.

As you saw on the video, we have a number of recycling systems that contribute to improving the environment and adding value to the wastes. One of the examples is the Vacuum Evaporation and Recovery System. We started our R & D activities on this concept a decade ago. This system has been proven to be capable of recovering 99.86% of pure zinc and over 99% of pure lead, aluminum from automobile shredder dust excluding engine, window glass, tires and seats. Any coated automobile metals can be processed through this system. The system has also proven to be effective in recycling aluminum foils and printed circuit boards. It can also accommodate various kinds of batteries such as manganese, cadmium, alkali, mercury, and removes all such ingredients for recycling. This system also proved to make economical sense for the recycling business in Japan. So, I would like to present our specific Vacuum Evaporation and Recovery System on the video at this time.
"Video Proceeding" 4-5 min.

We have not yet introduced this system to the other countries, including the United States of America. However, a number of companies and industries have expressed their interest in working as partners. We have other systems to offer to suit individual needs. Most of our systems have been patented and others are pending approval.

Due to the time limitation, I would like conclude my presentation without going into the details of our other recycling systems. However, during this 3 day session if you have any questions regarding any of our systems or about Ogihara Ecology Corporation, please feel free to contact us at any time.

Thank you very much for your interest in our efforts to support "ZERI" and sincerely hope this initiative is fully understood and sustained by everybody assembled here. Thank you again for your patience and interest.

Keynote Luncheon Speech

Hazel O'Leary
Secretary, U.S. Department of Energy

(The following is a literal transcription of the live speech.)

Good afternoon. As you can imagine, I am having from time to time all sorts of run-ins with all sorts of people who audit things. The latest thing I've been accused of is coming to a meal function and not reducing my per diem charge for the meal I eat. Please note that I normally don't eat a meal because I'm trying to figure out what I should say. I didn't eat anything this morning, so those of you who are at the front saw me eating my meal, so please rest assured I will deduct from my per diem the value of the meal.

I began this discussion to let you know that not only am I aware of the real challenges which Marilyn Lloyd has so eloquently articulated, but in today's public arena, as the Wamps well know and as Marilyn and anybody who is serving knows, the business of getting your work done often carries with it very special and unique burdens that we couldn't have conceived of twenty years ago. What I've done with those special and unique burdens is learned to laugh at them and to stay on course and to get the job done, and I know that in Chattanooga, you have learned to do that as well, because what we do with criticism or what we do with the realities of the facts that present themselves to us on any occasion is to ask ourselves what are our values, how do we build a coalition around our values which then help us to solve our problems, and this reality is no more apparent than in the city of Chattanooga where leadership in the city has always involved values first, which drives solutions.

And I want you to know that I know a little bit about Tennessee. I had the privilege and the pleasure of having been schooled for my undergraduate tutoring at Fisk University in Nashville, Tennessee, so I understand where Chattanooga had to come from in the sixties, having been dubbed the dirtiest city in America, and where it stands today as a leader, and first of all using the values of the state and the city to drive from that reality through the vision of sustainability, which I suspect, Wayne, no one even knew what to call it then. More importantly, this has been done in a collaboration, first of all, with all of the citizens of Chattanooga which is kind of the, maybe the way of the Volunteer State to just involve everyone, and then to use business and use academia to drive the vision.

What I like, and has been averred to and I'm sure others have said, is that Chattanooga is now the turnaround city in the United States of America on issues involving sustainability because I want to go further than the environment. For that reason I need to congratulate all of the people in this room and recognize the leadership from ZERI and say what better place than at this luncheon than to bring together the Chattanooga Summit, focused on high quality, high value, meaning high-paying jobs, through the use of technology to bring back what has always provided the jobs, which

quite frankly is the manufacturing sector. I want to marry that with ZERI because it belongs so, because the only way you approach the issue of zero emissions is to ask the question: How do you drive that reality?

And as Congresswoman Lloyd has pointed out and looking right in Al Trivelpiece's face, I only know one way to drive it: not in a car, but to drive it with science and technology, because those are the tools of change, and interestingly enough, while they're the tools of change for the manufacturing sector, they're also the tools of change for medicine, and I believe that they're the tools of change for lifestyle as well, but we don't like to talk about that.

I wanted to start by introducing those of you who have not met them to the delegates from ZERI, and I'd like you all to stand up because you really are a part of this party.

(Applause.)

Bravo. Welcome. How nice to see you, thank you. Yes, I know, and I'm delighted to see you again, Mr. Rector, delighted to see you again. The reason that's important to do -- please be seated now, thank you very much. The reason that's important to do is because this ties so beautifully on either sides of the themes of the two conferences. I really love it that we're sort of just separated by this very thin curtain because that curtain isn't real to us. The goals of this Summit and the goals of ZERI are in fact the same, and I wanted to take just a moment to place them into context in Tennessee because that's where we are. Why did ZERI come to Chattanooga? Obvious. Because Chattanooga has not only opened the door to the vision of sustainable development, sustainability, and zero emissions, but also because Chattanooga is recognized as a leader in delivering on the goals of sustainability.

If I had a theme here, it would be the interstate connection between Oak Ridge National Laboratories, which just happens to be one of the Department of Energy's laboratories, and the city of Chattanooga, and the goals espoused by these two groups; and why would that be? Well, we've already heard about why Chattanooga, because of the vision, it has a leadership in recycling, it has the largest fleet of electrically powered buses now making downtown Chattanooga a marvel, it has the record for developing housing that is beginning to be sustainable and meets the needs of so many people, and indeed pulling around this issue that's put Chattanooga on the map.

So what would be the connection down the interstate between Chattanooga and its goals with the ZERI goals and Oak Ridge National Laboratories? You've heard from Al Trivelpiece today. Where's Al? Stand up. There he is. This is the guy with the technology, has he got the technology for these issues, and been a leader in using this laboratory to bring technology to solve problems of small and large businesses within East Tennessee. For the people in the business community or the people in the academic community who have used this laboratory to good advantage, and that sometimes means the bottom line, profits, because without profits we can't get it done, would you just stand up because I think people need to see how many people run that

interstate between Oak Ridge and Chattanooga, or Tennessee generally. Anybody worked with this laboratory, stand up. Somebody's worked with this lab. I dare you to stand up. Thank you very much. Thank you.

(Applause.)

Wow. I would hope that by the end of next year when ZERI's meeting at another place and when the summit is held in another city in Tennessee, that more of you will be here and be able to stand because of your engagement with our laboratories.

I just had on this board over here a few of the logos of businesses in Tennessee that do work with Oak Ridge and recognize that Oak Ridge through its manufacturing center has the capability to answer most of the questions involving how we meet what seemed an impossible goal, which is to deliver on the economic challenge of the 21st century with new but tested technology that meets the goals of zero emissions or something close to it, and does it while at the same time providing equity. And later on if you have a few moments, if you have some opportunity to look at the logos, you will see Mitsubishi, you will see ABB whose CEO spoke to the ZERI people on yesterday, you will see DuPont, you will see the Challenge for Sustainability as well. You will see many partners, you will see Saturn Motors, many partners working with the laboratory to get at its expertise.

Now, what could that expertise be and where did it come from? This laboratory with its history in helping us win what was then called World War II, subsequently the cold war, which now drives this nation to provide the international leadership that is felt so strongly in the challenge, especially to France, that we as nuclear power nations could finally declare an end to nuclear weapons testing, that finds us now in Geneva with all of the nations of the world in conference to begin to finish the deliberations so that we can sign a comprehensive test ban treaty. Okay. Now, how does all that happen and how does Oak Ridge on that history get to deliver what they deliver today? I'm over here to tell you that this national security mission continues today, but from that mission come these valuable tools that drive the goals of this summit and the ZERI conference as well: sustainable technology.

Someone said, Well, why would you call it that? Well, people don't understand pollution abatement; it sounds better anyway. But when we talk about sustainable technologies, we really are talking about technologies that are not wasteful. That sort of expresses it in the idea that perhaps we design things to consider how to prevent pollution as opposed to how to throw something on the smokestack to stop it once we have created it. That's very simple language that --you know, my test for this thing has always been: Grandmother has to understand. That technology again comes out of our national security mission now of 50 years, 51 years in fact.

Information technology, if I were going to talk about that in another way, I'd talk about the power of computers. I'd talk about the kind of computers today that are so strong that they permit us to begin to do the thinking at one time for thousands of people so that we can answer in a second, less than a second, in a heartbeat and the

flutter of a heart, issues that five years ago would have taken five people a year to try and solve. That's what we mean when we talk about information technology: powerful use of information bringing many solutions to the table to be solved in one simultaneous sweep. That's the best way I know how to explain it: thinking to solve problems faster than a bullet can move, problems that would have taken years to solve 20 years ago. I think that gets it.

How about advanced manufacturing? When you build this nation's supply of weapons after you have created the material to do so, you're really in a manufacturing plant because you're building things, and so when you talk about the manufacturing sector, that's the value that Oak Ridge brings to the table. Now agile, now assisted by computers, now really using the best technology in robotics to get the job done, this is some kind of marvelous miracle.

How about biomedical technology? I've talked about using computers. Let me talk about another implement. Am I going to have to explain this? Let me just get this out of my hand. Often when we talk about biomedical power, we forget that nuclear medicine, 100 years old this year, also came out of this -- I'm telling you this is tough work, this mike is really deadly. This is called an endoscope, and trust me, I don't know how to use it but here is what it does. It gives you a noninvasive look and an ability to treat cancer of the esophagus. If anybody remembers that we lost Carl Stokes, the first black mayor of Cleveland and more lately serving our administration too as an ambassador, was undiagnosed. This machine, without invasion, without surgery, takes a look at the esophagus and lets us know what's happening and prevents, through early detection, cancer that could be life-threatening.

If you don't like that implement, how about using a computer-assisted mammography that early on can detect the smallest cell that couldn't be seen by the eye, and more importantly we can use one of these computer-assisted mammagraphies to get the answer sooner for the smaller tumor and, more importantly, zap that information to some other research center where a diagnostician, a radiologist, can read that information and zap it right back to a community maybe in rural Tennessee. All this stuff is coming out of this jazzy lab of ours.

I want to stop for a minute and talk about Tennessee industries. The major industries in manufacturing which provide the lift to the economy for these high-paying jobs that we're looking for are textiles, not a surprise, but a tough industry which has taken a hard hit because competition from other nations with lower costs are beating us out of the marketplace and very close to a half a billion jobs have been lost in that industry in the last 25 years. I'm going to come back to that, important industry to Tennessee.

How about printing and publishing? There's some of the printing is done because so many of our religious institutions and from that has grown an expanding

base of publications as we all need to read in very tiny issues where we have an interest these days because we're all so specialized.

Or transportation, which is something we have got to solve and we've been working on with a clean car to reduce energy consumption -- let's own up to it -- gasoline consumption in automobiles. That work gets done at Oak Ridge, some of it.

How about forest products? Improving, again, the productivity of our forest while at the same time making sure that we're not clear-cutting, and we're creating a factory, a plant, if you will, for the creation of pulp and paper that is less energy consumptive, therefore more profitable, and is sustainable at the same time. All this needs to happen in Tennessee and it's going on in our laboratories.

I have one little picture and the benefit is to these five people in this corner who can see this picture, but nonetheless, I have a picture. Our national laboratories, some nine of them including Oak Ridge, have what we call a cooperative research and development agreement with the entire textile industry, the entire industry, vertically integrated from the cotton grower right down to the retailer and Sam's Clothing Store. Why? Because in order to get these jobs back or to hold the jobs we're losing, we have got to do a better job; and you know where we do that better job? In pollution prevention, in just the kind of technology Chattanooga is interested in, and it benefits Tennessee.

What we have here is called the CAFE. It's the computer-aided fabric evaluator. This loom helps in the creation of the fabric by seeing, before it occurs, the fault in the weave. Not a bad idea because it doesn't become a second. We now got high quality. Not bad. It does something else: It prevents the use of too much water, which again is a pollution issue and a sustainability issue. If you can reduce waste by 10 percent, we get jobs back. You can use that computer capability to help the retailer by sending information about what people bought or ordered last week so that he or she are not stocking their shelves, which means that of course we can't go to the discount store anymore because people got what they want, but in the long run,that makes more sense.

Well, where is somebody who's shaped differently at the top than at the bottom? Maybe all of us? Using that same assistance from the computer to walk in the store and say, I like the red dress but I was thinking this time about having navy blue. Yeah? But I want the same dress and, oh, by the way, I've lost ten pounds. Stepping into a computer, some little room that reads your body, God forbid it should tell anyone, and three days later you get exactly what you want. Those are the things that are happening in the laboratories to make us much more competitive and at the same time to protect the environment.

And I can take this walk, but I won't do it, to almost any commodity, any one of the manufacturing sectors, and tell you that science and technology makes it all

happen. From the basic science that Marilyn Lloyd talked about, which is the how do I explain that, it's the imponderable why do things happen or I think I understand the theory, to finally I understand the theory, now I've stopped wondering, now I know; and how do I take that knowledge and apply it to something that affects people's everyday lives. I don't know if Al Trivelpiece would approve of that, but that's what I call applied technology. It takes the science, the imponderable basic scientific question, and now gives you the answer which you apply to automobiles, which you apply to fabrics, which you apply to manufacturing.

How do we know we're doing any good with that stuff? You know, is the endoscope the only thing going? Is the CAFE loom the only thing? No. Let me tell you how we know how we're doing with this stuff. There's something called the R&D 100 Award, and in this R&D 100 Award now for thirty years -- actually I could do 1995, but this is an old chart because I'm saving money -- what you need to know is that every entity engaged in producing applied technology who thinks that their company or their laboratory has a new technology ready to be deployed which assists the lifestyles of people and helps us in our international quest for cleaning the environment, for quality of life, for being healthier, gets submitted to this R&D 100 Award panel and every year awards are given.

What you need to know and Al Trivelpiece wants me to tell you is that Oak Ridge National Laboratory leads the pack in the laboratories within the Department of Energy in winning these R&D 100 Awards, and more importantly, the Department of Energy's national laboratories lead all entities in the number of R&D 100 Awards acquired, and by that I mean GM, GE, the Department of Defense. You name the entity, the national laboratories have the edge. Why should we care? Because you can take this powerful force and use it to drive our vision of the 21st century.

Someone talked about arming themselves. I forgot exactly what Wayne said, but it sounded to me like, Get your gear on because we're about ready to go to battle, and I know that doesn't mean we bring guns, but it means we bring the technology; because as the United States of America won the hot war and the cold war and won the economic competition for the 20th century, so must we win it for the 21st if the goals of this Chattanooga Summit are to be realized, and we want to start winning that competition right here in East Tennessee.

Now, what you need to be concerned about is the fact that, and again I've got my stats to '91, I don't have them to '94, not because I'm saving money, but because the National Academy of Science hasn't given them to me but I know them, but just let me tell you where we are. The blue line here riding high all by itself, '61, staying on top until about '79, is the United States of America and the measure here is for total research and development investment, that's defense and nondefense, and we're comparing ourselves with our international competition, and they are with respect and honor to some of our competitors who are working in the room with us today, West Germany, France, and Japan, and the sad fact of life is that the United States, having

lost the game in the late seventies, pulled ahead, pulled ahead, pulled ahead, up until '85, has started on this abysmal trajectory down.

This is not good news, folks. This is not good news at all. Now, let me tell you why it is not good news. It is not good news because if those goals of ours to continue to develop the basic science to drive us to sustainability and to equity, we have to do it on the back of our technology.

Just a little bit of the reality of life. I had somebody paste this up for me. Where are we going? Vice President Gore said in a recent speech that the way we're headed is that by the year 2000, the United States will be behind in these investments, and worse than that, at the same time we're falling behind, so is our private sector because we are so focused on returning profits today, business does not invest for the long term because we, their stockholders, won't let them. If there are pension funds, we withdraw those funds in two years if they're not returning as we had projected. So the United States is almost on the cusp of trying to decide whether, A -- you have to decide and understand well enough whether technology is the answer, and if it is, do we want to lose this battle?

Now, spare me to indulge me a bit because I rarely read a thing, but you need to know that of the House of Representatives mark on the work I'm talking about at this minute that affects Tennessee, let me tell you what the budget mark does. Well, first of all, the total funding is down. The funding for this kind of work is down by $132 million from its current level of about 600 million.

This would terminate the Spalation neutron source. I think your governor when he was here with you spoke of how much he supported this opportunity because it expands our ability to answer the basic science questions. The fusion program about which Mrs. Lloyd spoke? Terminated, with an adverse impact because we got to pay to finally put all the outstanding contracts to bed. Anybody here like the radioactive ion beam? Gone. The tech transfer collaborations which I'm talking about and celebrating today? No more, no more. No more opportunity to participate in the sustainable challenge for other cities, gone. Now, this is not so much about politics as it is about the future, our economic future, so I simply leave anyone who has an interest with this information and tell you there are other copies available.

I want to start almost where we began. I'm looking over at the map of the interstate with Chattanooga at the bottom, almost opening the door not just to East Tennessee but to all of the South with its opportunity for lifting jobs in a community that understands the value of collaboration with science and technology, and I want to end by paying respect to ZERI, but in so paying respect, want to tell you what's at stake globally. This simple map of the globe spread out with some interesting flags upon it captures the marketplace for energy, and when I talk about sustainable development, that's where I start. These are not my statistics, but someone has captured the opportunity for deployment of new energy technology internationally at $4.1 trillion,

and I'd like to say before I came to the Department of Energy, I never had occasion to use the word "trillion." I was just kind of playing around in the billions.

Why do I leave with you this thought, having told you what the opportunity is for technology, tying that to the Chattanooga Summit, tying it to sustainability? Because this is the marketplace we're after. We're after sustainability at home, but there's no point in taking care of business at home if we haven't taken care of the globe. More importantly, guess what? The developing world is going to grow at a rate far faster than we do in the United States. The population growth alone in the next forty to fifty years is going to be 40 percent. That's a staggering growth. Presume now all this growing population in places like Asia and Latin America and Russia and Eastern Europe will require energy. Understand in the United States we have now broken the formal tie between the growth of the gross domestic product and energy consumption and done a good job of it, we have to make sure that that happens with the rest of the world developing. That's why there's a Zero Emissions Conference.

How do you do that? You do it with some of the great technology that's already coming out of the collaboration between industry and the national laboratories, to deploy great new technology for buses, for vans, for power generation, for manufacturing processes, and that's why the globe matters. That's why when your Governor Sundquist was here earlier in the week he told you that in his experience, the world opportunity is the opportunity to shoot at. If your ambassador now, former Senator Sasser tells you from China you've got to do business in China, fastest growing nation in the world with an energy need, if it's not done right, we don't have to worry about pollution in Chattanooga; we have to worry about pollution globally.

These are the challenges. A better audience I couldn't talk to. The international audience here with ZERI understands this challenge. Where is Brazil? Where is Brazil? You got to help me with your energy minister. We really have to focus on this zero emissions piece because what we have learned in Chattanooga and what people who are here for the Zero Emissions Conference understand is that the goal of environmental correctness, environmental protection, and the goal of economic expansion can go hand-in-hand without damage and at the same time we can do equity to all. We haven't been so sure how we want to talk about equity, but I know how we talk about it. It's about expanding the middle class to which we all aspire, and if you do this correctly, we can almost, like the beautiful fabric coming off of that CAFE loom, weave this impossibly beautiful fabric that meets all of the goals that are supported by our basic values that say this: We want a world free from harm and trauma. We want the environment clean. We want education for our children. We want communities that work. This is what sustainability is all about.

Now, I want to commend all of the people who have been responsible for pulling this conference together. Our jobs as we leave this room? Of course they're to focus on Chattanooga and its strategy, understanding clearly that this is a global strategy, and if any of this has made any sense to you, then please ensure that the nations that we

represent, and there are many here today, begin to understand this ethic so that the investment in the technology that drives us to realizing our value is not at risk, but it is lifted up and celebrated while at the same time we take care of ensuring that the government doesn't spend its way into a terrible mess. We know how to do this, and leaving this room, we must all be ambassadors for the possible, which is sustainability.

Thank you very much.

Towards Zero Emissions: Maximizing the utilization of the biomass of the oil palm industry in Malaysia

Abdul Rahman bin Ramli,
Group Chief Executive Golden Hope Plantations Berhad, Malaysia

INTRODUCTION

Firstly, I would like to take the opportunity to thank the Congress Organizer, particularly the UNU Zero Emissions Research Initiative (ZERI) for the kind invitation to address the Second Annual World Congress Zero Emissions. It is indeed my honor and privilege to be in the City of Chattanooga to share our experiences and views with distinguished speakers and participants from around the world.

My presentation will focus on the present and future utilization of the biomass of the oil palm industry within the context of zero emissions. However, as many of you are familiar with Golden Hope and the oil palm industry, I feel it would be useful to commence with background information.

GOLDEN HOPE PLANTATIONS BERHAD

Golden Hope Plantations Berhad is a leading Malaysian public listed corporation with its shares listed on the Kuala Lumpur and London Stock Exchanges.

Having established a strong foundation in the plantation sector over the last 100 years , the Group has now developed into a diversified conglomerate, involved in four dynamic business sectors - plantations resources-based manufacturing, property development and overseas operation.

Plantations

Golden Hope has played a major role in the development of the Malaysian plantation sector for more than a century. Today, the Group's core business remains at the forefront of the plantation sector with more than 172,000 hectares of oil palm, rubber, cocoa, coconut and fruit plantations under its ownership and management. The Group produces and processes palm oil, palm kernel, rubber, cocoa and fruits at its processing centers on its estates. It also owns and operates a palm oil refinery, a palm oil bulking installation and a latex bulking installation.

Resources-Based Manufacturing

Taking cognizance of its strengths in plantations, the Group has ventured into the valued-added manufacturing of resource-based products. Golden Hope is currently involved in the manufacturing of spray-dried coconut milk powder, tropical fruit juices, edible oils, rubber footwear and oleochemicals, primarily for the export markets. Other resource-based investments are the manufacturing of medium density fiberboard (MDF), furniture components and parquet from rubber wood.

Property Development

Property development provides an alternative strategy for Golden Hope to diversify its earnings base. The Group is a major player in property development and is currently involved in several large-scale mixed industrial, residential and commercial development projects in Malaysia.

Overseas Operations

Golden Hope has established major overseas investments through joint-ventures to build and operate edible oils and fats refineries in Vietnam and China. To ensure that marketing activities in the European Community are better focused, Paul Tienfenbacher GmbH & Co. KG of Germany was acquired in 1994. In USA, our associate company, Planter's Pride Inc., was set up in New Jersey, to pack and distribute the Group's pink guava and other tropical fruit juices.

THE OIL PALM INDUSTRY

Introduced from Africa, the palm oil *Elaeis guineensis* is today the most important widely grown agricultural crop in Malaysia, its cultivated area being more than 2.51 million hectares that produced about 7.81 million tons of palm oil in 1995. Also known as the Golden Crop, oil palm is the highest contributor to the country's income from the agricultural sector. In 1995, it contributed about RM 10.9 billion (US$ 4.4 billion) to the total export earnings of the country. Malaysia is the world's largest producer of palm oil accounting for more than 50% of the world's output.

The oil palm typically has an economic life cycle of about 25 years. Harvesting usually commences about 30 months after planting. Each palm can produce 12-18 fresh fruit bunches (FFB) per year, each FFB containing about 1300 fruitlets. One hectare of oil palm can produce about 23-25 tons of FFb per year which can be processed into 4 to 5 tons palm oil per year. The oil palm is the world's most efficient oil crop in terms of energy utilization and productivity. It is 10 times more productive than soya beans and 6 times higher yielding than rape seed.

The palm oil is a unique crop that produces two types of oil, palm oil from the fibrous mesocarp and lauric oil from the palm kernel. In conventional palm oil milling process the fresh fruit bunches are sterilized and stripped of the fruitlets which are then digested and pressed produce crude palm oil (CPO). Nuts separated at the pressing station are cracked to obtain palm kernels which are crushed in another plant to produce crude palm kernel oil (CPKO). CPO and CPKO are further processed in oil refineries to produce a variety of refined oils, palm oil products being used mainly as cooking oils and shortenings while the lauric palm kernel oil is a major feedstock for production of oleochemicals.

CURRENT STATUS OF OIL PALM BIOMASS UTILIZATION

The main uses and recycling of various by-products or wastes from the growing and processing of oil palm are shown in Figure 1.

The Oil Palm Plantation

In the plantation, the biomass consists mainly of oil palm trunks and fronds and fresh fruit bunches. FFBs and their subtending fronds are removed regularly during harvesting, the former being sent to the mill for processing while the fronds are stacked in the avenues and interrows. These fronds return organic matter and plant nutrients and protect the soil from erosion.

At the end of its economic life, old oil palms used to be replanted using mainly the clean clearing method where the biomass was burned. Apart from loss of organic matter, this technique causes air pollution. Since 1989 Golden Hope Plantations Berhad introduced the zero burning technique whereby the old stand is felled and shredded and left to decompose in situ. The zero burning technique not only contributes to a cleaner environment but also replenishes soil organic matter, improves the physical properties of the soil and enhances its fertility. Large quantities of plant nutrients are recycled into the soil through the decomposition of the palm residues (Table 1). Thus, utilization of inorganic fertilizers is reduced accordingly. Today, the zero burning replanting is used commercially by Golden Hope and other plantation companies.

TABLE 1. AVAILABLE NUTRIENTS FROM PALMS RESIDUES AT REPLANTING

Nutrients (kg / ha)

Palm Residues	N	P	K	Mg
Palm Trunk	219.6	21.2	314.5	52.6
Fronds	119.8	11.0	109.7	23.3
Total	339.4	32.2	424.2	75.9

	Urea	CIRP	MOP	KIES
Fertilizer equivalent	73.9	204.8	848.4	487.5

Source: Mohd.Hashim et al, 1993.

The Palm Oil Mill

The main by-product / wastes produced in the oil mill are as follows:

*Empty Fruit Bunches (EFB)
*Palm Oil Mill Effluent (POME)
*Fiber
*Shell
*Boiler Ash / Clinker

Empty fruit bunches are obtained after FFB has been sterilized and stripped of the oil bearing fruitlets. In the past, EFB used to be incinerated at the mill to produce an extremely alkaline bunch ash. As incineration causes air pollution, this practice has been discontinued. Instead, EFB is used as a mulch and organic fertilizer for oil palm and other crops.

Mulching is carried out at a rate of 250 kg / palm / year. In terms of fertilizers value, one ton of EFB provides an equivalent of 8 kg urea, 2.9 kg rock phosphate (CIRP), 18.3 kg Muriate of potash and 4.7 kg kieserite. The evacuation of EFB from oil mill to the field is by tractor / trailer where the EFB is side-tipped to the "station" between the palms along harvesters' paths.

Palm Oil Mill Effluent (POME) is the collective term for effluents produced during the palm oil milling process. This is potentially a highly polluting process as for every ton of oil produced, there would be 2.5 tons of POME which has an average biochemical oxygen demand (BOD) of about 25,000 ppm. Under the Malaysian Environment

Quality Act, the BOD level must be reduced to below 50 or 100 ppm, depending on locality, before treated POME can be discharged into waterways.

POME is essentially treated by biological processes involving anaerobic and aerobic digestion. As treated POME is also rich in plant nutrients, it has been used as a fertilizer substitute; land application of treated POME is an accepted commercial practice in Malaysia.

Several systems of land application have been developed. In Golden Hope, application of treated POME in oil palm field using the tractor / tanker system at the rate of 360 and 550 liters / palm year for coastal and inland soils respectively. In terms of fertilizer value per palm, this application is equivalent 2.0 - 3.0 kg of urea, 1.8 - 2.8 kg rock phosphate and 1.5 -02.2 kg or muriate of potash and 2.3 - 3.5 kg of kieserite per palm.

Mesocarp fiber and kernel shell are currently the main sources of energy in the palm oil mill, their combustion in boilers produces more than sufficient energy to meet the oil mill's energy demand. Excess energy is supplied for domestic consumption in the plantation while surplus shell is normally used for road surfacing. Burning of fiber and shell produces small quantities of boiler ash and clinker. The former can be used as a fertilizer but the clinker is usually discarded in landfills.

The Effluent Treatment Plant

Besides treated POME which is used as a fertilizer substitute, other by-products from the effluent treatment plant include sledge cake and biogas from anaerobic digestion. Sludge cake is a good feed supplement for cattle and other animals but its usage has not been significant. Biogas can be recovered from the anaerobic closed tank digester. a 60 ton FFB per hour oil mill is capable of producing about 20,000 cubic meters per day of biogas which can generate about 1000 KW of electricity continuously. However, utilization of biogas at present is limited to only a few mills.

At the end of the effluent treatment process, the treated waste heater from the aerobic pond is discharged into waterways. In our effort towards attaining a closed loop system, attention is given to possibility of having zero discharge effluent treatment systems. A recent successful example is treatment of effluent produced from the processing of rubber latex concentrates. In the Golden Hope Zero Discharge Treatment System, partially treated effluent at the aerobic stage is subjected to further treatment and recycled as clean water for process or other uses. This new system consists of a clarification system with mixing and aeration features that make use of both physiochemical and biochemical processes to reduce the solids content, the Chemical Oxygen Demand (COD) and the Biochemical Oxygen Demand (BOD) of the effluent. It is based on innovative technology and practical application of sound principles of hydraulics and biochemical reactions.

With the new treatment system, we have been able to reduce the BOD and COD levels of the effluent water by 90 - 95%; we have consistently recorded BOD levels of less than

10 ppm. This system has to\date been installed in three production centers i.e. our two latex concentrate factories and our medium density fiberboard manufacturing complex.

FUTURE DIRECTIONS IN BIOMASS UTILIZATION

Although the biomass and by-products from oil palm cultivation and oil palm processing are utilized or recycled to a large extent, there is still considerable scope for improvement, the ultimate aim being towards zero wastes and zero emissions. Two approaches could be considered; in the first instance, effort should be directed at improving the efficiency of oil palm cultivation and processing so as to optimize the use of inputs and energy and reduce the generation of wastes and effluents. For example, a recent breakthrough in oil milling technology is the Golden Hope-Pieralisi process which has reduced the total effluent load by 800%.

The second consideration should be focused on increasing the value and extent of utilization of the biomass and by-products. At present, they are used mainly as organic fertilizers in the plantations and sources of energy for the oil mill. However, the industry has identified a wide range of value-added products that could be produced from the palm biomass. Potential products are as follows.

*Wood products
*Pulp & paper
*Lignocellulose products
*Furfural
*Biogas
*Biofuel
*Oleochemicals
*Food Products

Considering the large volumes of biomass in the form of oil palm trunks, fronds and empty fruit bunches (Table 2) that are readily available throughout the country, downstream production of wood based and lignocellulose products has immediate prospects of commercialization. Development work undertaken by the Palm Oil Research Institute of Malaysia (PORIM) and the Forest Research Institute of Malaysia (FRIM) and plantation companies has shown the feasibility of producing products such as medium density fiber board (MDF), particle board, oriented strand board, gypsum-boards from oil palm biomass.

TABLE 2. ESTIMATED AVAILABILITY OF OIL PALM BIOMASS IN MALAYSIA IN 1996

Biomass	10(6) tons dry weight
Trunk	4.36
Felled fronds	0.83
Pruned fronds	19.09
Empty fruit bunches	2.27

Source: Husin *et .al.,* 1995.

Potential food products are vitamin E from palm fronds and palm fatty acid distillate (PFAD), beta-carotene, xylitol and single cell proteins. Golden Hope, in collaboration with PORIM has started pilot scale production of vitamin E from PFAD, a by-product of palm oil refining. This product is differentiated from other natural sources of vitamin E as it is composed mainly of tocotrienols instead of tocopherols.

In order to achieve zero emission through full utilization of biomass, an integrated and coordinated approach should be considered. I see the plantation industry as a source of valuable renewable raw materials for clusters for complexes of industries that would produce environmentally friendly products.
Golden Hope has already adopted this concept for the development of its rubber based industries. In the past, the rubber (*Hevea brasiliensis*) was cultivated for the extraction of natural rubber which is used mainly for production of tires and latex dipped products. The rubber biomass has limited residual value and use and in many situations, they were burned during replanting. With growing global concern for the protection of the environment which resulted in an increasing demand for wood products made from sustainable forests and forest plantations, rubber wood has become a preferred material for the furniture and wood-based industries.

Recognizing this global shift towards sustainable production, we have developed an fully integrated rubberwood-based manufacturing complex to make full use of the rubber biomass. This US$100 million complex which occupies an area of 25 hectares has the following industries.

1. Golden Hope Fiberboard Sdn .Bhd, which has a capability of producing 100,000 cubic meters of medium density fiberboard (MDF) per year from rubber trunks and branches.

2. Golden Hope Furniture Sdn. Bhd., a joint venture with IKEA to produce knock down furniture components using rubber trunks or MDF from Golden Hope Fiberboard.

3. Golden Hope Parquet Sdn. Bhd. to produce factory-finished 3-ply parquet from rubber trunks.

4. A particle-board factory is being considered to make use of the rubber twigs, roots boles and the off-cuts and residues from the other three factories.

With this integrated approach the biomass of the rubber tree will be fully utilized. As rubber wood has now become a co-product, we have refocused our objectives for breeding and selection of rubber cultivars and have developed a number of clones that are capable of producing high latex and rubber-wood yields.

We are adopting a similar approach for the downstream value added production from the biomass of oil palm. As I see it, the oil palm plantation and oil mill could be the primary production units for raw materials fro the following clusters of industries.

1. Food based industries for the production of refined vegetable oil, Vitamin E, beta-carotene, xylitol etc.

2. Lignocellulose based industries for the production of MDF, particle boards for palm fibers, lignin etc.

3. Oleochemicals production.

4. Energy production through biogas and biofuel.

Figure 2 is a road map showing the potential routes that could lead us to the goal of zero wastes and hence zero emissions. We have made some progress in this journey; the crude palm oil (CPO) produced in our oil mills are processed into refined vegetable oils and a range of edible products such as coco butter substitutes. We have joint ventures with Henkel KGaA of Germany and other partners to produce fatty acids, fatty alcohols, glycerin etc. from palm oil and palm kernel oil in an integrated oleochemicals complex. With our experiences in rubber wood manufacturing industries, we are ready to explore the possibility of producing value-added products from the lignocellulose biomass of oil palms. As mentioned earlier, we are collaborating with PORIM to produce vitamin E from a by-product of the palm oil refinery.

CONCLUSION

In the past, palm oil and palm kernel oil are the primary products from the oil palm. However, within the context of zero emissions, they can be regarded as co-products as the oil palm biomass offers tremendous opportunities for the production of a wide range of value added products. The oil palm plantation and oil mill could form the nucleus for clusters of industries focused on production of lignocellulose-based

products, oleochemicals, food and fuels. Although active research and development is being pursued by the Malaysian industry to maximize the use of the oil palm biomass. I hope my presentation will stimulate researchers around the world to join us in our quest towards zero emission from the oil palm - the Golden Crop.

Perspective on the Feasibility of Zero Emission Industrial Systems

Hiroyuki Fujimura,
President and Representative Director Ebara Corporation

Four years have passed since the 1992 Environmental Summit in Rio de Janeiro. During this time, each country in this global community has endeavored to develop innovative solutions in an attempt to actualize sustainability. As an industrialized country, Japan realizes not only its role in the world economy, but also its responsibility to protect the environment both globally and locally. We aspire to find the right direction to sustainability.

But, if each industry, or worse, each company works on it own, we cannot expect to make as great an impact on the environment globally. With this in mind, The Japanese government has created the vision for Industrial Environment through its Ministry of International Trade and Industry to guide and coordinate the industry. The Vision outlines "the framework for environmentally-friendly industrial activities, based on the new developments in environmental issues." This vision presents the industry with guidelines and measures for environmental performance in the 21st century. Under these guidelines, the Japanese Industry is reconstructing itself according to the Zero Emission concept. We believe that this concept is one of the most important policies for attaining sustainability in the 21st century. Furthermore, Japanese people are now demanding that our own social system, which is the foundation of the industrial activity, reduces its impact on the environment to become more environmentally efficient. It is expected that, in the near future, there will be a great shift in the social system which involves not only the industries but also the foundations of society itself. The Zero Emission Initiative of the United Nations University shows the new direction for the 21st century, and provides the necessary momentum. Outstanding among these efforts is the work of Mr. G. Pauli, to whom we all give thanks and appreciation.

As you may know, EBARA Corporation is an environmental engineering company. It is our job to offer our expertise and assist industries in their restructuring toward Zero Emission. Now, if I may, I would like to present some examples of how environmental engineering companies, such as EBARA, contribute to Zero Emission.

Let's compare the industrial infrastructure to the human body. In Japan, we often refer to the business sector that deals with treatment of industrial waste as the "veins of industry;" and the business sector that supplies required energy and materials to the rest of industries as the "arteries of industries." Ebara is also involved in developing conversion technologies necessary to provide engineering service for supplying the "arteries" with the valuable energy or raw materials that are recovered from the "veins."

Now, I'd like to show you these figures! Figure 1 depicts the Thermal Recycling system for municipal and/or industrial wastes, integrated with the Fluidized Bed Gasification Process, a conversion technology being developed by EBARA. This Waste to Energy conversion system is far superior to the traditional boilers in efficiency and impact to the environment. Granted, this gasificator still cannot be called 100% Zero Emission because of the CO2 release from the stack. These releases, however, are significantly less than the release associated with CH3 offgassing from the waste, had it been landfilled.

In addition to Thermal recycling, this Fluidized Bed Gasification Process (fig. 2) can be applied to integrate other resource recovery systems for industrial/municipal waste. Along with the recovery of melted metals such as iron, copper, aluminum, and nickel, this system recovers some useful chemicals in the gaseous phase. With additional treatments, valuable materials, such as H2, alcohol, methane, gasoline precursors, ammonia, etc. can be recovered from this process. Residual ash can be melted together and utilized as a construction material, or as an ingredient in cement. Furthermore, the gasification process effectively eliminates HCI at a low temperature; and the melting process completely destroys hazardous chemicals such as dioxin and PCB with a reduced air ratio at a high temperature.

Figure 2

The conversion technologies and conversion systems which make it possible to achieve the maximum utilization of the industrial/municipal waste in the "vein" to recover the valuable energy and raw materials to be supplied in the "artery" are imperative to the Zero Emission system. Now, let me present other possible applications of some of the advanced conversion technologies.

As you may know, Agriculture is one of the main industries in China. There is a great demand for cheap, good fertilizers, and we expect that the demand will continue to rise in the future. In 1992, China produced approximately 20 million tons of fertilizer. This is a 230% increase from the quantity produced 15 years earlier. Now the government plans a even further increase of the production to 30 million tons/year by the year 2000. Demand projections, however, place the need for fertilizers to outstrip this increased supply by far. In addition, the rapid economic growth in China created a great demand for electric power for the industrial base. It is expected that more power plants will be built to secure a 300 million kW capacity by the year 2000. Presently about 80% of electricity is generated through fossil fuels, especially cheap and abundant coal. This trend is expected to continue. However, as we are aware, coal fired power plants produce sulfurs oxidized and nitrogen oxide, a main cause of acid rain, which has the detrimental effect on the global environment. A considerable amount of investment has been made on the desulfurization units for coal fired power plants.

Based on the Zero Emission concept, Ebara has come up with a innovative conversion system which we call the Electron Beam Fuel Gas Treatment System (fig. 3).

Figure 3: E-beam Flue Gas Treatment Process (EBA)

This system solves the gas emission problem while contributing to the production of fertilizer. By adding ammonia to the power plant furnace effluent gas, and then irradiating with an electron beam, ammonium nitrate and ammonium sulfate are produced. Both are main components of fertilizer. Many of you may recall that Ebara had first introduced this process at the 1st Annual World Congress on Zero Emissions last year.

A pilot plant was constructed in Nagoya, Japan. We are now also building a pilot plant with 300,000 Nm3/h treatment capacity in Su Chuan Sheng Cheng du, China. The construction is expected to be finished in December of this year. As I mentioned before, Chinese government plans to build power plants enough to secure total capacity of 300 million kW by the year 2000. Let us assume that 70% of these power plants burn coal as the fuel, and that we were to install the Electron Beam Fuel Gas Treatment System to the half of these plants. The total capacity of these plants would be 100 million kW. The theoretical production rate of the fertilizer here is then calculated to be 20 million tons/year. If we assume that the total demand for the nitrogen-based fertilizer in China is about 100 million tons/year, then the calculated supply rate would be 20% of that amount. Then we can grow tasty lettuce.
This is a good example of applying the Zero Emission concept application towards sustainability. It successfully promotes economic development in China through increased food production and electric power generation, while contributing to environmental protection by cleaning up the harmful effluent gas from a power plant at the same time.

The biological refuse generated in our daily life also requires an effective treatment system. Here, too, integrating the electron beam treatment system with the traditional end-of-pipe process enables us to recycle ammonia for the fertilizer production. Ammonia recovery from municipal waste and industrial waste is also possible by the application of our Pressurized Fluidized Bed Gasification Process, which is a process more advanced than the above mentioned Fluidized Bed Gasification Process. The recovered ammonia can be recycled for many potential usages in industry, including fertilizer production.

Figure 4 summarizes the application of the conversion/recycle technologies mentioned. From an engineering point view, we have a great hope in transitioning to Zero Emission systems.

Without a doubt, reduction of energy and raw material consumption along with the minimization of waste generation is important to our environment. However, if we can make profitable the recovery of valuable material from the waste, we would then succeed in promoting nature-friendly economic development in our quest towards sustainability.

For example, recovery of thermal energy from industrial waste is becoming a good business in Japan. Industries in Japan generate a total of about 400 million tons of

waste per year. If we combine 20 million tons of this industrial waste with the 37 million tons of municipal waste and incinerate it, assuming 30% energy conversion efficiency, we can obtain about 50 billion kWh per year of electricity. With the last year's Japanese government legislation to relax restrictions on the sale of electricity, businesses that converts waste to energy are sprouting up in Japan.

Figure 4

As another example of good economics, let us go back to the application of the Electron beam Fuel Gas Treatment System in China. As I mentioned before, this system produces main components of fertilizer from power plant effluent gas. Assuming we build a system to treat 2 million Nm3/h of effluent gas from power plants with total of 6000 thousand kW capacity. If the buying price of ammonia is 13 yen/kg and the selling price of the fertilizer is 10 yen/kg, capital costs can recovered in 10 to 15 years. This balance calculation indicates that the electron beam treatment system is productive enough to be called a fertilizer production system.

Now, increased popularity of plastic products created an yet another industrial waste problem, shredder dust. However, through the waste gasification process, we can recover H2 from the shredder dust. The recovered H2 can be used in ammonia production. Assume we are to produce 1000 tons/day of ammonia, using 900 ton/day of shredder dust, and 600 ton/day of coal in Japan. If we charge 20 thousand yen/ton

of shredder dust, the ammonia production cost can reduced by 1/2. This system can recover the initial investment in a few years. It is economically worthwhile to install the system for ammonia production. Of course, some numbers used in this calculation - such as the interest on the borrowed capital, price of fertilizer, and tax - would differ from one country to the other. However, with more research and development, I believe that it is possible to develop even more economical processes that would make Zero Emission systems feasible.

From both technological and economical point of views, it is quite possible that we, as a global community, can move much closer to the Zero Emission society and attain sustainability. Therefore, I believe that it is an industrially advanced country's duty to actively participate in the development of ideal Zero Emission systems for improvement of the global environment. Also, this concept must be appropriately developed, applied and strongly utilized by developing countries, especially those with great economic potential, and hence great environmental peril, such as those in Southeast Asia. It will not be easy to develop the necessary conversion technologies. Therefore, cooperation in the global community, with the industrial sector as its leader, is critical. We must all help one another, sharing the technologies we have obtained through years of effort to solve environmental problems.

Zero Emission is sure to be the theme in the 21st century's battle to solve our globe's environmental problems. As a member of this global community, EBARA Corporation is leading the vanguard in developing and sharing integrated technological solutions. We do this in cooperation with industry, government and society, for only together can we meet the challenge before us all.

DuPont and its commitment to Zero Emissions

Dr. Paul V. Tebo
Senior Vice President for Environment, Health and Safety, DuPont

Distinguished guests, ladies, and gentlemen. It is a pleasure to be a part of this important conference. DuPont applauds the direction of the United Nations University Zero Emission Research Initiative and congratulates the organizing committee of this Second Annual World Congress on Zero Emissions. We agree that Zero Emissions ("use all of it"), along with Zero Defects ("make it right") and Zero Inventory ("get it there just in time"), are important stages of the total quality management revolution.

I plan to spend a few minutes talking about DuPont's goal of "Zero" for all injuries, illnesses, incidents, waste and emissions and how it is an important element of our journey towards global sustainability in the 21st century.

Our commitment to zero injuries and illnesses has been a core value for DuPont since our founding almost two hundred years ago. As a result of this long-standing commitment and lots of very hard work every day, in 1995 we operated over 200 plants in 70 countries with 150,000 employees with less than 40 people hurt in a way that resulted in a lost day of work. In addition, we experienced zero major fires or explosions, only one major transportation incident, and reduced our accidental environmental releases to 45, a 63% reduction since 1992.

This level of performance versus industry average saved the company over $100 million in potential costs associated with worker's compensation, lost productivity, or rebuilding facilities. In addition, the value of lost business from a major incident is usually at least four times this number. However, the primary benefit of our goal of "Zero" is the result that most DuPont employees work an entire career without a work-related injury or illness.

As many of you know, we have now extended our goal of "Zero" to include all emissions and waste. This has created a very powerful shift in mind set and culture within DuPont by setting "Step Change" versus "Incremental" as the expectation for change.

Let me first discuss recent progress in emission reductions in our priority areas -- Air Toxic and Carcinogens, Ozone-Depleting gases, and Greenhouse Gases -- then use a few examples to demonstrate the direction we are headed.

Since 1987, we have reduced the emissions of Air Toxic and Carcinogens by almost 70% in the U.S. and 50% globally; and we expect these emissions to be significantly closer to "Zero" by the year 2000. We have reduced the emissions of Ozone-Depleting chemicals from our plants by 50% since 1991 and have essentially eliminated the production of

CFCs for sale while bringing production capacity on line for several alternatives. We have reduced the emissions of Greenhouse Gases from our plants by 14% since 1991 and expect achieve a 60% reduction globally by the year 2000.

We are proud of this progress but recognize we still have much work to do. We have found that it is very important to make voluntary commitments to emissions reductions rather than to wait for regulations to be the driver. Our experience shows that the cost per pound of emission reductions is generally three to five times less when done voluntarily than when done by regulation and, in many cases, we find ways to save money. Clearly, voluntary commitments and progress where innovation and creativity are the drivers can be very good for the environment and for business.

Let me now discuss our goal for "Zero" waste. This clearly represents our biggest challenge...and our biggest opportunity!

We have conservatively estimated that the business opportunity for our next 50% reduction in waste generated per pound of product to be at least $3 billion. This is not the reduction of cost to treat, landfill, or incinerate the waste but the lost business opportunity by having our ingredients end up as waste, not as high-value products. In this case, the concept of "Zero" waste is very similar to the concept of "Zero" defects, a quality objective once thought of as unattainable only 15 years ago.

To capture this opportunity, we have a growing list of examples that can be grouped into five broad categories: reuse and recycle; co-product development; yield improvement; zero waste and emission technology; and sustainable products and services.

Let me use four brief examples to illustrate our progress. In none of the cases have we achieved "Zero" waste and emissions. However, in all four we have made important steps forward.

To illustrate an example of Recycle, I'll describe our embryonic "Carpets to Cars" program that involves our nylon plant here in Chattanooga. For the last several years, we have begun to take back worn out carpets from customers in exchange for new business. Recently, we have started up pilot facilities to separate the nylon from the carpet backing, remelt the nylon, and produce mineral-reinforced nylon for use in automotive parts. One current program involves removing all of the carpeting from Ford's World Headquarters to produce Air-Cleaner Housing for Ford cars. This is only a beginning of our program to recycle nylon but adds to our existing efforts to recycle polyester and other important materials. The impact on the environment is lessened in two important ways: less material goes to landfills,and less virgin feedstocks are required. And, the economics improve as the infrastructure to support recycling grows and the volume increases.

A second example, which our chairman Ed Woolard will mention at tonight's dinner, involves our manufacturing plant in new Johnsonville, Tennessee, the world's largest facility for producing titanium dioxide, a white pigment used in paper, plastics, and many other applications. Among the site's many environmental improvements they have:

* Reduced Carbonyl Sulfide Emission (an air toxic) by 87% since 1987, while production has increased substantially. This was achieved through source reduction using improved process control.
* Eliminated Air Carcinogen Emissions by replacing Methylene Chloride with Calcium Chloride in process refrigeration applications.
* Totally eliminated CFC's from all process equipment.
* Shutdown the site's Coal Burning Boilers, thereby eliminating all associated emissions. The site now purchases their steam from the Tennessee Valley Authority.
* During 1995, recycled 91 tons of paper bags, 117 tons of cardboard, 1.2 million pounds of scrap metal and over 9,000 Semi-Bulk product bags.

In addition, this summer the site will begin start-up of co-product facilities to convert the waste stream currently injected into deep wells to high purity Sodium Chloride Salt, Iron Carbonate, and Carbon Dioxide, all of which will eventually be sold into useful applications.

For these and other accomplishments, the site received the Tennessee Conservation League's Industrial Conservationist of the Year Award at their 50th anniversary meeting in early May at the Tennessee Aquarium here in Chattanooga.

A third example involves our new agricultural products manufacturing facility located in Surbaya on the Island of Java in Indonesia. Started up in 1995, this facility was designed with ZERO waste and Emission as its goal. The only thing that leaves the site is the Herbicide Product and a small bag of ash, once per week. All of the process water and the sanitary and laundry waste are treated on-site with water eventually evaporated. The air is thoroughly filtered before release, and the solid waste is incinerated on-site with only minimal residual ash. The environmental investment was less than 10% of the total investment, and treatment costs are only few percent of total operating costs. The plant was built and started up with zero injuries and has run almost one year with only one relatively minor hand injury. While the site is fairly small, it represents the mindset we take into new construction today, everywhere in the world, and the type of performance levels we can achieve.

As a final example, let me use another agricultural products story to illustrate how we have developed products that move us closer to "Sustainability."

About 15 years ago, our agricultural products business developed a vision that describes their strategic intent as a "Growing Partnership With Nature." Since that

time, DuPont has lead the development of a broad range of products that have retained the desirable properties of high crop yield but which have allowed a reduction in application rate per acre by 50-to-100 fold. On an industry basis, this has resulted in a reduction of over 200 million pounds of chemicals applied to the soil each year. In addition, the chemical waste associated with the manufacturing of Agrichemicals has been reduced by four to six billion pounds annually. Finally, a related benefit is that the packaging required for these products has been reduced substantially; and, in some cases, the product is supplied in consumable pouches.

While the impact on the environment has been lessened several fold, the value to the farmer has increased; and the DuPont business has grown over the past 15 years from number six or seven in the marketplace to number two today.

In closing, let reemphasize that we are in the early stages of a very important journey. This journey will include global growth, increasing shareholder value, and decreasing impact on the environment. Our goal of "Zero" for injuries, illnesses, incidents, waste and emissions is an integral part of our commitment to a future world. We view it as good for the environment, good for people, and good for business! "Everyone Wins!"

Industrial Ecology at Lawrence Livermore National Laboratory

Thomas J. Gilmartin
Senior Researcher at Lawrence Livermore National Laboratory

It is very exciting and appropriate for us, Lawrence Livermore National Laboratory, to participate in this Second World Congress on Zero Emissions. Under the management of the University of California for the United States Department of Energy, we bring together the resources of universities, the government, and private industry to solve important national problems and to push science and technology over the horizon. And what more important problem is there than to sustain life with high quality and preserve our planet into the indefinite future.

This quest has many aspects, some socio-political or economic and some technological, and some in which the soft and hard sciences become indistinguishable, as in visionary national strategies, like Holland's, and futuristic regional and city development plans, like those of Kagoshima and Chattanooga, of which we are learning at this Congress.

Vision for Livermore Laboratory

The expertise of Livermore is in applied science and advanced technology systems. Our vision is that we will be an internationally recognized center for industrial ecology, collaborating nationally and internationally in the integration of energy, materials, technology, scientific, and environmental factors to create the basis for a sustainable global economy. For historic and strategic reasons, our principal areas of research at Livermore are:

- *Global Security,*
- *Global Ecology, and*
- *Bioscience.*

Global Security

While Global Security continues to require expertise and vigilance regarding the residual weapons of the Cold War and international involvement in the control of regional conflicts, security will increasingly involve understanding and mitigation of the underlying ecological sources of conflict, like population instabilities, energy resource limitations, shared water, international air pollution, global climate changes, and major natural calamities. Integration of the concepts and goals of security and sustainability will increase as globalization increases. This trend is an explicit assumption in the National Security Science and Technology Strategy published last year by the US National Science and Technology Council. While these topics are extremely interesting and important, I will focus this summary on issues more relevant to Zero Emissions.

Global Ecology

Our activities in Global Ecology are based on the field of industrial ecology, and focused on primary and secondary energy resources, materials, environmental

technology, and global system modeling. I will give examples of some our technical goals in each of these activity areas.

Energy for Transportation

One of the principal emission generators in the wealthy countries of the world is our transportation systems. Several hydrogen, electric, and hybrid alternatives are under development.

If the hydrogen in a gallon of water is separated and then burned back to water, the burning yields the energy equivalent of about a half of a gallon of gasoline. This water to water fuel cycle is zero emission if the energy needed to separate the hydrogen and the hydrogen combustion process are both clean. The burning of gasoline is, of course, not recyclable; produces CO2, a greenhouse gas; and produces particulate and gaseous pollutants. Burning methane is better than burning gasoline because it involves burning more hydrogen than carbon, but some CO2 is still produced. Hydrogen is a good alternative fuel and not that far from currently available technology.

Hybrid electric vehicles will use the hydrogen energy to generate electricity which is stored in flywheel systems or ultra capacitors, which in turn power the vehicle through electric motors. The intermediate energy storage allows the vehicle's hydrogen powered electric generator to operate at peak efficiency while the vehicle's power requirements vary. Similarly, the electrolytic production of hydrogen acts as a load-leveling intermediary for the utility electric source, thus allowing utility power to be used on an as available basis, and absorbing the variability of many renewable primary energy sources.

Another option is the refuelable battery, like our zinc-air battery which can produce five times the energy per unit weight of a lead acid battery and can be "recharged" in 10 minutes, about as long as it takes to fill your gas tank. There are no emissions from this battery and its materials can be recycled and reused, also with zero emissions. The weight of such batteries along with the motors and drive units for a 300-mile range weigh slightly more than the gas tank, engine, and transmission for a current technology car of the same range and peak power.

We are developing these technologies in various combinations with the goal of an efficient, safe, low or zero emission vehicle that competes in cost and performance with current gasoline powered cars. Some of this work is being carried out under the Partnership for a New Generation of Vehicles with US auto makers.

Fusion Energy

If hydrogen is burned thermonuclearly in a fusion reaction, rather than chemically in normal combustion, the energy equivalent of the hydrogen, actually deuterium, in a gallon of water is about 500 gallons of gasoline. This burning occurs when the nuclei of the hydrogen atoms collide and fuse to form helium. The inherent

fusion energy yield per unit of fuel mass is potentially a million to ten million times greater than the energy yield for chemical combustion.

This process has two remarkable advantages. First, the energy available on Earth from hydrogen fusion is virtually unlimited. After all this is the same process that drives the sun. And second, the inherent "emissions" or residues are zero, although the design of a practical reactor will involve the generation of some radioactive waste.

Livermore is the world leader of the use of lasers to drive controlled fusion reactions and is in the process of designing and building a system, the National Ignition Facility, which will demonstrate the scientific feasibility of this process by generating more energy from a micro-fusion reaction than is put in by the laser. We are also participants in the international magnetic fusion program and are modeling advanced concepts for machines in which a continuously burning fusion plasma is contained in a magnetic field.

When clean, unlimited fusion, and undoubtedly also advanced nuclear fission, and, hopefully, solar electric energy sources are coupled with hydrogen or battery transportation systems, the essential energy needs of a zero emission sustainable society will be satisfied.

Materials

Turning to materials, let me say that in our advanced technology programs, the performance of materials is always the limiting factor. As a result, we have developed some fairly exotic materials that have application for sustainability. Examples are aerogels, solid materials that are so porous that they are about the same density as air. Depending on the materials from which we make them, aerogels can be either the best thermal and electrical insulators known or able to store electrical energy with extreme density in ultra capacitors. Aerogels have also been demonstrated to purify salty water economically on scales suited to a single traveler or a major city.

Cermet is another example. Cermet is a ceramic-metal alloy, one which is tougher and more durable than steel and as light as aluminum, uncorrodable, non toxic, and superior to glass or metal for many high-volume uses, such as engine parts, although still expensive and difficult to machine. It is the lightness and durability of cermet that could reduce life-cycle materials use; and its inertness that could minimize disposal problems.

Superplastic steel is extremely small grained steel that can be formed to final shape with good enough precision to require no machining, thus, producing little or no waste. This was developed in cooperation with commercial partners, but is not yet in common use.

In two weeks, we will hold a working conference at Livermore on the material data base requirements for Design for Environment. The purpose is to eventually make

environmental-load data readily available to designers and manufacturers. This conference is focused on materials for automotive and electronic manufacturing, but is intended to define the general characteristics needed for the implementation of industrial ecology.

Environmental Technology

Within Livermore Laboratory's own operations, we are committed to the protection of human health and the environment, and the integration of life-cycle environmental quality into all of our activities. We have made many in-house process improvements (described in the Spring 1996 issue of Total Quality Environmental Management) which either recycle troublesome materials or eliminate or greatly reduce their use and wastes, particularly in plating, cleaning, and material test operations. We would be glad to share our experience with anyone engaged in similar activities.

Much of current environmental technology development is focused on the remediation of contaminated sites across the nation. However, the sensors for the detection of pollutants and the cleanup techniques are adaptable to material and manufacturing processes, as methods for cleansing and transforming used material for recycle, alternate use, or harmless disposal. For example, microbial destruction of volatile organic compounds (VOCs) can be used to either cleanse reusable liquid or porous materials of the VOC contaminants or to transform the contaminants into useful materials like alcohol. Sensors developed for detection of pollutants in soil and ground water can also be used on line as process and environmental quality monitors.

Finally, we have developed and are continuing to enhance and increase the linkages between computer models for the global climates, the oceans, and regional atmospheric, surface, and subterranean material flows and pollution effects, from atmospheric CO2 and the greenhouse effect to hydrocarbon, metal, and brine contamination of soil and water. Our purpose is to provide the tools that are needed to assess the impacts of and define the highest priority responses to human generated emissions.

Bioscience

Our work in bioscience is concentrated on genomics, the decoding and study of the functions of DNA, primarily of humans, but expanding to animals and plants. One of our goals is to understand how environmental insults damage DNA leading to cancer and other health problems. In some cases, DNA is able to repair itself and counter specific environmental threats. We have now mapped human chromosome 19 entirely, and have identified about 500 genes and genetic markers; three of the genes are repair genes. Understanding the fundamental strengths and weaknesses of life forms is essential in establishing environmental priorities.

Another application of genomics is the improvement of human health and the engineering of plants and animals to increase their productivity and environmental performance, that is, their disease and pest resistance with less or no chemical assistance.

Finally, genomics will eventually be the basis for measuring and managing biodiversity. Genetic codes will comprise the catalog of life forms and functions. The current libraries of genetic fragments and the gnome databases are the initial phase of this evolution.

Conclusion

At Livermore our hope and our intention is to make important contributions to global sustainability by basing both our scientific and technological research and our business practices on the principles of industrial ecology. We will:

- Support and develop multi-disciplinary programs which create the scientific basis for environmentally and economically efficient technology.
- Utilize a lifecycle, systems-based approach which integrates environmental considerations and promotes the conservation of natural resources.
- Encourage the development of responsible, technically and scientifically valid, cost-effective environmental laws and practices.

In these ways we share and support the goals of the Zero Emission Research Initiative.

Acknowledgement

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Design for Zero Emissions

Prof. William McDonough
Dean, School of Architecture, University of Virginia

I also have the great pleasure to tell you that I will leave tonight to Istanbul where I will be giving the plenary keynote address to the World Business Forum, a meeting of a thousand businesses and a thousand mayors coming together, and I will send them your greetings and report to them on your meeting.

I am going to focus on the textiles, and I'm coming at it from a little bit different position than a zero emissions position because you can see obviously that zero emissions is one of our most critical agendas because it allows us to reflect upon the first industrial revolution as something that we need to modify, and zero emissions is part of that modification. What I'm going to look at as a designer is to look at design itself as a signal of human intention and describe one example of what happens when we start by designing from scratch.

I'm going to give an example of a design where we start at the beginning, based on these concepts, rather than an end-of-the-pipe process of zero emissions. It's a front-of-the-pipe design using a concept I call no-pipes design. It's really what I consider the next generation, and as a designer, there's an old joke that when all you have is a hammer, everything starts to look like a nail. I'm a designer, so everything looks like a design problem to me. When I was approached to design fabrics, we approached it with a different design position, and I'd like to describe that.

First I'd like to say that I work very closely with Michael Braungart, a chemist from Germany who has developed an intelligence product system with which I work, and we developed something we call ecologically intelligent design protocol. We set up a company to do this called McDonough-Braungart Design Chemistry and our current clients include companies like Interface, Monsanto and so on, very large corporations around the world.

When we were asked to design the fabric, we explained to the Steelcase Corporation, which is the largest manufacturer of furniture in the United States for offices, that we needed to approach the design not just in terms of appearance but in terms of the fundamental making of the fabric, and they said, We thought you'd say something like this, so we have conceived the ideal environmental fabric for furniture which you're sitting on. They said it would be cotton, which is natural, and PET from Coke bottles, which is recycled. And isn't that wonderful, natural and recycled both together, all the important environmental concepts in one place, and it's inexpensive and it works.

And we said “This is interesting, but it is a product that should not be made”. No one had ever said something like that to them, and so we explained it. What we're

looking at is that the world is made of two metabolisms. One is the organic, or biological metabolism, and the other is the technical metabolism. And we're finding that as designers, we need to design into the metabolisms without mixing them up. In the first industrial revolution, we have designed so much into the organic metabolism that it's killing it. We need to design into the technical metabolism for something to stay within that metabolism and not be released to the detriment of the environmental or organic metabolism. So as designers, we can start to look at design protocols that allow us to do this.

To give you a sense of this from a design perspective, let me give you an abstract version of the first industrial revolution as a design assignment, and you tell me if this is an ethical instruction. Design a system that produces billions of pounds of highly hazardous toxic material and puts it in the soil, the air, and the water every year. Design a system that measures productivity by how few people are working; that measures prosperity by how much of your natural capital you can push through the system in a one-way-flow throughput and deplete, burn, dig up, otherwise waste; that measures progress by your smokestacks, as Chattanooga did in 1880 where they have all the names on the smokestacks and the engravings indicating the prosperity of this city; that requires thousands of complex regulations to keep people from killing each other too quickly; and that while you're at it, create a few things that are so highly toxic that they will require thousands of generations of maintaining vigilance while living in terror.

That is the retroactive design assignment of the first industrial revolution. The next industrial revolution says we don't need regulation because we're not trying to kill each other; that we measure prosperity by how much of our natural capital we can actually invest in closed-loop systems that continuously reinvest and accrue solar income; that measures productivity by how many people are working; and that measures progress -- and here's the zero emissions connection -- that measures progress by how many buildings have no pipes, no pipes; not end of the pipes, no pipes.

And let me describe what happens to design when you take on this concept. First of all, you can use some design principles, and the only design principle we have been able to discover in the first industrial revolution was that if brute force did not work, you were not using enough of it. What we need now are design principles that say that waste equals food, that we work with current solar income, that we work with the one form of energy that comes from outside the system; and that we respect diversity, that we are all different, everywhere in the world is different, all sustainability is local.

We need to develop new design criteria. There have been three criteria that have been used by designers: cost, performance, and esthetics. Does it work, do I like it, can I afford it? To that we have to add: is it ecologically intelligent and is it just? So we have developed this protocol for products because if waste equals food, then everything is a

product as you've seen in your zero emissions initiatives, and if everything is a product, then what are the products? How do we characterize these products?

And so Michael and I can characterize products as either consumables or products of service. It's either consumable within the biological system or it's a product from which you wish to have the services, and that we should design into either one. If we're going to design consumables, they should become soil safely, no mutagens, no carcinogens, no heavy metals, no persistent toxins, no bio-accumulative substances, no endocrine disrupters; that if we're designing into the technical metabolism, we can design things to go back to those industries forever without release and without down-cycling. Currently what we call recycling is often
down-cycling. We're losing the quality of the material. We're actually developing protocols right now to develop up-cycling where we can program things, program designs and production systems that move the products up the quality ladder instead of down.

So for the fabric, we decided to work with the organic nutrient cycle for the first one, and this product was done in Switzerland. We looked at this cotton-PET mix that was proposed and said “You see the problem?”. If you put these two together, cotton is responsible for something like 20 percent of the world's pesticide use, it causes hydrological disasters, and it has never been associated with social fairness. PET is petrochemical, it's potentially full of antioxidants, UV stabilizers, antimony residues from catalytic reactions. It doesn't necessarily belong next to your skin because it wasn't designed to be there.

So we designed an organic product made from wool from New Zealand, ramie from the Philippines grown organically, and -- but after developing a product around interviewing people in wheelchairs to find out what the worst case of sitting would be and it turned out to be moisture buildup, so the fabric is designed to absorb moisture and wick it away from you. Once we had developed that protocol, we went to the chemical industry, 70 chemical companies in Switzerland and Europe, and said “Who would like to work with us on the basis of developing dye stuffs, finishing materials, based on the concept that the filters of the industrial future are not on the ends of smokestacks, that they are not on the ends of pipes; that they are here [indicating the head]. And the filter is no mutagens, carcinogens, heavy metals, persistent toxins, bio-accumulatives, endocrine disrupters, and so on; could we use that as a way of designing?”.

And we didn't have a great response. In fact, it was uniformly signaled by doors slamming. Ciba-Geigy agreed to work with us, and very quickly we were able to analyze 8,000 chemicals in the textile industry, and with that filter, we had to eliminate 7,962. We were left with 38 chemicals which we used to make the entire line of fabrics, and what was very interesting is that if Henry Ford in the first industrial revolution said that you can have any color as long as it is black, in the next industrial revolution

we discovered you can have any color you want as long as it's not black. We're working on black.

But what is very interesting to this group, I would think, is what happened at the factory. When the inspectors came to inspect the water after the experimental dye lots were run, something very interesting occurred. The people thought that their equipment had broken. The water coming out of the factory was cleaner than the water going in. The water going in was Swiss drinking water. It turned out that the fibers and the fabrics themselves were further filtering the water and because we hadn't added anything to the process concerned, the water coming out was actually cleaner than the water going in. When you reach the point where a factory would rather use its effluent than Swiss drinking water, you can cap the pipe.

Zero emissions means zero regulations. This approach to design is an approach that hopefully will be emulated throughout all of our industries. Right now we're working with the largest carpet manufacturer for carpet tiles for offices with these same protocols, in their case as technical nutrients. We're redesigning whole systems of fabric development for these companies and others. We're working with the big chemical industries to work with these concepts because if our countries and companies expect to be wealthy in the future, we can't afford the regulatory structures required to protect ourselves from killing each other too quickly, we can't afford to develop our own response systems within our corporations and companies to respond to those regulations because none of these activities are productive. None of these activities are creative, so by actually redesigning design itself to work within these closed-loop concepts, the goals of zero emission can become design goals. As we are work towards zero, because we have a situation which requires our mitigating our bad acts, we can start then to focus on how we get to 100 percent sustainability and develop a positive agenda based on redesign, based on new principles.

Thank you very much.

Keynote speech at the Award Dinner

Edgar S. Woolard
Chairman, DuPont

Good Evening! It's a great privilege for me to join you in presenting this year's award, and as last year's honoree, I appreciate the opportunity to share some thoughts with you this evening.

The former executive director of Greenpeace International, Paul Gilding, was quoted in a business magazine recently as saying that the ideological battle for the environment is over and the environmentalists have won. I interpret him to mean that as a social value environmental protection is now a precept in virtually every country of the world. It has also become a central concern of international deliberative bodies and treaty organizations. School children the world over learn environmental concepts in the early grades.

Unquestionably the environmental movement has done an outstanding job of raising the consciousness of billions of people. It has been a remarkable, historic feat. The challenge we all face is how to act on the values we have come to share. The hard work of changing lifestyles, production practices and consumption choices has only begun. And here Gilding made another important observation. Now, he said, "the real environmental leadership in the 21st century will come from the business community" because "modern liberal capitalism is infinitely capable of adapting to new realities in order to survive."

I take some satisfaction in what Gilding and other leaders in industry and the environmental community are saying along these lines, because it was DuPont's position back in 1990. That year I said to the European Society of Chemical Industry that "given a sustainable development scenario, the only sector that can truly solve our environmental problems is industry." A year later I told an ethics symposium at Dartmouth College that "I believe that in the next quarter century the most significant net contribution to a greener world will be made by industrial corporations. Governments can regulate. Environmentalists can agitate. But only industry can innovate. "

Five or six years ago, those were considered bold statements. A measure of our success as a global community is that they are typical of environmental discourse today. But even then, we could see that ultimate victory in environmental matters has less to do with ideology than with performance, and performance is where industry excels.

Consider one example. Back in 1988, several hundred U.S. corporations - DuPont was one of them - voluntarily joined a U.S. Environmental Protection Agency program to reduce emissions of 17 large-volume toxic chemicals by at least 50 percent by 1995. That goal was largely accomplished, and we continue to make further progress.

The general public on the other hand has its heart in the right place judging from opinion polls, but has yet to make the necessary lifestyle changes. We called attention five years ago to Wendell Berry's observation that "we cannot continue to divide the world falsely between guilty producers and innocent consumers." Many of us realize that industry will be the spur to progress by offering consumers the value they want in goods and services that are produced with less environmental impact than the products they replace.

For companies to be in the vanguard of environmental leadership in the years ahead, they will have to embrace what I call step change. I distinguish step change from incremental change. Step change, for those of us committed to zero emissions, requires a major shift in the way we integrate business growth with environmental objectives. Step change is necessary because society has moved from the idea of pollution prevention to the concept of sustainability, of which pollution prevention is only one component.

Global industrial companies are ideally positioned to introduce sustainable practices in economies around the world. But we cannot continue to do what we've always done, only incrementally better, and expect to achieve sustainability. If sustainability is to be achieved, we will have to rethink virtually all our industrial processes. We have to devise new ways to protect the environment while also building a competitive advantage for business growth. At DuPont we maintain that this has to occur from the ground up, which is why we speak more often of the reality of sustainable communities rather than of the theory of sustainable development.

We need look no farther than right here in Tennessee to encounter examples of what we're doing.

One approach is to redesign processes to make materials without generating waste in the first place. Our nylon facility here in Chattanooga is striving for zero waste and emissions by improving yields. That plant now has a 99.8 percent yield of ingredients to products, which leaves only 0.2 percent waste. The plant has developed a plan with the City of Chattanooga to treat this remaining waste in the city treatment facilities, allowing the site to shut down its own treatment facilities. The plant site saves $250,000 per year in operating costs and eliminates the need to spend up to $20 million to upgrade the waste treatment operation. The city utilizes its treatment capacity and receives additional revenues.

Another DuPont plant in Tennessee at New Johnsonville won the Industrial Conservationist of the Year Award from the Tennessee Conservation League. That plant is the world's largest manufacturing facility for titanium dioxide, a product used to impart whiteness to paint, paper, plastics, and textiles. During 1995, the Johnsonville Plant reduced carbonyl sulfide emissions by 300,000 pounds, or an overall 18 percent reduction. This achievement represents the latest success in a toxic air emissions

reduction program that has demonstrated an 87 percent reduction in total pounds of carbonyl sulfide emissions, over 8 million pounds, since 1987 even as production rates have been increasing. These reductions are due entirely to improved process control which has enabled this accomplishment to be a true source reduction.

We've invested over $60 million to build a new facility that will eliminate deepwell operation and replace it with a process which will produce three new products - high purity sodium chloride salt, iron carbonate, and carbon dioxide. The salt will be sold in existing markets, including food. Markets for iron carbonate are being developed for brick manufacturing additives, cement, and fertilizer, and the CO2 will go into beverages. Start up is targeted for later this year. Deepwells at the site will be eliminated by the end of 1998.

Now what are the management principles behind these developments and the many others that could point to our plants throughout the Americas, Europe, and Asia?

The first guiding principle should come as no surprise to this audience: a zero goal for waste and emissions. This step change requires our research people and our engineers to think about environmental consequences from the start. If you invent a product, then you'd better think of a way to make it without a lot of waste. If a plant already has a lot of waste, we won't be content to see it cut by half or a third. We want to see a plan that moves in the direction of eliminating it all. Waste is raw material we paid for that didn't make it into product we can sell.

The second principle guiding us is the absolute need to integrate fully business and environmental performance. We are long past the time when corporate environmental performance can be driven by a small cadre of specialists. That is yesterday's model and it's not sufficient for future progress. Business people have to drive environmental change. We have found that they're very good at it. Our experience at DuPont suggests it's easier for a business person to learn, understand, and manage environmental performance than for an environmental specialist to manage a business. Don't misunderstand - you still need both types. But they have to work hand in glove, and business has to lead.

The third principle guiding our step change in environmental performance has been to reverse the traditional view of environmental compliance as a cost or a burden and begin to look at environmental innovation as fuel for the engine of growth.

Let me give you a solid example. In our Agricultural Products business, we designed a portfolio of low application rate herbicides that took us from the number seven company in the marketplace to the number two company. Farmers used to measure herbicides by the barrel. Our products are measured by the thimble - in grams and ounces. Without any decrease in crop yield, our sulfonylurea herbicides have allowed a 50- to 100-fold reduction in herbicide application per acre. Since these products were introduced, over 200 million fewer pounds of chemicals are applied to

the soil each year to control weeds. That represents about an 8 percent reduction worldwide from this one class of products. Chemical waste associated with manufacturing agricultural chemicals has been reduced by four to six billion pounds annually. The result for us is a very profitable, multi- billion dollar, global business.

Overall then a company has to make three commitments to achieve environmental step change and to make it pay off in terms of global growth:

-- There should be only one goal for waste and emissions, and that goal is zero.

-- Environmental goals and business goals must be completely integrated and the business must lead environmental progress.

-- The mindset of the company must be that environmental progress is accomplished through innovation that improves competitiveness and growth.

With these ideas guiding us at DuPont, it should come as no surprise that 1995 was both our record year for earnings and the year in which our wastes and emissions have been the lowest opposite our base years. In a company where step change is occurring, success in these areas is interlinked. The result is profitable growth and global success.

Where do we go from here? Zero emissions is one essential step change on the way to sustainable communities. There are other goals that industry should begin to contemplate. Fresh water is one concern. Another pressing issue is land use. In many countries of the world, we continue to use green fields for industrial development, while brown fields sit abandoned. The reasons for this are many. In the U.S. they include government policy, liability laws, and other concerns.

However the continued development of green field sites should not be viewed as a sustainable practice. I may seem ahead of my time, as I did in 1989 or 1990. But I propose that the UN University or other appropriate organization begin to contemplate a goal of zero green field development and consider creating an initiative to pursue that goal. I can imagine the skepticism at which such a proposal will be greeted. Five years ago people scoffed at the idea of zero emissions. But as I said here in Chattanooga on another occasion a year and a half ago, at the heart of any vision of sustainable communities must be the preservation of green space.

It will be impossible to accomplish such an objective without dialog between the public and private sectors and without substantial involvement of local communities. We should welcome that. Dialog across sectors and involvement of people at the grass roots level are vital ingredients of long-term sustainability. And that is our ultimate goal. I congratulate our honoree this year.

I applaud all of you who have done ground-breaking and historic work as part of this initiative. I urge you to take up new challenges for the common good of all the world's people and the benefit of generations yet to come.

Presentation of the UNU Zero Emissions Leadership Award

Prof. Em. Dr. Carl-Goran Hedén
Chairman of the UNU ZERI Scientific Advisory Board 1994-1996

The Rector of the United Nations University (UNU), Prof. Heitor Gurgulino de Souza, has endorsed the recommendation of a scientific advisory committee, chaired by Prof. Dr. Carl-Göran Hedén of the Royal Swedish Academy of Sciences, to award the 1996 Unique Leadership Award to Minister Sarwono Kususaatmadja, Indonesian Minister of Environment and Chairman of the UN Biodiversity Convention. The award, related to UNU's Zero Emissions Research Initiative (UNU/ZERI), is being made to Minister Sarwono for his efforts in steering business towards sustainability in general and the concept of zero emissions in particular.

Minister Sarwono passed a decree in December 1995 which classifies the environmental performance of companies using a color coding system as follows: black (for companies facing forced closure), red (polluting companies), blue (companies meeting legal standards), green (companies exceeding all legal norms) and gold (zero emissions companies).

The report of the UNU/ZERI scientific advisory committee states: "The passing of a decree, classifying corporations into five categories, whereby the highest gold category is reserved for Zero Emissions companies, is an act of leadership and a proof of vision. While regulations would never be able to force companies to reach the zero standard, this decree will motivate many to go for the honor. As we learned, corporations are already striving for the gold/zero emissions standards in a way no regulatory measure could ever have achieved."

The program is called the Enterprises Performance Assessment Program or in Indonesian PROPER PROKASIH. It is the first time indeed that such a program has been implemented.

The Minister has submitted to the Rector of the UNU that he is quite willing to accept the award on behalf of the team of the PROPER PROKASIH project at the Environment Impact Management Agency. This team, of very young collaborators, who conceived and developed the concept of ratings with gold as the top standard for Zero Emissions.

It is therefore that we invite Minister Sarwono to receive this award on behalf of the PROPER PROKASIH project team.

Please welcome Minister Sarwono.

Acceptance Speech for the UNU Zero Emissions Leadership Award

HE Sarwono Kusumaatmadja
State Minister of Environment of Indonesia

Prof. Dr. de Souza, Distinguished Guests,

Thank you to ZERI and to the Chattanooga Committee--this is indeed an honor not only to me but it is a tribute to the young staff within my agency. They are young, well educated and dedicated. Jobs are waiting for them in the private sector at 10 to 20 times the salary they receive now. But they are sticking with us. For this I have the greatest admiration. And they have been tutored and advised and cajoled by senior officials. They have been with my predecessor since the Ministry of the Environment was founded in 1978, five years after the Stockholm conference. One of them is here and I would like to recognize him, Prof. de Souza.

Let me, Prof. de Souza,ladies and gentlemen, give a brief account of the program. In 1989, seven governors in Indonesia and my predecessor, Prof. Emil Sali, had an agreement over the dinner table that they would join hands and ask the private sectors in our provinces to comply with our regulations on water emission standards. The companies signed up, 1024 of them, and since then we have had evasiveness on behalf of the private sector, we had a formalistic attitude from bureaucrats in some cases, but we did see compliance go up. And in 1993 we did have a review of this program, called the Clean River Program, and during the review we found out that we had to subscribe to 20 follow ups in order to push forward with compliance. And so we thought that there was no way to do it except to be transparent about compliance and performance. So we classified these companies according to their size, and we decided to go after the biggest ones first. We classified them according to the nature of their waste streams and we came up with a list of possible candidates and the number was 190. We then made an announcement to the public that we would be rating private companies in the future. We were surprised that 30 private sector companies volunteered to be rated. And strangely the management of those companies wanted to be rated even though they knew that their ratings would not be good. Why? They wanted their owners to know that they are having problems. In the Indonesian culture it is the attitude of the owners which are essential in a company's performance. They said that if it is black or red it doesn't matter, but they have to be transparent because we want the owners to sit up and take notice.

So the ratings consisted of 190 companies provided by our provincial government plus volunteers was performed. The list was announced in June 1995. We only announced the winners, and we notified everybody that we would be announcing those ratings later that year. Politics in Indonesia as well as other countries is involved, and the owners, government officials and others were trying to influence the announced results. So I decided to announce the ratings in December which is the time of year that

the elite are on holiday. So, they would have to react by mid-January and it would be too late. (laughter)

It is a tribute to my staff and to the Indonesian press, because it is the press that keeps the issue alive. It is also a tribute to the Indonesian NGO's. We have agreed with our NGO's that we don't have to like each other just because we need each other. It is a tribute to the Indonesian community for increasing activity relating to the environment. So this award is a very pleasant surprise to Indonesians, and it is a very heavy responsibility. It is another benchmark that you and ZERI have set up for us as a guiding benchmark.

This is how we work in Indonesia. We set up a benchmark for everything--for family planning, for self sufficiency in food, for the environment, for growth. We are proud of our achievements, but we realize that we are changing the problems of yesterday for the problems of tomorrow. We are thankful for your support and look forward to further cooperation in the future, and I would be very happy to see you all at the next conference in Indonesia next year.

Thank you very much.

Press Release of December 1995 on Proper Prokasih,
Enterprises' Performance Assessment Program

It has been since early 1994 that you all have heard about PROPER PROKASIH, which at that time was temporarily called Business Performance Rating (BPR). Indeed the concept of PROPER PROKASIH started to be developed in that period. This development process needed a long time, much longer than was expected. This was due to the fact that such a program was never before implemented in any other country. In the course of its development inputs from various parties were received and discussed, and if needed added to the basic concept. At this time, the mass media performed a meaningful participating role, giving information to the public as well as an input source for the improvement of the program.

Today, at last the development stage of PROPER PROKASIH has reached the dissemination of information phase. This dissemination of information is a part of PROPER PROKASIH, which is intended to improve legal adherence, and not for any other objectives. Hence, the information provided here is also adjusted to this objective. Aspects considered in providing this information are:

*That it is inherent to the common perception of environmental management from various heterogeneous parties.

*That the quality of data collected is influenced by factors inside as well as outside the PROPER PROKASIH management systems.

*That is is heterogeneous, because the basis of an industry obtaining a certain rating, for instance the Red rating, may be caused by the unwillingness to conform, inappropriate technology, or because that particular industry is still in the process of conforming to the regulations.

In the month of June 1995, 187 companies were assessed, comprising 172 PROKASIH participant companies, 11 volunteer companies, and 4 special participants. The results of this assessment are as follows:

* Gold Rating.....0 companies or.....0%
* Green Rating.....5 companies or.....3%
* Blue Rating.....61 companies or.....33%
* Red Rating.....115 companies or.....61%
* Black Rating.....6 companies or.....3%

.....TOTAL.....187 companies of.....100%

In June 1995 these ratings were still held as restricted information and only known to the related companies. The companies which obtained the Red and Black ratings were informed in writing and counseled about their respective ratings, that is if they intended to improve their ratings, the PROPER PROKASIH Technical Team may visit these companies again.

By December 1995, a change had occurred in the number of participants as well as the composition of their rating results. Including the 187 companies participating in the month of June 1995.

* Gold Rating.....0 companies or.....0%
* Green Rating.....5 companies or.....2.35%
* Blue Rating.....88 companies or.....41.31%
* Red Rating.....115 companies or.....53.99%
* Black Rating.....5 companies or.....2.35%

.....TOTAL.....213 companies of.....100%

From the assessment of the month of December 1995, it is apparent that:

1. Without the participation of small scale industries, the 213 companies taking part in PROPER PROKASIH may be used as an example to assess the level of present adherence due to the fact of the heterogeneous state of the industries, their scale, and geographical location. From the results mentioned above, it is clear that the level of adherence is 43.66% (Green 2.35% and Blue 41.31%), and for those that do not yet conform is 56.34% (Red 53.99% and Black 2.35%).

From this conclusion it is apparent that the application of PROKASIH using the partnership principle gave good enough results in improving adherence, even though there was no pressure of any legal instrument.

2. The industries obtaining the Red rating, a total of 115 (53.99%), were those companies which had already started to treat their waste but did not achieve the level required. This was due to mistakes in the design, procurement of equipment, or operational weaknesses.

Using guidance accompanied with the application of the PROPER PROKASIH instrument, these companies are relatively easy to upgrade to the Blue rating.

3. The Black rating is given to companies which have not yet put any effort into managing their pollution and which are causing contamination. The PROPER PROKASIH shows that companies which are at this rating level are a small minority (2.35%).

4. No participants achieved the Gold rating. This was due to the fact that to achieve the Gold rating, on one hand a different technology is needed and hence a new investment in the field of technology, and on the other hand prior to the introduction of PROPER PROKASIH no encouragement in the direction of zero waste disposal was present.

Nevertheless, from the consultative meetings with some of the company owners, in particular those owning larger groups, the intention to achieve the Gold rating was clearly displayed.

With the availability of the PROPER PROKASIH acting as an encouraging instrument, it is expected that in the not to distant future new industries with zero waste disposal will be established.

5. A total of 5 companies achieved the Green rating. However, a change occurred in the companies achieving this rating. Three companies which previously did not achieve this good rating, achieved the Green rating in December 1995. Also another company which achieved this good rating in June 1995, degraded to the Blue rating in December 1995. One company which in June 1995 achieved this higher rating, was not able to be assessed in December 1995 because it was undergoing an environmental audit (PT Cheil Samsung Indonesia).

The change from Blue to Green rating is possible because to attain the Green rating from the Blue, the company can put effort into improving the efficiency of the existing equipment and perform waste minimization with both not needing a significant investment. But on the other hand, the change from Green to Blue can easily occur, because a decrease in efficiency can happen, especially in the first months when an extra effort is needed due to the instability of the system.

Also, a temporary increase in the production volume (for instance due to a sudden increase in orders from a buyer) can cause a decrease in efficiency, which could also result in a rating decrease.

6. PROPER PROKASIH for December 1995 involved 213 companies, comprising 132 of PMDN (Local Capital Investment) status (61.97%), 41 PMA (Foreign Capital Investment) (19.25%), 3 non-facility companies (1.14%), 36 BUMN (Government Owned Enterprises) (16.90%), and 1 BUMN (Local Government Owned Enterprises) company (0.47%). The companies' rating comparison can be seen from Table 1.

RATING	PMDN(%)	PMA(%)	BUMN(%)
Gold	0	0	0
Green	0.80	7.4	2.8
Blue	30.3	70.7	50.0
Red	65.9	19.5	47.5
Black	3.0	2.4	0

TABLE 1: Composition of PROPER PROKASIH Participants and their Performance Rating According to Company Ownership status.

As can be seen from the above data, the performance of Foreign Capital Investment companies seems to be quite good (78.1% adherence) including 7.4% achieving the Green rating. But on the other hand, it is necessary to observe the companies from this group given the Black rating (2.4%), compared with those of the Local Capital Investment Companies (3%). Also the performance of the Government Owned Companies is 52.8% adherence, including 2.8% achieving the Green rating.

It is important to mention that no company from the Government Owned Enterprises group was awarded a Black rating. The effort to improve adherence should be focused more on the Local Capital Investment group, as well as on the Foreign Capital Investment group where 21.9% were not yet adhering, rather than on the 47.2% of the companies from the BUMN group which still achieved the Red rating.

7. Four companies could not be assessed due to them currently undergoing an environmental audit. These companies are:

* Cheil Samsung Indonesia which is undergoing an environmental audit due to recent developments. The focus of this audit is on relations with the public.

* PT Wastra Indah in Batu, Malang, and PT Texmaco Jaya in Pemalang, which are undergoing environmental audits in the context of improving their environmental performance.

* PT Sri Rejeki Isman (SRITEX) which is performing its environmental audit in the context of looking for the optimal technology to meet the existing requirements.

* To compare the June and December 1995 results, it is necessary to take samples of the same (187) companies. This observation can be followed on Table 2.

	JUNE 1995		DECEMBER 1995	
RATING	Number of Companies	%	Number of Companies	%
Gold	0	0	0	0
Green	5	3	4	2.1
Blue	61	33	72	38.5
Red	115	61	108	57.8
Black	6	3	3	1.6
TOTAL	187	100	187	100

TABLE 2: Comparison or Ratings of 187 Companies in the Months of June and December 1995.

It is clear from the above table that the change in the Green ratings of 0.9% is insignificant. What is more significant is that to achieve the Green rating, the change for those companies is not so difficult (no investment is needed), but on the other hand it is easy to degrade to the Blue rating due to the degrading of management levels as was explained previously.

The increase in the number of companies achieving the Blue rating (5.5%), the decrease in the number of companies obtaining the Red rating (3.2%) and the Black rating (1.4%), shows that as an enforcing instrument PROPER PROKASIH is effective even in a short time span.

9. In the past six months, two large companies upgraded their rating. Firstly PT Indobharat Rayon, which in June 1995 obtained the Black rating, upgraded to the Blue rating in December 1995. Secondly, PT Inti Indorayon Utama which in the past caused a lot of controversies in its environmental management, and in June 1995 was registered as company undergoing its environmental audit, achieved the Blue rating in December 1995. The upgrading of these two companies was greatly influenced by them taking part in the PROPER PROKASIH.

10. In general those large companies which have a number of factories in their group do not possess a homogeneous industrial performance. From the four industries in the Sinar Mas Group, namely PT Indah Kiat Tangerang, achieved the Green rating, PT Indah Kiat Perawang and PT Tjiwi Kimia the Blue rating, while PT Indah Kiat Serang was given the Red rating. But from the PT Raja Garuda Mas Group, Inti Indo Rayon achieved the Blue rating while PT Raja Garuda Mas Panel Pekanbaru obtained the Black rating.

The PT Kalimanis Group seemed to be consistent in the management of the environment, where Kalhold Utama achieved the Green rating, and all the other members obtained the Blue rating, namely PT Kalimanis Plywood, PT Santi Murni Plywood, PT Kiani Saki and PT Gany Mulya Sejahtera Industry.

What has to be paid attention to by the Kalimanis management is their plywood glue factories. By observing their efforts, we may expect that in the near future due to the performances of their plywood-glue factories, PT Lakosta Indah and PT Batu Penggal Chemical Industries will upgrade to the Blue rating.

Because in the Indonesian business-culture a strong influence is exerted from the ownership and policy is not only dependent on the management, the owner's commitment will form a decisive factor in the company's performance.

It is necessary to underline the fact that PROPER PROKASIH is still in its beginning phase, while the use of information as an instrument is not yet common. Hence BAPEDAL is acting accordingly in providing this information. The level of openness which will develop is according to the development of the level of transparency in the government, business, and public sectors.

We hope that the information provided here can be used in the best sense by all parties involved to improve the adherence to environmental impact management.

Jakarta, 29 December 1995

Environmental Impact Management Agency Head

signed,

Dr. Sarwono Kusumaatmadja

ADDENDUM I

PROPER PROKASIH BACKGROUND

In its effort to improve adherence in the field of environmental impact management, the Government implemented the use of a combined instrument. This meant that various enforcement instruments were applied simultaneously with the choice and stress as according to the condition encountered. As an example, the partnership instrument is used in the Clean River Program, in conjunction with an economic incentive instrument (exemption of income take and soft loan). Besides that mentioned above, the administration sanction instrument was also used through the application of the Disturbance Ordinance, as well as the legal instrument.

At the beginning of 1994, it was felt that it was time to apply the information instrument. This opinion was mainly based on the assessment that the awareness and

participation has reached a significant enough level. Another factor which pushed the application of an information instrument was that the application of PROKASIH was developed: PROPER PROKASIH. The objective of PROPER PROKASIH is to improve adherence through the application of the information instrument. As mentioned above, this instrument is used in conjunction with other enforcing instruments. In the PROPER PROKASIH, the information provided on the company's performance in managing the environment is presented in an easy understandable form. The information, with the company's name and its ratings in color is as follows:

gold: is awarded to companies which have the potential of disposing wastes but which are successful in achieving zero disposal, and hence are worthy to be an example,

green: is awarded to companies capable of reducing their wastes up to a level less than the maximum allowable by the stipulated waste quality standards,

blue: is awarded to companies capable of conforming to the stipulated waste standards,

red: is awarded to companies which have tried to conform with waste quality standards but have not succeeded in meeting the defined waste quality criteria,

black: is given to companies which have not yet tried to adhere to the waste quality criteria, which are causing pollution.

The companies participating in PROPER PROKASIH are companies which:

*were already participants in PROKASIH,
*declared that they voluntarily wanted to participate in the PROPER PROKASIH, and
*were special participants, or companies outside the above mentioned categories but considered necessary to take part so that their adherence could be encouraged.

The companies participating in the PROPER PROKASIH program could have their rating results temporarily postponed if due to some circumstances, those companies decided to perform an environmental audit.

To support the development of PROPER PROKASIH, a PROPER PROKASIH Review Board is being prepared which will have the task of providing input and considerations to the Minister of Environment. The membership of this board will consist of echelon I officials from a related institution and members from the business world, non-government organizations and the mass media.

Plenary Session II:
Zero Emissions Initiatives in Cities and Regions

May 31, 1996

Zero Emissions : The Case of Yakushima
presented live over Internet network video

Japan time: 9:40 P.M. - 10:20 P.M.
Local time: 8:40 A.M. - 9:20 A.M.

Place: Kagoshima Prefectural Comprehensive Education Center

Proceedings:
General Chairman: Hugh Faulkner (former Minister of Science, Canada)
Chairman, Kagoshima Meeting: Takamichi Hamada (Director General, Commerce, Industry, Tourism, and Labor Department, Kagoshima Prefecture)

[1] 9:40 - 9:43
Message from Dr. Kenichi Fukui (Nobel Prize laureate, member of Yakushima Environment and Culture Council)
Message: "Thoughts on Yakushima"

[2] 9:43 - 9:53
Raising the Problems of Yakushima
Town mayors of Kamiyaku and Yaku will present points regarding the problems being faced on Yakushima and steps being taken, and appeal for advice from around the world.

(1) Town Mayor of Kamiyaku (5 min.)

(2) Town Mayor of Yaku (5 min.)

[3] 9:53 - 9:58
The Development of the Yakushima Environmental Culture Village Concept and the Yakushima Zero Emissions Model Project
Based upon the above presentations, the prefectural government's viewpoints on the problems and their efforts towards solving them will be introduced.

(1) Takamichi Hamada, Kagoshima Prefecture Director General, (5 min.)

[4] 9:58 - 10:03
Proposal for a Metabolism Civilization from the Yakushima Zero Emissions Model
Posing the problem from the viewpoint of an outsider who promotes zero emissions in cooperation with the UNU.

(1) Moto Yoshimura, Director of the Environmental Planning Institute (5 minutes)

[5] 10:03 -10:20
Discussion with other participants led by General Chairman, Hugh Faulkner

Thoughts on Yakushima

Kenichi Fukui
Nobel Laureate Chemistry

Director, Institute for Fundamental Chemistry

My love for nature is second to none.

I have been fascinated by the beauty of Yakushima for five years now. Yakushima alone, through its unique natural features, shows how to preserve unique forms. This island is the perfect place to show us how special nature is. There people can feel the mystery of nature, and realize how we must respect it. For the human animal, nature is the source of our thoughts, arts, science, and spiritual matters.

However, human beings influence the physical order of this special place, and have learned scientific ways of changing nature. The most important thing now is to pay attention to the fragility of nature before irreparable changes are imposed on the earth through the negative influences of science.

I remember giving a speech upon receiving the Nobel Prize to the effect that scholars must preserve the heritage of the earth and aspire to a sustainable existence for human beings. I wish to say the same to those people who will be the protectors of Yakushima's global heritage from now on.

Raising the Problems of Yakushima

Mr. Shiba
Mayor, Kamiyaku Town

Thank you for your kind introduction. I am Mr. Shiba, the town mayor of Kamiyaku Town.

These days environmental problems are of global interest. Here on Yakushima, our basic principle is to structure the island through the peaceful coexistence of human beings and nature. To preserve this global natural heritage island, we are continuing to develop an unparalleled system of environmental policies.

Therefore, this meeting of the World Congress on Zero Emissions comes as a timely event for Yakushima, and I wish to express here my deepest respect for all the members whose efforts made this meeting possible.

Now I would like to present some cases on Yakushima with regards to the environment and zero emissions, and raise a number of problems related to these issues.

As I believe everyone here is aware, Yakushima is divided into two administrative areas, Kamiyaku Town and Yaku Town. When thinking of the environmental problems of Kamiyaku town, it must be kept in mind that the major topics are not

limited in scope to Kamiyaku Town alone. That is, Yakushima is one environmental system, so policies based on the value of the entire area are necessary. Acting on this understanding, both towns have been working together from a relatively early period, and in July of 1993 enacted the Yakushima Charter, in which lifestyles and actions befitting the residents of a global heritage island are defined. This was followed in April of 1995 by the promulgation of the Basic Environmental Ordinance.

This Basic Environmental Ordinance, which is based on mutually shared values and is the same in every way for both towns, defines the basic course to follow for preserving the environment of Yakushima for future generations. At present, also the same in both towns, basic environmental plans and guidelines are being developed.

However, some of the problems have different aspects in each town, and there are points at which the opinions of the people of the two towns differ. Now we face the question of how to eliminate these problems and gain the understanding of the residents.

In both towns, it is understood that the source of the natural abundance of Yakushima is water, so the most pressing problem in protecting the island's environment is the maintenance and purification of the water environment.

For maintenance of the water environment, national law in Japan calls for an impurity level of 20ppm or below. However, in Kamiyaku Town, we have independently set a stricter limit of 5ppm, and have been installing water purification devices capable of achieving this level in public facilities, such as restrooms, since 1992.

Next I'd like to move on to problems associated with having been registered as a World Heritage landmark that must be dealt with from now on. There are two problems that require immediate action: improvement of facilities for dealing with the sharp rise of garbage and human waste resulting from the increased numbers of tourists, and treatment of the human waste of people who come to the mountain areas.

In regard to the former, a task force organizing efforts in both towns is preparing to commit 2 billion yen to high level facility maintenance over about two years, beginning in 1997. In addition, both towns are working together to develop plans for improving garbage management facilities.

As for the latter point, to respond to the sharp rise in visitors to the Mount Oku-dake and Jomon Sugi cedar areas, it is necessary to install public restrooms, but it is impossible to provide enough water and electricity in the world natural heritage area, so we must find some effective way of dealing with human waste.

In short, we hope to draw on the knowledge of all of you to somehow find solutions to our problems. I would like to close by asking for suggestions based on similar situations from all over the world. Thank you very much.

Raising the Problems of Yakushima

(Yaku Town)

As explained in the homepage visitors guide, Yakushima is surrounded by the Pacific Ocean and the East China Sea. Being surrounded by seas has fostered a self-sufficient lifestyle among the local people of Yakushima. In particular, the circulation system between consumption and production has played a marked role in agriculture, forestry and fishery. Let us quote some examples.

Firewood for daily use produced ash, which was then returned to the soil as fertilizer and improved the chemical features of the farmland.

Leftover food was given as feed to domestic animals. Their waste was absorbed by the bed material of wild plants and was used as fertilizer, thus returning to the farmland.

Daily waste water was put into simple settling ponds within private grounds. The top fluid was used as a reservoir for vegetable gardens and other gardens, while the sediments were returned to the farmland. This was how water pollution was prevented. All human waste was used to fertilize the farmland.

These are only a few of many examples. In any case, things were utilized to the fullest, which was taken for granted and has been routinely practiced. We believe that this is the prototype of zero-emissions which is being discussed in the meeting today.

Being surrounded by sea, this place is also isolated. Technological advancement and materialistic civilization have helped improve the convenience of our lifestyle by developing easier access and saving time. As a result, the self-sufficient lifestyle which inevitably arose from isolation was changed to the disposable way of life. In addition, the lifestyle of the local community was changed from the production environmental type to the life environmental type. I strongly feel that this has discouraged the idea of self-sufficiency and leads us to the discussion of zero emissions.

I am trying to establish the circulation of the material through agricultural production. This can be done by making composts from forestry related wastes, stockbreeding wastes and agricultural processed wastes. I believe that this will be a model of zero emissions and that a consensus can be obtained in the community of a life environmental type. With this circulation, I am aiming at establishing "Fruit Island Yakushima" where fruits can be enjoyed throughout the year.

As of now, we plan to produce 1,400 tons of compost annually by utilizing the raw material of 1,000 tons of forestry waste (such as bark and saw dust), 500 tons of cattle

waste and 850 tons of agriculture processed food waste per year. This will enable the low import of compost and contribute to reducing production costs.

We will either bring the compost directly from the compost center to the farmland by vehicles or pack compost into 20 kg bags for consumers who only need small amounts, or for convenience when delivering it to narrow places where it is difficult to use cars. According to the increase in users, the use of plastic bags will also increase, hence adding to the new waste material.

There are many contradictory problems to be solved. Recycling systems, the use of materials, and the utilization of microorganisms in the compost production process should be considered in order to improve the production environment. I look forward to the presentations of the participants of this conference for solutions to these problems.

The Development of the Yakushima Environmental Culture Village Concept and the Yakushima Zero Emissions Model Project

Takamichi Hamada
Director General, Kagoshima Prefecture

1. As a part of the aim of "Nature and Humanity Coexisting" found in the Prefectural Comprehensive Basic Plan set in motion to give a vision for the 21st century to Kagoshima Prefecture, the Yakushima Environmental Culture Village Concept was created, and the project is progressing.
The core facilities for environmental studies, the Yakushima Environmental Culture Center and the Yakushima Environmental Culture Learning Center, will soon be completed, making hands-on experience of environmental study possible, and the Yakushima Environmental Culture Village Concept has been developed according to this idea.

Zero emissions efforts, the attempt to eliminate the waste caused by human endeavors and utilize it as a new resource for industry, is a concrete example of the steps being taken by the Yakushima Environmental Culture Village Concept to move toward the 21st century by establishing low-impact lifestyles and industry.

2. Promotion of the Yakushima Zero Emissions Model Project

(1) On Yakushima, 90% of the electricity needed on the island is the clean energy of hydroelectricity. Hereafter, increased demand for electricity is predicted to be a natural result of the progress of the Yakushima Environmental Culture Village project.

Yakushima, with protection of the environment as its watchword, must work towards becoming a closed system through promoting natural energy, energy self-sufficiency, and zero emissions. Through the introduction of wind power, solar power, and power produced from garbage, it should be possible to realize zero emissions in the field of energy production.

(2) Recycling is already established in agriculture and fishing on the island, and the awareness of the residents of the efforts toward zero waste is high.

3. The zero emissions model on Yakushima is advanced, and Yakushima is the closest in the world to reaching the goal of a zero raw-waste, material recycling community.

4. To encourage even the slightest progress of concepts such as the zero emissions model on Yakushima, the prefecture also wishes to use the power of the country and support the efforts of both towns.

Proposal for a Metabolism Civilization from the Yakushima Zero Emission Model

Professor Moto Yoshimura,
Director of the Environmental Planning Institute

It is said that there is no waste in nature. In an attempt to build a society that operates as efficiently as nature, we have undertaken three major objectives for implementation on Yakushima Island, to make full use of the regional resources of Yakushima Island, the elimination of fossil fuels from the island, and zero waste emission. Based on the industries and livelihood of the island, we shall work toward the ideal of the construction of a resource cycling, sustainable society that will exist within the precious nature and ecosystem of the island. We propose the "Yakushima Island Zero Emission Model" as a series of policies working to make this concept a reality, positioning this proposal as a guideline for the actual application of these concepts on Yakushima Island. The subject of the coexistence between nature and the approximately 13,700 inhabitants of the island that is expected to be achieved, the various processes needed to take this concept from the proposal stages to actual implementation, is common to the serious global ecological problems facing all areas of the world. These problems have resulted from the large-scale production, massive consumption, and voluminous waste of the 20th century industrial civilization. Humankind now faces a trilemma bound by the complex cause and effect relationship that mutually regulates "economic development", "energy -- resources -- food" and "the global environment". Solving these structural problems necessitates the creation of a "21st Century Metabolism Civilization" as a paradigm of symbiosis between humankind and the global environment. This paradigm is a model unifying the concept of "environmental ethics"

that possess a sense of reverence for the biological life of the planet, "the fostering of new industries through industrial connections that place importance on nature", industries that emit extremely small amounts of waste emission and use small-quantity diverse manufacturing systems, and "the creation of a life-culture that will coexist with nature" that realizes suitable consumption, low-energy use, recycling, etc., supported by a system of material cycling and regeneration. This is the Yakushima Zero Emission Model (Yakushima Model), basically a miniature model of the water and nature ecosystem of the Earth. The Yakushima model signifies a reform of present-day civilization to a metabolism model that will coexist with global nature. We believe that the Yakushima Model will send an effective message to the world concerning the global environmental problems which will grow more severe in the 21st century.

The concept of zero emissions is that total waste emission resulting from industrial manufacturing activities is reduced to zero, that is, waste generated by one industry is used as raw material by another, resulting in zero waste emission. The zero emission concept is advocated by the United Nations University and conforms to the Rio Declaration, a basic concept for global preservation of the environment, and the Agenda 21 Plan of Action, both adopted by the 1992 World Summit. The project we are planning to implement for this concept on Yakushima Island is the "Yakushima Zero Emission Model". The concept of zero emission is supported by criteria signifying a conservation of resources, and a sense of environmental ethics based on an acknowledgment of the rights of nature and on the concept of coexistence with nature. With only a limited amount of arable land, the livelihood
of the people of Yakushima Island once relied heavily on the mountains and the sea. From this existence was born folk religions such as "Takemairi" (worship of the mountain god) and the faiths of "Funadama-sama and Ebisu-sama" (the guardian deity of ships and the god of commerce and fishing), through which people would ask the gods who provided blessings from the sea and mountains for permission to cut trees and pray for abundant harvests and safe fishing. To share the fixed amount of resources and maintain a sustainable society, laws protecting the lumbering and fishing industries as well as taboos and legends were passed down through the generations. While these laws and rules developed from the reverence the people had for Sangakujin (mountain worship) and for the Funadama and Ebisu gods as well as their appreciation for the blessings of the sea and mountains, they were also a result of the wisdom the people acquired that took them from lives of over-exploitation to lives of protecting nature.

With elevations from sea level to approximately 2000 meters, the island has a diverse climate ranging from subtropical to subarctic. Yakushima Island is home to 6000 year old Jomon cedar trees and has been recognized for its rich diversity of life. In recent years, lumbering activities, particularly the felling of Yaku cedars over 1000 years old for the construction of temples and monasteries, has caused repeated tension in the relationship between humans and the natural resources of the island. The island's population at one time reached 25,000, centering on forestry workers. Until recently the island had sustained a balanced population said to include 20,000 monkeys, 20,000

deer and 20,000 people, but the human population has dropped to 14,000, and monkey raids on farm lands have caused serious damage to the island's agriculture. The island also suffers from unusual tourism concentrated around the Jomon cedars. Problems with upstream pollution of drinking water and garbage have developed, and the tourism could even bring crime to the mountains.

In 1993, Yakushima Island was registered in the World Legacies Treaty. Taking this as an opportunity, the residents of the island proposed the Yakushima Island Environmental Culture Village Plan based on the concept of eco-tourism, as they continued to search for new forms of interrelation between nature and humankind within the limited natural resources of the island. However, an entirely new concept is needed to achieve strict preservation of nature while at the same time working to solve problems such as depopulation, an aging population and industrial stagnation. Here is where the concept of zero emissions becomes effective; it makes it possible for industry and human lifestyle to exist with nature on a basis of environmental ethics. The goal of zero emissions on Yakushima Island is to create new environment-based industries and jobs, and to actualize strict policies for environmental protection through the full-scale creation of a lifestyle culture unique to the island that will feature low energy use, recycling, and reproduction functionality. The foremost step in concrete plans for the project is to eliminate the use of fossil fuels from the island. The second step is to promote zero waste emission. The third step is to construct a system that fully utilizes the region's resources. The verification of the logic of this zero emission project that protects wildlife, set on the stage of Yakushima Island, will promote a transition in the values of all people who live on and visit the island from the utilization and exploitation of nature to a direction toward harmonious coexistence with nature. Furthermore, the reexamination of the existing industrial structure and the creation of an industrial linkage system that produces zero waste emission by continuously recycling resources will give consideration to the structure expected of the advanced nations of the 20th century that utilize massive amounts of natural resources and energy, increase awareness of the need for concrete responses to global environmental problems, and can serve as an indicator of the stages of actual development. The results of this project will also be extremely useful to the world's developing nations. The 21st century holds the possibility for a transition from the cluster lifestyle that has existed thus far to a decentralized network of dwellings, thus reducing the burden which humankind places on the environment. We believe that the Yakushima Island Zero Emission Model can make great contributions to the structure of regions and cities of tomorrow, contributions to the concept that, "Dwelling on the Earth equals Eco-habitat."

Zero Emissions on the Island of Gotland

Håkan Ahlsten
Project Director

Chairman, ladies and gentlemen:

I am honored that I have the opportunity to present my island and what we are trying to do there. (Video.)

The island of Gotland as you can see is at the heart of the Baltic Sea. We are a tiny island with a great big history based on living traditions from the Viking times to the middle-age, from our special role as an important trading port in the Baltic. The city of Visby has recently become a member of the Genesco World Heritage List. There almost 60,000 people living on the island of Gotland, and our major industries are agriculture, tourism and cement, with expanding sectors including technology and services.

My name is Håkan Ahlsten and I am one of those people with several jobs. Apart from being a busy father of four, I am manager of a local bank, I am chairman of a group of politic companies, and I am also chairman of a group of food producers who trade under the name Product Gotland.

Because of our island's heritage, I suppose that we Gotlanders are not content with waiting for developments to catch up with us. We try to take the initiative to see to it that our island can take an active part in the trade in our region. Because of our roots in agriculture, I suppose we Gotlanders are not content to wait on government regulations to tell us how to produce clean and healthy food. We try to take the initiative to see to it that our island can continue to provide our mainland neighbors with top quality food products based on some ecological and commercial principles.

Three years ago, a number of local companies, my own included, decided that we needed to take an important initiative to create a quality standard for our food products which could be used for quality control, for our own efficiency and for increasing our share of the market. With the help of the scientists from the Department of System Ecology at the University of Stockholm we have found a method which is suitable for small companies. Each company has its activities analyzed by a researcher, and all the processes are looked at from a systems ecological point of view. The scientists then can identify those methods which are most urgent in order to reduce negative environmental effects. The company's management can then develop an ecological strategy that clearly states which measure will be taken and when. This method gives each individual company a chance to start an ecological process from where they are standing right now. The ecological strategy they decide on as well as the results of the study made are available in the public domain--freely available to consumers and the media. The only exception to this rule is where commercial secrets are involved.

The concept we arrived at was called Product Gotland. Food products used on the island should conform to a strict ecological standard monitored by independent scientists from the University of Stockholm. This process is open-ended with an aim to produce top quality food for the market demand. Companies have joined the Product of their own free will, simply agreeing to stick to the guidelines. Producers who develop an ecological strategy and stick to it can use our Product Gotland logo type. Consumers can be safe in the assurance that any product bearing our logo type has been produced according to these principles.

The results of our project have been very encouraging so far. Several of our member producers have increased their markets, and the outlook for the future is even better. But we are not the only group working in this direction on the island of Gotland. The regional and local authorities have done some very important groundwork drawing up guidelines for different areas of activity. One study produced in 1994 is called Vision 2010. In this major study a strategy for sustainable growth of our island region is drawn up. Another important initiative is the ecological Municipality Program which ties in with the Agenda 2110 Program. Here the local authorities have drawn up strategies for the region and also started a number of growth projects to this end. The number of initiatives is too great for me to present here and many of these programs are similar to other programs undertaken in other regions.

The method we have used in the case of Product Gotland is specifically designed for small companies, and has been successful in getting them started in a practical ecological process. Even though we have just started, I would now like to take this principle farther. Since I can see that working toward such a challengeable goal as zero emission would lead to the creation of a powerful amount of insight which would make this process even better. My vision of the future is, therefore, that the island of Gotland should become the first zero emissions zone in our part of Europe. The local support from industry is already in place. Once again, perhaps it is our island's character and farming tradition, but there is a good understanding in our region for the concept of using "All of it". Using "All of it" is part of our culture heritage. How else could our tiny island in a stormy sea survive and thrive throughout the centuries? The local support from government is also in place. Our local politicians, many of them sons and daughters to farmers, fishermen, and local traders, are quick to understand the common sense of the concept of using all the resources available and for creating a sustainable society. So my vision is not so far-fetched as some people might imagine.

I believe that Gotland as a zero emissions zone at the heart of the Baltic Sea could be an important example to our neighbors in the former Soviet Union, for our friends on the Baltic islands and for our colleagues in other rural regions. I believe that this process can be started now. And that I will have the pleasure of meeting with you all again at the next Zero Emissions Congress either in person or in a virtual forum to report back to you on the concrete growth toward becoming a zero emission region that Gotland has made. I could be accused of sticking my neck out but remember that I am a bank manager too, and I don't believe in taking uncalculated risks. Having seen the progress

and enthusiasm from our friends in Japan, Namibia, Indonesia, and many other countries, and not least, in this wonderful city of Chattanooga, I feel that the risk factor is becoming smaller and smaller. Its time for us to put our money where our mouth is. It's time for Gotland to take its place in the world family of zero emission communities.

Thank you for your attention.

Plenary Session III:
Concrete Results from the Zero Emissions Research

May 31, 1996

Zero Emissions Projects in Tanzania

Prof. Dr. Keto E. Mshigeni
Chairman, United Nations University's ZERI Advisory Council 1996-1998
Pro Vice Chancellor of the University of Namibia

INTRODUCTION

(1) Tanzania, with a human population of a little over 25 million, became politically independent in 1961. It is a country characterized by a strong national cohesion amongst her 125 or so different tribes and ethnic groups, by a sound political stability, and enviable peace and harmony. It is country which has never been subjected to military dictatorships.

(2) Tanzania recognized the significance of science and technology as a driving force for socioeconomic advancement of society, right from the onset of independence. In 1968 the newly independent nation established the National Scientific Research Council (NSRC), which was given the mandate of coordinating and promoting scientific and technological research in the entire country. In 1988, the Council was replaced by the Tanzania Commission for Science and Technology (COSTECH). This was done in an attempt to remedy some of the shortcomings of the former body and to accelerate the pace of S & T development in the country.

(3) Tanzania is one of the few countries in Africa with a fully fledged Ministry of Science, Technology and Higher Education, and with a clear Science and Technology Policy. Recently, Tanzania was selected to house the Center of Excellence for Industrial Technology and Marine Sciences, under the Third World Network for Science Organizations (TWNSO) based in Trieste, Italy, to cater for the entire South. This newly established Center will work through the networking of scientists and technologists from the national Universities, from the key science-based organizations in the country, and from the Private Sector. Its headquarters will be at the Tanzania Industrial Research and Development Organization (TIRDO) in Dar es Salaam, for the industrial research aspects, and the Institute for Marine Sciences (IMS), Zanzibar, for marine resources development activities.

(4) Various studies have revealed that Tanzania is relatively well endowed with an impressive number of scientists and technologists with bachelor's degrees, and also with postgraduate qualifications. The Faculty of Engineering at the University of Dar es Salaam alone, for example, has 45 Ph.D. degree holders. Through the networking of inter-related institutes and industries, and of various scientists and technologists, and through multidisciplinary research approaches, Tanzania is very suitably placed for embarking on Zero Emissions Research Initiatives.

(5) Accordingly, on March 13, 1995, COSTECH convened a meeting of key scientists and technologists from within COSTECH, and from organizations such as TIRDO, IMS of Zanzibar, the Tanzania Sisal Authority (based at Tanga),the University of Dar es Salaam (Faculties of Engineering and Science) and others. The meeting was aimed at providing a briefing on the mission of ZERI, and facilitating a discussion on what projects the Tanzanian scientific and technological community conceives to have the highest priority, in the context of ZERI.

(6) This paper presents a summary of the deliberations and recommendations emanating from that historic meeting, on Zero Emissions Industrial Projects, for Tanzania.

KEY FEATURES OF TANZANIA'S ZERI PROJECTS

(7) At the meeting, the Resource Person (Keto E Mshigeni) gave some key highlights on ZERI, and also made reference to the documents which had been communicated to COSTECH by Mr. Gunter Pauli of the United Nations University Headquarters in Tokyo. These had been distributed to the participants of the meeting.

(8) Reference was also made to the ZERI Brewery Project, which will feature significantly in China and which had been suggested also for Africa on a smaller scale of operation, and which would also involve elements of aquaculture. The participants were informed also about the proposed visit to Africa by Gunter Pauli at the beginning of May, 1995.

(9) In the course of the discussions, it was noted that the invited participant from the Tanzania Breweries had not shown up. Therefore it was not clear to what extent the Company would be interested in participating in the Brewery-Aquaculture ZERI Project. But the scientists and technologists who participated in the discussions made a strong case for the following potential ZERI Projects for Tanzania:

(a) ZERO-Emissions Sisal Industry

The participant from Tanzania Sisal Authority (TSA), based in Tanga, Tanzania, presented a very strong and convincing case on the need for a ZERI Sisal Project. He was unanimously supported by all other participants, in view of the following facts:

(i) Tanzania's climate is ideal for sisal cultivation. Indeed, at the onset of independence, sisal was the leading cash crop in the country.

(ii) The world's interest in sisal has been reactivated, since the synthetic products which had led to the decline of the world market for sisal, are non-biodegradable, and hence unfriendly to the environment.

(iii) The sisal industry involves an astoundingly great wastage. The sisal fiber that is extracted represents only 2% of the biomass of the plant. To date, as much as 98% of the sisal harvest has been thrown away at a great cost, financially, and also environmentally. At its peak in the 1960's, the Tanzania Sisal Industry produced 230,000 tons of fibers per annum. This meant that as much as 11.5 million tons of the sisal biomass was being thrown away every year; thrown away to pollute the environment.

(iv) Research on sisal in Tanzania already involves a lot of institutional collaboration and networking. The collaborating research institutions include: Tanzanian Sisal Authority, the University of Dar es Salaam, Sokoine University of Agriculture, and several private companies and overseas research institutions. Research undertaken to date indicated that many commercial products can be produced from the million of tons of sisal waste that are currently being thrown away. The products include:

* Renewable energy in the form of electricity from biogas. It has been estimated that Sisal Industry in Tanzania can generate up to 85 Megawatts of electricity per hour, if all the 95 decorticators in place were working.

*Organic fertilizer for various agricultural crops.

*Animal feed for livestock.

*Male sex hormone, which can serve to promote growth in immature animals.

*Extracts for chicken treatment against Newcastle disease.

*Pulp for paper making.

*Alcohol (from the sisal juices).

*Citric acid (also from the sisal juices).

*Medicinal products (e.g., for treatment of diabetes, stomach ulcers, and heart ailments; for regulating cholesterol levels; for removing toxins and heavy metals from the body, etc.).

*Cement forming products.

I am strongly convinced that the ZERI Sisal Project has a lot of merit. The Managing Director of TSA, Mr. S. Shamte, was proposed coordinator of the Project.

(b) ZERI Sugar Processing Project

The participants of the meeting gave this Priority Rating No. 2. The Institute of Production Innovation (IPI), University of Dar es Salaam, has already done a lot of good research on this. The Director of IPI, Prof. J.S. Mshana, was proposed coordinator of the Project.

(c) ZERI Seaweed Processing Project

This project was recommended in view of the fact that Tanzania's coastal village communities have already acquired the technology of cultivating seaweeds on a commercial scale.

Currently some 5,000 tons of seaweed (dry weight) are exported. But they are exported in a dried, unprocessed form. In the countries of the North, the seaweed is re-soaked and boiled to extract the hot-water-soluble hydrocolloid: **carrageanan**. Fifty percent of the biomass which is exported, and which is not carrageanan, is still rich in inorganic mineral nutrients, including vital trace metals, and also in some useful organic substances. These could be used as livestock feed supplements, or as agro-fertilizers. But this rich biomass is currently discarded, and thrown away: in the North. The ZERI Seaweed Project, when taken up by Tanzania's rural communities, will also lead to the production of livestock feed supplements, agricultural fertilizers, and other useful products. The establishment of a seaweed processing industrial plant

in Tanzania, will promote further interest in seaweed farming, and also encourage the aquaculture of other aquatic species, some of which are currently in danger of extinction due to over-exploitation. We need to protect these biota, and guard against any loss of biodiversity, which constitute our global heritage. Prof. A. K. Semesi of the Botany Department, University of Dar es Salaam, was proposed to be the Coordinator of the Project. This activity will involve close collaboration with the Department of Chemical and Process Engineering, the University's Faculty of Engineering, and the Institute of Marine Sciences, Zanzibar.

(10) It was agreed that the proposed coordinators would write comprehensive research proposals, in the language of ZERI. One or two of the projects should be selected for funding through the ZERI Emissions Research Initiative.

STATEMENT OF COMMITMENT

(11) The Tanzania Commission for Science and Technology (COSTECH) showed a great deal of interest and support for the ZERI concept. Indeed, COSTECH paid for the travel and per diem expenses of the participants who had come from centers which are away from Dar es Salaam (e.g., Tanga and Zanzibar).

(12) The Tanzanian scientific community as a whole also showed a great deal of interest and enthusiasm towards participating in ZERI projects.

(13) The Zanzibar government has, since the first meeting, committed US $20,000 for the initial phase of the ZERI Seaweed Processing Project.

ACKNOWLEDGEMENT

I am most grateful to Mr. Gunter Pauli and also to Prof. Carl-Göran Hedén, who had facilitated my visit to Tanzania for the briefing meeting, and also to the Director General of COSTECH (Dr. Yadon Kohi) and his team (Prof. M. Sheya, Mr. Mlaki, and Mr. Asman) who had made my contacts with the Tanzanian Scientific Community so efficient.

Material Separation Technologies and Zero Emissions

Prof. Dr. Habil. Janis Gravitis
Head of the Wood Materials Research Department
Latvian Institute of Wood Chemistry

In general, phytomass separation technologies have two variants. First is the separation of the plant material into individual biological cell units- fibers or their bundles. Second is the separation of the individual chemical components of the fibers. For plants the three polymers cellulose, hemicelluloses (the group of carbohydrate polymers) and lignin (a group of phenolic aromatic polymers) are the major components. The latter of the above mentioned variants leads to the material becoming unusable as a fibers source. In this case, the separation technology produces chemicals for different chemical industries. As a rule, large scale sulfite and sulfate (kraft) pulping industries combine the two variants mentioned above.

During pulping, the plant material in water is treated with sulfur chemicals at elevated temperatures. As a result the fibers contain mainly cellulose and loose hemicelluloses and lignin. The target material and wastes respectively make up about 50% of the mass, and the wastes (lignin+hemicelluloses) are usually burned. I don't want to focus on the advantages and disadvantages of conventional separation technologies. I will point out the demands for new separation technologies, for instance that for the totally chlorine free bleaching for the removal of residual lignin after pulping (this problem is solved). Other demands are:

- sulfur free lignin (pulping without chemicals);
- effective consumption of water resources, energy and pulping time. Demands for closed-cycle processes;
- 100% utilization of chemical components;
- "tree-free" pulping (replacement of by other raw materials).

There are some unconventional technologies, such as organosolv, biodelignification, supercritical extraction and others, more or less meeting these demands. For hardwoods the steam explosion (SE) technology is one of the separation technologies meeting the mentioned demands.

In general, steam explosion is simple. The plant material is rapidly treated with high temperature (up to 250 deg C; 40 atm.) saturated steam for a short reaction period (up to some minutes). Then the reaction vessel is instantly decompressed, for example, from 40 atm. to atmospheric pressure. Hence, the material is "exploded". In fact, acid pulping chemicals, mainly acetic acid, is generated during the steam explosion from the components of the plant material itself. The explosion is important not only for the mechanical defibreing, but also for the sudden "freezing" of chemical processes. The main part of the batch steam explosion device is a stainless steel vessel with fast acting valves ("gun"). Once optimized for input of a particular raw material, steam explosion

mobile equipment can be extended by adding more batch reactors operating as a multibarrel "gun". The steam explosion method is fast, has a low energy consumption and is ecologically safe, because apart from water for the steam, it uses a very limited amount of chemicals (mild NaOH, ethanol, which can be recycled, and H2O2 in low concentrations, for bleaching) in the separation process. Steam explosion demands cheap steam. One possibility for generating cheap steam is the following. The harvesting of sugar cane lasts for 6 months per annum. For the remaining 6 months the sugar factory can serve as the steam source for steam explosion. This contributes in addition to solving the problem of full year employment. The preliminary calculation of the cost of operation and raw materials for a batch Tigney plant with a capacity of 20 tons raw material per day (24 hours) is 3,000,000 USD / year, but the potential revenue is 15,000,000 USD / year.

The principal scheme of the separation of chemical components after steam explosion is very simple (fig. 1):

figure 1

- hemicellulose and sugars can be extracted with water;
- lignin can be extracted with a mild alkaline solution or lignin solvents;
- the residue is cellulose, which can be bleached with H_2O_2.

The main problem is, of course, how to optimize fractionation technologies including vacuum evaporation, microfiltration, ultrafiltration, reverse osmosis, etc., after steam explosion treatment.

All steam explosion products have a variety of applications.

HEMICELLULOSES (fig. 2), during steam explosion, hemicelluloses can be hydrolyzed to sugars as xylose, mannose, arabinose and others and then used as molasses, the substrate for fodder, yeast, or bioethanol. The xylose sugar can be hydrogenated to xylitol (sweetener) and can also be dehydrogenated to furfural. Furfural is excellent feedstock for chemical processing.

figure 2

The most economical use of the pentosans produced in the steam explosion process is their conversion into furfural. The production of furfural is always increasing,

especially since the oil crisis in 1973, because furfural always competes with the products of oil chemistry in cost and possible applications.

New methods and technologies for furfural production, based on essentially new theoretical backgrounds, have been elaborated by the Latvian State Institute of Wood Chemistry, Riga.

By the first method furfural may be obtained before the steam explosion process, and in such case a lower pressure is needed. After that, a conventional steam explosion is realized. A second method allows one to obtain furfural from pentosic solutions directly after the steam explosion process. This method is based on coupling the advantages of homogeneous and heterogeneous catalyses, and it is realized at a pilot plant as a continuous process.

LIGNIN (fig. 3) can be used as binder for plywood, fiber board and particle board.

figure 3

Lignin has also been used as a component in the production of coatings and foams. Lignin and its modifications serve as dispersants, slow-release fertilizers, sorbents, insecticides and plant hormones too. Many lignin derivatives show good properties, but their commercial potential is still unclear. The sulfur containing lignin produced

by conventional technologies is often burned and used as a heat source. The steam explosion lignin is sulfur free and chemically reactive. During the steam explosion treatment lignin coalesces on the cellulose fibers surface as spheres with some micrometer diameter, promoting enzymatic attack of the cellulose.

CELLULOSE (fig. 4) can hydrolyzed to glucose. The enzymatic isomerization of glucose to fructose is well established. Glucose can be fermented to acids, alcohols, polyols and ketones. Cellulose can also find use as a source for different derivatives. They serve as animal fodder, a substrate for microorganisms and mushrooms, super high swollen gels, liquid crystals, etc.. Microcrystalline cellulose is used in the paper industry and also in the food and pharmaceutical industries. The SE produces cellulose microfibrils. It looks promising to use homogeneous dispersion of the cellulose fibrils within a polymer matrix, leading to a nano-composite structure (the nano-technology). Finally cellulose fibers are a fundamental source for the paper making industry.

figure 4

Steam explosion and TREE-FREE PULPING: In addition, steam explosion technology is flexible in meeting the demand for tree-free pulping ("tree-free paper"). Extensive deforestation demands production of the fiber materials not from wood but also from sugar cane, bagasse, bamboo, straw, kenaf and others. Steam explosion allows large

variations of the steam treatment parameters. All these alternative raw materials can be separated into components with steam explosion. One prospective raw material for steam explosion technology is oil palm. Plantation growing of oil palm have been increasing mainly in Malaysia and Indonesia. However, palm oil mill effluents and oil palm plantation wastes are also increasing. Today, the main part of all bagasse in Brazil and palm oil mill by-products in Malaysia and Indonesia are incinerated. But they can be used as raw materials for steam explosion. Preliminary laboratory studies at the Latvian State Institute of Wood Chemistry (Riga) showed the potency of steam explosion for oil palm by-products - fruit bunches, fronds and trunks utilization.

GENERAL CONCLUSIONS,

- separating plant material into its chemical components using steam explosion proceeds without using chemicals;
- the method is fast, has a low energy consumption and is ecologically safe;
- the yield from the raw material input using steam explosion is 90-95% (theoretically 100%);
- all the steam explosion products can be converted into value added products;
- all the products are biodegradable;
- steam explosion equipment ensures mobility.

The main idea of the ZERI is zero wastes and the clustering of industries. Steam explosion can serve as a seed for dispersed yet integrated clusters with the components: the fine chemical industry, the paper industry, the construction industry, the food industry, the pharmaceutical industry, the fuel industry, biotechnology and farming.

Zero Emissions Brewery Projects

Prof. George Chan
Environmental Engineering Consultant
United Nations University ZERI Project Director in Fiji, Namibia and Tanzania

INTRODUCTION

A survey was made of the main pollutants from agro-industries around the world to set the priorities for the Zero Emission Research Initiative (ZERI) Integrated Biomass Systems pilot projects. It was found that breweries produce the biggest quantities of liquid, solid and gaseous wastes, and that the number of breweries in the developing world is increasing rapidly. The objectives are to recycle those wastes and reutilize all the byproducts in various farming activities to prevent any adverse effects on the environment. What is more important is the economic benefit derived from the free inputs, which reduce their production costs considerably to make a substantial profit. These savings can make a big difference to the viability of the brewery itself, which would go bankrupt if it had to deal with the pollution problems in the conventional manner.

So a decision was made to implement as soon as possible 3 pilot projects using Integrated Biomass Systems to deal with the liquid and solid wastes of breweries for the 1995-96 period in Fiji, Namibia and Tanzania in what was called the ZERI-BAG program, because it uses aquaculture and agriculture to recycle the brewery wastes. Based on my past experience over 30 years in Integrated Farming Systems (IFS), which recycle the liquid and solid wastes of livestock-aquaculture-agriculture-agroindustry farms in a completely closed cycle, I was appointed the first consultant to the ZERI-BAG program.

I would like to add that I was NOT part of the expert team which came up with the ZERI-BAG concept, but it was a pleasant surprise for me to learn that those top professionals from various countries have come up with a concept exactly the same as my own research program, which had been funded by the International Foundation for Science (IFS). So UNU did not have to waste time on the conceptual planning and design, and we could start with the pilot project without any undue delay. My present duties are to survey, plan, design, implement, and operate the whole system which will recycle all the brewery spent grains and waste waters. At the same time, I had to direct an appropriate training program for all the people concerned.

PILOT PROJECT

The present paper describes the various processes which are being used in the Fiji pilot project to recycle these wastes. Although the project is at the Montfort Boys' Town because of the space and facilities there, besides the 140 students already involved in livestock, aquaculture and agriculture, the spent grains will be obtained from a

brewery nearby. It is not convenient to bring in the waste water as well, so the wash water from livestock will be used instead.

The following processes are ALL working well, particularly in the wet tropics, and most of them have been tested for centuries and are still going strong, but some are threatened by so-called modernization and vested interests. The ZERI-BAG program would welcome any suggestions to add to the effectiveness and efficiency of the various processes, and I would be grateful if some participants could do some research to enhance their development.

For those who are not familiar with such systems, ANNEX I gives some brief notes on how such processes are performing in some parts of China. ANNEX II shows the Wastes Recycling chart.

A. SPENT GRAIN-LIVESTOCK-DIGESTER-BASIN-POND LINE

1. Only a small portion (15%) of the grains is used in beer-making and the rest is given away or sold cheaply to livestock farmers. The high lignocellulose content of the residue makes it difficult for livestock to digest, and the only economic way of breaking it down is through simple microbial processing using mushrooms, which is a fermentation process and yields a high-value product. It is mixed with rice straw, wheat bran and other crop or processing residues, and the substrate after mushroom growing becomes a good quality feed for livestock. If too much 'inedible' residues such as sawdust, newspaper, textile wastes, shells and soil are used in the substrate, the residual product after mushroom culture can be used as a soil conditioner.

1a. The easier and more extensive culture of selected earthworms as high-protein feed for chicken and shrimp is also being done.

2. The daily livestock wastes are treated up to 60% BOD reduction in a proper digester for 5-10 days' hydraulic retention time (HRT) to produce biogas to meet the energy requirements of the farm, and the effluent is further treated in shallow basins for 3-5 days' HRT, with or without contact oxidation filters placed at strategic points, for a further 30% BOD reduction, before using the effluent to fertilize big and deep ponds connected in series.

2a. The shallow basins can also be used for primary treatment of the big volume of waste water from the brewery, and are designed accordingly as shown under B. WASTE WATER LINE.

3. The big and deep ponds receive every day an adequate supply of readily available nutrients for fertilizing the growth of various plankton to feed 5-6 different, but compatible kinds of fish, feeding at different atrophic levels. No artificial feed is added except for selected grass grown on the edges of the pond for the grass carp or

other herbivorous fish. A well-managed pond of between 3,000 and 4,000m2, 3m deep, can produce an equivalent of 15 tons of fish / hectare / year.

3a. No artificial aeration is necessary if a scavenging fish such as the Common carp or other compatible fish is present. There must be an adequate number of every kind of fish to consume the daily production of plankton in the pond, as any non-consumed feed can accumulate and become a pollutant. Daily monitoring of pH and dissolved oxygen is necessary until the operator acquires enough experience to judge the 'health' of his / her pond by sight.

3b. The edges of the pond have trellises made of bamboo or mangrove sticks for the growth of climbers. Gradually, up to half the surface of the pond will be covered with bamboo and / or plastic floats for aquaponic culture of various crops. No watering, manuring or weeding needs to be done, and enough nutrients should be removed daily to prevent eutrophication.

4. The dikes are used for livestock and various crops using multicropping, rotation of crops, and aeroponics / hydroponics, using the nutrient-rich pond water for fertigation.

4a. Crops such as oil seeds, grains and fibers will be grown as raw materials for processing into higher-value goods, using biogas energy to enhance the processes.

4b. Subsequently, the fish and livestock will also be processed using physical, biological, chemical and refrigeration processes, enhanced with biogas energy when its yield is increased with higher temperature and additional digestible materials such as small macrophytes.

B. WASTE WATER LINE

1. The bigger volume of brewery waste water, which contains very little organic matter as it is only used for washing grains or the equipment, bypasses the digester mentioned above and enters the shallow basins directly for the same 3-5 days' HRT. So the basins will be much bigger.

1a. If necessary, as in the case of human sewage entering the same drainage pipe from the brewery, a primary treatment is done in a narrow channel with or without a floating plastic cover to control odor, followed by one or more channels with macrophytes and / or contact oxidation filters for 3-5 days' HRT. If this primary treatment is adequate, the algae basins in A. above need not be enlarged and can also be bypassed, with the last channel discharging directly into the first fish pond.

2. The effluent entering the fish ponds will have little effect on the whole system because of their relatively big buffer capacity. No other water is added, unless the evaporation rate is higher than the daily flow entering the system, and any overflow

will go to some distribution canals, usually with macrophytes on the surface, and used in case of need.

2a. Any crop grown on the dikes will get its water and nutrients automatically through its roots from the nutrient-rich groundwater.

ANNEX I

HOW VARIOUS PROCESSES ARE PERFORMING IN CHINA

1. DIGESTION of liquid wastes with up to 60% reduction in Biochemical Oxygen Demand (BOD), in a properly designed and built digester with or without UASB (Upflow Anaerobic Fermentation Sludge Bed), was very successfully done in the Guangdong, Sichuan and Zhejiang provinces. Zhejiang's system is the best because it is fully integrated with livestock, fish, plant and feed, while the others emphasize the energy aspect.

2. OXIDATION of digested effluent for a further BOD reduction of 30%, or of washwater, with algal growth in shallow basins, is practiced in Hainan province, Taiwan and Cuba where the algae are produced for commercial purposes, or in deeper ponds with contact oxidation media for higher efficiency as in Sichuan and Zhejiang. Some provinces grow macrophytes in shallow ponds to use as livestock feed and to partially treat raw livestock wastes before they flow into fish ponds.

3. POLISHING of the effluent entering the deep fish ponds for polyculture of fish as in Zhejiang: Guangdong has many more polyculture ponds but, like most other provinces, uses raw livestock wastes instead of treating them in digesters first. Zhejiang has cleaner ponds which must be better for the fish, but can only operate their fish culture for 2/3 of the year because of its colder climate, but warmer Guangdong can certainly benefit from the waste treatment addition.

4. AQUAPONIC culture of cereals, fruits and flowers on half the pond surface using bamboo floats with nylon netting below to protect the roots, as done in Zhejiang and Jiangsu provinces, controls eutrophication caused by excess minerals, without interfering with the fish polyculture. The economic implication is enormous when it is considered that there is twice as much water surface than land in an integrated farm.

5. MACROPHYTE culture of useful Chlorella, Spirulina, Azolla,Llemna, Pistia and even water hyacinth, for use as livestock feed is done in shallow channels which distribute the highly-mineralized pond water to the plants on the dikes. The macrophytes are used to grow mushrooms, using simple structures and methods as widely practiced in Fujian province, which produces 10% of the world's output. Instead of having an expensive controlled environment to grow one or two species, the farmers vary the species to suit the weather in their mud-lined buildings. They can

grow high-priced shiitake (*Lentinus edodes*) or button (*Agaricus bisporus*) mushrooms at very low costs during 2 seasons of 3 months each every year.

6. AEROPONIC & MULTICROPPING cultures of various vegetables and fruits on the dikes using the pond water to irrigate and fertilize them, without having to use agrochemicals, was universal in rural China until recently. The Chinese Ecological Agriculture program, implemented in ALL provinces, is trying very hard to get the farmers to reduce their use of agrochemicals. Again, the crop residues are used for mushroom culture or for raising earthworms as chicken feed.

7. PROCESSING of produce for preservation and/or value added. The vegetables, oil seeds and tubers are used to prepare condiments, sauces and even valuable products such as citric acid. The factories are using their agro-industrial wastes to produce most of the energy they need, with Sichuan and Zhejiang having the biggest programs. In Jiangsu, there is a biogas plant producing 1.5 Megawatt of electricity.

8. MARKETING of produce and goods is quite impressive even in the rural areas where vegetables and meat are sold fresh, and fish and poultry are sold live. In Fujian province alone, there are 50 factories to can all the button mushrooms and asparagus produced by the farmers, and the goods are mostly exported. Some factories are using their wastes to produce biogas for electricity generation, with Sichuan being the leader. Fujian can certainly benefit from their experience.

Annex II

New Technologies to Disseminate Research Information and a Review of Commitments made in 1995 towards Zero Emissions

Kazuhiko Nishi
President, ASCII

Well I would like to start off by explaining what I said last year.

Gunter invited me to the United Nations University on April 6, 1995, to attend the previous Congress on Zero Emission. And I gave this presentation to the participants. This is a review.

Let me spend half of my presentation reviewing what I promised. My company did more than $500 million and the second one was my commitment to producing what would be the first published books and magazines using chlorine-free paper. We did it. This is our magazine. This is first Japanese magazine printed with totally chlorine-free paper. This copy comes from the first World Congress of Zero Emissions. We did it, and I was very pleased that there was a tremendous positive response from our leaders. And also we worked out with a paper mill company that the cost of chlorine-free paper would be as good as that of ordinary paper. The issue is, do we have enough infrastructure for such paper for long term consumption and are we making our best effort? So, three more commitments to go, including nonpolluting, softer packaging for minimum materials use. We are going to try for nonpolluting softer packaging for the next year. Also other things, like asking for PC logic chips suitable for green PC's, are almost done. Reducing parts consumption is very important for the future of personal computing. The main point about today's presentation is our commitment to communications, for understanding and promotion of Zero Emissions.

Let me explain why I feel Information Technology is very important. First of all, many people care about the cleanliness of a room. But very few people care about the cleanliness or dirtiness of the earth. They don't really care. Why? I think this is because of the lack of the basic organization and understanding about this issue. The reason why people are not caring about the earth being polluted is not because of the bad personality of these individuals. It's because of the lack of information, it's because of not knowing the facts. We feel it is very important that the children which are going to be playing the key role in the coming Twenty-first Century be taught, we need to let them know about issues regarding the environment. This is one of the most important issues we are facing. This is our number three requirement of education. We need to make 100% sure that environmental issues become one of the major subjects of school education. Also, making sure that all this environmental information is going to be available over the World Wide Web is important. So if anybody wants to understand and know the importance of an environmental issue, they can access this information.

Companies have being paying a lot of attention to making money but not paying attention to keeping the environment clean and pollution free. But as these issues

become more and more recognized through networked information and the World Wide Web, I think society will not accept a company that ignores pollution to only focus on profit. This is one of the most important points that Information Technology will have to collaborate with the Zero Emission Initiative on. I have been thinking about why I am part of this activity, being a publisher, being a software producer. I have committed to make a Zero Emission product available to Information Technologists. I have made sure that this activity, this information, be widespread and given to everyone. Mr. Pauli invited me to be a visiting Professor of United Nations University and I have been serving in that role since this April. It is a great honor to be here as a visiting Professor of the UNU. My expertise is realizing understanding and peace through the Internet. I am helping Zero Emissions Project Initiative through communication and information technology.

Thank you for your attention. My speech was delivered through both telephone and the Internet. This really shows we're in the transition between technologies. Next year I hope I will be talking to you, saying this is our Zero Emission software packaging, 100% totally through the Internet. I miss my friends in Chattanooga and I hope that the conference is a good success.

Thank you from the bottom of my heart in Tokyo.

Plenary Session IV:
Action Plan for Zero Emissions

May 31, 1996

The UNDP and Sustainable Development

Anders Wijkman
Assistant Administrator, United Nations Development Program
Director, Bureau for Policy & Program Support, UNDP

Mr. Chairman, dear friends, it's a great honor to be here, to be invited to this very important event, and I thank you for putting me, as a matter of fact, as the first speaker in this session. That was really not my intention, but, as you, I'm leaving for Istanbul where we have a lot of things to do together. I represent the United Nations Development Program, an institution that is undergoing a lot of change, both in regards to what we do and in how we do it. You read a lot about crisis in the UN, and to some extent there is a real crisis, particularly when it comes to funding, but some of us are alive and doing a lot of useful things, and we in UNDP hope that we can be part of this very exciting movement that is emerging out of these two conferences.

Our role is to promote development, in particular in the least developed countries, to help build capacity and competence, and our model of development is not the traditional one emphasizing primarily production growth. We try to bring about consistency between production, social development, cultural development, and environment. We have 137 offices all over the world and you could sort of look upon us as sort of the anchor of the UN system in those countries. We have our problems in terms of efficiency and effectiveness, but I don't think I'm exaggerating when I'm saying that, particularly in the poorest countries of the world, our services are highly appreciated, and we very often act as a very important intermediary between different donors, between the private sector and the government, between the scientific community and the government, et cetera.

The challenge in front of us is colossal: to change not only modes of production and consumption but also to rethink the way we use resources. The linear flows of resource use dominating the industrial society thinking are, as we know, not viable. If we continue like this, I think it's right to say that we will all drown in the waste products we have generated. In the long term, the problems we face can only be solved through a shift in values. The present focus on maximum profit and looking at value primarily as equal to well-being in the present will have to give way to a much broader objective. To change mind sets, to transform values, takes a lot of time. It's not easy. We all resist change.

It takes leadership. It requires rethinking of our educational systems, but it can be done, and I think it's wonderful that this conference takes place in a city which has done a lot of rethinking and which provides such wonderful leadership. The struggle for sustainability, however, must be fought on different levels, and in particular, as Hugh Faulkner said this morning, we need good examples which demonstrate that value creation and well-being can be achieved through other modes of production and

consumption and without resorting to the very high throughput of entity and materials that has been the case.

We need an efficiency revolution, and the ZERI concept is very much contributing to that. We have others out there working in the same direction, like the Wuppertal Institute, like Emeril Evans and his group in Colorado, and we also have some very good people working within UNDP specifically on energy policies, We have, in my mind, developed strategies which are very, very cutting edge. We are, in UNDP, one hundred percent committed to giving support to the efforts to promote the efficiency revolution that is needed. What is very much needed, and Professor Chan really emphasized this, is a blending of traditional knowledge and cutting edge technologies, and we know that there are enormous possibilities in terms of new technologies, both in the biotechnology field, information technologies, that together will help us to reach the goal.

But the problem we face today is the enormous gap between technology's potential, what it could do, and its reality, what it's really doing. Technology could be used much more effectively to tackle some of the problems that have been coming to the fore here, and I might add the problems of poverty, moralization and so on and so forth, and I think we all know that the market alone will not bring about the technology solutions needed, and that's why we need the right kind of incentive systems, and we are working on that, but we also need public/private partnerships like Mr. Faulkner said. And I very much believe that the United Nations Development Program could act as a catalyst by identifying problem areas together with governments, by building capacity, by providing seed money, and by providing and promoting links between the private sector and the public agencies.

I will leave tomorrow, as I said, for Istanbul and this will be one of the many issues we will bring to the fore. We are prepared, as regards ZERI and UNDP, to act as a broker and to become involved in setting up pilot projects because, as I said earlier, we need demonstration projects. I also believe that the fact that we have more than 130 offices all over the world offers a potential for dissemination and sharing of experience which could be very powerful. We look upon our role very much different today as compared to only five or ten years ago. We don't control the big money; we shouldn't be the investor. We should concentrate on capacity building, on consultancy, on acting as a catalyst, acting as a risk-taker, and promoting public/private partnerships and indeed brokerage also with the scientific community.

Our focus will have to be the least developed countries. There is, as we know, an enormous amount of private capital out there looking for good investments, but unfortunately to a large extent, the private money that so far has reached developing countries is concentrated to some ten, fifteen countries. The least developed countries get very little of those investments, and I believe that we could play a useful role as intermediary and catalyst in trying to open up channels for private investment in many

more countries, and in my mind, it's not either/or. We need both development cooperation and we need investment.

And I would like to close by saying that I hope very much that we can play a useful role in this work. We look forward to being one of ZERI's partners because we believe ZERI offers a very powerful strategy to improve efficiency in resource use, to do away with pollution, to provide jobs, and enhance human well being. Thank you very much.

MR. PAULI: Thank you so much. Also in particular for -- I just have one question for you, Anders, perhaps if you would be prepared. In terms of the educational strategy and the capacity building, what is your view on the ZERI chairs? What is your idea on that?

MR. WIJKMAN: Now you're cornering me.

MR. PAULI: It's an open corner. You can go through the ...

MR. WIJKMAN: No. I mean as I indicated at the outset, of course, education is fundamental. We need to change curricula because, to a large extent, and I learned that very much during my years as head of SAREC, the Swedish Agency for Research Cooperation with Developing Countries, that we tried to promote capacity building which was different, which dealt with integrated systems problems and not so much with a very vertical discipline-oriented problems, and it was so difficult to do. It was so difficult to do.

And so still today we are bringing about support to building the very same kind of capacity that, to some extent, have led to the problems we are in because we do not see the links, and that everything is linked to everything, so I am very fascinated by the idea to set up these ZERI chairs in various universities and I'm awaiting proposals, detailed proposals from UNESCO and maybe you. You and I hope that we can find at least some money to support that because it is so important.

MR. PAULI: Thank you.

Structuring the Implementation of Sustainability

the Hon. J. Hugh Faulkner
Executive Chairman, Sustainable Project Management

MR. PAULI: I wonder, I am looking here again at Hugh Faulkner. Is it appropriate for you to give some comments here, or would you like to give some extra comments later? Because it may tie in very well with what Anders has been saying, please, and I think particularly the idea of how one can structurally approach ZERI, SPM. How can we structurally approach this? Foundation structure, Foundation 21; where are we? What could we do?

MR. FAULKNER: Well, Mr. Rector and Gunter and friends, I have, we have, been thinking about this before. It's particularly obvious to me now to see the potential linkage between the work of Sustainable Project Management and ZERI. ZERI is in the process of researching into new industrial systems, new design processes to eliminate waste. We are in the business of putting those sorts of developments into projects and mobilizing the financing of those projects. Therefore, it seems to me obvious that we should be working more closely together. Both are clearly committed to the notion of zero emissions.

Sustainable Project Management, because of its origins within the Business Council for Sustainable Development, comes at it through eco-efficiency, that eco-efficiency ultimately is about zero emissions, so we come at it with the same mindset. We're committed to smaller projects. We think there's enough dynamism in the larger projects, and that what particularly needs attention are the smaller projects. I was enormously impressed with the speech this morning that reminded us that the newer technologies are often not the best technologies. There are historic approaches to some of these things, and we have to incorporate those.

The problem, as I said this morning, is not technical. There isn't an environmental problem for which there isn't a suitable technology today. The problem is fundamentally political. I speak strongly about that having spent a lot of time in politics. I think the only real way to get at the political inertia is through a multiplying effect of demonstration projects that show clearly how this process can take place; why is it commercially viable, et cetera. And I think the public/private partnerships as Anders Wijkman just described are an important vehicle in the developing world to implement this approach.

I think at the end of the day, what we have to do is mobilize the sort of seed money to allow us to set these projects going, and I think we can work together on that because I believe that if we can, with the seed money, identify the project framework, within that framework we will bring in the private capital.

And as Anders made the point, the enormous flows of the private sector today, private sector money today are the dominating feature of the global economy, but not

much of it today is committed to zero emissions or even eco-efficiency. So what we have to do is, by collaborating together, move those flows into projects which are committed to the sort of goals we are talking about. So I would say partnership with ZERI, partnership with the UNDP, partnership with the private sector, partnership with the donors, collectively we may be able to make a difference. I'm certain individually we won't make much difference.

I have enormously enjoyed today and yesterday. I've met people I have never had the pleasure of meeting before and found about technology I had never heard of. It's been an enormously enriching experience, and remember, Gunter, Mr. Rector, ZERI was not on the agenda at Rio. You should be satisfied with the progress you're making. Thanks very much.

Industry Perspective: Collins & Aikman Floor Coverings

Mac Bridger
President, Collins & Aikman Floor Coverings

It is a great pleasure for me to represent Collins & Aikman Floor Coverings at this very important international conference. I want to thank Gunter Pauli for asking me to participate. Throughout the last couple of days you have heard many distinguished people from all disciplines express their views, their vision for a better world. I was privileged last night to hear Chairman Ed Woolard of DuPont outline the environmental goals for that great company. One of the tenets of Mr. Woolard's message is that business leaders must drive the step change necessary to create a sustainable industrial world. I totally agree. I believe that business must understand that environmental solutions are an opportunity, not a burden. Providing environmental solutions, in reality, can be a distinct competitive advantage, in addition to being the right thing for us to do, the necessary action that business must take today for future generations. I want to take a few minutes to relate to you briefly our journey toward full resource utilization and sustainability at Collins & Aikman.

Candidly, our initiatives began as a result of listening to our customers, not through a specific altruistic interest. When we began our journey, I must confess that we did not understand the breadth of our environmental crisis. Thanks to visionaries like Paul Hawken and others, we now have a much clearer understanding of the problems that we face together. I also believe that the solutions to these issues are at the fingertips of business.

At Collins & Aikman, our emphasis has been on resource management and recycling. The process has taken years and millions of dollars to complete, and I want to add that every single dime was invested by Collins & Aikman in this program. These monies were invested to take us through uncharted waters, to develop a completely new technology that would convert post consumer and post industrial waste into usable, value added products. Today, we are converting this waste stream into food for new products. The program is two fold: We do downcycling to produce profile composites that are used as parking bumpers and industrial flooring block. In both cases, the down-cycled products are far superior in performance to the products which they replace. We are currently working on a program with General Motors to replace carpet in their facilities, and to divert their old carpet from landfill to our facility as raw material for us to produce industrial block which they purchase for use on their plant floors. At the same time we are also eliminating an environmental problem, creosote treated timber. This is a small but important example of resource management and sustainability at work in partnership, business to business.

Later this year, we will roll out the carpet industry's only recycled content floor product made from post consumer and post industrial carpet waste. As with our profile extrusion, the recycled product will be equal to or superior to the products which it replaces.

This truly closes the loop, carpet waste becomes food for new value-added carpet products. From this point forward our products will be products of service, never to be landfilled or incinerated. Through our recycling capability we can reclaim every square yard of product that we have ever made.

So, we are proof that environmental stewardship can be profitable. It can result in a competitive advantage for business while, at the same time, making significant contributions to our environment. The responsibility for the future lies at the doorstep of business leaders around the world. Think of the power business has, such as that of two of the great companies that have addressed this conference, GM and DuPont, both customers and suppliers to Collins & Aikman. I have to believe that working together with our resources, with our technologies, we are making a difference.

In closing, I want to encourage businesses to support other businesses that are making a difference. Business to business we can make a change. As Mr. Woolard said last night, it's going to take a step change to make it work. Together, I am confident, we can do it.

Thank you.

Zero Emissions and MITI

Kazuhiko Hombo,
Chief Representative of New Energy and Industrial Technology Development Organization's Washington D.C. Office.

I would like to thank the United Nations University for inviting us to this successful gathering of the World Congress on Zero Emissions. The second annual meeting is coming to a close, and I'd like to take this opportunity to deliver "a message from Japan" on behalf of the Ministry of International Trade and Industry, which supports this Congress. My organization, NEDO, is affiliated with the Ministry.

First of all, I'd like to express our deep respect for everyone who has worked so hard to bring about the zero emissions research project. The concept of zero emissions, which aims at manufacturing without any form of waste, is widely recognized today because of the efforts of those who have worked on the project.

MITI agrees with the idea of zero emissions. We're working to implement policies that will allow society to shift away from a 20th century socioeconomic system based on mass production, mass consumption, and mass waste disposal. And we're working to help establish an eco-friendly society of the 21st century that will generate less environmental impact.

Now I'd like to introduce some of the policy measures MITI has implemented that might be of interest to those of you who work on the zero emissions research.

[New environmental problems]

Japan has achieved phenomenal success in overcoming industrial pollution. We have managed to leave many environmental crises behind us because of government actions and anti-pollution measures taken by businesses.

However, we have recently seen the rise of newly created environmental problems. One group of problems centers on municipal and daily living-related activities such as waste disposal, while the other group includes threats to the world environment such as global warming. Both groups of problems stem largely from industrial activity and from the products of daily life in consumer societies. To combat them, all parties including national governments, municipalities, businesses, and citizens, will have to bear a fair share of the burden. We must take voluntary and active measures to create an eco-friendly socioeconomic system. Corporations in particular are urged to play a leading role in the effort to respond to the emerging environmental crises.

[Environmental Vision of Industry]

Acting upon these convictions, MITI, which is responsible for overseeing a broad range of industries, outlined its own "Environmental Vision for Industry" in June of

1994. The report is designed to facilitate voluntary and active involvement by corporations, the primary players in business activity. This report provides clear guidance for greater industry-involvement in environmental issues.

In the report, we have identified fifteen major manufacturing sectors, and studied the environmental impact of each industry in all phases of corporate activities. These activities include procurement of material, manufacturing, distribution, sales, and waste disposal.

Then, after thoroughly reviewing existing environmental measures, the report proposes a new direction for additional measures and the way in which they should be integrated into corporate activities.

We also realize that to reduce the environmental impact created by business activities, we not only need the involvement of each industry group, but also inter-industry cooperation. Therefore, we have included examples of successful inter-industry cooperation in the report: examples in which one industry's technology, facility, or information has successfully been used to reduce the environmental impact of another industry. The examples include wider use of recycled products made possible by raw material and parts industries, working in partnership with process and assembly industries the use of steel mills' thermal supply facilities to generate heat for local communities; and the promotion of recycling by using smelting and waste water treatment facilities for mining.

At the same time, we are witnessing the rise of a so-called environmental industry. We are beginning to see environmental issues not as a negative factor in the economy, but as a business opportunity. In the report, MITI assessed the current and future outlook of this new industry. Our analysis shows that the current market, worth fifteen trillion yen (about one hundred fifty billion dollars), will expand to thirty-five trillion yen (about three hundred fifty billion dollars) by the year 2010.

The report offers direction on environmental measures for industries in a multi-faceted and organized manner. It is a road map for industries in their effort to reduce environmental impact.

[Recycling Measures]

The Zero Emissions research project has been paying close attention to the total utilization of input and also to the possibility of turning output into input, by using waste as raw material. Now, I'd like to discuss about recycling efforts by MITI. Today in Japan, waste generation has reached a critical level. The capacity of existing incineration and final treatment facilities is reaching its limit. To solve this problem, we not only need to boost our treatment and disposal capability and to reduce waste, but we also have to transform our socioeconomic system. We need to build a society designed for conserving and recycling resources.

To alleviate the impact of the serious waste problems and to promote efficient use of resources, we at MITI are implementing a variety of measures to establish a framework for a “recycling economy." For example, we enacted a law entitled "Act For Promotion Of Sorted Collection And Recycling Of Containers And Packaging" last year. It is designed to promote the sorting and collection of cans and plastic bottles by municipalities and general recycling by enterprises.

MITI is also actively pursuing the development of new recycling technology. One example is the research and development of eco-cement, which is one of the topics at this Congress on Zero Emissions.

[Closing]

I have briefly outlined MITI's environmental effort as outlined in its report "Environmental Vision of Industry," and as put into practice through "Recycle Measures."

The United Nations University's zero emissions research aims at eliminating all kinds of waste stemming from manufacturing at once and at building a new industrial structure. The goal is broad and far reaching. It is also timely because it could contribute greatly to resolving many of the environmental problems we face today.

I sincerely hope the zero emissions research continues to advance and play a greater role in solving global environmental problems. We at MITI will also devote even more effort to resolving environmental problems from now on.

I'd like to close the message from Japan by once again paying tribute to the organizers of this Second Annual World Congress on Zero Emissions for putting together a very successful gathering.

Thank you very much.

The Sugar Cane Industry towards Zero Emissions

Dr. Fernando de Mattos Oliveira
President, Usinas Santa Fe, Brazil

It's a pleasure for me to have the opportunity to bring to you an idea about the Brazilian sugar and ethanol industry. I apologize for my poor English, but I hope you can understand how huge the potential of our industry is, within the zero emissions program.

Sugar cane is one of the most efficient vegetable converters of solar energy to chemical energy. Brazil is the world's biggest producer of sugar cane with a production of 270 million tons this year. The cane is converted into 12.4 million tons of several types of sugar; 6 million cubic meters of anhydrols (ethanol for gasohol, with a 22 percent gasoline mixing program) and 8.2 million cubic meters of hydrated ethanol for straight use on 4.5 million cars powered by this ecological fuel.

This year 6.7 million tons of biogas, roughly speaking the cellulose part of the sugar cane, is produced. 95 percent of it is used for power and electricity cogeneration production; two percent, after being hydrolyzed, is used as cattle food; one percent is used for other applications; and two percent is still being discarded because of lack of market. As a by-product of ethanol, we produce protein for animal feed and we hope, after some research, to produce low-cost high-protein concentrated dried yeast. From the biogas it is possible to obtain biologically degradable plastic. This is about to be released into the market. We also produce an additive to diesel oil which prevents the formation of sulfurous gas during combustion.

We hope in about one year's time to release into the market something we call diet sugar, which is an especially modified molecule of saccharose which is not absorbed by the human metabolism and which does not produce tooth decay. From the sugar, we can also produce biodegradable detergents, shampoos, softeners and many other products.

From the ethanol, we are producing industrial diamonds with better quality than mineral ones. With regards to the environment, the carbonic gas balance of ethanol use is 112 percent positive, considering the CO2 released during the production and burning in car engines against the consumption for the growth of the corresponding sugar cane. This means that the consumption of the sugar cane's ethanol cleans the atmosphere of CO2 at a rate of 12 percent. The 144 million tons of sludge produced by the distillation of the ethanol contains 95 percent of the potassium that comes with the sugar cane and therefore is recycled to the fields, mixed with all other residual waters of the factory as irrigation. Processing by biodigestion one-third of the sludge produced by one factory into biogas is enough to run all trucks and tractors used to produce and transport the correspondent sugar cane to that factory, and at the same time the potassium can be recycled.

As you can see, our industry is on the way to becoming a zero emissions industry, but there are many branches of research to be done and much funding is needed to develop more valuable and ecological products and methods. Furthermore, we believe that there are in Brazil, other sectors where the zero emission philosophy can immediately be applied, such as in the iron and steel industry, which is based on charcoal, and in food-agriculture industries like the poultry, leather and shoe industries, and also in basalt exploration. We hope that ZERI philosophy could be funded in our country, and that at the next Congress in Indonesia, we can present some practical cases. Thank you.

Ongoing Projects of the EPA

Suzanne Giannini-Spohn
U.S. Environmental Protection Agency

My agency, the U.S. Environmental Protection Agency, or EPA, sent me to the Second World ZERI Congress to learn from you, the leaders of zero emissions research, and I would like to take this opportunity to thank each and every one of you who I had conversations with, either as a formal talk or informally during the breaks, because I take away with me something of value from each of our conversations for myself and for my agency. Thank you very much.

We at EPA realize that we are at a turning point in regulatory policy and that we need to plot a new course for protecting the environment for the next ten years. We know that we can no longer derive major incremental gains in environmental quality from the technology-driven end-of-pipe controls that have served us well in the past and that we need to move toward market-driven performance-based systems and market-driven incentives. Zero emissions is certainly in keeping with that approach and is in harmony with it.

I would like to describe very briefly some of EPA's programs and approaches that are in keeping with themes that I heard during the Second ZERI Conference. In the opening session Wednesday, Dr. Curt Nicolin discussed the connection between economy, the environment, environmental quality, and democracy. This talk reverberates with a theme that we have heard from President Bill Clinton, Vice President Al Gore, who is from Tennessee, and EPA Administrator Carol Browner, that it's not necessary to choose between jobs on the one hand and the environment on the other, but rather we find that a clean environment and a sound economy go hand-in-hand.

Yesterday, Dr. Bill McDonough introduced the concept of design as a signal of human intention. Let me direct your attention to three important design documents for a sustainable future. First is the Report of the President's Council on Sustainable Development. EPA Administrator Browner, along with four other cabinet level officials and input from probably hundreds of other people, helped develop this report for the President of the United States. The report identifies issues, it suggests action and strategies to move the country toward a sustainable future. Yesterday it was announced that the report has been reprinted, and on the back table is information on how to obtain copies.

Also at your tables were CD-ROMs of two EPA documents, Bridge to a Sustainable Future, and its companion, Industry Leadership for a Sustainable Future. These are also available on the Internet and again in the back of the room is a flyer explaining how to access them.

Yesterday in the sessions on Industries of the Future, Dr. Keizo Yamaji shared his vision of restructuring our present non sustainable product, planning, and management attitudes into a new cooperation for attaining a sustainable civilization. He made some specific recommendations in that talk, some of which are underway at EPA. For example, his suggestion for creating a market demand for ecologically sound products, I believe he called it green purchasing. We have something like that at EPA where we use only recycled paper. Indeed, I believe the entire federal government uses only recycled paper, and we are moving toward a paperless office. Our green lights program and green buildings program are voluntary initiatives with industry that have also helped increase the demand for energy-efficient products. EPA is also working with representatives of six U.S. industries to develop industry-specific environmental strategies in our common sense initiative.

Yesterday, Hiroyuki Fujimura described an environmental engineering firm's perspective on the feasibility of zero emissions. He stressed the profitability of marvelous new conversion technologies for achieving zero emissions. EPA's market-driven approach to regulation is in line with this. Our Office of International Affairs has an international program called the U.S. TIES Program, for U.S. Technology for International Environmental Solutions, and it is a program to promote education, promulgate the new technologies, and to transfer technology.

At the award banquet last night, Edgar Woolard spoke of the mindset of zero defects, zero inventory, and zero emissions. He introduced a striking new challenge that resonates at EPA and especially in my own division of Urban Economic Development, that is, zero green fields development. The laws of green fields in the U.S. is an unappreciated problem, but since the eighteenth century, our nation has lost over 80 percent of its wetlands to development, and much of our prime agricultural land now lies under pavement in cities, in suburbs, and now in outer-ring suburbs. Meanwhile, tens of thousands of old industrial sites are abandoned in the hearts of American cities. The twin problems of green fields development and brown fields underutilization is being addressed by the agency's brown fields action agenda which will lay the groundwork and technical capacity for future brown fields cleanups.

At the awards banquet and the session on Industries of the Future, His Excellency Sarwono Kusumaatmadja and Isabel Urben illustrated how public recognition is a valuable tool for motivating companies to move towards zero emissions. Their assessment of industry's environmental performance clearly shows that some companies are leaders in the drive towards sustainability. This ties in with EPA's Project XL, which stands for excellence in leadership. Project XL is a cornerstone of EPA's efforts to reinvent regulations and to determine what works for our new course through experimentation. EPA will select fifty projects, including businesses, communities, federal facilities, and industry-wide sectors to receive regulatory flexibility in exchange for enforceable performance-based commitments to achieve better environmental results with broad and representative participation of the

community, industry, and other stakeholders. In the back of the room is a pamphlet describing our Project XL for Communities.

I thank the conference organizers for this opportunity to sketch some of EPA's ongoing projects. Please do not hesitate to contact me if I can be of further help. Thank you.

The Sisal Industry in Tanzania

Francis Nkuba
Director, Tanzanian Sisal Authority

Mr. Chairman, Distinguished International Participants, Ladies and Gentlemen.

1.0 It is indeed a great honor to me and my company to be given this opportunity to address this gathering.

1.1 I would like to join other speakers in thanking the organizers and most of all the people of Chattanooga for providing this rare opportunity to share views on the important issues of zero emissions in manufacturing.

1.2 I work with the Tanzania Sisal Authority (TSA), the largest vertically integrated sisal company in East Africa, as director of Planning and Investments and I am also responsible for Research and Development.

The main features of the 14 sisal estates covering more than 80,000 acres of fertile land in areas whose climate, geology and topography are very suitable for sisal growing as well as other crops are:

- A sisal spinning mill with an annual capacity of 45,000 tons of labor twine which is slated to be the biggest in the world under one roof.
- A Specialized Carpet wearing mill producing carpets, and capable of producing buffing cloth for use as a polishing cloth in industry as well as cloth of Geotextiles.
- A livestock division with more than 3,400 dairy and heifer breeding cattle which form a captive market for sisal cattle feed concentrate.
- A 50% share holding in the Melonge hotel (read “Sisal”) a tourist hotel in Tanga Town on the East African coast.
- Research and development initiatives focused on increasing the utilization of the total sisal plant for economic and environmental benefits.
- A privatization program aimed at promoting managerial, technical and market networks through strategic alliances with environmentally conscious and futuristic companies, is expected to take off this year.

1.3 I am going to talk on Sisal and how the ZERI concept has fitted in admirably with the hopes and aspirations of the people of Tanzania in their struggle to achieve sustainable development.

1.4 Tanzania is over 80% dependent on Agriculture for its livelihood. More than 90% of the people live in the rural areas. Its per capita income is estimated by the World Bank to be around US $120 per year.

It is however, a country endowed with many, little tapped resources such as precious minerals, gas and abundant wildlife such as you people of America had in the frontier

days. It is Africa's country of the great lakes with Lake Victoria the source of the Nile in the North, Lake Tanganyika the second deepest lake in the World in the West and Lake Nyasa in the South. Mount Kilimanjaro, the majestic snow-capped highest mountain in Africa and the third highest in the world is in Tanzania. The country rolls from the forested mountains in the North and South, through the great central plateau of rich brown Savanna grass and bush down to the tropical coastline where one finds the beautiful clove islands of Zanzibar and Pemba. Yet paradoxically, Tanzania is one of the poorest countries in the world.

1.4 In the 1960's and before the merger of Tanganyika and Zanzibar to form Tanzania, Tanganyika was the world's largest producer of sisal. Sisal, which had been smuggled from Florida in the 19th century where it had failed to grow, was in the 60's being exported in an amount matching in value all other exports including diamonds and gold. It was then known as the "White Gold of Africa".

Since then sisal has been subjected to stiff competition from synthetic products and lost more than 40% of the market share in agricultural twine, the main stay of the industry until now. Tanzania's sisal production has dropped from 230,000 tons in the 60's to 28,000 tons last year. Causes of this decline are many but I would especially like to dwell on one which has been an important catalyst for our ZERI endeavors.

1.5 We established contact with UNU about two years ago. Prior to that TSA had been working in the ZERI direction, not knowing that a parallel concept was being developed at UNU. The ZERI concept received immediate acceptance because it perfectly matched with Management's Vision of where we would like to take the company in the 21st century. Our corporate plan which was developed before we established contact with Gunter Pauli is almost a plagiarisation of his ideas. I would like to assure this august gathering that we in TSA are committed to implementing the ZERI concept. We are especially grateful to Prof. Dr. De Souza, Rector of the UNU, Prof. G. Chan, Prof. K.G. Mshigeni, Prof. M. Sheya, our Government, and most of all Gunter Pauli for having worked tirelessly to make this a reality, and quelled the skeptics who are many at home.

While before we were only a voice in the wilderness, we now feel no longer alone and we are beginning to see the light at the end of the tunnel. I will show the results later.

2.0 In 1994 sisal was selected by the Tanzanian Scientific and technological community as the No. 1 ZERI activity in Tanzania. The Board of Directors of TSA has agreed to commit funds and approved plans to mobilize funds from other sources in implementing the ZERI vision which is also TSA's vision.

To this end TSA is working with University of Dar es Salaam and Sokoine University in Tanzania tapping the local human resource capacity. TSA is also collaborating with foreign research institutions in Denmark, Holland, Britain, Russia,

Canada and the USA in developing low cost construction materials for walls and roofs answering insulating aspects of construction. We need to work with other American companies in the Energy sector and laboratories engaged in developing medicines and pharmaceuticals. Some people believe that sisal could save the rhino from extinction. We need to confirm this. TSA has signed Cooperation agreements with the University of Dar es Salaam and Sokoine University, the Tanzania Commission for Science and Technology, the Danish Technological Institute, and most importantly of all, UNU in Tokyo.

3.0 WHY ZERI?

With your permission I would now like to explain why TSA adopted the ZERI vision.

3.2 The first reason why TSA embraced ZERI was based on survival. Five years ago and even now many people in Tanzania and some in other parts of the world felt sisal was dying. This was because its market share was declining due to stiff competition from synthetics and technological changes in the baling of hay and straw, the major use of agricultural twine and the fiber. The prices to twine which are set by the price of Brazilian fiber were falling. For one hundred years the sisal industry in Tanzania had been producing the same products with more of less the same technology. Little change was being effected. Due to low prices of baler twine the industry was unable to maintain the 10% replanting required every year to sustain production. These were a sure sign of a product which had reached maturity and was on its way out.

3.3 The second development was the taking to court and conviction of a number of estates for pollution. You have seen the film this morning. The cleaning up of the production process can no longer be ignored.

3.4 The third reason had to do with escalating power costs and power shortages necessitating power rationing. During this period power costs increased from 20% of direct costs to more than 45% and are still rising, due to deforestation at water sources and other problems. Supply, which is largely hydro based, was being outstripped by demand in a ratio of 1:2 and rationing had to be introduced. Estates and other mills were forced to operate three days a week.

3.5 The fourth reason was rising expectations among the people, forcing the cost of living to rise. The unions have been agitating for an increase is wages from the present minimum wage of Tanzanian Shillings 17.500 per month (US $30 approx.) to Tanzanian Shillings 85,000 (US $140) and above. This is a very significant increase for Tanzanian industry. Though these demands have not been approved it is necessary for companies to keep them in mind. In TSA we believe we can accommodate these increases if productivity of labor, materials, capital, land and time is effected. The ZERI vision promises to offer the solution to this problem.

3.6 The fifth and most important reason therefore was that management realized that the sisal industry was producing too much waste. It was incurring costs in infrastructure, sisal growing, maintenance as well as production in order to extract a fiber which is only 2% of the sisal plant. We were throwing away 98% at great cost financially and environmentally. Only gold could possibly survive such wasteful production.

4.0 What Now?

4.1 We have looked at what products can be produced from the waste and the sky is the limit. There is a paper on the "Future of Sisal" which distinguished delegates can pick and read.

4.2 The strategy we have adopted in implementing the ZERI vision is to initially establish pilot plants for those products whose R&D has reached the commercialization stage. This will confound the skeptics and start us on the long road to zero emissions.

4.3 Before I go into details of implementation I would like to give you an idea of the wastes we want to exploit.

4.4 There are several forms of wastage on sisal estates and in the production process. At decortication the leaves are decorticated, producing fiber, but of this fiber only 2% of the leaf is extracted and the remaining 98% is thrown away into rivers polluting water or dumped less than 100 meters away using 10,000 gallons of water to push away the biomass. This waste biodegrades, emitting methane and CO2 into the atmosphere.

4.5 In the field the first young leaves are often left to rot because they have not attained the optimum long fiber content. Ten years after planting the bole with the butt ends of cut leaves and roots are crushed with crawler tractors and burnt to mitigate against weevil infestation. The burning pollutes the air. The grass in between the rows of sisal after the first two years is cut and left in the field causing fires. Fortunately, sisal does not die from fire. After rains it often recovers but production is affected.

4.6 Since huge quantities of water are required the estates are often located near rivers but also have dams built. This water has been wasted, and the dams not fully utilized.

5.0 Action Taken

5.1 TSA has taken concrete measures to reduce waste with the goal of achieving Zero emissions. We have already instituted dry decortication on one of our estates reducing water consumption by 90%. Since signing the agreement with the UNU I am happy to say funding for the following projects has or is about to materialize:

5.2 A US $3.5 million pilot biogas plant to produce biogas from the leaf waste for electricity production and fertilizer is expected to start being constructed before the end of this year. This project is being funded through a grant from DANIDA via the Global Environmental Facility of the UN, equity contributions from Biocontractors of Denmark and a loan from the East African Development Bank. TSA needs funding after this for replication on other estates, to produce enough electricity for the company, with 80% to spare for the Tanga and other regions.

5.3 This month the government of Tanzania is expected to sign project, grant and loan agreements with FAO, UNIDO, IFAD and CFC for a US $5.4 million project for R&D, Sisal Bole Pulp production, animal feed, market testing and small holder sisal growing. TSA and the National Coordinating Agency have agreed to put in US $219,000 into the project. The project is for 5 years and will be implemented in Tanzania and Kenya. A large component (more than 60%) of the money will be spent in Tanzania. The experience gained will be disseminated to all Sisal growers in the world.

5.4 To construct a biogas plant properly adapted to the ZERI vision, TSA, through the UNU, is working with Prof. George Chan. Prof. Chan has volunteered to take care of solid and liquid waste from the biogas plant in an integrated Sisal fish farming project involving mushroom farming as well. Despite the huge lakes and sea, fish is still not very affordable for the people, though it is an important protein source. This project will significantly improve nutrition among workers and surrounding villages. We have pledged to match UNU assistance dollar to dollar.

Ladies and gentlemen this is only a scratch on the surface in developing new products from sisal. There are many more others which we have in mind. We need international cooperation in implementing the ZERI vision and building a better future. Most of the products envisaged will be consumed in the developing world. We ask you to assist us in doing it right and come in as our partners in developing the products of the future. The future of ZERI lies in international cooperation. Do not deny us assistance when we come to you. We will all benefit and that is the best way of cooperating.

Once again, I thank you all and especially the people of Chattanooga for listening to me. I look forward to a future of cooperative endeavors and the return of the glory of sisal as the “White Gold of Africa.”

Remarks from the Centre for Sustainable Design

Martin Charter
Editor, Green Management Newsletter (UK)
Director, Centre for Sustainable Design University of Sussex

What I want to do here is just communicate some very quick observations, some very practical ideas and some commitment. On the observations, I think one of the most important things is that the ZERI program has added a goal and an aim. We have had discussion of eco-efficiency and dematerialization since '92 and before, but I think the important thing is that ZERI adds a goal and an aim for people. People are struggling with what could a sustainable vision be, and I think this is a key relevance of the ZERI project. I think it's also important to remember that zero emissions is actually part of, if you like, the quadruple bottom line of sustainability--managing social, economic, environmental, and ethical needs, and that is an element that should be continued to be built on through the ZERI program.

I think another important element of it is in a sense looking at the three Ps. We focused a lot today on process, but what also has cropped up is the need to look at product design, design issues at its source, but also increasingly it's important to remember that actually people actually have to make these things happen, so if we're looking to implement these ideas, we need to focus on people.

It's also important in my view to think creatively and think out of the box. We won't achieve these solutions in the same level of thinking we have done before. As George Chan presented, we have to break away from some of the solutions and ideas already there. We may be just not looking in the right places, so let's not forget that the developing world has many of these ideas that we can borrow on and learn from.

It's also about communication. It's about adapting the message to the audiences you're dealing with, so as some people call it, hitting the green wall. You can get the concepts that far in the organization, but unless you're translating it to the language of the people you're operating with, the manufacturing director, the marketing guy, it will stop. But it's not just about hitting the green wall, it is, if you like, hitting the blank wall. It's actually opening that door to enable people to actually start to make some of these interconnections, so communications is a key issue.

It's also very important to look at the fact that it's great to see the examples from many of the large Fortune 500 companies, but we have to remember that a majority of businesses in the world are small and medium-sized enterprises, and one of the things that is particularly important is: how do you diffuse ZERI or zero emissions through, and cascade it through to the small companies in a language they understand, when they don't have enough time to take these issues?

MR. PAULI: Martin, could I just ask you, concretely, what can we do?

MR. CHARTER: Some ideas for action both for ZERI and for Chattanooga are: I think Chattanooga particularly has got a model example here, particularly in the area of business, which from a local authority context, most local authorities, certainly in the UK, are struggling with. The UK may be leading on a lot of initiatives to do local Agenda 21, but they're failing to involve business. I think focusing particularly on Chapter 30 of Agenda 21 and marrying it with Chapter 28, the local authorities aspect, is a good idea.

Also, a key aspect, too, is that lots of ideas will spin out of this event but then there's a need to put the frameworks and coordination in. One needs sustainable, if you like, development management committed to make sure you don't lose these ideas, to keep the coordination going. Specifically don't just look at new zero emission parks but also look at how you retrofit existing eco-industrial parks, examples in Dalhousie in Canada and Calemba are examples that are drawn. The idea of eco-clusters as well, you've started it with in effect not just zero vehicle technology, but the components and other elements there. You're looking at eco-culture, spinning out these particular things.

Specifically for ZERI, I think one of the very key aspects has been that we focused a lot on the technology, but ultimately in the business context you actually have to make it happen. I think there is a need for a manual, for example, of how we actually implement zero emissions objective strategies within the firm, aimed at chief executives, how you put it in place. I think it's also important to look at the business case; translating what the previous speaker said: What are the business benefits? And I think again, it's the need to translate it down into the product design. Designing a lot of products is the essence of many of the complex organizations. It's important to draw that balance out between making it relevant for complex organizations with complex products as well as for simple companies with simple products.

I 'd like to say some final things. We won't have time to show you something which is quite exciting, but maybe we --

MR. PAULI: Over coffee right after.

MR. CHARTER: Over coffee, okay. Some specific commitments: For the first part, in the area of sustainable publishing, we would like to talk to Gunter about helping them with an electronic book on the manual on zero emissions. As part of the event today we have spoken to Socrates Online about the idea of an electronic book that you can actually send straight down the line into the computer, eliminating packaging, eliminating transportation, et cetera, and we have an example of this that we can show over coffee if required.

Just two final points, and also another commitment: We, through the Green Management Letter, if we receive information we will publish it, case studies particularly. And lastly, because it's a commitment, it's an opportunity: We also have

funding to produce a training package on sustainable product design, and again I'd like to work in cooperation with you on that.

The U.S. Department of Energy on Sustainable Energy

William Parks
Director, Technology Development, Office of Industrial Technologies,
U.S. Department of Energy

Good afternoon. It's a real honor to be here, having heard the tremendous discourse going on here, having spent two days here listening to highly motivated people, and I just want to say that it's a real, real pleasure to be here. I feel that I could speak for an hour about all the ideas that have come to my head and about the things I've learned about here. I could speak for another hour about the kinds of programs that we're doing and how they kind of complement the kinds of things that are being talked about here, but I know that Gunter is already upset with how much time I'm going to take, so I will not do that.

What I would like to do is very briefly introduce you to the kind of work that we're doing and then throw it open for questions.

I'm from the Office of Industrial Technologies within Energy Efficiency and Renewable Technologies, Department of Energy. Within EE, we have the responsibility to look at energy-efficient and renewable technologies for transportation, for buildings, utilities, and the industrial sector, which I'll talk about today. Those include alternative fuels, alternative vehicles, biomass production for energy, a host of activities that we are involved in.

We within the Office of Industrial Technologies are concentrating on seven industries within the United States, then working with them on a public/private partnership program. These industries represent about 80 percent of the manufacturing energy use in the United States and about 90 percent of the industrial waste in the United States. What we have done is develop a partnership program where the industry develops their idea of the vision of the future, where they're going not just in the next quarter but over the next 20 or 25 years. They're developing technology roadmaps on how to get there, and we're helping them implement that through a series of actions, including facilitation and some seed money.

This approach and the value that this brings to American industry is that it enables an entire industry, like the steel industry, to work together for the first time and pull together the diverse parts of the industry, for example, the integrated mills and the mini-mills working together toward common goals where they are traditionally just competitors. It also provides a strategic vision which again, with the long-term needs, it allows us to use our limited resources and their limited resources to target just the key activities that need to be done and provides a means for matching national capabilities.

What we have done is we have aligned seventeen national laboratories, including Oak Ridge, to work with these industries as a one-stop shop for these

industries to come into and to give collective help on the particular problems that each industry faces. We have also done a lot of work with universities, their selective research programs tied to industries for university members, and to help in the education process.

Where does this stand? If you can read the top left corner, the forest products vision was first signed in November of 1994, and it deals with a host of things, including closed water cycles for the pulp and paper plants in the United States. The steel industry is looking at zero emissions as one of their major targets. The metalcasting industry representing over 3,000 metalcasters in the United States are looking at 100 percent recycling. The glass industry is looking at 100 percent recycling. The aluminum industry is looking at what they call continuous life-cycle use of aluminum, renewing again and again the aluminum cans that are used.

In June, the chemical industry will put out their vision of 2020 and what that looks like, and that has been an extremely complex process due to the diversity of the chemical industry. They have about forty areas that they want to concentrate on, including biochemical development from biomass feedstocks to plastics and those kind of areas, so I think that fits very well with what's been talked about here today. The refinery industry continues to put their plans together, which will be be diverse. I'm not sure what date that will be completed.

Just to talk for a second about the forest products industry, this was the first industry to sign something called Agenda 2020, and they have identified six areas within the forest products' industry that they want to work on. They now have completed or have completed drafts of the roadmaps for these areas and have initiated projects in these areas, looking at a host of different areas targeting on these major topics.

If I could now go to a very short video that talks about our partnerships:

"NARRATOR: Energy, the fuel that keeps America working. Each year the United States spends almost $300 billion to light and heat homes and offices, to run transportation systems, and to operate factories. About one-third of all the energy consumed in this country is used by industry to convert raw materials into steel, aluminum, paper, chemicals, glass, and the many products we buy, use, or export to the world. For American industry, using energy efficiently is a key to staying competitive.

"HAZEL O'LEARY (Secretary of Energy): Now we're clear that the way we accomplish your goals, the national and now global goals, but first of all the national goal, having your businesses remain competitive, is in this collaboration. The other point. What I would leave you with is that we're not betting on one or two companies within your industry. Because you have wanted to come to the table as a vertically integrated group with your technology expertise and your company expertise, we can

spend relatively small sums of money on behalf of the American taxpayer to create more of those high-paying, high-quality jobs as we reduced your costs and helped, I hope, to expand your market.

"ROBERT WILLIAMS (CEO, James River Paper Company): DOE has been among the most understanding and cooperative agencies in the federal government that we've dealt with, and we can only hope that together we'll set the example for other industries and other government agencies to see the real value here for America and to join us and to help us with this partnership.

"VAUGHN MACARRY (President, Steel Foundry Society of America): One of the early successes of this effort has been to get this diverse group of metalcasters together and agree upon seven key challenges that face our industry in the future and to set goals for each one of those challenges. As you can see, this industry is developing, along with the Department of Energy, a technology road map, and this road map is going to guide our efforts toward achieving our vision. When we successfully meet these challenges, the U.S. metalcasting industry will be the worldwide preferred supplier of net-shaped metal components beyond the year 2000.

"JAMES R. MALONE (Chairman, Anchor Glass Container Corporation): One of the things that I am particularly proud of for our industry as a whole and for the Department of Energy is that they have sought our help, and we, in my humble opinion, have been smart enough to take that request for help and guidance in how the partnering is to proceed and provide that input from the standpoint of the private sector so that there truly can be a partnership of the private sector and the public sector working together, and in this kind of environment, it's what makes that return on the dollars. Are they quick? No, there is no R&D that is ever quick.

"NARRATOR: Today more than ever, American industry is challenged to build a stronger economy at home by becoming more competitive in the world marketplace. Some of the biggest challenges are faced by energy-intensive industries, including metals, glass, paper, chemicals, and petroleum refineries, because energy use can account for as much as one-fourth of their production costs. These industries need new technologies that lower the cost of processing raw materials such as iron ore, bauxite, oil and natural gas, into basic materials such as steel, aluminum, fuels and chemicals.

"Working with industry, the Office of Industrial Technologies looks for new technologies that enable industry to use energy more efficiently, to use alternative sources of energy, and to make better use of energy that is now lost as waste or heat. Energy-efficient technologies also benefit the environment by cutting harmful emissions and greenhouse gases. OIT works closely with industry to identify research and development needs and then to develop new technologies.

"All OIT programs are cost-shared with partners from the private sector. Some projects help specific energy-intensive industries. For example, direct steelmaking is a

new process that will help steel companies reduce use by as much as 20 percent, eliminating a major source of pollution, and reduce capital costs by" --

MR. PARKS: We can probably cut this short. Could you stop the video please.

Just to summarize at the end of that, and it was almost over, I think we have a lot of projects going on and I have just touched on the partnership concept, but we have a lot of things going with these industries, things like anaerobic digestion of tuna sludge and chemical approaches to making plastics through biomass, and I'd just like to end and say that I think there's an opportunity for synergies here and that we'd be glad to talk to you over the next year and see if we can find some concrete things that we could do together. Thank you.

Exporting Environmental Technologies

Anne Alonzo
Deputy Assistant Secretary for Environmental Technologies Exports,
U.S. Department of Commerce

It's a pleasure to represent the United States on this distinguished panel of foreign dignitaries. At the outset, I just want to congratulate Gunter Pauli and the United Nations University Zero Emissions Initiative for their vision, their hard work, and their laudable efforts, if you will, in trying to establish the goal of a global network for zero emissions.

A couple things in terms of the U.S. I've been in the environmental protection arena now for about thirteen years, and I've always been, if you will, in the field of environmental protection. I was an enforcement lawyer for seven years for the Environmental Protection Agency in Chicago on Superfund and RCRA matters. Thereafter, I served as a diplomat and attaché, if you will, for the United States in Mexico City during the NAFTA negotiations, so I became very aware of trade and environment issues and development issues affecting a country like Mexico.

Now I serve as the government official with the global mandate under the U.S. Department of Commerce, and I think that on a very practical level, I've seen and experienced issues and seen an evolution of thinking in the United States in terms of environment and sustainable development. And I'm particularly pleased, and I'd just like to hone in on this, with the focus and connection that I'm seeing occur in the area of economic progress and the creation of jobs and the competitive advantage that is occurring here and abroad because of the issue of environmental technologies. I don't think we've ever seen this target and this focus so clearly as we have now, and as the Senator pointed out at lunchtime, good environment can also mean good business.

And I think that with that background in mind, I had just want to hone in on the role of the private sector, and I know we have many representatives here from the private sector, both U.S. and abroad, because I think that they play a very critical role in the discussion over the last two days in the development, the commercialization and the deployment of environmental technologies. And I was very struck by the chairman for DuPont yesterday when he made the observation about the respective roles of government and that as being a regulator in the environmental arena or the environmental community, and I think he meant the nongovernmental organizations, as that of an educator, but lastly and I think very importantly, he honed in on the role of the private sector as the innovator and the implementer, if you will, of this area, and I think for lack of a better term or phrase, this is where the rubber meets the road, and I think that many times in practice, we're seeing especially now the importance of the innovation and application of environmental technologies by the third party or the third part of the equation: the private sector.

At the U.S. Department of Commerce, I head up a focus on assisting U.S. companies export their environmental technologies globally. This focus is a new focus by the Clinton administration on environmental technologies, and one of the key reasons that we've employed this focus on the promotion, if you will, of U.S. environmental technologies is that we think we can do well by doing good. We have 25 to 30 years of having a very strict regulatory system in place in the United States, and we have especially in developing countries a need for foreign expertise, imports, if you will, of goods, services and equipment, and we are poised to work hand-in-hand with our U.S. private sector to meet these new needs in this new global economy.

I wanted to mention, just in terms of background to our visitors, is that perhaps in an unprecedented way, the U.S. Government Department of Energy, the AID, EPA, Exum Bank, OPIC, and other U.S. federal agencies are working together to target and leverage different markets, and the focus of our work, the client, if you will, of our services is the U.S. private sector.

And I wanted to mention that because I think I've been listening to a little bit of a discussion and I wanted to come up to some recommendations, for Gunter and the Initiative in terms of how we can do a better job and assist in this very laudable goal of zero emissions. I think that we have a lot of different programs throughout the U.S. government focusing on pollution prevention and to some extent on some zero emission initiative, but I think what we could do a better job of is inventorying and summarizing what some of those programs are.

For example, at my own department, the Department of Commerce, we have under our MEST program, manufacturing extension program, and there are awards that we have been giving out to assist small and mid-sized manufacturing companies in the area of training them in the area of pollution prevention. We have eighteen training sessions planned for the United States this year. Also we're planning an information database, a clearing house of pollution prevention and manufacturing activities in the U.S. I think it's important for us to get a better handle on some of the activities we have going on within the department and across the federal government.

Also, another agency, the Agency for International Development, AID, has a specific, a very large program in Asia called the U.S. Asian Environmental Partnership, and one of their new programs for 1996 is to install clean technologies or assist U.S. companies in the promotion of clean technologies in Asia, and as one of the gentlemen was talking about earlier, we want to hone in on priority sectors such as chemicals, pulp and paper, architecture and design, food processing, and match U.S. companies to trade associations and sectors in those countries.

We think that that this is very critical because a large portion of the industrial base of Asia will be constructed in the next fifteen years as opposed to a situation in the United States where, by the year 2010, 100 percent of our industrial base will be in place, and we are at the pipe or after the pipe in terms of cleanup, if you will, or end-of-

pipe technologies versus what we ought to be promoting on that as pollution prevention and zero emission-type technologies for the countries that we're trying to target and get into.

Also, regarding the Environmental Protection Agency, I know that you've had a representative here from the EPA, and that there was some discussion about grant monies and demonstrations. I think that that is probably singularly the most important tool we have in terms of work in this arena. For example, I know that for 1995, 40 to 50 percent of EPA demonstration grants have been in the area of pollution prevention. In fact, there's one specifically dealing with zero emissions for the Valley of Mexico dealing with the demonstration project for fuel-cell-operated buses in Mexico, especially looking at the high altitudes at the Valley of Mexico.

The reason I bring this to your attention is because I think that we have, within our purview and our ability, the ability to help track and inventory the myriad of different grants and proposals in the United States that can assist in your endeavor, and also given our focus on helping U.S. companies promote their technologies overseas, we can do a better job of guiding and making sure that in a certain manner, we are working further along the continuum of pollution prevention and zero emissions in our efforts, especially as we give a lot of priority to U.S. company exports of environmental technologies.

And lastly I spent the last two days touring Chattanooga, which quite frankly is one of our stellar examples, if you will, of a living laboratory in the United States, and whether it's zoning or fleet vehicles, electric vehicles, or eco-industrial parks, this is truly a stellar city for the United States. I think that coming here and viewing it, as I'm sure many visitors or foreign dignitaries have also had the opportunity to tour Chattanooga, is important. If you haven't been discussing this over the past two days, a important point is that there should be a center or defining place where people can view the application of environmental technologies, and Chattanooga in the United States comes to mind as one of those centers. I'm sure that you have other ideas in terms of other countries, but I really do think that going back to the initial suggestion by many, the showcasing and the actual demonstration of technologies, perhaps centered in some spot is very helpful in a very practical and real way for your efforts.

With that, I just wanted to thank you. We come at it from sort of a different point of view. We're not a research arm of this equation, the work we're doing is really at the delivery side, end of delivery really, and I hope that that's been somewhat helpful. We'd appreciate working with you in the future and bringing to bear many of the resources of the U.S. government in support of the U.S. private sector. Thank you.

Remarks from Chattanooga

David Crockett
Councilman, City of Chattanooga, Tennessee

Eighteen months ago, as Gunter said, Gunter arrives here, working with us as part of what we're doing in Chattanooga, being a living laboratory for technology, for design, and for policy, and realizing that those answers don't all reside here, that to be successful to be a defining place, that we had to be open and also to go seek all that we could bring here, to combine with our people and what we had learned in the design of a city, in design of a business, and design of process and education, to see if we could create a modeling place. Chattanooga is not a model. It is a place to model. It is a place where things can be tried as is the case for any city.

Carl-Göran Hedén, Keto Mshigeni, Gunter, Prof. De Souza, Wally Mbow with Habitat for next week, and a number of distinguished guests and the rest of the delegation from the first meeting of ZERI, joined us in Chattanooga on the occasion of the meeting of the President's Council on Sustainable Development, which involves a good part of the cabinet of the United States, corporate leaders, environmental groups, civil rights groups, and tri-NGOs who were trying to put together a policy. I can't imagine that more has been learned in a shorter period of time by both us in the city and remarkably at national and international levels.

Eight task forces of the President's Council started out to try to craft a national vision for the United States. They were looking at transportation, energy. They were looking at housing. They were looking somewhat in very traditional ways, and they were very disparate groups or different groups that in the past had not always collaborated. In a period of two years, starting out with some fundamental ideas, I think that what came to be important and distilled out of all that process, including this ZERI process, is that three fundamental things had to happen to achieve sustainability, here defined as prosperity that builds from each act to the next, from each generation to the next, and to reverse acts that had not done that in the past where we had confused activity with prosperity.

One was the design of cities, that they had to be cleaner, greener, safer. They had to be designed in a different way, as Bill McDonough has talked about. Two, the design of products that you and Paul Hawken have talked about, is that no longer could you design products with the point of design of a styrofoam cup where you use them once and throw them away, that that would no longer work. The resources were not there to accommodate it and the cost in human terms and in capital and financial terms wouldn't allow it in the future. The design of products had to change. And the third, education, that even though we might possess technical backgrounds or Ph.D.s, that learning and education through all levels to learn about the interdependency of all these elements and how they act and relate to each other was critical and had to take a fundamental change.

The term "zero emissions" still is an unusual term, still causes apprehension among many who confuse it with a term of the past about regulation, but in the last 18 months, I think we have come further in thinking about how we do things in the future than I could have ever imagined, from the President's Council on Sustainable Development which recognizes the need for doing not only the design of cities but that at a city level is where all of these things come together. We've seen case studies this morning, and only in the city can you see all of those policies, including industrial policies, come together and see how they interrelate and see the intended and the unintended consequences of an action.

And the point of designing to completely eliminate waste brought by ZERI, and others, Paul Hawken and Bill McDonough and Gunter Pauli and other leaders and visionaries like yourselves offer a compelling vision of the future. We're at a point in time where we're not just fine-tuning, as we have learned from DuPont and others and people in this room, but it is, I think, a large step. The word of the time is called a paradigm shift where we're entering an age that will be defined in retrospect much the same way as the industrial revolution or the industrial age, the computer age, the automobile age was, and each of the people who are sitting at this table are the pioneers of that age, in a quiet meeting that is charting a course that will have that much impact on the way we live in the future.

Regarding a commitment standpoint from our city, I would first of all tell you that our commitments are to be that living laboratory, to form the partnerships with the cities that have participated here, with the companies that have participated here on an ongoing basis, and with our partners from technology laboratories to national laboratories to the sites that we have where we're committed to make those new industrial policies go into action, to everything we do in the city. We're also committed to action. Keto Mshigeni talked about vision. There's a saying that vision without action is just a daydream; action without vision is just activity. We're committed, along with you, to put vision into action in this conference.

The last thing that I would leave you with is something said by someone in this country named Stephen Covey, who talks about change, who wrote a book called The Seven Traits of Effective Leadership. He talked about changing a habit or changing a culture and he said that three things are necessary: You must know why you should do it to be properly motivated; you must know what you have to do; and you must know how to do it. I think we have realized why; we're determining what; the how will only be done by doing it. We will learn together. We will learn in the process of doing it, and I would say that the where is that we will learn at a city.

Next week in Istanbul, the cities of the world will come together and the businesses of the world will be there, but that's where all the elements, business, government, and our communities come together and I believe that's the where. From Chattanooga we're committed to this path along with the other cities. We look forward to Indonesia being the next place for the where. We're honored by each of you being

here. We're honored to take this little step on a path that is changing to a new direction, and we're honored to have you here and look forward to partnership with you in the future.

If you will indulge me, I'd like, as I close, to ask my colleagues in Tennessee who have helped organize this to stand because it has been a long process over eighteen months. Then if you could stand in the back, please, Geri and others, and I'd like to applaud them.

(Applause.)

And I would like to thank the Rector of the United Nations University, and I'd like to thank Gunter Pauli, and I'd like to thank each of the delegates for being here, and I look forward to an active next year, not a waiting till next year as someone said, but to have much to report on in Indonesia. Thank you for being in our city. We look forward to seeing you again.

Closing

Prof. Dr. Keto E. Mshigeni
Chairman, United Nations University's Zero Emissions Advisory Council 1996-1998
Pro Vice Chancellor of the University of Namibia

Mr. Chairman,
Your Excellencies
Distinguished Participants
Colleagues
Ladies and Gentlemen:

1) When addressing eminent and distinguished experts and industrial entrepreneurs such as you, especially towards the end of a World Congress, one has to be very careful. Indeed, I am guided by what William Shakespeare left on record for us: "Brevity is the soul of wit."

2) I am reminded also of a contest in a theological college. Young theologians were asked to describe the event that took place at that wedding in Cana of Galilee, when Jesus transformed water into wine. The one who would write the shortest, yet most colorful essay, would get an award. The shortest, and winning account, was written in only one short sentence: "Water saw its master, and blushed!". Yes, I shall try to be brief.

3) When recently, I was invited to serve as Chairman of the ZERO Emissions Advisory Council, my initial reaction was far from positive. Yes, I remembered also the first reaction by biblical Moses, when he was called upon by the Lord to lead the Israelites from Africa to the promised land,

" ... Lord, who am I? ...
...Lord, behold, I am not eloquent!".
But, in the end, Moses accepted the challenge.

4) I was personally hesitant to do so, partly because of reasons similar to those that Moses had given, and partly also because it is not easy for one to find any UNU/ZERI Advisory Council Chairman who can feel comfortable in the shoes of our outgoing Chairman, Prof. Carl-Göran Hedén. A great leader, a most remarkable, enlightened visionary and distinguished scientist, technologist, engineer, medic, scholar.... you name it!

5) Carl, on behalf of the UNU/ZERI Advisory Council, and on my behalf, I wish to take this opportunity to thank you, most profoundly, for the excellent work you have done, and for the dedication you have shown, towards the promotion of the ZERI vision, since your appointment as Founding Chairman of the Advisory Council. But I

am consoled that you will continue to work with us on the committee, as we move forward with confidence.

6) Mr. Chairman, Ladies and Gentlemen:

It is with that understanding that I accepted the challenge: as a great honor to Africa, to the two universities that I serve (the University of Dar es Salaam in Tanzania and the University of Namibia). It is a great honor to me, and to my family. It is also a great honor to the Third World Academy of Sciences, where I am serving as Chairman of its Agricultural Sciences Committee and a great honor to the African Academy of sciences, where I am serving as Editor-in-Chief of the Academy's Journal Discovery and innovation. I thank you for the confidence.

7) But let me tell you a story, or rather let me make a brief remark:

Sir Isaac Newton, whose laws of thermodynamics, were quoted abundantly throughout this World Congress, is known to have said: "If I have seen farther, it was by standing on the shoulders of giants!". Now, if that giant of a scientist had the humbleness to say so: "What shall this economy-size *Homo sapiens* from a remote village in tropical Africa say? I am out of words!".

8) My dear friends, brothers and sisters:

As you will recall, when Professor Hedén was making his remarks last night, he had said that I had been accorded a wonderful opportunity for Continuing Education. How wisely said, and how true!

9) Indeed, my exposure to ZERI is still very elementary. Yes, here we are talking about elementary continuing education. What did you all start to learn in your elementary education days? You know it: addition and subtraction. Yes, through accepting this new challenge, I have added many friends. All of you, thousands of you, from around the globe. My dear father and mother, who are in their late 80's, will be proud to hear about that arithmetic. So will my dear wife, Grace, and my three daughters, Aloha, Leilani, and Lulu.

10) But what about the elementary arithmetic of subtraction? Yes, through working together, as a visionary team, with dedication and commitment, following the ZERI vision, we shall subtract many enemies, which are inclusive of pollution and poverty!

11) Ladies and Gentlemen, when I visualize the genesis of ZERI, I see a kind of a Trinity or a Trio, if you like to call it that way. I see three prominent individuals, almost synonymous with ZERI.

I see Mr. Gunter Pauli, who brought to us the ZERI seed.

I see the Rector of the United Nations University, Prof. Dr. Heitor Gurgulino de Souza, who nurtured the ZERI seed in his garden at the UNU.

I see Prof. Carl-Göran Hedén, who facilitated the growth of the ZERI seed, in close collaboration with Gunter, and with our Rector.

I see this trio as the nucleus of ZERI. But the nucleus of a living cell cannot exist alone: it needs protection. It needs nourishment and support, from all the organelles in the cytoplasm. There is where all of us come in. Some of you, as it were, serve as chloroplasts, others as mitochondria, some as ribosomes, some as the endoplasmic reticulum, etc.

12) Our dear hosts in Chattanooga, Tennessee in general, and David Crockett in particular, and of course also the members of his team, played a vital role amongst the important organelles that have sustained the ZERI vision to its present shape. Indeed, our first UNU/ZERI Advisory Council meeting, was held here in the city of Chattanooga. The Congress will remember your wonderful, cordial, and memorable hospitality, as the ZERI embryo develops and grows.

For now, what I want to see recorded is the fact that we do not have sufficient vocabulary to express our gratitude to you all for what you have contributed, individually and collectively, towards the growth of ZERI, towards making our Congress so successful, and our stay so pleasant and memorable. Your remarkable ZERI-related accomplishments will serve as a light to guide the rest of the world, on the path along which we should tread. We sincerely thank you for this enrichment. Let us give our colleagues from Chattanooga, and all those who kindly sponsored this Congress, a big applause!

From the various discussions held during the Congress, it is crystal clear to most of us, that ZERI is on the right track, and has made significant advances forward. Professor de Souza, sir, Gunter, Professor Hedén, sir: Congratulations!! Let us give these dear colleagues a big applause!

13) At this juncture, I want to make reference to one frequently quoted quote:

“Behind every successful man stands and exhausted woman.”

Madam, Mrs. de Souza, you were at the high table last night, and I believe everyone will agree, you certainly did not look exhausted. Today also, you still look alert and energized, this is possibly due to the following two factors:

One: You have stamina.

Two: Our Rector is extraordinarily extraordinary! To you also Madam, and to the spouses of the other members of the ZERI trio, I say, "Congratulations!". Let us clap for them!

Now as we return to our respective countries, let us all paddle harmoniously together, and strive to attain the Zero Emission targets that we have collectively set out to achieve. With the eyes of my mind, I can see each one of you looking back in the foreseeable future, and saying:

Thank you LORD! You have taken us safely through hostile deserts, and turbulent seas. We have followed the ZERI way, and we have reached the Promised Land. A land devoid of pollution. A land where we mimic nature, a land teeming with natural milk and honey. The world has benefited from what we gave.

14) But, before I return to my seat, please let me emphasize one point: Africa. There is big hope in Africa if we go the ZERI way. And, as they say, Hope is like clouds**.** Some pass by, others bring rain. Please help to seed the clouds of hope in Africa, with you financial and technological support, so they may bring rain.

15) Now, to the millionaires and billionaires I see out there... Please remember: The only wealth which you will keep forever is the wealth which you have given away, for a good cause.

And some day you will hear a voice saying:

"I was thirsty and you gave me clean, drinkable water."

"I was hungry, I had kwashiorkor."

"I had goiter, and you saved me."

"I was naked, poor, and despondent, and you gave me a new hope, and a better future."

Yes, through supporting ZERI, financially. I THANK YOU!

Concluding Remarks and an Invitation to the 1997 World Congress

Dr. Surna T. Djajadiningrat
Assistant Minister for Coordination
Indonesian State Ministry for the Environment

Thank you for this opportunity to extend an invitation to hold the 3rd Annual Congress of ZERI.

The position of the Ministry of Environment is, that we would act as a facilitator to bring together the necessary partnerships in Indonesia, and that those partners of ZERI will be acting as your host. Therefore, the coming Congress of ZERI will be an international event with public and private participation, in which the Indonesian private sector and state enterprises will play their part.

We are looking forward to a visit in the few coming weeks by Mr. Gunter Pauli, to Indonesia, to work on the details of the coming Congress. We are anxious to utilize the holding of the 3rd Annual Congress of ZERI, in providing the needed "push" in at least two directions:

First, in getting the commitment of the leaders of industry to the best practice in environmental technology. The six "green: companies in the proper rating would love to know how to get a "gold" rating. Others would like to bypass the rating system and come out on top immediately. Hopefully, ZERI would be in a position to launch a steam explosion pilot plant in Indonesia.

Second, to get together scientists, business and governments to support and encourage the realization of the enormous cultural and bio-diversity potentials of developing countries. Through the experiences of China, Tanzania, Namibia and Fiji that we have seen during this congress, the world will perhaps realize that the concept of ZERO emission has its basis in the nature oriented cultures of the peoples of the developing world.

Moreover, we are also hoping that the coming Congress will be a meeting place for entrepreneurs, enlightened officials and environmentalists such that synergetic alliances will result.

There are several possible sites in Indonesia, not only Bali and Jakarta. We would love to discuss possibilities of holding the Congress in some other interesting place.

Thank you.