INTERNATIONAL CONFERENCE ON SUSTAINABILITY ENGINEERING & SCIENCE

# KEY NOTE ADDRESS

# ENGINEERS AS LEADERS IN THE TRANSITION TO A SUSTAINABLE FUTURE

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As IPENZ President for 2004 my Presidential theme is “Engineers a Leaders”. My message to IPENZ members as I travel around meeting with them, reinforces that engineers are stunningly successful at technology transfer and innovation. In an increasingly complex technological world, society requires people who can assimilate and adapt emerging technologies and direct the implementation of them. In a word, engineers.

In my view, the contribution of engineers to society and national prosperity is under-valued. I reinforce the message that we will not make the transition to a sustainable world without engineers showing leadership. I encourage them to stand up and be counted as leaders. The title of your conference “Sustainability Engineering” reinforces my message.

The term sustainable development has been interpreted and used many ways, but for this address I propose to interpret it as “development that meets the needs of the present generation without compromising the ability of future generations to meet their own”. There can be no dispute that this is a goal that we should all embrace but, in reality, as a global population we have been slow to come to terms with the reasons we should do so and apply resources.

To understand what actions we should take today implies that we understand the meaning of the words “the ability of future generations to meet their own” and the technologies that will be available to satisfy future needs. It also implies that the future is pre-ordained. We should be clear that the future is not pre-ordained, not somewhere we are going, it is something we are creating today. We have the power to create the future that we want. If the future was pre-ordained then I suggest to you that many of us would be richer than we are today!

Mankind is becoming globally inter-dependent. Global population is presently 6 billion and somewhere in the next 40 to 50 years it is predicted to peak at between 9 billion and 12 billion people. Recently I heard a speaker say “there is no place on earth where the hand of man has not set foot”. Given the fact that we are beginning to see signs of population implosion in some developed countries, it would be wise to anticipate that we will share this planet with at least 9 billion other people in about 40 years time and we need to do something now about preparing for it. Postponing action may no longer be an option. But how much further ahead should we plan to meet the needs of future generations? What advances in technology will change the targets that we set today? What resources will those people need and how will they be priced? What kind of future do we want to create? How will we work together to achieve the targets?

The questions posed are not easy to address. They require understanding of the problems, clear targets and a commitment from all nations to achieving them. We must be careful not to lock up resources for tomorrow’s generations and so place an unfair burden on today’s generation.

IPENZ has been an active participant in the sustainable development debate, both in New Zealand and in international fora. From 1991 to 1999 David Thom has been Chairman of the Committee for Engineering and the Environment for the World Federation of Engineering Organisations and has represented IPENZ in that forum. In March 2003 IPENZ Informatory Note 12 "Sustainable Development – Turning Concept into Reality" was published. In 2004, under the stewardship of IPENZ Past President Gerry Coates, The President's Task Force on Sustainability produced its report. As IPENZ President under the "Engineers as Leaders" theme I am delivering the message that engineers must stand up and be counted as leaders, not just in the creation of national prosperity and our return to the top half of the OECD league tables, but as leading New Zealand to a sustainable future. The "technician in the back room" image has to go; engineers must be recognized as leaders for the contribution they make to society and our future well-being. As Maurice Strong, UN Commissioner on Sustainability and Development put it quite simply and succinctly, "achieving sustainability without engineers will be impossible".

Engineering has played a critical role in increasing health and quality of life over the past 50 years. While the medical profession has contributed to increases in life expectancy, the contribution is small compared to that which engineers have made over time to improved quality of life and reduced disease. Better water supplies, municipal sewer systems, wastewater treatment plants, earthquake resistant design of buildings, protection from natural hazards, improved agriculture through irrigation, and safer transport systems have all contributed. But what can we expect in 100 or 1000 years time? One thing we can assume is that the basic human needs of food, shelter, and security will not have changed. Our dependence on fresh water will not have diminished. In fact, as I will show shortly, if historical trends continue we will become more dependent on fresh water and consume more than we do today, unless we change something.

In developing this keynote speech, I thought what better example than to show than the relationship between the work of engineers and that commodity that we take for granted, fresh water. In New Zealand we have taken access to fresh water almost as a god given right, but this is changing rapidly, and perhaps more rapidly than we realize.

One of our greatest successes globally has been irrigated agriculture. In fact we have been so successful that, if left unchanged, it could threaten our future existence. For example, over the past fifty years we have been successful in increasing food production to meet population growth through the use of new seeds, crops and irrigation. But irrigated agriculture, the industrial revolution, and the population explosion means that today we use 45 times more water than we did three centuries ago. India, for example, through the use of new rice varieties and irrigation, has become self-sufficient in rice to feed it's 1 billion population. Artificially, low cost electricity for farmers to power tube wells has been one of the drivers of this increase, but falling groundwater levels show that his practice is unsustainable.

Globally, the demand for irrigation water is outstripping supply. Irrigation, which accounts for 70 percent of water use, grows 40 percent of the world's food making it possible to feed the planet's present 6 billion population. Australia, for example, is now beginning to realize that it may face permanent water restrictions to satisfy its critical demands for water.

By 2025 it is projected that another one billion people are expected to join the ranks of the highly water-stressed bringing the total to 2.8 billion people. Approximately half of the world's population will have an insufficient supply of water. About 1.6 million people die every year of diarrhoeal diseases caused by unsafe water and lack of sanitation. Yet the World Health Organisation estimates these lives could be saved by basic improvements in supply and treatment with a payback estimated to be between five and 60 times the amount invested in improvements.

New Zealand is fortunate that it's geographical, geological and climate advantages mean that we have not yet had to face these issues. We all have access to clean, fresh water. It will be a travesty if, through poor management, we face water resource constraints in the future which affect our quality of life.

But there are signs that we, in New Zealand, are coming up against constraints on water use. Climate change is changing rainfall patterns. Maybe the water is just falling in the wrong place, but it does seem that our river systems are changing and flood protection works are not coping. Irrigation to boost farm production is taxing groundwater and surface water supplies. There is competition for water resources between, say, harnessing their energy potential and irrigation, environmental or recreational uses. Project Aqua, the Tongariro Power Development Scheme and the Dobson hydro scheme are highly visible, current examples of this conflict.

Recently, the Canterbury region has seen the demand for water grow at an alarming rate, driven in part by the rapid growth of the dairy industry in an area where land values for dairy farming are lower than in the north . Canterbury contains 17% of New Zealand's land area. It consumes 58% of all water allocated for use in New Zealand. It contains 70% of the nation's irrigated land. We are seeing signs that his water demand cannot be sustained. Rising energy charges may well make such farming practices unsustainable as well.

Some more statistics. To produce 1 litre of milk one dairy cow must drink 4 litres of water. It takes 34 litres of water to grow a tomato. 1.4 billion litres of water are needed to produce a single days supply of US newsprint. A typical US toilet uses between 14 and 30 litres of water compared to low flush toilets which use 7 litres or less. These are serious demands on our fresh water resources. Perhaps one day we will look back in amazement that we used drinking water to flush away waste from our toilets.

In January 2003 the Department of Prime Minister and Cabinet released the document "Sustainable Development for New Zealand; Programme for Action". The four key areas are water, energy, sustainable cities and child and youth development. The issues around water are to do with;

- Allocation,
- Quality, and
- Social and cultural heritage values.

It is significant that water features so strongly in New Zealand's Sustainable Development Plan when many New Zealanders would believe that we have adequate, if not unlimited, access to freshwater.

The allocation and quality of water typifies the situation we as a nation, and as a global population, are going to have to face on broader resource management in general as we move towards a sustainable future. Not only will we have to think about quality and allocation issues, we will have to turn our minds to increasing the efficiency and productivity of resource use across the board; water, energy, transport, minerals, construction materials, and recycling of waste. We must also maximize the use of renewable energy sources to create a sustainable energy future. However, it is not clear that all New Zealanders understand the tradeoffs between environmental values, renewable energy and cost. Where we choose to hold environmental values higher than our national energy needs then we must work doubly hard to develop other renewable energy sources at competitive costs, or accept the use of carbon-based fuels and carbon taxes.

Hunter Lovins, of the Rocky Mountain Institute in Colorado, was the keynote speaker at the IPENZ Convention in Christchurch earlier this year. Hunter's theme was "Natural Capitalism" or how to create sustainable competitive advantage through;

- Radically increased resource utilization
- Copying nature in creating closed loops, or what she calls biomimicry,
- Reinvesting in our "natural capital".

She pointed out that an outcome of the industrial revolution was that labour productivity increased about 100 times through the introduction of plant and equipment and the access to abundant resources. The model at that time was people scarce, resource rich. In the revolution we are facing now, the model will be people rich, resource scarce. The new business logic will be to search for increases in resource productivity of 10 times or 100 times for every unit of resource consumed. Hunter, and other commentators, say we have about 50 years to tackle the problems facing us, so we don't have time to solve problems one at a time, we must adopt systems thinking and develop integrated solutions.

In her recent book "Factor Four; Doubling Wealth, Halving Resource Use" Hunter and her co-authors claim that we can accomplish everything we do today, as well, or better, with one quarter of the energy and materials we presently use. Their arguments are based on 50 case studies of known technologies; automobiles, building, insulation, air-conditioning, agriculture, information, railways, lighting and so on.

And that is where engineers come to the fore. Engineers have shown stunning success in adapting known and new technologies. Engineers are task oriented and attentive to detail. They have a disciplined approach to collecting data, assimilating information and applying knowledge, allowing them to make well-informed decisions. Engineers are comfortable with technologies and are prepared to challenge existing thinking and adapt new technologies. They have a systems approach to thinking and problem solving.

In 1986 I was privileged to attend a presentation by Don Roberts in Auckland on sustainable systems. Don, an engineer, was at that time a President of consulting engineering firm CH2MHill in the USA. Don proposed a new closed loop system for resource modeling and use to replace the current linear thinking on resource use. In the linear model resources are treated as in-exhaustible. Waste is discarded to air, water and soil after treatment, as required by regulation, at the "end of the pipe".

In contrast, the eco-systems he had observed functioned as closed loops, changing slowly, with wastes from one part of the cycle becoming nutrients for another stage of the cycle. This was new and revolutionary thinking. But there is a remarkable similarity between Don Robert's early work and the "biomimicry" that Hunter Lovins talks about in Factor 4.

Before leaving closed loops it is worth highlighting the special role of energy. Taking the water example, creating a closed loop for water often requires increased energy use to drive the loop closing process to create ecological sustainability. Similarly, improved sustainability in other resources often tends to increase energy dependency. This puts special emphasis on the need to increase the use of closed loop (renewable) energy sources. Put another way, if we move fast globally on closing the energy loop by vastly increased use of renewables it will make it easier to close the loop on other resources. In turn this will also tend to arrest climate change so we can then ensure greater stability in local water supply. This is really closing the loop.

The reality is that we have the most of the technologies available today, or they are at early development stage, to emulate the closed loops that Don Roberts and Hunter Lovins observed in nature. The issues relate to the level of technology applied to solve the problem, willingness to change, and cost. More often than not it is the application of technology that is the deciding factor as to whether we solve these problems or not.

Technology is developing at an unprecedented rate. We can only speculate on future developments but we can be sure that resource depletion and availability will strongly influence technology development relating to water, energy and materials. For example, as water becomes scarce, efficiency of use will follow. Demand management, principally metering and charging regimes, will reduce water use. For example, demand management in Auckland through water metering has curtailed an historical pattern of demand growth. In the future, cities will recycle wastewater initially for irrigation, industrial use and flushing. In Singapore recycled, bottled water is priced as a premium product.

Precision agriculture will assist the grower in using precise amounts of seeds, fertilizer, pesticides and water, reducing the demand for water and increasing production. We have the technologies to do these things right now, but they are not generally available to poorer countries where need is greatest. Globally the world produces approximately 2kg of food per person per day. That should be enough to feed everybody. Can you eat 2kg of food per day? But the food is not always grown in the right places, and the commercial drivers may be wrong. For example, why is it that flowers are grown in Kenya by low paid workers to be airfreighted overnight to the Amsterdam flower market and not more maize to feed the under-nourished Kenyan population?

There is no doubt that we will implement technologies to achieve all of the above and reduce resource use by a factor of several times. With time we will achieve the resource productivity increases of 10 to 100 times that Hunter Lovins sees as necessary.

We are about to reach the point in time where more people live in cities than in rural environments. Infrastructure will be overtaken by the rapidity of growth. We need to ensure that our cities are sustainable by addressing the environmental, social and economic issues associated with the urban environment. In London Peter Head, a Maunsell engineering colleague of mine, sits on the Sustainable Development Commission and is Chair of the London First Sustainability Unit. The

project is to aid construction professionals dealing with London's specific sustainability demands and challenges through development of a Code of Practice. It is intended the Code of Practice will be launched in early 2005 and, at current rates of consumption, the initiative will;

- Save 1 million tones of construction waste a year,
- Save between 150,000 and 300,000 tonnes of $CO_2$ emissions per year from new projects,
- Increase the supply of renewable energy to 100 times current levels in London,
- Conserve London's water resources.

If the rate of expansion in the built environment increases as predicted these savings will be incrementally increased year on year. This is without taking account of the revolution in materials that is taking place, that promises higher strength alloys and building materials, and composites based on biological materials.

While New Zealanders are in love with the automobile as means of getting from A to B, particularly the used Japanese variety, we all know that transport patterns and habits will have to change. Cars have about half the fuel efficiency of a bus, and a bus about half that of an electric tram. A bicycle is about 50 times more fuel efficient than a car. Integrated public transport systems will replace some private vehicle use. It is clear that those who choose to use cars at peak times will have to pay more, through road taxes and congestion pricing, than those who choose to use public transport. Eventually, the price and type of fuel may also influence those choices.

But our cities are not always organized to allow us to make those choices. People live in cities to work and to access amenities and cultural facilities. Public transport has often been neglected. The motor car gives us *mobility.* Perhaps what we need in place of mobility is better *accessibility* to work and recreation. Transport has to become more efficient, less carbon intensive.

As world population has grown so has resource consumption and the gap between rich and poor, distorting global equity. Over the past thirty years 30% more people are consuming 30% more resources and producing 30% more waste. But the distribution of consumption is not uniform. Over the same time the rich 20% of the world increased their share of world wealth from 70% to 80%. The poorest 20% saw their share diminish from 2.3% to 1.4%. The numbers of poor are increasing all the time as shown by the fact that ;

- Several hundred million are hungry,
- 1.2 billion people have no clean water,
- 2.4 billion people have no sanitation.

It has been estimated that, globally, water to irrigate the golf courses of the wealthy would supply the basic needs of 4.8 billion people, about 80% of the entire world population.

So, what would a sustainable community look like in the future? And remember the future is someplace we are creating, not somewhere we are going to;

- we would have stabilized population,
- we would have stabilized demand per person,
- we would have increasing not decreasing biodiversity,
- we would have a zero waste society,
- we would have drastically cut carbon emissions,

- we would have changed vehicle technologies and transport patterns to give accessibility not mobility,
- we would use a triple bottom line to assess projects.

There is no doubt that these changes will occur. The technologies exist today to effect most of the changes. The pace of technology development will increase, and there will be new technologies some as yet unseen. Sustainable development is no more than rational development. Engineers have proven their ability to adapt technology to solve problems facing mankind and, given fresh challenges, will rise to meet those challenges. While we need to continue with science-based research into sustainability, the urgency is with engineering-based research to apply existing technologies to solving these problems. The short term breakthroughs will come from existing technology platforms and the application of known technologies, not blue sky research.

The dynamics of our planet are characterized by critical thresholds and abrupt changes. We are dealing with a complex system that we do not know enough about. We must take a systems approach to solving problems. Applying narrow scientific knowledge to complex problems will not work in the time frame we have. We need a broad systems approach linking local to global.

Meanwhile the clock is ticking and if we are to address these issues within the fifty year time frame we must act now.

As Hunter Lovins said at the IPENZ Convention, “As engineers it is our responsibility to engineer a new future. Earth is the only place in the universe with life, there is no where else to go.”

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