Proceedings of the Institution of Civil Engineers
Engineering Sustainability 156
March 2003 Issue ES1
Pages 19–26

Paper 13264
Received 04/01/2003
Accepted 19/02/2003

Keywords:
economics & finance/environment/pollution/social impact

Sara Parkin
Program Director, Forum for the Future

Florian Sommer
Senior Sustainability Advisor, Forum for the Future

Sally Uren
Director, Forum Business Programme, Forum for the Future

Sustainable development: understanding the concept and practical challenge*

S. Parkin, F. Sommer and S. Uren

There are over 200 definitions of 'sustainable development'. But if defining it is difficult, putting it into practice is even harder. This paper reviews what 'sustainability' and 'sustainable development' actually mean in real-world terms, and discusses the practical challenge they represent. It provides an overview of the current UK sustainable development agenda and of the key drivers that will influence civil engineers and the companies and organisations with whom, or for whom, they work. It covers initiatives relevant to the construction sector in the context of changes at the macro level brought about by government policy and public opinion. Examples and references are given to facilitate further reading and research as well as to provide a mechanism for getting in touch with the initiatives themselves.

1. UNDERSTANDING SUSTAINABILITY

Over the last decade, much effort has been spent trying to deepen understanding about sustainable development, both as a concept and, no less importantly, in a practical sense. Governments represented at the 1992 Earth Summit signed up to sustainable development as an overarching policy goal. How exactly should sustainable development be implemented?

In *A Better Quality of Life*[1] the UK Government states that sustainable development

> '... means meeting four objectives at the same time, in the UK and the world as a whole:
>
> (*a*) social progress that recognises the needs of everyone
> (*b*) effective protection of the environment
> (*c*) prudent use of natural resources
> (*d*) maintenance of high and stable levels of economic growth and employment.'

The four objectives usefully start to unpack the most common way of conceptualising sustainable development as having three dimensions: environmental, economic and social. These dimensions are often symbolised as overlapping circles, and have been characterised by business in particular as the 'triple bottom line' (Fig. 1).

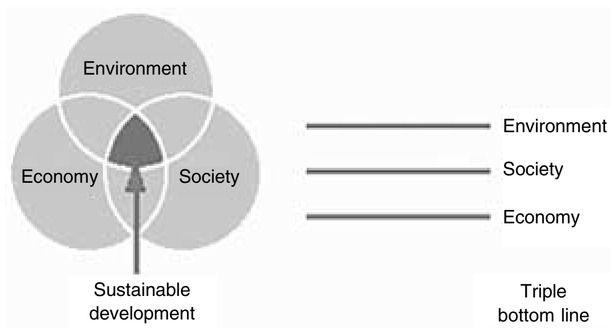


Fig. 1. Sustainable development: Venn diagram and the triple bottom line

But while such characterisations are really helpful in clarifying the *nature* of the challenge of sustainable development, they still do not get us very much further in understanding the challenge in a *practical* sense. What sort of things go into that little triangle in the centre of the sustainability Venn diagram? What does the triple bottom line add up to?

1.1. The five capitals framework

While the environmental and economic dimensions seem straightforward, many people find it more difficult to get to grips with the social dimension of sustainability. Trying to think of social sustainability *separately* from environmental and economic sustainability can run into difficulties. What the Venn diagrams illustrate is the complex interlinkages between all three dimensions. One way in which Forum for the Future has been tackling this difficulty is by conceptualising the resources available for human progress as different sorts of *capital*—natural, human, social and manufactured. Described by Paul Ekins *et al.* in 1992,[2] the *four capital model* was developed by economists at The World Bank[3] and then further by the UK sustainable development charity, Forum for the Future, where a fifth capital—financial—was added for the purposes of clarity and completeness (Fig. 2).

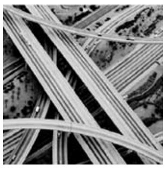
In reality, the five 'capitals' actually represent *all* the resources available to a society—or to any economic unit of that

*This is a revised and updated version of two papers originally published in Volume 138 of the ICE's *Civil Engineering* journal in 2000.

1 *Natural capital* (also referred to as environmental or ecological capital) represents the stock of environmentally provided assets and falls into two categories.
(*a*) *Resources*, some of which are renewable (trees, vegetation, fish, water), some non-renewable (fossil fuels, minerals). In some places ostensibly renewable resources (such as fertile soil) have become non-renewable (desert).
(*b*) *Services*, such as climate regulation or the powerful waste processing cycles.

2 *Human capital* consists of the health, knowledge, skills, motivation and spiritual ease of people. All the things that enable people to feel good about themselves, each other, and to participate in society and contribute productively towards its well-being (wealth). Recently recognised as providing a high return on investment, especially in developing societies (where investment in human resources is viewed as possibly the most essential ingredient of development strategies[15]) but also in the highly industrialised world.[31]

3 *Social capital* is all the different cooperative systems and organisational frameworks people use to live and work together, such as families, communities, governments, businesses, schools, trade unions, voluntary groups. Although they involve different types of relationships and organisations they are all structures or institutions that add value to human capital. Again, the importance of social capital has only recently been recognised; unfortunately however, there are increasingly visible negative effects when it is eroded.[32]



4 *Manufactured capital* comprises all of the human fabricated ‘infrastructure’ that is already in existence: the tools, machines, roads, buildings in which we live and work, and so on. It does not include the goods and services that are produced, and in some cases manufactured capital may be viewed as a source of materials (e.g. building waste used as aggregate for road building or repair).

5 *Financial capital* has, strictly speaking, no intrinsic value; whether in shares, bonds or banknotes, its value is purely representative of natural, human, social or manufactured capital. Financial capital is nevertheless very important, as it reflects the productive power of the other types of capital, and enables them to be owned or traded.

Note: Adapted from References 2, 3 and others

Fig. 2. The five-capital model of sustainability

society—for achieving sustainable development. In economic parlance each capital is represented by stocks, in which we may or may not invest, and from which we expect a range of benefits to flow. It can be argued that most if not all of our current environmental and social malaise may be explained by the unevenness of investment across different types of capital stock. By neglecting to invest in (or protect) the stocks of natural, human and social capital, some are now so diminished that the flow of benefits is slowed or, in the worst cases, halted. This sort of argument is familiar when discussing investment in manufactured capital (a railway system, for example), but it is only relatively recently that it has been applied to the environment or to people. Fig. 3 shows the opening-out of the three-circle Venn diagram to the five stocks of resources (capital), together with an illustration of some of the benefits that flow from them.

Venn diagram/ triple bottom line	Type of capital	Stock	Flow of benefits
Environment →	NATURAL	Soil, sea, air ecological systems	Energy, food, water climate, waste disposal
	HUMAN	Health, knowledge motivation, spiritual ease	Energy, work, creativity, innovation, love, happiness
Society →	SOCIAL	Governance systems, families, communities, oganisations	Security, shared goods (e.g. culture, education), inclusion
Economy →	MANUFACTURED	Existing tools, infrastructure, buildings	Living/work/leisure places, access, material resources
	FINANCIAL	Money, stock, bonds	Means of valuing, owning, exchanging other four capitals

Fig. 3. Capital stock and flows of benefits: a modernised economic model for sustainable development

Sustainable development is the process by which, over time, we succeed in managing the different capital flows in our economy on a genuinely sustainable basis. However, according to the scientific principles that underpin sustainability, it is worth noting that there are only two *real* sources of wealth—that which flows from the resources and services provided by the Earth (natural capital), and that which flows from our own hands, brains and spirits (human capital). Everything else derives from these two primary sources. Go a bit further, and given that the human species is a miraculously complex assemblage of basic natural elements, we could say that human capital is in fact a subset of nature—a true if sobering thought that confirms the overriding importance of achieving environmental sustainability!

1.2. Operationalising sustainability

The way of looking at definitions of sustainability, and of unpacking the conceptual and the practical nature of the challenge it represents, does not provide us with a blue- (or green!) print of what to do next. But it does provide us with quite a robust and logical intellectual framework within which we can work out just how any initiative, project or process might contribute to sustainable development. By posing questions that examine any proposed action's contribution to maintaining or improving the stocks of each of the five capitals, any negative impacts should be revealed and the characteristics of any trade-off that may have to be made can be explored.

For example, a new social housing project may surpass the highest energy-efficiency standards (helping to maintain natural capital), and may have delivered significant improvement in the stock of human and social capital through better health and reduced vandalism, but if it were built on part of a park rather than on a brownfield site (thereby decreasing natural capital), what is its net contribution to sustainable development?

There is no easy answer to that question of course, but thinking about actions in this way can lead to changes in the planning and design stage that can not only deliver right across the board on sustainable development, but can contribute to the financial bottom line as well.

Businesses and the engineering profession are beginning to integrate sustainability thinking. The result remains patchy, with change taking place rather more slowly than either the state of the environment or the global market opportunities would seem to dictate.

2. CONTEXT AND DRIVERS

The key contexts and drivers for sustainable development in the UK are evidence-based policy, ethics and values, the UK policy framework, risk assessment, innovation and technology, corporate responsibility and reporting. This section reviews each of these influences in turn and how they relate to civil engineers and the construction sector generally.

2.1. Evidence-based policy

It was the weight of evidence presented that led to first the 1972 UN Summit on Environment and Development, then the UN 'Earth Summit' in 1992 in Rio de Janeiro, and no end of international, national and sectoral meetings and conferences in between and since. Indeed, nothing short of convincing evidence would have prompted governments to tackle anything so complex and far-reaching as sustainable development.

The wider environmental evidence is well summarised by the World Resources Institute (WRI)[4] and the United Nations Environment Programme (UNEP),[5] and that of climate change is well summarised in the Select Committee on Environmental Pollution Report *Energy: The Changing Climate*.[6] The failure of unprecedented levels of global and economic growth and affluence to tackle poverty, inequality and other human injustices is reported on by the UN Development Programme.[7] The current implementation crisis in these areas was again well documented at the Johannesburg summit in 2002.[8]

There are some sceptical environmentalists, such as Bjorn Lomburg,[9] who argue that the evidence of substantial environmental damage is not convincing, and it is of course always wise to listen carefully to the dissenting minority voice. But in the case of scientific evidence it is essential also to critically analyse the provenance of the evidence. For example, the Intergovernmental Panel on Climate Change (IPCC), set up by the UK Government, engages hundreds of scientists in a publicly transparent, fully published and peer-reviewed process.[10] Their voice is not one with a particular industrial axe to grind. The same cannot be said of some corporate research relating to genetically modified organisms, which may have implications of a not dissimilar magnitude.

The weight of environmental evidence, backed by much improved technological capacity to track issues ranging from forest loss or coastal erosion and pollution to endocrine disrupters in drinking water, is pretty overwhelming. So is the impact on human health and economies (see the WRI website for examples). It is difficult to aggregate all environmental impacts for civil engineering, but the following figures for the UK construction industry illuminate its potential dimensions—as well as the opportunities for improved resource efficiency

(*a*) consumes 6 tonnes of material per person per annum
(*b*) obtains less than 20% of the 240 million tonnes of aggregates used from secondary sources (that is, it uses freshly quarried material) per annum
(*c*) generates 70 million tonnes of waste per annum
(*d*) throws away unused 13 million tonnes of material delivered to sites per annum
(*e*) is the most frequent industrial polluter, with increasing incidents against a falling overall trend.

The impacts of major civil engineering projects on society are not, apparently, aggregated either. It is often only when the project generates significant opposition (recent examples include big dam projects in India and Turkey) that wider ethical and social issues such as land rights, human rights and other effects on local communities come to light. Modern communications do mean the world hears about such impacts more easily, but it is surely right for such projects to be subject to a full social and environmental review at the earliest stage as a matter of principle rather than through fear of being caught out.

2.2. Ethics and values

'Science without ethics is blind; ethics without science is empty.'[11] This quote kicked off the findings of a report produced by young engineers in the UK,[12] and it reflects a wider feeling among people that decisions that affect not only themselves but also people in other countries are being made beyond the reach of any sort of democratic accountability and in some sort of ethical void. This feeling was manifest, for example, in the reaction at the World Trade Organisation meeting in Seattle, and in the response to attempts to introduce genetically modified organisms into the food chain.

The young engineers argued that it is a profound mistake to view ethics and values as 'soft, subjective and personal' whereas science is 'hard, objective and factual'. Issues of right and wrong, or good and bad, are not like preferences for thin- or thick-cut marmalade. Reasons underpin ethics and value choices—and reasons can be analysed, held to account and subjected to rational debate.

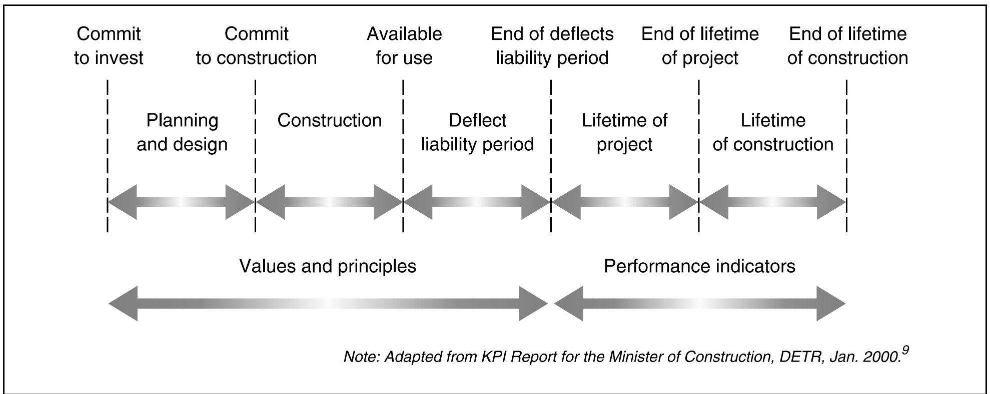


Fig. 4. Values, principles and performance indicators over the lifetime of a construction

Typically, a construction client wants the lowest capital cost and timely delivery. These are valued—indeed, are values—for engineers working with a client on a project. It should be a natural step, however, to question other things the client values that may not be explicit in the brief, or even in the client's mind. What is it about the end-product that they value? Is it really what they are looking for? For example, is it literally a building like the one next door that's required, or a healthy and comfortable work environment that enables clients to make the most of the human capital they employ and invest in? Do they just want a powerful engine, or is it a car with good acceleration that might be lighter and smaller?

When it comes to the major civil engineering projects—from road bypasses to big dams—the need for an ethical and value-driven process from the outset of the project is no different. It may be more complex and take more time, but the questions, the need for a transparent process, and an analysis of the reasons behind the decisions are the same.

In 2001, the Construction Industry Research and Information Association (CIRIA) published the first set of sustainability indicators for the construction industry. The indicators can be applied at both company and project level to measure performance and raise awareness about sustainability.[13]

As a separate initiative, the UK Department of Trade and Industry has sponsored a research project to develop a guide on 'how to be a socially responsible construction client' (to be completed mid-2004). The work is being delivered by CIRIA, Buro Happold, Forum for the Future, and the Prince's Foundation.

Initiatives such as these are helping engineers and others to link the outcomes and outputs of their activities back to the initial values and principles that influence how and where those activities are designed and carried out in the first place. In the context of sustainable development, of course, it is the *lifetime* of the building or structure that is of concern, not just the lifetime of the project in which an engineer might be engaged (Fig. 4).

The economic, environmental and social costs of running, maintaining and eventually disposing of the construction *after* the project is formally completed is as important an issue in a practical as well as in an ethical sense. When taken into account it can change the 'full life costing' calculations dramatically (Fig. 5).

For instance, if low energy use, low maintenance costs and low transport costs are given a high value by the client, then higher costs at the design and construction phase can often be justified—economically as well as environmentally. Payback periods from straightforward measures can be very short. Reducing emissions of CO_2 and other greenhouse gases is a top priority that may be pursued either through more efficient use of fossil fuels and/or by replacing them with energy from renewable sources. Full benefits are best realised by designing and planning them in from the start. Some engineering institutions have embedded sustainable development and the importance of ethics and values into the codes and standards that govern their membership and practice. The rules of the Institution of Civil Engineers, for example, say 'a member shall have full regard for the public interest, particularly in relation to the environment and shall discharge duties to the employer or the client both impartially and with complete fidelity.'[14]

But is this sufficiently explicit for the sorts of ethical issues that arise from sustainable development? Learning about ethics, perhaps, should be as fundamental a feature of education as the scientific principles of sustainable development.

2.3. UK policy framework

International treaties (for example, the Kyoto Protocol on greenhouse gas emissions) and European legislation shape the UK policy framework in which civil engineers are working.

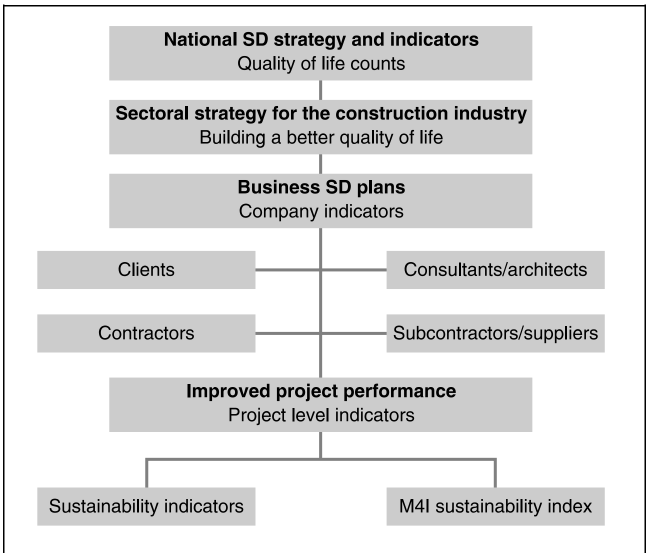


Fig. 5. Sustainable construction strategy and indicator hierarchy (Source: CIRIA 2000)

To give a flavour of other initiatives, the UK Government has also

(*a*) pledged to go beyond its legally binding international commitment to 12·5% reduction in greenhouse gases by 2012 (from 1990 levels) to achieve a 20% reduction by 2010
(*b*) published a UK Strategy for Sustainable Development in 1999[1] and regular progress reports[15] based on a set of sustainability indicators[16]
(*c*) established a Minister for Corporate Social Responsibility in the DTI
(*d*) made sustainable development, along with education, an overarching theme of the DTI/Foresight programme[17]
(*e*) built in sustainable development as a key factor for policies and proposals of the regional development agencies
(*f*) introduced a climate change 'levy' on energy use and a tax on waste disposed in landfill.

After two years of consultation, the UK Government published its sectoral strategy for the construction industry in April 2000.[18] As part of this process Sir John Egan's Construction Task Force published *Rethinking Construction* in 1998,[19] and the Movement for Innovation (M4I) was launched to identify and disseminate examples of good practice. One such example, the replacement Queen Margaret Hospital in Swindon, shows how more sustainable buildings and structures can benefit client and community. The contractor worked with The Natural Step, a science-based learning and decision-making tool, to evaluate the project from a sustainability basis.[20]

In 2000, HM Treasury, in partnership with M4I and the Office of Government Commerce, published a set of recommendations and targets for the Government's own construction procurement with a view, over three years, to achieve

(*a*) procurement in line with value-for-money principles on the basis of 'whole-life costs'
(*b*) less waste during construction and in operation
(*c*) targets for energy and water consumption for new projects that meet at least current best practice for construction type
(*d*) the protection of habitat and species, taking due account of the UK Biodiversity Action Plan and the biodiversity action checklist for departments agreed by the green ministers
(*e*) targets developed in terms of 'respect for people' for procurement of the Government estate
(*f*) a contribution to the goals of less pollution, better environmental management, and improved health and safety on construction sites.

Importantly, this is an HM Treasury driven initiative, and, as the Government is a major construction client, it is likely to drive the sustainability agenda through the construction sector in a significant way. It enshrines the principle of whole-life costing—that is, calculating costs over the lifetime of the *building*, not the *project*—so operating costs must be considered alongside construction costs. This push to render central government spending more sustainable is also a feature of the drive for best value in service provision by local government.

The main point here is that sustainable development is not a policy fashion that will have its day and then disappear. Not only is it real, but it has started. And like any other major change in society (such as globalising communication systems and markets), it is the people, companies and organisations that understand the implications best that are able to grasp the opportunities offered by change rather than be swallowed up by it.

Sustainability policies are unlikely to stop coming down the pipeline. Civil engineers, and their companies and clients, who read and understand the implications of existing and new policies, and who use existing voluntary initiatives (such as the indicator work mentioned earlier) to help them change their practice, can position themselves *ahead* of legislation (that is, not be held up by it) as well as gain market advantage immediately.

2.4. Risk assessment, innovation and technology

A very large volume of literature exists on risk assessment techniques for engineers. Professional bodies and individual organisations have codes and guidelines designed to frame procedures to avoid or minimise risks. When it comes to risk and sustainable development, especially environmental sustainability, there is a polarisation developing between the relative merits of the 'scientific' against the 'precautionary' that is not at all helpful, and is very unfortunately becoming tied up by various parties with particular political or commercial objectives.

The precautionary principle was defined in the 1992 Rio Declaration on Environment and Development as follows

> 'Where there are threats of serious irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation'.

The 'precautionary approach' is now enshrined in much environmental and health policy and law at a UK, European and international level. The scientific/precautionary dichotomy is unhelpful because, as usual with these things, and especially with something as complex and interrelated as sustainable development, both approaches need to work in tandem to achieve a satisfactory outcome. An interdisciplinary report published in 1999 to the EC Forward Studies Unit looked at the key issues arising from application of both 'science' and 'precaution' to the management of technological risk.[22] The report concluded that key elements of the precautionary approach are in fact entirely consistent with sound scientific practice and can help with a response to acknowledged intractable problems in risk assessment such as 'ignorance' (we don't know what we don't know) and 'incommensurability' (we have to compare apples and pears). In fact, with the different assumptions adopted in different risk assessment studies often yielding results that vary by several orders of magnitude, the precautionary approach (which acknowledges such difficulties) can provide a *more* scientifically rigorous way of assessing technological risk than a narrow 'risk-based' approach.

Companies such as Shell and Monsanto have learnt the hard way that technological risk assessment that excludes a proper consideration of the environmental and social consequences will not wash. 'Proper' here means not only ensuring that the context for the evaluation is correct, but also that the process of arriving at a conclusion is both transparent and properly rigorous, and that it includes the views of all 'stakeholders' who are likely to be affected by the consequences of that decision. Get any of that wrong, and it is a long haul to recuperate reputations and/or commercial advantage, especially in a climate where people

(*a*) are questioning all authority, including scientific authority
(*b*) have little trust in science that is not clearly independent
(*c*) are suspicious of governmental and institutional secrecy
(*d*) feel their own values are not always reflected in the way the scientific establishment behaves
(*e*) are concerned about the objectives of science and their own capacity to feel in control and able to make their own choices.

Regular public opinion polls report similar drops of public confidence in business and politicians. In 1997 the Government's chief scientific adviser issued guidelines on *The Use of Scientific Advice in Policy Making.*[33] Its main theme is openness, and it recommends that, where scientific advice is uncertain, this should be admitted from the start. The House of Lords Select Committee report *Science and Society*[23] came to a similar conclusion, pointing out that 'in modern democratic conditions, science like any other player in the public arena ignores public attitudes and values at its peril.

> 'Our call for increased and integrated dialogue with the public is intended to secure science's 'licence to practise', not to restrict it.'

In an article published in the same month, Sir Ian Lloyd, the first chairman of the Parliamentary Office of Science and Technology, said: 'we delegate at our peril decisions on major risks to those who have no comprehension of risk analysis and probability.'[24] Sir Ian is seemingly out of touch with the capacity of the ordinary people to conduct speedy and sophisticated calculations on risk and probability when backing horses, for example, or when participating in the television programme *Who Wants to be a Millionaire?* But he is right to point out that scientific research and technological development are becoming more and more complex. However, Professor Judith Petts of the University of Birmingham has established, by using good-quality public participation procedures, that the public are actually quite capable of reaching technically and socially complex decisions that are neither irrational nor zero-risk-based.[25]

When operating in a climate in which uncertainty and public scepticism are the norm, civil engineers are advised to minimise the risks in risk assessment by, as a rule of thumb, enlarging the arena for the assessment and the decision-making up through the company and out into society in proportion to the degree of uncertainty and the scope of the potential impact of the project. The importance of transparency in the process, and in seeking the essential scientific rigour through the precautionary principle 'not instead of it' is emphasised. The difficulties of decision-making in the context of sustainable development and increasing technological sophistication are increasing, it is true, but then so is the price of getting it wrong.

Life-cycle assessment (LCA) methodologies, and concepts such as clean technology, reveal opportunities not only for improved performance of existing products and processes but also for developing innovative opportunities that are ideally on the route to achieving the Factor 10 improvements in resource efficiency identified in the companion paper in this journal,[26] and in the context of whole-life costing referred to earlier in this paper. Although rarely positioned as such, LCA and clean technology approaches may also be used as risk-assessment tools. Answers to the questions that need to be posed in either approach are similar to those that would arise in a risk-assessment process that covered environmental and social impacts to the full. They also echo the sorts of value-driven questions that any ethically responsible engineer should use on any project.

The concept of clean technology has developed out of the drive for cleaner production, but approaches the problem of sustainability at a more fundamental level. It concentrates not on a product but on the human benefit that it delivers. Clean technology thinking can be embodied by a set of simple questions to be applied to any commercial activity that aims to meet a human need. These questions are now listed, where 'it' is any material input, product, by-product, feedstock or reagent.

(*a*) Where does 'it' come from?
(*b*) Where does 'it' go?
(*c*) Must 'it' be used at all?
(*d*) Must 'it' be made at all?[27]

The first two questions help us to think about the whole life cycle, and include questions that identify potential alternative energy sources (e.g. less carbon-intensive, renewable) and the use of recycled materials. Question (*b*) is particularly important in relation to chemicals (such as agrochemicals, detergents and PCBs), which may not be so easy to 'see' as piles of cement or aggregate. Questions (*c*) and (*d*) relate to the use or manufacture of any materials associated with a high environmental risk. Question (*d*) is the critical test. Can the required service be provided without making and/or selling a material or materials at all? The Royal Academy of Engineering is running a Visiting Professors Scheme to develop case studies for use in teaching engineers how to use LCA techniques in different situations.

2.5. Corporate responsibility and reporting

Quantitative proof of the link between sustainability strategies (for example, improved environmental performance and greater social responsibility) and increased shareholder value—or more specifically increased share price—does not seem to be readily available at first glance. This is because the economy currently treats natural resources as largely inexhaustible and freely available, and tends to 'mop up' the costs of social and environmental impacts in a range of different budgets (such as health, regeneration and social security) rather than embody them in the true cost (and therefore value) of goods and services on sale.

However, scratch the surface a bit and shareholder value and profitability can be seen to stand on things such as resource productivity, reputation and risk management, employee satisfaction, innovation, market advantage/differentiation, creativity, supplier and stakeholder relations, as well as on product or service cost and traditional productivity measures.

The markets too have woken up, or at least have raised an eyelid, to the opportunities of sustainable development. For example, Dow Jones launched a new global Sustainability Index at the end of 1999.[28] It ranks 300 out of the 2500 largest (by market capitalisation) quoted companies, recognising not only financial performance but also

(*a*) pursuit of sustainability opportunities
(*b*) reduction/avoidance of sustainability risks and costs
(*c*) quality of information available.

There are questions around the weightings and assumptions enshrined in the model that Dow Jones uses for this index (they are confidential), but it does acknowledge a real move towards investor portfolio diversification into companies committed to innovation, shareholder relations and social well-being, as well as to industrial leadership. Indeed, general growth in interest of investors in existing ethical funds has been sending signals for some time to companies that might hitherto have felt sustainable development was something that did not concern them. Moreover, a key outcome from the Engineer of the Twenty-first Century Inquiry[29] was that the next generation of engineers want to work for companies that are not only embracing the challenge of sustainable development in the work that they do, but also in the culture of the organisation. They expect interdisciplinary collaboration and stakeholder consultation as a norm, and rewards for the broadly experienced and knowledgeable engineer as well as for those with specialist skills. Recruiting top graduates will become more difficult for companies that do not recognise such values and expectation in their workforce.

Another dynamic area is corporate reporting on social and environmental performance. This has improved sharply over the last five years. In 2002, 103 companies out of the FTSE 250 published stand-alone reports, in print or on the world wide web, with 50 of them having reported for the first time.[30] There are clear signs that reporting will continue to improve over the next five yeas in terms of both quantity and quality. The UK Government or the EU might make it a mandatory requirement as established in France in 2002 and demanded by the CORE campaign—a UK coalition of NGOs and civil society groups. Global guidelines and standards, such as Global Reporting Initiative, AccountAbility 1000, and the SIGMA project, will further improve the quality of reporting.

Being recognised as a leading reporter in the Global Reporting Review carried out by UNEP and SustainAbility is already a real challenge.[31] In 2000 it was almost only a question of simply publishing a report. Today leading reporters, such as the Co-operative Bank and BAA, report along clearly defined indicators linked to their sustainability strategy and based on an intensive stakeholder consultation process.

New guidelines for multinational enterprises went before OECD ministers at the end of June 2000. The guidelines establish a non-legally binding code covering a range of issues in business ethics, including employment and industrial relations, environment, information disclosure, competition, financing, taxation and science and technology. The UK Government has already expressed its support, and the guidelines are endorsed by the business community, labour federations and, by and large, civil society organisations. Although voluntary, the codes are likely to help shape good practice for international companies and organisations.

Over the last decade, the move to more transparency and to better accountability of companies to all stakeholders including the environment, and not just shareholders, has gathered momentum. The 'licence to operate' now covers labour standards, community engagement, human rights, corruption, supply chain issues, and environmental performance among other issues.

The initiatives mentioned, including the review of company law in the UK, are attempts to come to terms with new perceptions of corporate responsibility in a rapidly changing and uncertain world. Engineers, and the companies they work with and for, are strongly advised to track these initiatives, but not to delay setting up their own sustainability management systems and reporting mechanisms. Those that have done so find that, however difficult it may be at the start, it provides a route to market advantage, risk minimisation and an enhanced company reputation that is attractive to customers and employees alike.

3. CONCLUSION

The objective of this paper is to give civil engineers—and others—an overview of some key contexts and drivers that will affect both individual engineers and the companies they work for as society 'operationalises' sustainable development—that is, turns the concepts and the principles into practical realities. The process has in fact started. The hope is that some readers, who have felt that sustainable development is not for them, will now feel able or even inspired to get started on what is an inevitable process of change.

In the paper on clean technology quoted earlier,[27] Roland Clift, a pioneer in teaching and researching engineering and the environment, describes what is happening in engineering in the context of changing paradigms in the interaction between human society and the rest of the universe. There is a move from dilute-and-disperse through clean-up technology to clean technology, and from thoughtless exploiting of resources, through life-cycle assessment to integrated material management. From here, it is only a short step to seeing the commercial advantages of no longer selling products (where responsibility for ultimate disposal is dispersed and the quality of the material often too degraded) but *leasing products and providing services* instead, thereby maintaining control over the material embodied in the product and high-value reuse and recycling opportunities.

Certainly, the way the engineering profession positions itself—practically and morally—in this new age will be as critical to the profession as it will be to the way society copes with the challenge of sustainable development. At every turning point of history, there has been an engineer in there somewhere, and meeting the challenge of generating wealth and human well-being without destroying the environment is as pivotal a moment in history as when the agricultural age gave way to the industrial era.

REFERENCES

1. Department of the Environment, Transport and the Regions. *A Better Quality of Life: A Strategy for Sustainable Development for the UK*. DETR, London, May 1999.
2. Ekins P., Hillman M. and Hutchinson R. *Wealth beyond Measure: An Atlas of New Economics*. Gaia Books, London, 1992.
3. Serageldin I. and Steer A. Expanding the capital stock. In *Making Development Sustainable: From Concepts to Action* (Seregeldin I. and Steer A. (eds)). The World Bank, Washington, DC, 1994, ESD Occasional Paper Series No. 2.
4. World Resources Institute. Washington, DC, at http://www.wri.org
5. United Nations. *UN Environment Programme State of the Global Environment Report* at http://www.unep.org/sge
6. Royal Commission on Environment and Pollution, London, at http://www.rcep.org.uk
7. United Nations. *UN Development Programme, Human Development Report 1999*. UNEP and Oxford University Press, Oxford, 1999.
8. Walter J. and Simms A. *The End of Development? Global Warming, Disasters and the Great Reversal of Human Progress*. New Economics Foundation, London, 2002.
9. Lomburg B. Measuring the real state of the world. Cambridge University Press, Cambridge, December 2001.
10. Intergovernmental Panel on Climate Change, at http://www.ipcc.ch
11. Des Jardins J. *Environmental Ethics*. Wadsworth, 1997.
12. Forum for the Future. *The Engineer of the 21st Century Inquiry: Final Report*. Forum for the Future, London, 2000.
13. Construction Industry Research and Information Association. *Sustainable Construction Indicators*, CIRIA C563, London, 2001.
14. Institution of Civil Engineers. *Rules for Professional Conduct*. ICE, London, 1999.
15. Sustainable Development Commission. *Achieving a Better Quality of Life: Review of Progress towards Sustainable Development*. Government Annual Report, 2001.
16. *Sustainability Counts*. DETR, 1998.
17. Foresight Programme. Website at http://www.foresight.gov.uk
18. Department of the Environment, Transport and the Regions. *Building a Better Quality of Life: A Strategy for More Sustainable Construction*. DETR, London, April 2000. Website at http://www.construction.detr.gov.uk
19. Department of the Environment, Transport and the Regions. *Rethinking Construction (The Egan Report)*. DETR, London, 1998.
20. Tarmac Special Projects Pathfinder Projects. *Princess Margaret Hospital Relocation, Swindon*. The Natural Step, UK, 1999, http://www.naturalstep.org.uk
21. Edvinsson L. and Malone M. S. *Intellectual Capital*. HarperCollins, New York, 1997.
22. Stirling A. *On Science and Precaution in the Management of Technical Risk*. European Commission, Brussels, 1999, Final Report to the EC Forward Studies Unit.
23. House of Lords. *House of Lords Select Committee on Science and Technology, Third Report: Science and Society*. The Stationery Office, Norwich, 2000.
24. Lloyd I. The tyranny of the L-shaped curve. *Science and Public Affairs*, 2000, Feb., 14–15.
25. Petts J. The public–expert interface in local waste management decisions: expertise, credibility and process. *Public Understanding of Science*, 1997, **6**, 359–381.
26. Parkin S. Sustainable development: the concept and the practical challenge. *Civil Engineering*, 2000, **138**, Special Issue, 3–8.
27. Clift R. Clean technology: the idea and the practice. *Journal of Chemical Technology and Biotechnology*, 1997, **68**, 347–350.
28. See http://www.dowjones.com/djsgi
29. Company Law Steering Group. *Modern Company Law for a Competitive Economy: Developing the Framework*. Company Law Steering Group, London, 2000, p. 185.
30. Green Futures Editorial Team. *Reporting Fatigue in Green Futures*. Green Futures, 2002.
31. Sustainability and UNEP. *Trust Us. The Global Reporters 2002 Survey of Corporate Sustainability Reporting*, London, 2002.
32. Social Exclusion Unit. *Bringing Britain together: a national strategy for neighbourhood renewal*. CM 4045. The Stationery Office, London, 1999.
33. *The Use of Scientific Advice in Policy Making*. Office of Science and Technology, DTI, London, 1998.

Please email, fax or post your discussion contributions to the secretary by 1 September 2003: email: kathleen.hollow@ice.org.uk; fax: +44 (0)20 7799 1325; or post to Kathleen Hollow, Journals Department, Institution of Civil Engineers, 1–7 Great George Street, London SW1P 3AA.