Engineers New Zealand

*IPENZ Informatory Note Twelve*

# Sustainable Development – Turning Concept into Reality

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*IPENZ ENGINEERS NEW ZEALAND:*
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## Part I: Understanding the Goal

Sustainable development can be defined as development that serves the needs of the present generation without compromising the ability of future generations to meet their own. It is an absolutely necessary goal, but one difficult to achieve in practice without appropriate and concerted action. Strategies for ensuring sustainability in some areas have already been developed, but not always translated via policy into effective actions. How hard it is to gain traction is illustrated by the limited success of our efforts to date to restrict and then lower global warming effects, either nationally or internationally.

Progress towards a sustainable society is about ensuring that the development and use of new technologies respect the needs of the future – not about turning back the clock so that people cannot enjoy the benefits of existing technology. Part I of this note interprets the above definition of sustainable development in a realistic way, and explains how the thinking of engineers can contribute to practical sustainability policies. Part II, due for release later in 2003, will look in more detail at ways of achieving real progress towards being a sustainable society.

### Measuring resource quality

Anticipating the long-term effects of particular resource uses is fundamental to devising effective policy instruments for sustainable development. Two physical concepts routinely applied by engineers can illuminate the measurement of sustainability. The first is the idea of *conservation* – energy and mass are conserved (that is, neither created nor destroyed) in any process. The second concept is that of measuring the *quality* of a resource, and analysing how that quality changes in the course of a resource-using process. Quality can be measured in terms of both the *concentration* of the resource at any point in the process, and its potential *usefulness*.

The analysis of quality change involves the concept of *reversibility*. Perfect sustainability would entail the achievement of complete reversibility: upon completion of any process, the quality of the resources used would be undiminished, leaving them available to future generations in the same state we found them. In practice, all real processes fall short of the ideal, and involve *irreversibilities*, where what was there previously cannot be restored. Working towards sustainability can be interpreted as reducing the extent of irreversibility or the rate at which irreversibility is created, to the point where the degradation of the quality of resources is so slow that the resources remain available on a long-term or sustainable basis.

Some examples may serve to clarify the relevance of these concepts to the development of public policy for sustainable development. They can be applied in a systematic way to take account of the interdependence and complexity of the factors that impact upon sustainability.

If we consider a valuable chemical element (say lead) the first concept establishes that the total mass of lead in the world is for all intents and purposes constant. We will never run out of lead. Since lead was first used we have sought out high-quality sources (ores with a high concentration of metal), and increased the quality (or concentration) further by using other resources, particularly energy, to recover virtually pure metal; then we have used the lead. When a particular use of lead is finished, our disposal practices have reduced the quality of the lead by dilution – disposing of waste lead among other solid wastes lowers its concentration, and hence the quality of the resource. Segregated disposal, by contrast, retains more quality; concentrating the same mass of lead in a small volume of waste makes recovery and re-use more technically and economically viable. Public policy can exercise some control over quality loss, in this instance by limiting permissible disposal methods.

The instance of lead also illustrates why sustainability analysis must not be focussed too narrowly. The quality of the lead resource is improved in the ore-refining process – but only at the expense of reducing the quality of an energy source. The notion of quality must also be applied to the energy used, which can be analysed in terms of the second part of the quality measure – *usefulness*. Much energy is stored in the form of the chemical bonds in fuels. If we break those bonds (for example by combustion) the energy is given out and can be recovered, normally as heat, but possibly as a more valuable form of energy (called work). Work is more valuable because it can be used in more than one way. Irrespective of the form of the energy the quantity measure (usually in Joules) is the same, but the quality (usefulness) will vary. A Joule of electricity is of higher quality, in that it has more potential uses, than a Joule of stored chemical energy in natural gas, which is of a higher quality than a Joule stored chemically in coal, which has more value than a Joule stored as high-pressure gas or steam (either could power an engine), which is of a higher quality than a Joule distributed as heat in a warm room.

The concepts of resource quality and its erosion – irreversibility – can be extended to discharges to the environment. In waste streams, quality is negative if we are dealing with problem materials; so increasing concentration drives quality lower (making it more negative), as also does increasing the quantity of the waste. The effects of lead discharged to the environment also fit this model. Not only does the dilution by distribution of the lead reduce its availability for re-use (thereby increasing irreversibility), but it also makes the remediation of toxicity difficult.

This example demonstrates that even an apparently simple system – the utilisation of the world's lead – is part of a highly complex system involving multiple resources, and incurring a variety of environmental (and social) impacts. So it is vital to take a broad view in developing policy for sustainable development; complex systems analysis is required. One such technique is already available for the assessment of sustainability, in the form of life-cycle analysis – the assessment of the total impact of a technology over its lifetime, taking into account all the processes involved in its creation, use and ultimate disposal. Such analysis can be used to identify current best-practice clean technologies – those that minimise quality reduction as far as is reasonably possible with our current technological knowledge, and present economic and physical resources.

The concept of minimising irreversibility or quality loss extends to health and biological systems (vaccines, for example, allow us to eradicate certain diseases by tackling what had previously been irreversible disease and consequent death, extinction of a species being the ultimate irreversibility). The same style of analysis can be applied, by analogy, to social systems. In this context, limiting irreversibility equates to minimising the number of people who are denied, through systemic failure, the ability to participate fully and constructively in society.

Rigorous analysis is needed to underpin decisions about encouraging, discouraging or proscribing particular activities. Irreversibility and resource quality are powerful concepts. Applied properly, for example via complex systems analysis, they can assist in making and testing effective policy for sustainable development.

### Energy

When this kind of analysis is applied across an economy, energy is a pivotal resource. Improving the quality of another resource necessitates reducing the quality of the total energy resource available to humanity, unless the primary energy source is solar. Growth in our population and the increasing sophistication of our lifestyle generate a spiral of increasing energy demand. In the short term, this creeping demand can be at least partly compensated for, because technology can vastly improve the efficiency of many existing energy-using processes; so increased demands could possibly be met by less energy in total if we had a real will to make this happen.

Overall, the energy quality available to humanity continues to decline, but at such a slow rate that the availability of supply in general will not present a practical problem for many hundreds of years, although two high-quality energy sources (liquid oil and natural gas) are being rapidly depleted, and coal will be exhausted in centuries. Nuclear energy has a longer supply horizon; its safety and environmental impacts represent a more immediate constraint. Renewable sources (including wind and hydro) derived directly or indirectly from solar energy are the exception, as the source is outside the biosphere. Harnessing energy from renewable sources slows the overall degradation of the quality of the total available energy. In fact, apart from constraints related to costs, the most immediate energy-related problem we face is that the human race conducts too much combustion-based activity. Within our present ecological understanding, and with our existing mix of technologies, the amount of energy we can use is limited most immediately by the ability of the biosphere to absorb combustion gases without deleterious impacts.

### Moving towards sustainability

Very few people will willingly or voluntarily forgo things that enhance the quality of life – the heated towel rail, air-conditioning in relatively temperate climates, and luxury foods delivered halfway across the world by aeroplane. Better technologies may mitigate the resource degradation incurred (for example, surface transport with better refrigeration and packaging might eliminate the need to air-freight food), but humanity's quest for improvements in the quality of life is very unlikely to cease.

A jurisdiction can define at any time a target for its sustainable development policy: the level of resource consumption or degradation that would be needed to maintain the well-being of its citizens, if current best-practice clean technologies were used. It might choose to tailor its policy to discourage activities it does not want (those with too harmful an impact despite best-practice technologies, and even though people might want them), and to encourage such new activities as it considers it can sustain. The closeness of approach to the target is a measure of the efficacy of the policies. Over time, developments in technology will change the target, and the policy environment may change to include or exclude activities to reflect changing values; but nevertheless, the target should also become closer if the policy instruments are effective.

The need to develop cleaner technologies to conserve physical resources is paralleled in the social arena by the need to develop a better understanding of our social environment, so as to identify the sources of irreversibility and devise ways to eliminate them. It can be argued that investment in education increases that quality of the human resource, reducing the economic, social and environmental losses that result from poor decision-making on resource use; the only apparent quality trade-off is a short-term diversion of economic resources.

### Public Policy implications for New Zealand

There is still much debate about what are sustainable growth rates, and whether they are applicable to developed and developing countries at the same levels. Nevertheless, New Zealand's sustainable development policy goal could be defined as finding realistic ways to minimise degradation and irreversibilities in its available resources, while maintaining at least mid-OECD per capita economic growth rates to provide a reasonable standard of living. Without sufficient prosperity, we cannot afford to buy cleaner technologies or educate our people and lift the quality of life. The policy must create incentives for desirable changes in our behaviour as citizens, and disincentives for harmful activities.

The national vehicle fleet is a classic example. Savings in fuel and emissions would be most easily achieved by modernising the car fleet, and encouraging people not to choose vehicles oversized for their needs. In this area, as in many, the difference between needs and perceived needs, or wants, can be critical. It is perhaps perverse that we have to permit luxuries (such as air-conditioning) as incentives for change, in the knowledge that a modern efficient car, despite air-conditioning, is potentially more sustainable than an old one, with poor fuel consumption. The right incentives are crucial. We need to get the older vehicles off the road, rather than driving down their prices so that each family owns more cars and travels further, and we need to address the mix between private and public transport.

The expansion of traditional industries also raises complex issues. Capital starvation is common during the start-up phase of new projects, and it is very common for relatively old technology to be used until cash flow is generated. Best-practice clean technology can be adopted when revenue forecasts are more accurate, reducing the risk of further investment, and profit has been made to generate the capital. A shrinking limit on permitted irreversibility as a venture ages might ensure that this happens.

The development of industries in the premium areas of health/safety/well-being and fashion/entertainment tends to be much less resource intensive at start-up than traditional industries, so the earlier introduction of cleaner technologies is possible. Analysis and policy need to take account of such distinctions and complexities.

### The January 2003 Government plan of action

The Government Plan of Action recognises four areas – freshwater, energy, sustainable cities and child and youth development. The programmes of action proposed are concerned with what should be achieved, but little attention is given to how it should be done. The Plan of Action is short on concrete policies to increase the uptake of best practicable clean technologies, and on identifying and limiting activities that incur significant irreversibility.

*Freshwater:* Both quality (for example, the potential for irreversible degradation of the Lake Taupo ecosystem) and the available quantity are perceived as issues. The report acknowledges the need to control artificial redistribution (for power supply or irrigation), and the need to ensure that degradation of quality is minimised. It concentrates on planning for optimising the use of a limited resource and limiting undesirable contamination, with almost no mention of smart reuse strategies: these should be central to the plan. Engineering-style analysis could be used to devise a more comprehensive response.

*Energy*: Conservation and efficiency, increasing use of renewable energy and access to a secure electricity supply are the main areas addressed. Targeting conservation and efficiency is one thing, policies to achieve the targets another, and the Plan is too short on the latter. Proper complex systems analysis should be undertaken to identify irreversibility, and not just costs, in our energy systems, to support practical policy measures to minimise it. Otherwise, in a few years, New Zealand will find that yet another set of energy targets has not been achieved. Ironically, part of the Plan for energy supply is still about searching for more combustible fuel – maintaining our reliance on a highly irreversible process, and unlikely to reduce our greenhouse gas emissions.

*Sustainable Cities:* the plan primarily addresses planning and infrastructure, with a strong Auckland focus. It is strong on liveability (minimising social irreversibility), but less forthcoming on how to cope with the concentrated irreversible processes that cities create. There is a need to improve understanding of what planning processes lead to the best long-term outcomes, minimising the actual and potential irreversibility of urban processes, according to both social and technical measures.

*Child and Youth Development:* the report establishes that the quality of the preparation we give our young people will partly determine how they will fare in the future. They must be technologically literate if they are going to maintain progress towards sustainability. The Plan recognises the goal as minimising irreversibility in a social sense. It seems, however, to assume that the necessary physical and economic resources will be available to provide the quality of upbringing we desire for our young people. It fails to recognise how heavily that quality depends on our capacity to improve the sustainability and viability of many of our economic activities, and secure the economic and environmental benefits of a high-quality human resource. In a sense this category closes the loop – how well we can afford to do socially depends on whether we succeed in limiting irreversibility in the more technology-driven areas.

**Closing remarks**

Sustainable development must be more than an aspirational goal. It is essential to the future wellbeing and survival of humanity. It involves choosing priorities and defining concrete measures to take right now. These choices must reflect a clear understanding of the route to sustainability – rational choices that maintain or improve quality of life, while taking strong and specific actions that reduce the level of irreversibility we will tolerate in the use of resources. Only when we tackle the issue of sustainability accordingly can we truly say that we have not compromised the ability of future generations to meet their needs.

## Other Informatory Notes

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| Note Two | Policy and Leadership Framework for Wealth Creation in New Zealand |
| Note Three | The Role of Technology Education in New Zealand's Future Prosperity |
| Note Four | Sustainability and Climate – An Engineering Response |
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| Note Six | Climate Change and the Greenhouse Effect |
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